Habitat Utilisation by the White Rhinoceros and Status of the Species in Namibia

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by

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This prime dominant bull on a Namibian game farm died in September 1996, two weeks after this photograph was taken, from a poacher's bullet wound. Although poaching incidents are infrequent, they remain a significant threat to all rhino populations.

Abstract

This study investigated habitat utilisation of the white rhinoceros (*Ceratotherium simum simum*) in a semi-arid environment and established the history and current status of the species, following its introduction to Namibia.

Most early introductions of white rhinos to private land were not successful due to poaching, over-hunting and poor management. The value of the animals has increased significantly since 1989, which has encouraged farmers to protect and manage rhinos sustainably, and numbers are now increasing. Effective management involves protection from poaching, regular monitoring and providing supplementary feed when grazing is poor. White rhino numbers in National Parks have increased due to co-ordinated management and protection operations.

Spatial utilisation of a group of white rhino in a potentially marginal, semi-arid environment was investigated by comparing rhino habitat selection with that available. Following an intensive assessment of the habitat in the area, traditional African tracking techniques were applied to observe and record rhino habitat selection, grazing and activity patterns at approximately 2,000 GPS locations. Rhino activity locations were overlaid onto spatial maps of environmental parameters and analysed using GIS techniques. In this study, the rhinos were found to primarily select the dominant, soft grass species and areas with high grass density and biomass. They had apparently successfully adapted to utilise this semi-arid environment. Habitat utilisation was generally broad, only highly rocky and steep areas being avoided.

Certain parts of Namibia's semi-arid environment were considered to be marginal or inherently unsuitable habitat for white rhino due to overgrazing and low rainfall, but with management support, rhinos can persist and thrive largely independent of the available habitat. With respect to the favourable status of the species world-wide, continued introductions were recommended, providing owners were aware of management requirements. An information booklet was produced to assist understanding of the implications, requirements and problems when considering introductions.

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Chapter 1

General Introduction

1 General Introduction

1.1 The White Rhinoceros

1.1.1 Rhinoceros in Southern Africa

Two species of rhinoceros historically occur in southern Africa. The white rhinoceros (*Ceratotherium simum*) or square-lipped rhino, hereafter referred to as 'white rhino' or 'rhino', is a large grazer (Smithers 1983) and is the third largest land mammal. Adult males weigh between 2,000 and 2,300 kg and have a shoulder height of up to 1.8m (Owen-Smith 1988). The black rhinoceros (*Diceros bicornis*) or hook-lipped rhino is a browser (Smithers 1983), and is smaller than the white rhino with a shoulder height of 1.4m to 1.6m (Owen-Smith 1988).

Distinguishing between the black rhino and white rhino species is not possible by colour, as both are grey. However, when white rhino were initially identified as a separate species, first sightings were believed to be of paler rhinos as they had been rolling in the calcareous soils of the western Cape, and they acquired the name 'white' rhino (Figuier 1870; Owen-Smith 1973).

1.1.2 History and Present Status of the White Rhinoceros

Large numbers of the southern white rhino (*Ceratotherium simum simum*, Burchell 1817), could be found in southern Africa in the early part of the nineteenth century (Harris 1839). Early explorers and hunters were mainly responsible for the subsequent decline in animal numbers. By 1929, only 120 of this sub-species survived in the recently designated Umfolozi Game Reserve (hereafter referred to as Umfolozi) in South Africa, with an additional 30 on neighbouring property (Owen-Smith 1973). Relatively secure from poaching and hunting, numbers increased and in the 1960's, the relocation of animals began to other conservation areas and zoological institutes around the world (Player 1972). Most introductions have been extremely successful. For example, in the Kruger National Park (hereafter referred to as Kruger), a twelve year reintroduction programme released 345 white rhinos up to the early 1970's. By 1993, numbers had increased to 1,875 (Pienaar 1994a&b).

Emslie (1996) reported the numbers of southern white rhinos in the wild to have increased from 4,670 in 1987 to 7,530 in 1995. World-wide, it is estimated that in 1997 there were approximately 9,000 white rhinos (UK Rhino Group 1998; Frädrich 1997). Of these approximately 624 were located in captive situations outside the continent of Africa (Frädrich 1997).

1.1.3 Other Rhinoceros Species and Sub-Species

In sharp contrast to the population recovery of the white rhino, the black rhino has been steadily declining over recent decades. Population estimates for 1970 suggested 60,000 animals, which dropped to 15,000 animals in 1980, and only 3,800 in 1990 (Cumming *et al.* 1990). Subsequently, numbers have remained reasonably stable at around 2,410 since 1992 (Emslie 1996). There are seven sub-species of black rhino (Owen-Smith 1988), of which *Diceros bicornis bicornis* is physically the largest. This sub-species is adapted to semi-arid conditions (Lindeque 1994) and most specimens are now living in Namibia.

There are two sub-species of the white rhino (Owen-Smith 1988). In the wild, the northern white rhinoceros (*Ceratotherium simum cottoni*) now occurs only within the Garamba National Park in Zaire (Van Gyseghem 1984). It has a very similar appearance, ecology and behaviour to the southern sub-species, with minor differences in morphology such as a shorter body length, slightly longer legs and lack of body hair (Owen-Smith 1988). Numbers have declined from approximately 2,000 animals in the early 1960's to only 29 animals in 1996 (Emslie 1996). The future of this sub-species remains uncertain as their protection depends critically upon the stability of Zaire.

1.1.4 International Legislation

A total ban on trade in all rhinoceros products was instigated through listing of the species in Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) in the late 1970's. In 1994, at the ninth meeting of CITES, the southern white rhino was down-listed from Appendix I to Appendix II to allow the sale of live animals to 'appropriate and acceptable destinations' and the export of hunting trophies from South Africa (CITES 1994).

In 1997, South Africa judged that they had sufficient white rhinos to secure the species future and at the tenth meeting of CITES they submitted a proposal which sought to remove trade restrictions and to open a market of sustainable utilisation. This proposal was closely rejected by a vote (Buijs 1997). South Africa argued that if restrictions on trade in rhino horn were removed, it would allow sustainable utilisation of the species and provide some revenue for conservation programmes in Southern Africa. However, there is international concern as to whether a ban on any illegal trade can be enforced while legal trade can takes place (Buijs 1997).

1.1.5 Poaching and Protective Measures

Rhino poaching for the horn has caused the decline of many rhino populations in Africa (Leader-Williams 1992; Western & Vigne 1985). Although trade in horn is illegal under CITES, organised poaching and illegal trade continues (Nowell *et al.* 1992). Rhino horn is used in the far east as a component of traditional medicine (t'Sas-Rolfes 1996) and in the Yemen where it is used for dagger handles, symbolising the wealthy status of the owner (Martin 1980; Vigne & Martin 1996).

In an attempt to prevent the possibility of total extinction of the species, protection has intensified with armed poachers being shot on sight in countries such as Zimbabwe and Kenya (t'Sas-Rolfes 1996). Commitment to law enforcement is suggested as the most effective method of preventing poaching (Rachlow & Berger 1997), whilst other techniques include de-horning rhinos (Berger *et al.* 1993).

Regularly patrolling and monitoring of rhinos is an integral part of protecting a population. Techniques for monitoring include tracking or following the rhinos footprints (Owen-Smith 1973, Stander *et al.* 1997) and attaching radio transmitters to animals via horn implants or collars (Pienaar & Hall-Martin 1991).

1.1.6 Sustainable Utilisation

Purchase prices of white rhino were fixed by the Natal Parks Board at low, subsidised values until 1989. Prices were then allowed to reach their true economic value at auction and they increased considerably, which has encouraged owners to regard the animals as valuable assets worth conserving. Private ownership of white rhino is usually a business, which must make profits to survive, therefore sustainable utilisation of the animals has become very relevant.

Sustainable utilisation has been defined as harvesting only a certain proportion of a population, so that future use is not affected (Spellerberg & Hardes 1992). It is legal to trophy-hunt white rhinos in Namibia but the practice is strictly controlled by permits from the Ministry of Environment and Tourism under CITES guidelines. Hunting is a controversial use of wildlife in the eyes of some conservationists (Geist 1988). However, when properly controlled and managed, trophy hunting can be a sustainable and ecologically sound form of utilisation of rhino populations, and incorporates an element of profitability in return for ownership and conservation on private land. Trophy hunting may be used to manage populations by removing 'surplus' animals (generally males) which would otherwise be using the grazing resources of breeding animals, or might fight and kill other rhino (Adcock & Emslie 1994). The income generated from hunting and the value of rhino populations encourages owners to improve security (Adcock & Emslie 1994). An alternative non-lethal form of hunting is the 'ecohunt' in which a hunter pays to temporarily immobilise an animal (Chilvers 1993).

1.1.7 Ecology

i) Age Classes

Owen-Smith (1975) defined age categories for white rhino with respect to their social behaviour. A calf is considered a juvenile until it is 2-3 years of age, when it is driven away by its mother after the birth of a subsequent calf; it is then regarded as a sub-adult. Young females remain sub-adults until the birth of their first calf at 6½ to 7 years; they are then regarded as cows. Males or bulls are regarded as adults once they become solitary at approximately ten to twelve years old. At this stage prime adults establish territories and become dominant bulls, while younger or older bulls become subordinate or submissive to these individuals.

Rhino age can be visually assessed from the size (see Appendix VIII), appearance and horn development (Hillman-Smith *et al.* 1986). However the best indications of age class can be obtained by checking stages of tooth eruption, general tooth wear and the attrition in height of the first molar tooth. This may be carried out via dental impressions taken from immobilised animals (Wucher 1994) or from the skull of dead animals (Hillman-Smith *et al.* 1986). The highest cementum line count from a tooth section of a white rhino indicated an age of about 40 years (Hillman-Smith *et al.* 1986).

ii) Population Structure and Behaviour

A rhino's home range is an area where its physiological requirements are met when water is available (Owen-Smith 1973), and varies according to rhino density (Pienaar *et al.*1993b & 1994b). Within a confined area, an animal's home range usually extends to the boundary fences and is therefore not solely a function of the animal's preference. White rhinos are social animals and are commonly found in groups of two or three individuals although larger groups are possible (Owen-Smith 1988; Pienaar 1994b). Associations between individuals were sometimes stable, lasting longer than one month while others only last for several hours (Owen-Smith 1975).

Adult bulls tend to be solitary although they may be accompanied by females or sub-adults (Owen-Smith 1988). Dominant bulls occupy distinct non-overlapping territories (Owen-Smith 1972 & 1975) which they frequently patrol and mark by scattering their fresh dung and urinating in a powerful spray. They rarely leave their territory, except to proceed to water and on an occasional exploratory excursion (Owen-Smith 1988).

The territories of cows overlap extensively and may encompass many bulls' territories (Owen-Smith 1988). When a cow is in oestrus she will generally be accompanied by a bull and his advances are apparent through hic-throbbing sounds (Owen-Smith 1988). Cows have a gestation period of 16 months and will generally produce a calf every 2.7 to 3.5 years (Owen-Smith 1988). Over a four year period, it is unusual for a cow not to produce a calf unless she is infertile or had lost the calf shortly after birth. However, ecological conditions may cause birth intervals to vary or the foetus to be aborted early in pregnancy (Owen-Smith 1988). Owen-Smith (1988) estimated oestrus-cycle length at 27-44 days, however Schwarzenberger *et al.* (1994) indicated a cycle of approximately 10 weeks in a captive white rhino by monitoring faecal progestagen levels.

Rhinos have acute senses of smell and hearing but relatively poor eyesight (Owen-Smith 1988). Although very large, they can react rapidly and run or charge with considerable speed. The white rhino is a relatively placid animal, unlike the black rhino which is notoriously aggressive and will charge with little provocation.

For the purpose of this study, the total number of animals has generally been referred to as a group. However, at locations with six or more animals they have been collectively referred to as a population.

iii) Habitat

The basic habitat requirements of white rhino include open plains with short grasses, trees to provide shade and access to permanent water sources (Joubert 1996). Other requirements identified by Player and Feely (1960) included water for wallowing, adequate thick bush cover and relatively flat terrain. When white rhinos were introduced to Kruger, they moved into similar habitats to those in the Umfolozi, areas with gently rolling hills and relatively open woodland (Pienaar 1970). Subsequent studies of the landscape preference of white rhino in different areas of Kruger indicated a preference for open to moderate low-shrub stratum (<2m), a moderate tree stratum, an undulating topography with watercourses and the availability of small pans for mud baths (Pienaar *et al.* 1992, 1993a,b&c). Access to water is important throughout the year as white rhinos have a drinking frequency of every 2 to 3 days (Owen-Smith 1988; Smithers 1983), or every 2 to 4 days (Pienaar 1994a; Joubert 1996) during the dry season.

Habitats avoided by white rhinos were identified as by Pienaar *et al.* (1993a) as including areas with dense low shrub layers, very mountainous or broken terrain, soils with abundant stones and rocks on the surface and areas with a shortage of permanent water.

iv) Feeding and Nutrition

The white rhino was referred to as a megaherbivore by Owen-Smith (1988), because it is a plant feeding mammal with a body mass in excess of 1000kg. They may also be referred to as a bulk grazer (Joubert 1996) or gross feeder (Owen-Smith 1981). It is commonly regarded as a short-grass grazer (Player & Feely 1960; Foster 1967; Owen-Smith 1973; Smithers 1983; Joubert 1996), although at the end of the dry season in the Umfolozi, grazing activity concentrated on increasingly tall areas of grassland (Owen-Smith 1973). In Kruger, white rhino were described as preferring short grass species and moderate to dense grass cover (Pienaar 1994a). They selectively graze good quality more palatable species which were found growing in shady areas and along rivers as well as freshly sprouting shoots after a burn and also around termite mounds (Pienaar 1994a). Because they are adapted for the intake of large quantities of food, in situations where they are locally over-abundant they are capable of transforming grassland structure by continuous grazing pressure (Owen-Smith 1981).

Assessing the nutritional quality of the diet of a herbivore is possible by using various techniques including direct observation of the animal, chemical analysis of ingesta (Lamprey 1963), microscopic analysis of fragments of leaf epidermis in faeces (Stewart 1967) or chemical analysis of the quantities of nitrogen and phosphorous in faeces (Grant *et al.* 1995).

Grazing efficiency was considered by Hudson and White (1985), who studied the dynamics of foraging behaviour and described indirect evidence for broad habitat or patch selection on the basis of biomass, forage digestibility and other factors. Theories of how grazers and browsers select patches for feeding indicate that a forager would leave a particular patch when its net gain from staying drops to the expected gain from travelling to and starting to search in the next patch.

v) Carrying Capacity

The carrying capacity of a grazing area has been defined as the animal density at which the rate of forage production equals the rate of forage consumption (Caughley 1976). Stoddart and Smith (1955) earlier defined grazing capacity as the maximum number of animals that can graze each year on a given area of range, for a specific number of days, without inducing a downward trend in forage production, forage quality, or soil condition. To properly assess carrying capacity, it is necessary to consider various ecological factors including differences between seasons, spatial distribution of individual grazers, plant species composition, interactions between herbivores, interactions between plants and herbivores and seasonal changes in plant food value (Borthwick 1986). Analysis cannot be focussed on a single species independent of their interactions (Borthwick 1986), consequently the calculation of carrying capacity is particularly complicated in a wildlife system.

Exceeding the carrying capacity of a grazing area may lead to over-utilisation. For example the white rhino population in the Umfolozi expanded at the rate of 9.5% per annum between 1960 and 1971. This increased grazing pressure to the extent that areas of medium-tall grassland were being converted to short-grass grassland and also created areas of exposed soil due to erosion (Owen-Smith 1981).

vi) Resource Partitioning

White rhinos compete with other grazing animals for the available herbaceous (or grass) layer resource. Their actual dietary selection within this resource may overlap, also not all plant species are acceptable to all grazers (Bothma 1989). Assessing the degree of overlap of habitat and diet resources between different grazing species and through different seasons is very complex (Borthwick 1986). Borthwick (1986) indicated that in the Pilanesberg National Park, habitats utilised by white rhinos overlapped most with wildebeest (*Connochaetes taurinus*) and least with the plains zebra (*Equus burchelli*). Bothma (1989) identified other species which utilise similar habitats to the white rhino as including red hartebeest (*Alcelaphus buselaphus caama*), eland (*Taurotragus oryx*) and kudu (*Tragelaphus strepsiceros*).

vii) Condition

Visual subjective assessment of the condition of a rhino in the field was described by Keep (1971), primarily by looking for reductions in the muscle and fat deposits around the neck and shoulder of an animal (Table 1.1).

Table 1.1 Summary of Condition Classes Defined by Keep (1971)

Rating	Description
Good	No wasting of the muscles in the shoulder region. Skin ridges over the posterior ribs and the three dorsal protuberances are normal.
Fair	Just below the spine along the neck it is possible to see a groove caused by reduced fat deposits, especially when the head is in the grazing position.
Poor	The front edge of the shoulder blade shows as a sharp line as the suspensory muscles of the front limb begin to waste away.
Very Poor	The spine of the shoulder blade becomes very prominent and there is a general progressive muscular wasting all over the body.

viii) Interactions with other Species

White rhinos generally respond neutrally to other animal species, including predators such as lions (Owen-Smith 1988). Their response to human presence was generally to take a defensive posture and to appear agitated, subsequently fleeing away from the direction of the apparent disturbance.

ix) Management of Captive White Rhinos

McKenzie (1993) detailed accepted techniques for the capture and care of white rhino, which he described as an extremely powerful animal, best captured when in good physical condition. At a symposium on 'Rhinos as Game Ranch Animals' held in South Africa in 1994, papers were presented by managers and researchers on the status, habitat preferences and ageing of white rhinos (Pienaar 1994a&b; Wucher 1994; Adcock and Emslie 1994; Walker 1994). A study on captive rhinos was produced by Lindemann (1982), which highlighted the poor reproductive success of pairs of animals in captivity. A rhino husbandry resource manual for captive animals was compiled by Fouraker and Wagener (1996) for the American Zoo and Aquarium association. This detailed problems with small populations, which included vulnerability to disease and natural disasters, fluctuations in demographic performance and the risk of losing genetic diversity and of becoming inbred. Genetic diversity is needed for the vigour of individuals and also for the ability of populations to adapt, since their environment is increasingly likely to change rapidly under human influence. Inbreeding is of concern since it may cause reproduction and survival rates to decline, resulting in smaller populations.

1.2 Namibia

Namibia, formerly known as South-West Africa, is the most arid country south of the Sahara (Brown 1996). It is known for its African mammals, wilderness landscapes, remote areas and sparse human population. Following Independence in 1990, the number of tourists visiting Namibia has grown considerably (Holm-Petersen 1996), and the interest in wildlife continues to increase.

1.2.1 Habitat and Vegetation

Most of Namibia can be described as 'arid', comprising areas where the annual average rainfall is below 400mm (Bothma 1989). Average rainfall isohyets are illustrated in Fig. 1.1 (Van Der Merwe 1983). In Namibia, the rainy season extends between December and April and is erratic, both spatially and temporally. Over the past decade the country has experienced lower than expected rainfall, resulting in widespread drought.

There are three main vegetation types across the country, which are deserts, savannas and woodlands, as shown in Fig. 1.2 (Giess 1971). In this study, a description of 'semi-arid' has been used to apply to parts of the country receiving between 100 and 500mm average rainfall which are mainly savanna habitats. Areas receiving less than 100mm annual rainfall have been called 'very arid' and these include the desert coastal regions. Areas receiving greater than 500mm average annual rainfall include the tree savanna and woodlands associated with the Caprivi strip.

The grassland, locally called veld, may be classified either as sweet or sour veld and in some areas is a mixture of the two. Sweet veld generally occurs in areas receiving between 250 and 500mm average annual rainfall and is where critical forage species remain palatable and nutritious throughout their entire life cycle (Bothma 1989). Sour veld generally occurs in areas where rainfall exceeds 625mm per annum. In these areas, the most important forage species lose their nutritional value and become unpalatable at maturity and are therefore palatable and nutritious only during the growing season (Bothma 1989).

In arid regions most grasses are ephemeral, i.e. they last a very short time. After rain showers they germinate quickly, grow, produce seeds and disappear before the end of the dry season (Joubert 1996). The biomass of grass produced each year is related to the seasons rainfall (Dye 1983) and grazing pressure in the area. Grass species in Namibia were classified by Müller (1984), and their occurrence in relation to habitat type was briefly described by Giess (1971). Further details of the characteristics of each species was provided in Gibbs-Russell *et al.* (1991). In this study, grass species have also been referred to as herbaceous species. The tree species of Etosha were described by Berry (1982), in sufficient detail for this study.

In semi-arid regions a good correlation is usually found between geological formations including rivers and rocky areas, and soil type and plant communities (Bothma 1989). For the purpose of this study, the habitat variables and grass species composition were considered together as 'environmental parameters'.

A summary of the principal categories of habitat and vegetation characteristics is given in Table 1.2.

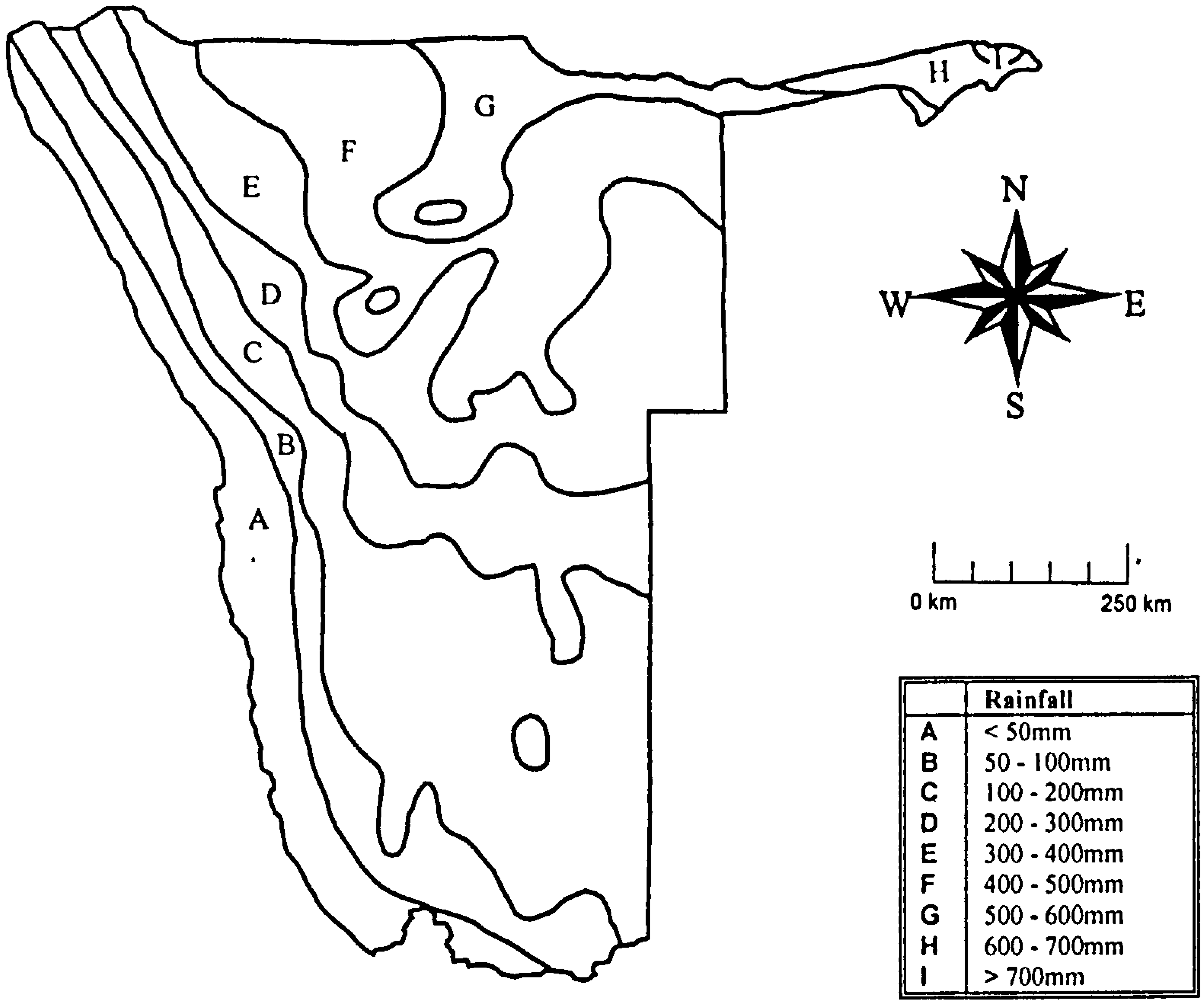


Fig. 1.1 Average Rainfall Isohyets in Namibia (from Van Der Merwe 1983)

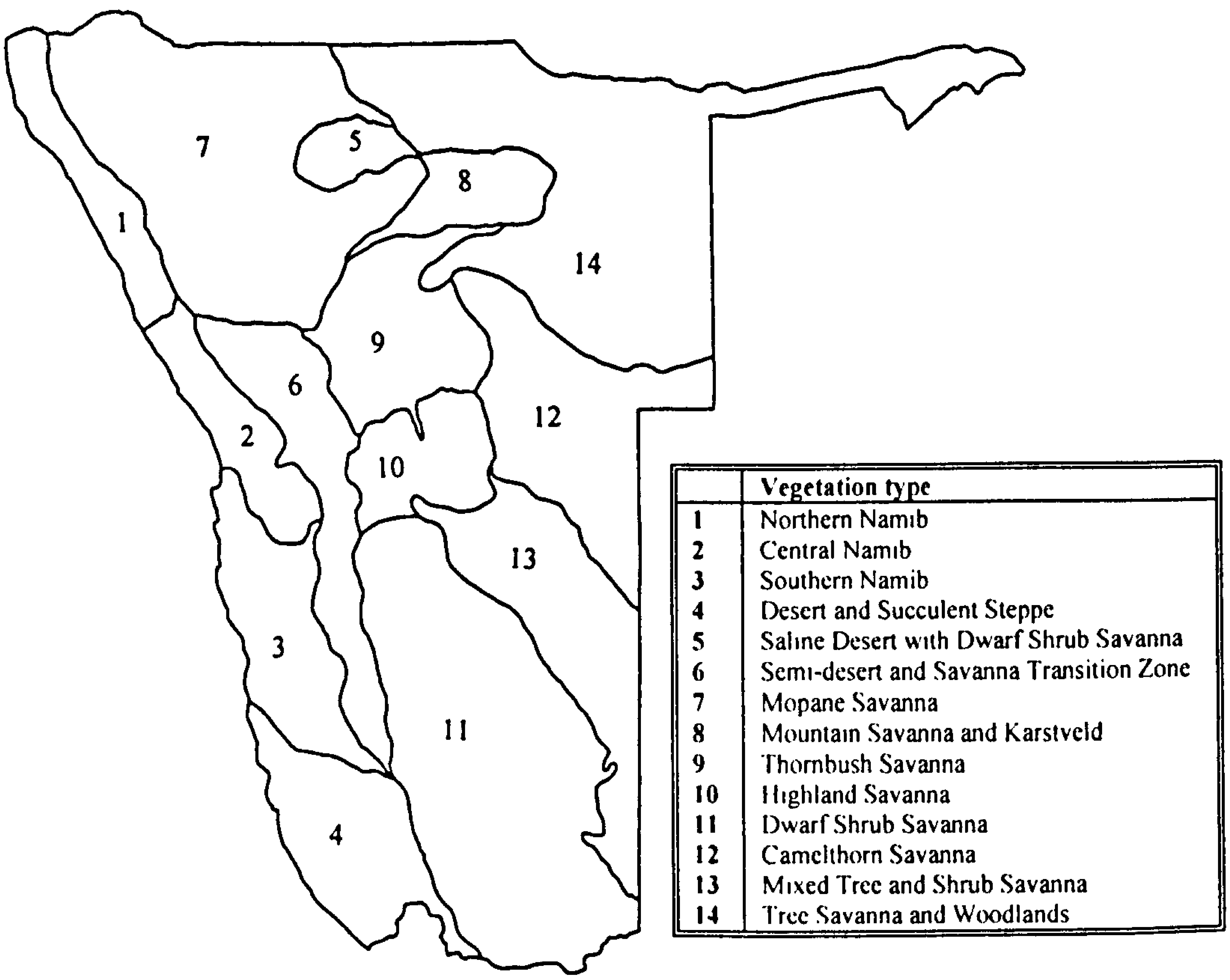


Fig. 1.2 Vegetation Map of Namibia (from Giess 1971)

Table 1.2 General Characteristics of Habitat and Vegetation in Southern Africa.

Average Annual Rainfall	Habitat	Main Vegetation Types	Main Veld Type	Grass Characteristics	Notes and Source
<100mm	Very Arid	Desert		Most grass is ephemeral or short-lived.	Includes desert coastal regions. (Adopted for this study)
<400mm	Arid				Applies to most of Namibia (Bothma 1989). (Joubert 1996)
100-500mm	Semi Arid	Savanna			(Adopted for this study)
250-500mm			Sweet Veld	Palatable and nutritious through life cycle.	(Bothma 1989)
>500mm		Tree savanna and woodland			Typical of Caprivi Strip. Adopted for this study.
>625mm			Sour Veld	Palatable and nutritious in growing season only. After maturity, grass is unpalatable and loses nutritional value.	(Bothma 1989)

Notes: i. Rainfall categories overlap due to figures adopted by various references.
ii. Habitat characteristics vary due to numerous local factors, and combinations often occur, e.g. mixed sweet and sour veld.

1.2.2 Enclosed Areas

Land in Namibia can be broadly categorised as either farmland, National Parks and Reserves (hereafter all called Parks) or communal areas. Stock fences are usually erected to mark the boundaries of farms and National Parks. Once an area is enclosed, it effectively becomes an ecological island (Bell 1983; Owen-Smith 1988) requiring management, since ecological trends are less able to regulate themselves (Pienaar 1983). Management may be defined as "any activity directed towards achieving or maintaining a given condition in plant and/or animal populations and/or habitats in accordance with the conservation plans of the area" (Bourlière 1964).

Due to escalating tourism, the number of privately owned farms converting from cattle to game (or wildlife) farming is increasing (Holm-Petersen 1996). This change is often beneficial to the farms herbaceous layer since correctly managed farming of endemic wildlife exerts less pressure on the grazing capacity of land than cattle farming (Bester 1996).

National Parks in Namibia are managed to meet the conservation goal of retaining the full historic diversity of habitats and species in the region (Leopold 1968; Pienaar 1983).

1.2.3 Habitat in Enclosed Areas

A habitat may be defined as the space that a particular species needs in order to fulfil its requirements, which are food, water and shelter (Joubert 1996). Truly natural habitats occur where there have been no management activities in an area to interfere with widescale movement of animals. Consequently, by erecting fences, animal movements over land which was historically seasonally utilised have probably been interrupted (Bell 1983). Ecological islands may then be created as the numbers of animals becomes unstable, resulting in the need for management (Owen-Smith 1988). Within enclosed areas the habitat, especially the herbaceous layer, becomes more dependant upon factors such as rainfall, grazing pressure and also management input in respect of water hole location, control of numbers of animals, etc. Since farms and National Parks in Namibia are generally fenced and provided with artificial water holes, they do not represent entirely 'natural' habitat, but one which is unique and possibly not typical of the surrounding area.

The grazing pressure a herbaceous layer can sustain is limited, especially in the semi-arid habitats of Namibia. In situations where the number of grazers is too high and the carrying capacity of the area is exceeded, overgrazing is the result. Overgrazing modifies the grass layer, increases soil erosion and threatens the overall productivity and stability of an ecosystem (Owen-Smith 1988). Conditions of overgrazing and under-browsing may subsequently lead to bush encroachment which is the rapid growth of a variety of thorn bushes (Bester 1996).

1.3 White Rhino in Namibia

1.3.1 Historical Distribution of White Rhino in Namibia

Historically a range of natural habitats were available across Southern Africa. Before extensive fencing, the white rhino's habitat may have covered an wide area, as they responded to food limitations during drought by moving to areas where conditions were more favourable (Owen-Smith 1988). Records of the historical distribution provide an indication of where natural habitat appropriate to their ecological requirements had been located. This is of interest since introductions to areas beyond a species historical distribution are generally less successful (Griffith *et al.* 1989; Novellie & Knight 1994).

Opinions of the historical distribution of white rhino in Namibia vary. The most significant discrepancy between these distributions covers northern Namibia, which includes Etosha National Park (hereafter referred to as Etosha). Player & Feely (1960) and Penny (1987) consider that Etosha may have been included, whereas Huntley (1967), Owen-Smith (1973 & 1988), Pienaar (1994a) and Joubert (1996) consider these northern areas to be outside the historical distribution, see Fig. 1.3. Occasional reported observations in north-western Namibia have never be substantiated (Shortridge 1934; Bigalke 1958; Owen-Smith 1970). Since the extent of historical distribution remains uncertain, it is not possible to ascertain whether a release in a particular area is an introduction or a re-introduction. Consequently for the purpose of this study all releases have been referred to as introductions.

1.3.2 Ownership and Management of White Rhinos in Namibia

The Ministry of Environment and Tourism (MET) manage Namibia's National Parks and also control the ownership of white rhinos on private land by a system of permits. They have the following aims in respect of white rhino (Erb 1996):

i) To develop a national rhino conservation plan.
ii) To establish a long-term viable population of at least 500 white rhino in suitable habitat.
iii) To allow sustainable utilisation of white rhino within the CITES regulations.

1.3.3 Habitat Suitability

Pienaar (1994a) observed that releases of white rhinos below the 400mm rainfall isohyet should be approached with caution and Joubert (1996) detailed evidence which indicated that white rhinos do not usually survive in drier parts of the subcontinent. These observations combined with the uncertain historical distribution of the species make it clear that enclosed areas in Namibia's semi-arid habitat may not all be inherently suitable for white rhinos without management assistance. This is further complicated by the unpredictable rainfall and local variations in grazing pressure.

In this study, a suitable habitat is taken to be an area where minimum management intervention (i.e. only the basic provision of water and security) is required to meet the ecological requirements of the white rhinos. In this situation, if a viable rhino population are found to be increasing in numbers, subject to external factors such as poaching, the habitat is considered to be suitable either inherently or through good management.

Beyond the basic provision of water and security, the environment may be inherently unsuitable for rhinos and they will require regular management assistance in terms of monitoring and supplementary feeding. An unsuitable habitat is therefore considered to exist either where intensive management intervention measures have been necessary to ensure the success of the population, or where the level of

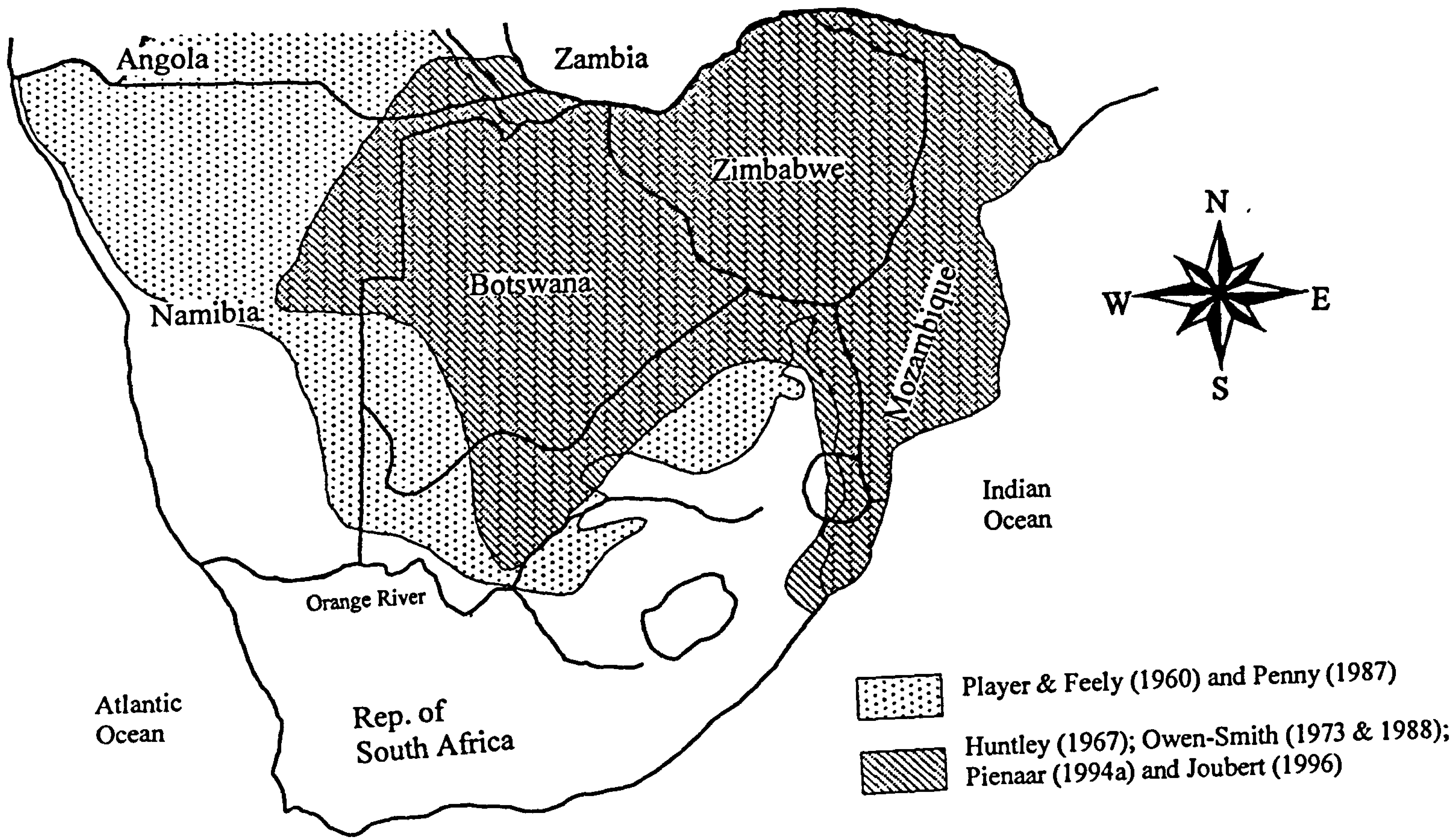


Fig. 1.3 Historical Distributions of White Rhinos in Southern Africa

management actually provided has been inadequate and has resulted in a decline in the population.

If a viable population of rhinos is introduced to an area with suitable habitat, it should produce young that survive to adulthood and in turn reproduce, i.e. the growth rate of the population should be upwards (W.C. Gasaway, Wildlife Services, Muskegon, USA, *pers comm*). Birth and survival rates therefore provide a primary indication of habitat suitability when related to the frequency of supplementary feeding and subject to recorded immigration, deaths and emigration.

To indicate either an inherently suitable habitat or alternatively a habitat requiring a certain level of management intervention, specific key factors were assessed. These prime indicators are recruitment, physical condition (Keep 1971), mortalities due to drought and the need for supplementary feeding.

1.3.4 Habitat Utilisation

A group of white rhino were introduced to Kaross, in the south-western corner of Etosha in the north of Namibia. This is a semi-arid environment, which was thought to be marginal habitat. It received an average annual rainfall of 366mm between 1966 and 1997. This annual rainfall is below 400mm which is the level that Pienaar (1994a) proposed as a minimum standard for habitat suitability. The rhinos are not provided with supplementary feed.

Habitat utilisation patterns of these rhinos were studied to establish how they have adapted to a semi-arid and potentially limiting environment. Studying animals in the wild is often hindered by their fear of man, unfavourable habitat characteristics and nocturnal activity patterns (Stander *et al.* 1997). Tracking, or the identification, following and interpretation of signs, such as spoor or footprints of animals, has been used as an indirect method of investigating the feeding patterns of carnivorous African mammals (Stander *et al.* 1997). It was considered to be applicable since it is non-intrusive (Bothma & Le Richie 1993) and is a recognised technique for use in ecological investigations (Stander *et al.* 1997).

The analysis of utilisation patterns, by comparing availability of habitat and herbaceous layer with that selected by the rhinos, was possible using a Geographical Information System (hereafter referred to as GIS). GIS is a computerised data processing system designed for the analysis and display of spatially distributed data. Its use as a tool for ecological research was recognised in the late 1980's, and although it has become a standard process in landscape ecology it remains less widely used by field ecologists (Johnston 1998). It enables layers of environmental parameters to be considered with respect to animal locations, and also allows spatial analysis of these data. For example, GIS was used to examine the characteristics of black-tailed prairie dog (*Cynomys ludovicianus*) colonies in Montana, with habitat parameters including slope, aspect, land tenure and distance from roads (Reading & Matchett 1997).

In this study animal locations were recorded with a Global Positioning System (hereafter referred to as GPS) receiver which provides a position fix via signals from satellites. A handheld receiver was reported to have an accuracy of approximately 73m (August *et al.* 1994).

1.4 Aims of the Present Study

The present study aims to establish the current status of white rhino in Namibia, to identify the main factors influencing introductions and to determine how white rhinos utilise a semi-arid environment.

Rhino utilisation has been interpreted by using GIS to create spatial maps of environmental parameters and habitat types, which were analysed with respect to rhino movements and activities. The findings were compared with studies in other areas (e.g. Owen-Smith 1973; Borthwick 1986; Pienaar 1993c). This enabled the status of the white rhino in Namibia to be considered with respect to its status world-wide and where possible conclusions have been drawn concerning the future of the species.

The specific objectives of the study were:

1. To determine the current status of the species in Namibia and to reconstruct the history of all introduced populations in game farms and National Parks.

2. In Kaross, an enclosed semi-arid environment within a low rainfall area and representing potentially marginal white rhino habitat:

   a) To survey and map specific environmental parameters (herbaceous layer and habitat), use multivariate analysis techniques to determine homogenous areas and map these with respect to landscape features.

   b) To compile information on the rhinos including herbaceous layer and habitat selection, activity and movements, inter-relationships between individuals, their condition and approximate ages. To propose explanations for poor recruitment.

   c) Using GIS and statistical analysis, to establish grazing preferences and identify patterns of habitat selection by relating rhino utilisation of environmental parameters mapped in a) above with activity and location data collected in b) above.

3. From the above data:

   a) To discuss the current situation of the white rhino in Namibia with respect to the status of the species world-wide.

   b) To identify the main factors influencing the success of a population after an introduction in Namibia in terms of management, habitat suitability, population size and composition.

   c) To determine the extent to which a semi-arid environment is inherently suitable for the introduction of white rhinos.

   d) To discuss the future of the white rhino in Namibia and appropriate levels of management intervention to assist their survival.

   e) To produce an information booklet identifying best practices for the introduction and management of white rhinos.

Chapter 2

White Rhinos on Game Farms

2 White Rhinos On Game Farms

2.1 Introduction

2.1.1 Background

White rhinos have been introduced to private game farms in Namibia since the early 1970's. While game species indigenous to this region are adapted to the semi-arid environment, the extent to which the ecological requirements of the white rhino as a large grazing herbivore, are fulfilled are uncertain. No comprehensive records of the history and status of these populations were available and the principal factors influencing their success, including management support provided, have not been examined in detail before.

2.1.2 Previous Research

Joubert (1996) briefly described the history of one of the white rhino introductions to game farms in Namibia but otherwise this topic has never been reported. In South Africa, the progress of numerous introductions of the species to game farms was monitored and recorded in surveys by Buijs and Anderson (1989) and Buijs and Papenfus (1996).

2.1.3 Aims

This chapter studies the introduction of the white rhinoceros to game farms in Namibia, with the following principal aims:

- To establish the current status of the white rhino on game farms in Namibia and to detail the history of the populations.

- To identify the main factors which have influenced the success or failure of the introductions in terms of anthropogenic (management), habitat suitability and population composition.

2.2 Method

A survey of game farms was carried out by contacting every game farm in Namibia which has introduced white rhinos. The farms were initially contacted by telephone and informed of the intentions of the project. A visit was then made to most of the farms and the owner or manager was asked to help complete a questionnaire covering the history of their white rhino. This was carried out on an informal basis and notes were made of any additional details or information provided. All potentially relevant factors were incorporated in the survey to ensure recording of any details the farmer may recall. If any of these factors produced no results of significance, they were later disregarded. Three farms could not be contacted, two of which no longer possessed white rhino.

2.2.1 Game Farm Survey

The survey questionnaire is attached at Appendix III. Data collected by the questionnaire covered the history of the rhinos as well as farm and management details, including:

i) The number of rhinos released, individual sex and age at time of release, place of origin and date of release;
ii) Number of calves born, sex of each calf, other population increases. Mortalities, cause of death, post-mortem results and any signs of illness;
iii) Number, sex and age of rhinos at present;
iv) Management required at any time, i.e., supplementary feeding, provision of water and monitoring activities. Frequency of sightings and locations. Recorded observations on condition and behaviour;
v) Motivation for introducing rhino. Awareness of the financial commitment involved with the introduction and maintenance of rhino. Anticipated returns from this investment from hunting and photo-tourism. Outcome of the release compared with expectations. Knowledge gained about the species, and willingness to undertake a possible release of additional rhinos;
vi) General awareness of the status of the white rhino in Namibia at present, for example the introduction of rhinos to Etosha;
vii) Knowledge of the biology and ecology of rhinos, and interest in obtaining additional information;
viii) If available, farm rainfall records;
ix) Estimates of the numbers of other grazers, if known, to allow estimation of the total grazing pressure;
x) Water availability and the type of water;
xi) Poaching incidents on the farm and precautions taken to minimise the risk;
xii) Any other items of concern or interest to the farmers.

If the owner offered access to the rhinos, a brief visual assessment of the landscape and rhino condition (Keep 1971) was carried out. Landscape features were noted in terms of topography and other distinguishing features.

2.2.2 Additional Sources of Information

To supplement the data collected from the survey additional information was also compiled. This was collected on an informal basis throughout the study period, primarily from the following sources:

i) The Ministry of Environment and Tourism (MET), primarily relating to their role in monitoring game farms which includes visits to assess game fences, vegetation assessments and the issue of hunting concessions. MET records of permits issued to individual farms were consulted to confirm dates of imports and hunting events.

ii) Several ex-MET employees with previous involvement in rhinos provided valuable background information on some of the introductions.

iii) The Protected Resources Unit (PRU) of Namibia Police (NamPol), with respect to cases of poaching and the assistance available to rhino owners concerned with improving protection.

iv) The Rhino and Elephant Foundation with respect to surveys of white rhino on private land in South Africa.

2.2.3 Analysis

All the survey results were compiled on a database and analysed to provide the following information. Records which were vague, possibly anecdotal or derived from remote or unrelated sources were marked as such and generally excluded from the analysis.

I) To establish the current status of the white rhino on Game Farms in Namibia.

Known details of the existing population of white rhino including locations and population composition were established and recorded.

ii) To reconstruct the history of introduced populations.

All relevant aspects of the progress and reverses of introduced populations identified from the survey were examined and recorded, to establish a database for future reference.

iii) To identify the main factors influencing the success of the introductions.

When assessing the history of each population, the principal factors which appeared to have influenced its progress were considered. These factors fell into the following categories:

a) Anthropogenic influences, including management, protection, monitoring and utilisation;

b) Habitat suitability in terms of recruitment success, frequency of supplementary feeding, physical condition and mortalities due to drought. These parameters were considered with respect to local environmental factors including habitat type and utilisation, overgrazing and annual rainfall.

c) Population composition, in terms of initial population size and numbers of males.

d) Additional factors including farm size, disease and breakouts.

2.3 Results

Summaries of the case histories of all the game farms in Namibia which have experience of the introduction of white rhino are described in Appendix IV. All additional and significant facts relating to each farm, as obtained from the survey and other sources, were included in these summaries. The farms have been named and animal numbers quoted as all farm owners gave their consent for this. In all of the tables, farms have been listed in order of initial introduction dates.

2.3.1 Status of White Rhino and History of Populations

White rhinos, both imported and native-born animals, have been introduced to private farms and government property across Namibia since the early 1970's. Fig. 2.1 shows the location of these farms within Namibia. Table 2.1 summarises details of all identified releases. This includes animals imported, transferred between reserves and those sold within Namibia. The overall number of white rhinos imported to game farms in Namibia was 92 (43:49). An additional 11 (3:8) or possibly more have been sold on by Otjiwa within the country and 8 animals (3:5) were exchanged between farms. No rhinos were identified as having been exported from the country, although there had been an unknown number of live sales and WABI, Otjiwa and Mt Etjo were all owned by game dealers.

Table 2.1 History of Releases and Existing Numbers of White Rhinos on Private Land in Namibia.

Farm Name	Initial Release Year	Numbers Released (m:f)	Numbers existing in 1997 (m:f:unknown*)
Otjiwa	1971-1973	18 (9:9)	22 (10:10:2)
WABI	1973	16 (8:8)	0 (extinct 1987/88)
Ohorongo	1975-1980	18 (9:9)	0 (7 relocated 1994)
Mt Etjo	1976-1982	16 (8:8)	13 (5:8)
O'vita	1981	2 (1:1)	0 (extinct 1993)
Okatumba	1981-1984	5 (1:4)	0 (extinct 1995)
Waldeck	1988-1990	3 (1:2)	4 (2:2)
Safari	1993	6 (2:4)	7 (2:4:1)
Ongava	1993-1994	7 (3:4)	11 (4:5:2)
Schmidt	1993-1994	2 (1:1)	1 (0:0:1)
Epako	1994	4 (1:3)	4 (1:3)
Oropoko	1994	6 (2:4)	7 (2:4:1)
Game Farm total	1971-1994	103 (46:57)	69 (26:36:7)

* Unknown includes rhinos whose sex is unknown as well as immature animals.

The relationship between the number of animals initially introduced and the present population is illustrated in Fig. 2.2.

The history of rhino population numbers for each year since the initial introduction is detailed in Table 2.2, with certain approximate figures given in brackets. The total number of animals in 1996 and 1997 has been increased to include the animals which had been translocated to a National Park, but which were still alive. These figures were used to calculate an annual increase of 0.9% in the number of rhinos on game farms between 1987 and 1997.

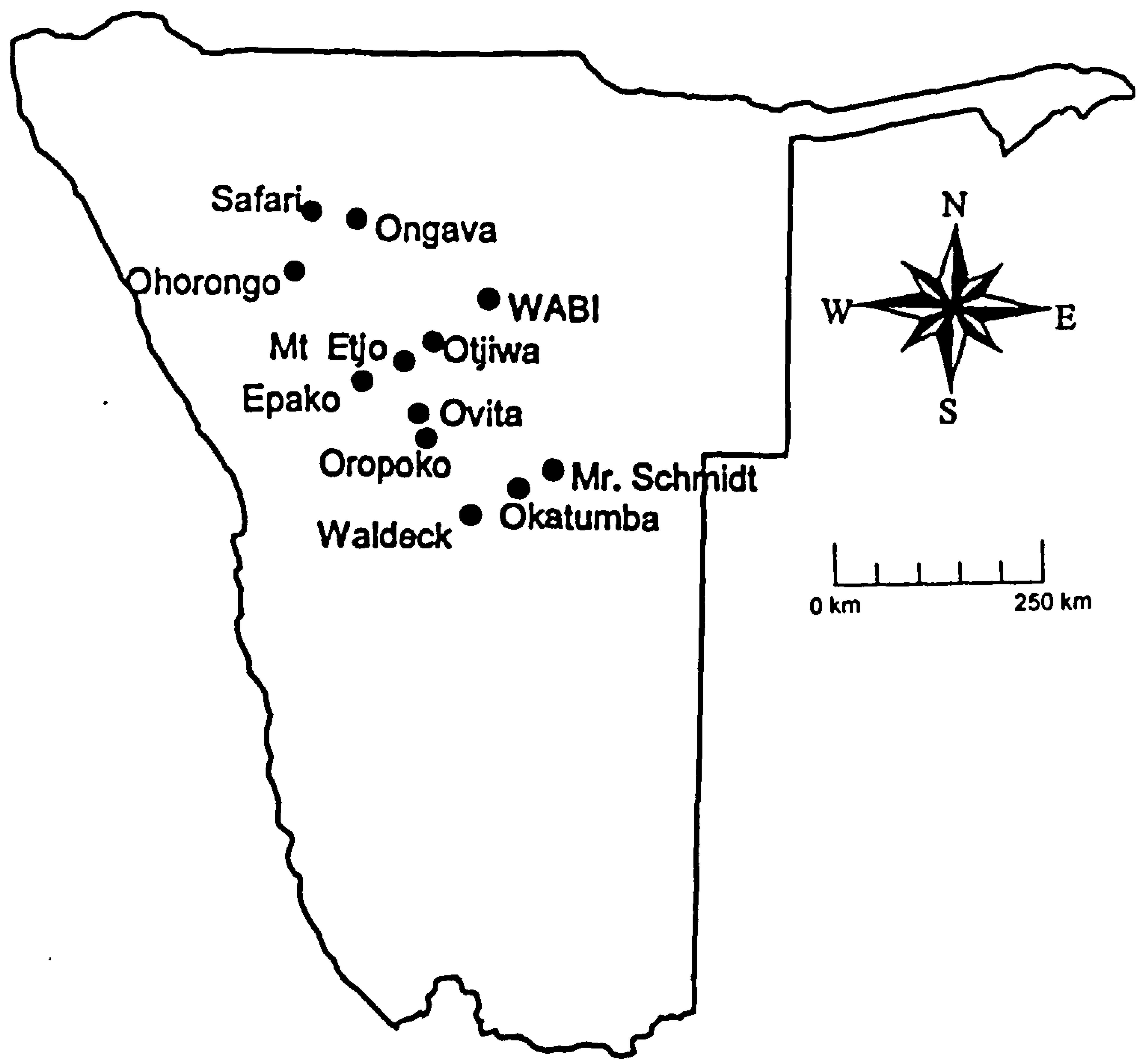


Fig. 2.1 Map Showing Location of Game Farms in Namibia

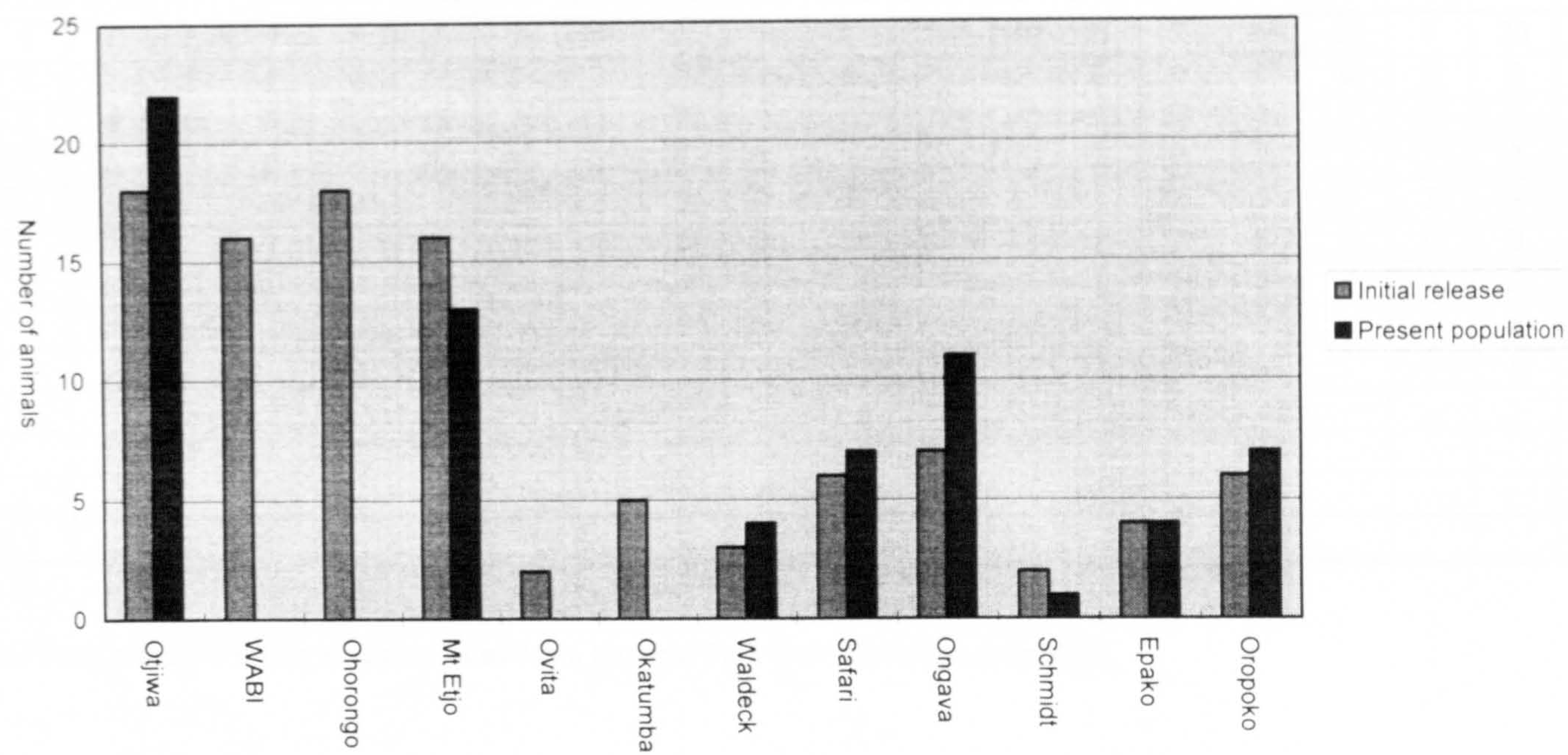


Fig. 2.2 Introduced and Present Numbers of White Rhino on Game Farms

Table. 2.2 History of Population Numbers on Game Farms

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Otjiwa	12	12	18	?	?	?	?	?	?	?	?	?	?	?	?	?	(30)	31	?	30	29	?	25	22	20	21	22
WABI			16	?	?	?	?	?	?	?	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0	0	0
Ohorongo					8	8	12	?	?	18	?	?	?	?	?	?	(14)	?	13	7	?	13	?	7	0	0	0
Mt Etjo						4	?	?	10	?	?	16	?	?	?	?	(15)	?	?	?	?	?	?	(14)	?	(14)	13
Ovita											2	2	2	2	2	2	3	3	4	2	3	3	4	0	0	0	0
Okatumba											1	1	1	5	5	5	5	5	5	6	6	0	0	0	0	0	0
Waldeck																		1	1	2	2	3	3	3	4	4	4
Safari																							6	6	6	6	7
Ongava																							6	7	8	9	11
Schmidt																							1	1	1	1	1
Epako																								4	4	4	4
Oropoko																								6	6	6	7
Totals																	67							70		70*	73*

( ) Indicates approximate figures

* Total rhinos on game farms, plus those still alive which were translocated to a National Park from Ohorongo game farm.

i) Sex Ratios

On the initial releases, the overall sex ratio was 46:57 males to females. This compares with an existing sex ratio of 26:36:7, which is similar to the initial ratio.

ii) Mortalities

Overall 61 deaths have been recorded, all of which have an attributable cause. These are detailed in Table 2.3 and summarised in Fig. 2.3. No mortalities have occurred on Epako, Ongava, Oropoko, Safari and Waldeck. A reduction in the number of individuals on some farms was due to live sales or exchanges. These included seven from Ohorongo, eleven from Otjiwa and an unknown number from WABI.

Table 2.3 Known Causes of Death.

Cause of Death and Location	Number
Hunted (Mt Etjo 4; Ohorongo 12; Okatumba 1; Otjiwa 1 +; WABI 2+) **Hunted after release** due to transport injury of a broken jaw (Mt Etjo 1)	20 1
Poaching (Otjiwa 3 +; O'vita 4; Ohorongo 3+) **Poaching attempts** leading to fatal injuries (Otjiwa 3)	10 3
Drought (Ohorongo 6+; WABI 2+; Mt Etjo 2 calves)	10
Anthrax (Okatumba 4; Otjiwa 1)	5
Males died fighting (Mt Etjo 2; Otjiwa 2)	4
Killed by bull (Okatumba 2 both calves; O'vita 2 one calf, one sub-adult; Mt Etjo female killed by bull accompanying a cow in oestrus 1)	5
Eco-hunt trial for subsequent sale, died in boma due to previous infection (Otjiwa 1)	1
Capture related stress and inadequate management (Schmidt 1)	1
Septic wound following Anthrax inoculation (Waldeck 1)	1
Natural causes	0

iii) Recruitment Assessment

Population success was graded by assessing the level of recruitment with respect to the population composition. The reproductive success of sexually mature females within each group was assigned an arbitrary recruitment rating factor according to the number of calves successfully recruited. Recruitment was regarded as excellent if an adult female had a mean inter-calving interval of approximately two years. Birth rates in populations with less successful recruitment were assessed as good, fair or poor. Birth details and the recruitment rating of each farm were provided in Table 2.4. In cases where an introduction was relatively recent or where the sex composition of the group made recruitment impossible this was noted.

It must be recognised that the recruitment rating is a first approximation, which is complicated by factors including small population sizes. Ideally, if more data had been available, the birth rate could be more accurately calculated with respect to a population of known age and sex composition. Factors which may introduce potential sources of bias or error include:

- It was necessary to rely mainly upon information from the owner or manager of each rhino population.
- The precise age of animals is often not known, merely the owner's personal opinion or their general age class. Consequently, the time that females reached sexual maturity and the ages of sub-adults were not always known.

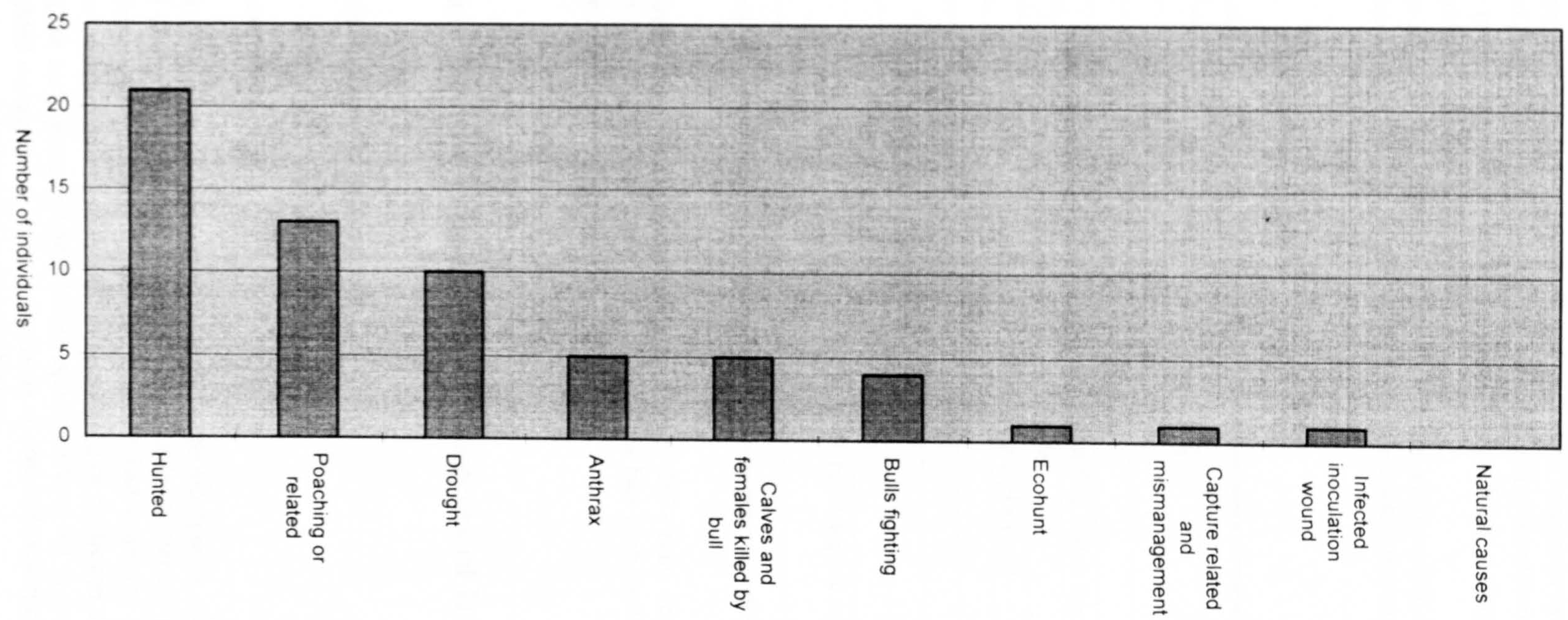


Fig. 2.3 Causes of Death

- Since many of these populations were established in the last few years, allowance can not be easily made for the disturbance of translocation, which may cause a delay in the start of breeding.
- It was assumed that no cows were pregnant on arrival, which may not be the case.
- Account needs to be taken of the number of males and females in each population.
- The size of the available grazing area will probably affect recruitment.
- Since the overall number of animals involved is not large, a single or unusual event may have a disproportionate effect upon the statistics.
- The larger introductions occurred in the 1970's and are less well documented. The history of the smaller, more recent releases are known in much more detail and with a higher level of certainty.

Table 2.4 Recruitment Ratings.

Farm Name	Details of Births	Recruitment Rating
Otjiwa	Details uncertain, but known to be good	Good
WABI	Unknown	Unknown
Ohorongo	Unknown, thought to be poor or none	Unknown / Poor / None
Mt Etjo	Uncertain but successful with more than five calves born	Fair / Good
O'vita	Over 12 years, four calves to one female	Excellent
Okatumba	Four females, produced two calves over eight years	Poor
Waldeck	Since 1990, two calves to one female	Excellent
Safari	Since 1993, one calf born	Poor / Fair
Ongava	Since 1993, four calves born.	Fair / Good
Schmidt	Not presently possible (only one rhino)	Not possible
Epako	Not presently possible as no bull of reproductive age present	Not applicable
Oropoko	Since 1994, one calf born	Poor / Fair

On several farms with recent introductions, the 1996 to 1997 rainy season has resulted in calves being born. On all farms with adult cows and bulls, calves had been born at some time, although precise numbers were sometimes not available.

2.3.2 Main Factors Influencing the Success of Introductions

2.3.2.1 Anthropogenic Influences

I) Management

Most farm managers or owners were found to be knowledgeable and interested in white rhino, but historically a variety of standards have existed. Some rhino ownership has resulted from a purchase by a wealthy investor who had rarely visited the farm but had employed a series of short term managers, leading to the occasional lack of continuous monitoring or protection of the rhinos. In addition, the low prices during the early years of introductions appear to have led to some opportunistic rhino purchases and short-sighted management. Current standards of care and protection are much improved and owners are now very aware of the high value of their rhinos.

ii) Monitoring And Protection

The arrangements for monitoring of animals and anti-poaching patrols on each game farm which has, or previously had rhinos, were detailed in Table 2.5. Ohorongo, Mr Schmidt and WABI have been omitted since they were not visited, and therefore protection details were not fully known.

Table 2.5 Monitoring and Anti-Poaching Activities.

Farm Name	Monitoring and Anti-Poaching Activities
Otjiwa	Daily monitoring patrols by four rangers on foot and on horses. Records of identification marks of each animal and its sightings are maintained. In the event of a missing rhino, ground and air search is carried out. History of problems with poaching. Current anti-poaching measures include showing an active presence along the fences, especially at night. Guards will probably be armed soon for protection against poachers.
Mt Etjo	Weekly monitoring of black and white rhinos on the ground by anti-poaching patrols. Also monitored from the air and sightings on game drives are recorded. One ranger is solely responsible for the rhinos. Nothing has evidently ever been poached from this farm.
O'vita	Sightings mentally noted during normal farm patrols. No other protective measures.
Okatumba	Sightings were noted daily or weekly by the owner and workers. No anti-poaching patrols. Some problems with poaching in the past, occurring near the road for meat.
Waldeck	Sightings recorded by owner and if a particular animal has been absent for a week, he will look for it. Some poaching of other animals for meat by the fence. Fence patrol once a week. Helicopter on farm which is flown if necessary.
Safari	Always one person on the farm who patrols each day on foot or motorbike. Sightings at least every other day. A very remote farm but no poaching history.
Ongava	Monitoring has varied according to management. Save The Rhino provided advice in 1994. At present three anti-poaching guards are employed and each rhino is located at least once a week.
Epako	The rhinos are often found at the water hole in front of the lodge, where supplementary feed is provided. They are occasionally followed if they leave the water hole because the farm is by a main road, and the rhinos often walk by this fence. No anti-poaching patrols. A few problems have occurred with other game being taken for meat near the road.
Oropoko	Sighted every day by one full time employee who is solely responsible. Animals are located in a small enclosure in the centre of the farm, which internally provides good protection. No problems with poaching.

Otjiwa Game Ranch has experienced most problems with poaching recently. It has the disadvantage of being situated on one of the countries main roads and is widely known for rhino ownership. Monitoring and security is therefore most intensive on this farm. Many of the other farms are in relatively isolated areas and are less well known, resulting in fewer poaching incidents.

Monitoring and protection of privately owned white rhinos is entirely the responsibility of the owner or manager of the game farm. Within Namibia, the MET (Ministry of Environment and Tourism) provide advice on monitoring techniques. The PRU (Protected Resources Unit) branch of the Police are responsible for rhino security and for investigating cases of poaching. They have compiled an advice leaflet for rhino owners containing information on poaching, management responsibilities, monitoring techniques and security measures.

De-horning of rhino was mentioned to all the farmers in the survey. None would consider de-horning their animals to deter poaching since the resulting appearance was considered detrimental to their appeal to tourists, hunters and owners. If de-horning was undertaken on farms, it would be an extreme measure to deter poachers.

iii) Motivation

The farm owners reasons for acquiring white rhino were listed in Table 2.6. This provided an indication of their intentions and whether management strategy was aimed at developing a long-term sustainable population. As before, Ohorongo, Mr Schmidt and WABI have been excluded from the table as these farms were not visited.

Table 2.6 Owners Indicated Intentions for the Rhino Population.

Farm Name	Hunting	Photo Tourism	Love of animal
Otjiwa	Yes	Yes	
Mt Etjo	Yes	Yes	Yes
O'vita		Yes	Yes
Okatumba	Yes		Yes
Waldeck		Yes	
Safari			Yes
Ongava		Yes	
Epako		Yes	
Oropoko		Yes	

When rhinos were purchased on Otjiwa, Ohorongo and WABI, the farm owners were known to be game dealers. However, it is not known whether any rhinos were subsequently sold on from these farms. It was apparent that owners purchasing rhinos primarily for hunting tended to acquire the larger groups of animals (Mt Etjo, Otjiwa and probably also Ohorongo and WABI). Conversely owners purchasing for the love of the animals and for photo-tourism were less concerned about the group size or composition.

From discussions it was found that many farm owners and managers were more interested in black rather than white rhinos, however the white rhino was the more affordable of the two. As one of the 'Big Five' African mammals (rhino, elephant, buffalo, leopard and lion), the appeal of the white rhino for both photo tourism and for hunting is obvious.

iv) Utilisation

Trophy hunting accounted for the highest number of mortalities. The number of animals trophy hunted in recent years was derived from records of hunting permits issued to farms by the MET. In some cases only recent permit records were available and consequently the period investigated varied between farms.

Hunting prices in Namibia were known to vary from N\$50,000 to N\$72,000 in 1997 (approx. N\$ 7.5 = £1), however at times some animals have commanded much higher values. Hunting has been practised reasonably extensively in the past, but now only occurs in populations which are steadily reproducing. On Mt Etjo the last adult bull was removed by hunting several years prior to the survey, thus halting recruitment and in 1997 there were no calves in the population.

Eco-hunting has recently been publicised as an alternative technique of non-lethal utilisation and Otjiwa is the only farm in Namibia which has tried an 'eco-hunt' (described in Appendix IV). Following this experience, which resulted in the death of the rhino, they are now cautious about carrying out further hunts.

Profit from a population may also be derived from the sale of live animals. Otjiwa is the only farm in Namibia which is known to have carried out live sales, but there may have been others. At auction in 1995, white rhino were reaching N$ 50,000 each. At least eleven animals have been sold to other farms in Namibia and there were other sales to unidentified purchasers which could not be traced. This sale of excess animals has become uncommon since it requires a large and successful population and trophy hunting was more profitable. Otjiwa also expressed concern that they were unable to confirm the suitability of rhino buyers, which could have led to purchases by incompetent owners.

2.3.2.2 Habitat Suitability

A definition of the factors considered to comprise a suitable habitat for white rhino is given in Section 1.3.3. To evaluate the suitability of the habitat, a range of indicators derived from the population histories obtained from the game farm survey may be used.

i) Indicators of Suitability

a) Mortalities due to Drought and Recruitment Assessment

Deaths due to drought occurred on Ohorongo, WABI and Mt Etjo (Table 2.3). On two of these farms, the main reasons for these losses appeared to be overgrazing and inadequate management. Recruitment rates were poor on Safari, Okatumba, and Ohorongo (Table 2.4). This may have been due to management factors, habitat suitability or population size.

b) Supplementary Feeding

Supplementary feed of *Lucerne* or other harvested grasses was sometimes provided to rhinos. In cases when supplementary feed had been provided, it may be taken to indicate that the natural graze on the farm was insufficient to maintain the animals in good condition at that time, usually due to low rainfall and overgrazing. Table 2.7 details the history of supplement feeding recorded.

Table 2.7 Provision of Supplement Feed.

Farm Name	Level and Frequency of Supplementary Feed Provided
Otjiwa	Every year for most of the year, began in June 1995 and in April 1996. Salt licks are also put out although not used by rhinos.
Mt Etjo	Provided when the rhinos visibly deteriorate in condition, which is very infrequently (according to owner J. Oelofse). However, apparently the animals have been fed every year since the mid 1980's (K. Venzke, c/o EEI, MET and R. Loutit, MET, Khorixas *pers. comm.*).
O'vita	Never provided.
Okatumba	Provided at the end of the dry season almost every year.
Waldeck	First year provided was 1996 which was a very bad year, supplied from June to January. Also given horse cubes.
Safari	Minimal *Lucerne* is provided, evidently to tame the animals and not for nutrition. However feed was being provided when the farm was visited in May 1996.
Ongava	Never provided.
Epako	Provided every day at the water hole in front of the lodge, except during and just after the rains when there is a lot of grass. Vitamins and molasses are also given on the *Lucerne*. Salt licks are available, but not used by the rhinos.
Oropoko	*Lucerne* and horse cubes are provided all year round as the enclosure is only 1,000ha.

Farm owners generally provided supplementary feed when the condition of animals had visibly deteriorated and occasionally to habituate them to observers. However, in many cases farmers seemed reluctant to disclose the extent to which supplementary feed was being provided. Of the nine farms surveyed, seven had provided this at some time. In 1996, four farms had been providing *Lucerne* as the primary source of their rhinos diet for over four months.

It was noted that the pair of rhinos on O'vita thrived without supplementary feeding, despite the low rainfall and overgrazing on this farm. Similarly, breeding on Ongava had also apparently not been adversely affected.

c) Physical Condition Of Animals

During the survey, some condition assessments were carried out utilising the techniques of Keep (1971) with the four condition classes in Table 1.1, but since this was early in the project, the assessments lacked the benefit of experience. In addition the rhinos were not seen on every farm. However, it was noted that the rhinos on Otjiwa which were regularly supplementary fed due to severe overgrazing, were visibly in very good condition (see Fig. 2.4). At Waldeck a rhino cow with an approximately six-month old calf was seen in fair condition.

ii) Local Environmental Factors

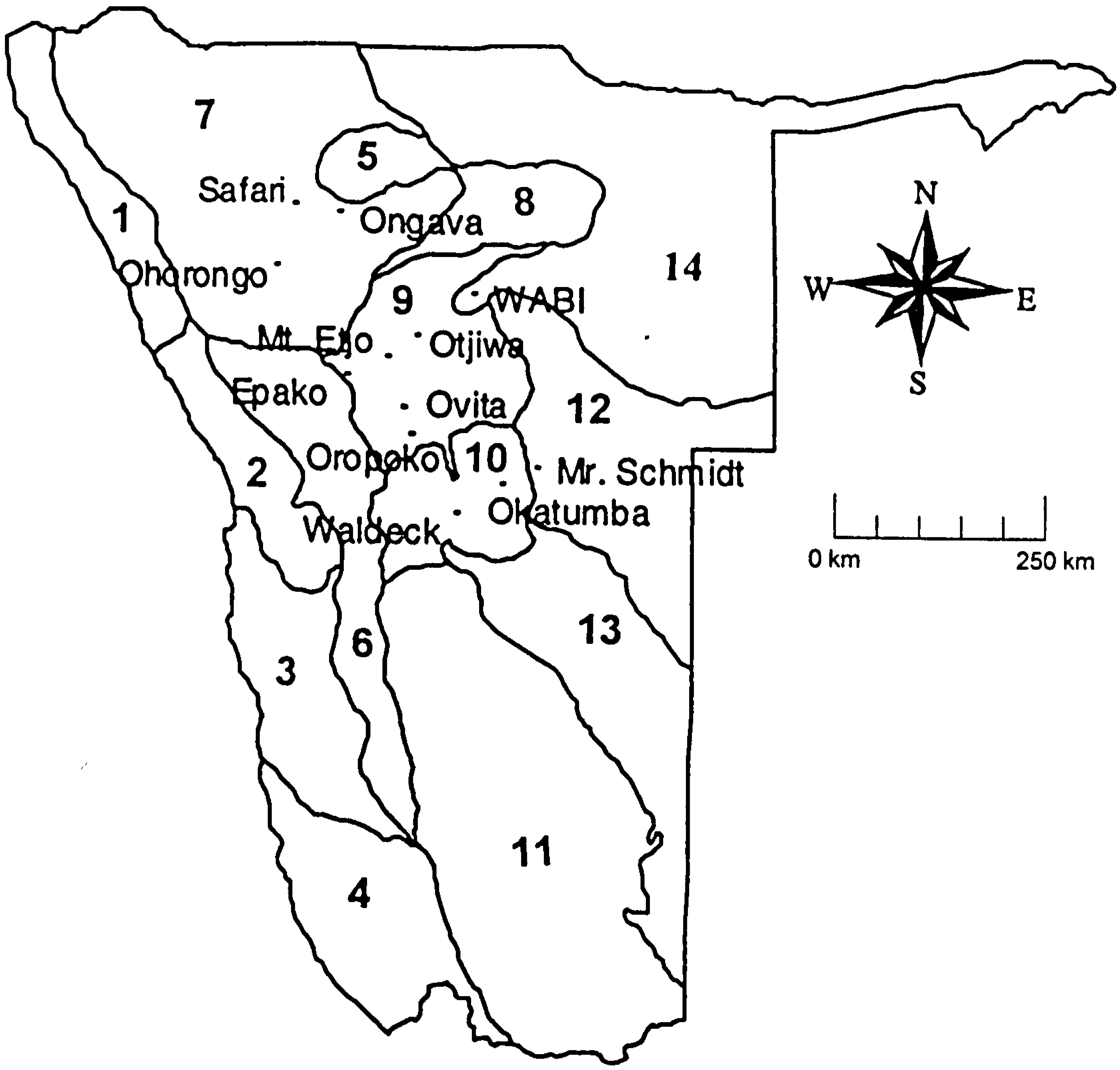
a) Habitat Types

Personal notes made during the survey on the landscape, woodland and grassland types were found to be inadequate, due to lack of time on each farm visit. Therefore locations of farms with respect to main habitat types were based on the habitat map by Giess (1971), see Fig. 2.5. Details of the main vegetation characteristics of these habitats were tabulated in Table 2.8. This indicated that of the available habitat types in Namibia, the majority of farms were in three main categories. Exceptionally, Mr Schmidt's farm and WABI fell outside these categories, but little is known of these locations.

Table 2.8 Savanna Type associated with Game Farm Locations across Namibia.

Farm Name	Savanna Type, Description and Vegetation Type Number (Fig. 2.5)
Ongava **Ohorongo** **Safari**	Mopane Savanna. *Colophospermum mopane* is characteristic of this vegetation type. Mopane trees are often present in riverine areas, and in certain soil types. Mopane shrub are found on the plains and mountain slopes. **(7)**
Epako **Mt Etjo** **Oropoko** **Otjiwa** **O'vita**	Thornbush Savanna. Varies considerably, but the typical form is grass veld interspersed with trees and large shrubs. Large areas are dominated by *Acacia* species, and bush encroachment by *Acacia mellifera* is becoming increasingly common. **(9)**
Okatumba **Waldeck**	Highland Savanna. Incorporates the central mountainous areas of the country and is characterised by trees such as *Combretum apiculatum* and *Acacia* species. **(10)**
Schmidt	Camelthorn savanna (Central Kalahari). This is an open savanna with a good grass cover, where Camelthorn *Acacia eriloba*, is the dominant tree. **(12)**
WABI	Forest savanna and woodland (Northern Kalahari). This area extends from the Waterberg plateau and across the Caprivi strip. **(14)**

Fig. 2.4 Rhino on Otjiwa



Number	Vegetation type
1	Northern Namib
2	Central Namib
3	Southern Namib
4	Desert and Succulent Steppe
5	Saline Desert with Dwarf Shrub Savanna
6	Semi-desert and Savanna Transition Zone
7	Mopane Savanna
8	Mountain Savanna and Karstveld
9	Thornbush Savanna
10	Highland Savanna
11	Dwarf Shrub Savanna
12	Camelthorn Savanna
13	Mixed Tree and Shrub Savanna
14	Tree Savanna and Woodlands

Fig. 2.5 Habitat Map with Respect to Game Farms in Namibia (from Giess 1971)

b) Habitat Utilisation

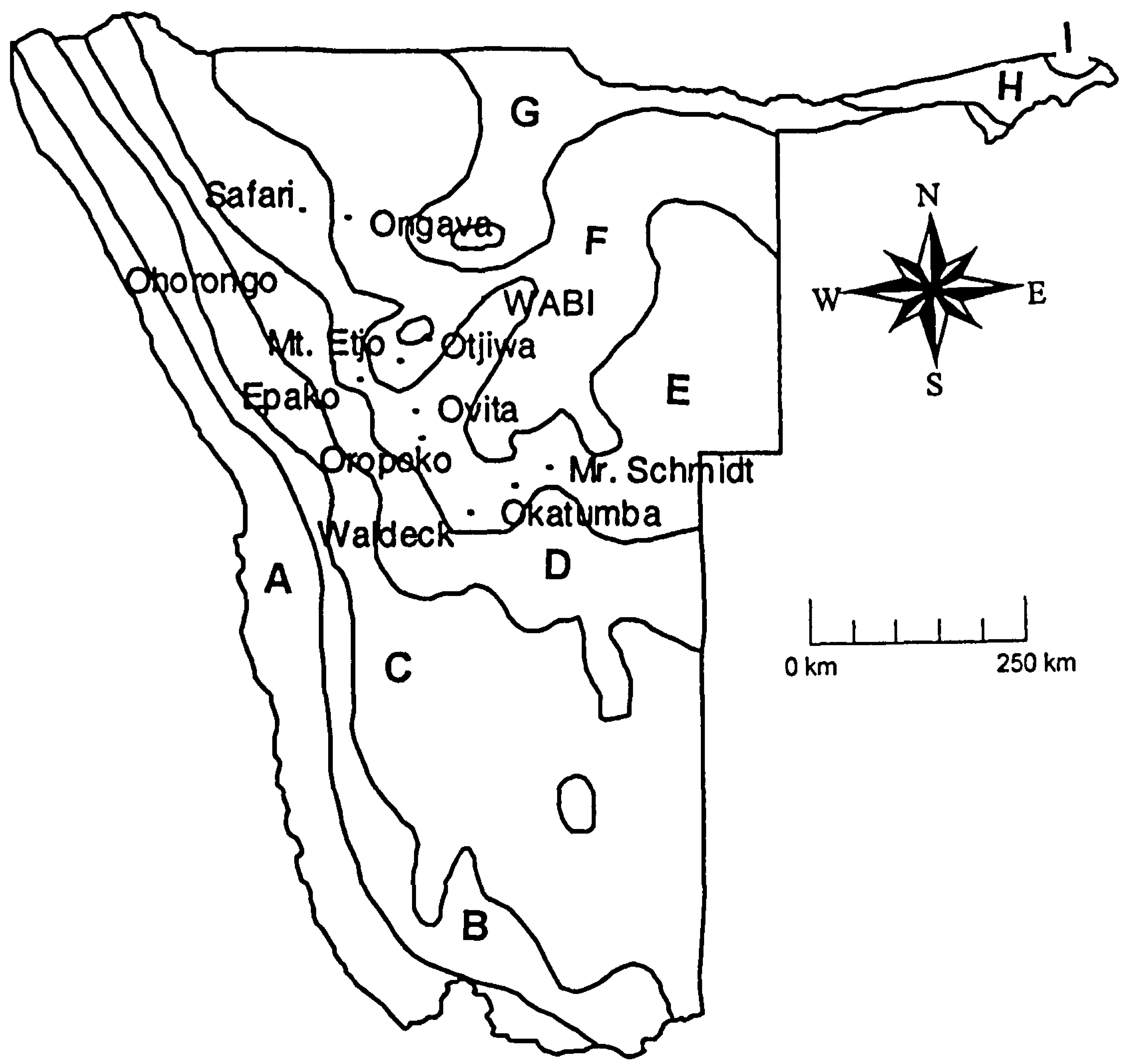
The owner or manager of each farm was asked to describe the farm areas preferred and avoided by the rhinos (Table 2.9). This reflects rhino utilisation of the farm area, however sightings may have been biased by ease of visibility which was affected by the thickness of the bush. Overall there seemed to be considerable variation between farms and the only conclusion to be drawn from this information was an avoidance of rocky and hilly areas.

Table 2.9 Habitat Types Preferred or Avoided by Rhinos, as Described by Owners.

Farm name	Preferred	Avoided
Otjiwa	Open flat areas and plains.	Thick bush.
Mt Etjo	Short grasslands, which are locally overgrazed. No problem with rocky areas.	
O'vita	No problem with *Aristida* sp.	*Stipagrostis* species.
Okatumba	Open plains and flats during the dry season and thick bush and small hills during the rainy season.	
Waldeck	Hilly areas due to better grazing.	Rocky and very hilly areas.
Safari	Thick bush and grass.	
Ongava	Plains areas during dry and rainy seasons.	
Epako	Riverbed areas with sandy soil.	Very hilly and rocky areas
Oropoko	Dry riverbeds and open areas.	Rocky areas.

c) Rainfall

Rainfall in Namibia is highly variable and unpredictable. Rainfall figures provided by the farmers were generally lower than those on the rainfall gradient map (Fig. 2.6) of Van Der Merwe (1983), which possibly demonstrates the extent of the recent years of drought. Table 2.10 compares the rainfall classes from Van Der Merwe with the rainfall figures provided by farmers. If these figures are correct, rainfall generally is below 400mm in the main rhino farm areas, which is below the critical figure suggested by Pienaar (1994a). However, the rainy season between 1996 and 1997 was better than expected in most areas, filling dams and resulting in a high standing crop of annual grasses even on badly overgrazed farms (personal observation at Otjiwa).



Number	Rainfall
A	< 50mm
B	50 - 100mm
C	100 - 200mm
D	200 - 300mm
E	300 - 400mm
F	400 - 500mm
G	500 - 600mm
H	600 - 700mm
I	> 700mm

Fig. 2.6 Rainfall Isohyets with Respect to Game Farms in Namibia (Van Der Merwe 1983)

Table 2.10 Average Rainfall described by Rhino Owners and Rainfall Isohyet.

Farm Name	Average Rainfall (mm) (1)	Rainfall Class (mm) (2)
Otjiwa	288 (1994-1997) 1997 total >400mm	400-500
WABI	Unknown	350-450
Ohorongo	206 (1992-1994)	250-350
Mt Etjo	302 (Between Otjiwa and Epako)	400-500
O'vita	150 (1977-1996)	300-400
Okatumba	304 (1984-1996)	300-400
Waldeck	326 (1990-1996)	300-400
Safari	368 (1993-1996) (3) 173 (1993-1996)	300-400
Ongava	370 (1966-1996) (3) 336 (1995/6 Etosha gate)	400-500
Schmidt	Unknown	300-400
Epako	317 (1991-1996)	300-400
Oropoko	210 (1993-1997)	300-400

(1) Average for years indicated, provided by the farmers.
(2) According to Van Der Merwe (1983), see Fig. 2.6.
(3) Derived from rain gauges in Etosha.

d) Overgrazing

Indications of overgrazing were obtained by visual assessment of the veld and animal condition, also by referring to the extent to which farmers provided supplementary feed. The high frequency of supplementary feeding on seven of the nine farms visited confirmed that overgrazing was common. Over-utilisation and degradation in the long term was also noticeable from bush encroachment, or the spread of opportunistic bushes across the farm, often *Acacia* species. This was particularly evident on Otjiwa. During the survey, many farmers expressed concern about their farm being overgrazed.

2.3.2.3 Population Composition

i) Initial Population Size

There have been introductions of white rhino to twelve game farms in Namibia. The four farms receiving the earlier introductions, between 1971 and 1982, received 16 or 18 animals each. On two of these farms, recruitment has been average to good and the population increase has sustained hunting pressure and the sale of surplus animals. In the other two cases these populations became extinct and insufficient information was available on their history to comment.

Later introductions, from 1981 to 1994, were to eight farms. These all had initial populations of less than ten animals, four of which were of less than five animals. Preliminary indications show that these small populations have not been a disadvantage, since in all of the populations with adult bulls and cows, at least one calf has been born.

ii) One Male Populations and Male Aggression

In Namibia there have been three introduced populations with only one male. In two of these cases, reproduction was apparently highly successful with inter-calving intervals of approximately two years. Both of these farms had just one male and one female.

However on two of the farms with one male, the bull is thought to have been responsible for killing his own offspring, resulting in the deaths of three calves and one juvenile. An additional four deaths were the results of bulls fighting each other. The aggression of males when accompanying a cow in oestrus has been demonstrated on Mt Etjo, where a bull fatally wounded a cow. At Waldeck the owner of the rhinos described the bulls aggression when the cow was in oestrus. In total, bulls aggression was responsible for nine deaths.

2.3.2.4 Additional Factors

i) Size Of Area Occupied By Rhinos

Analysis of the total area available on the farms to which white rhino have been introduced shows a wide variation in grazing area per animal (Table 2.11). The mean farm size was 14,230ha, with a median of 10,000ha.

Table 2.11 Total Grazing Area Available to White Rhino.

Farm Name	Total Grazing Area Available (Note 100ha = $1km^2$)
Otjiwa	10,000ha
WABI	Unknown
Ohorongo	43,000ha
Mt Etjo	14,000ha
O'vita	9,995ha
Okatumba	6,000ha
Waldeck	10,000ha
Safari	5,300ha
Ongava	32,000ha
Schmidt	Unknown
Epako	11,000ha
Oropoko	1,000ha camp

ii) Disease

Five deaths due to Anthrax have been recorded at two locations.

iii) Breakouts

Breakouts occasionally occur, sometimes immediately after release, for example on Mt Etjo and Mr. Schmidt's farm. These animals were presumably stressed due to capture and transportation. Ohorongo, Ongava, O'vita and Okatumba have also experienced rhinos pushing through fences some time after being settled. On Ohorongo, rhinos broke out of the farm due to extreme conditions of inadequate food. No breakout problems have occurred on Epako, Oropoko or Safari, or since 1994 on Otjiwa. The situation on WABI was not known.

iv) Control Of Ownership

Ownership of white rhinos is controlled by MET, primarily by issuing import, export, transport and hunting permits according to basic guidelines. Specific inspection of a farm is not usually carried out before issuing an import permit, unless there is an obvious reason why the request is not feasible (P. Erb, EEI, MET *pers. comm.*). Most farms have been inspected for a variety of other purposes, including vegetation assessments, at some other time. Hunting permits are issued if the conditions of international regulations on endangered species (Convention on International Trade in Endangered Species or CITES) are fulfilled.

v) Owners Association

Many of the white rhino owners in Namibia were members of the African Rhino Owners Association (AROA) which is part of the Rhino and Elephant Foundation (REF) based in South Africa. Several owners expressed an interest in establishing a Namibian rhino owners association to focus on local problems of rhino ownership.

In 1996, MET appointed a rhino co-ordinator and discussions were initiated on the possibility of establishing a Namibian owners group. However from past experience it was considered that such an organisation should be established as a result of the interest and commitment of owners. While larger farms were enthusiastic, believing that they would benefit from the sharing of help and advice in looking after their animals, other farms with fewer animals showed less enthusiasm.

2.3.3 Limitations

Collating the history of rhinos on game farms was dependent upon each farmer's recollections of historical events on their farm, and this was related from their point of view. Total accuracy of this information could not be assured and consequently an element of error may be unavoidably introduced.

Obtaining consistent and comparable figures of annual rainfall for all areas was also not possible for this study. This provides an example of the difficulty of obtaining definitive facts and figures to support data and is an unavoidable part of working in Africa, which does not always have the resources to monitor and document such parameters.

2.4 Discussion

This survey has provided the only known detailed compilation and analysis of the history of white rhino on game farms in Namibia to date. Although absolute accuracy in terms of the precise history of all introductions could not be achieved and statistical analysis was not possible, the data obtained were assessed in a context which has enabled a number of conclusions to be drawn.

Several factors were identified as critical for the success of a small rhino population. It was apparent that the natural environment on most game farms was not entirely suitable for rhinos, but appropriate management measures, consistently applied, normally enabled a viable population to prosper.

2.4.1 Past And Present Status

The results indicate that since 1971, 103 white rhinos have been introduced to private land in Namibia and at present 69 animals remain. Of the introduced animals, 92 were imported while the remainder were purchased or transferred from other farms. Identified mortalities account for the loss of at least 61 animals but the actual number of deaths is certainly higher than this. To estimate overall recruitment in Namibia, internal transfers may be ignored. This indicated that from the 92 imported animals and after the deaths of at least 61, plus an unknown number of exports, more than 38 rhinos will have been born in the survey period to produce the 69 survivors.

Analysing the recorded mortalities in Namibia, 35% of deaths may be attributed to poaching and 22% to hunting. A further 17% of deaths appear to be related to droughts, which adequate monitoring and management should have prevented. The majority of deaths therefore resulted from un-natural causes rather than old age. This high death rate in relation to recruitment accounts for the overall fall in numbers.

Sex ratio figures would imply that the early introductions were probably not solely for hunting since there was no greater decline in the numbers of males than females. It was possible to purchase greater numbers of bulls during the 1960's and 1970's (Buijs & Anderson 1989) specifically for hunting, however this opportunity did not appear to apply to most Namibian introductions. It should also be noted that since the early 1990's, the South Africa NPB policy on rhino sales has resulted in introductions normally being of six animals in a ratio of 2:4, which explains the observed ratio of fewer bulls than cows.

2.4.2 Comparison between Game Farms in Namibia and South Africa

Of the 103 animals introduced to 12 Namibian game farms, 69 animals can be accounted for in 1997 on eight farms. These figures have been compared with the surveys of white rhinos on private land in South Africa in 1987 (Buijs & Anderson 1989). Both of these surveys were conducted 26 years after the initial releases, although the actual periods were not coincident. Fig. 2.7 illustrates the decline in the number of animals after introduction over the survey periods in both countries, and Fig. 2.8 shows the number of farms which introduced rhinos compared with those with animals at the end of the survey periods. There is a strong similarity between these graphs, with the numbers of both animals and farms in each country declining by approximately one third since release. In South Africa, the decline in white rhino numbers was primarily attributed to excessive hunting, however other contributing factors included unsuitable conditions, lack of supplementary feeding, overstocking by more adaptable species, and reducing the number of males per population to one.

The outcome of each introduction to Namibia up to 1997 and South Africa up to 1987 (Buijs & Anderson 1989) were classified and counted according to whether an introduced population increased, remained the same, decreased or became extinct. The percentage of farms in each category were compared in Fig. 2.9.

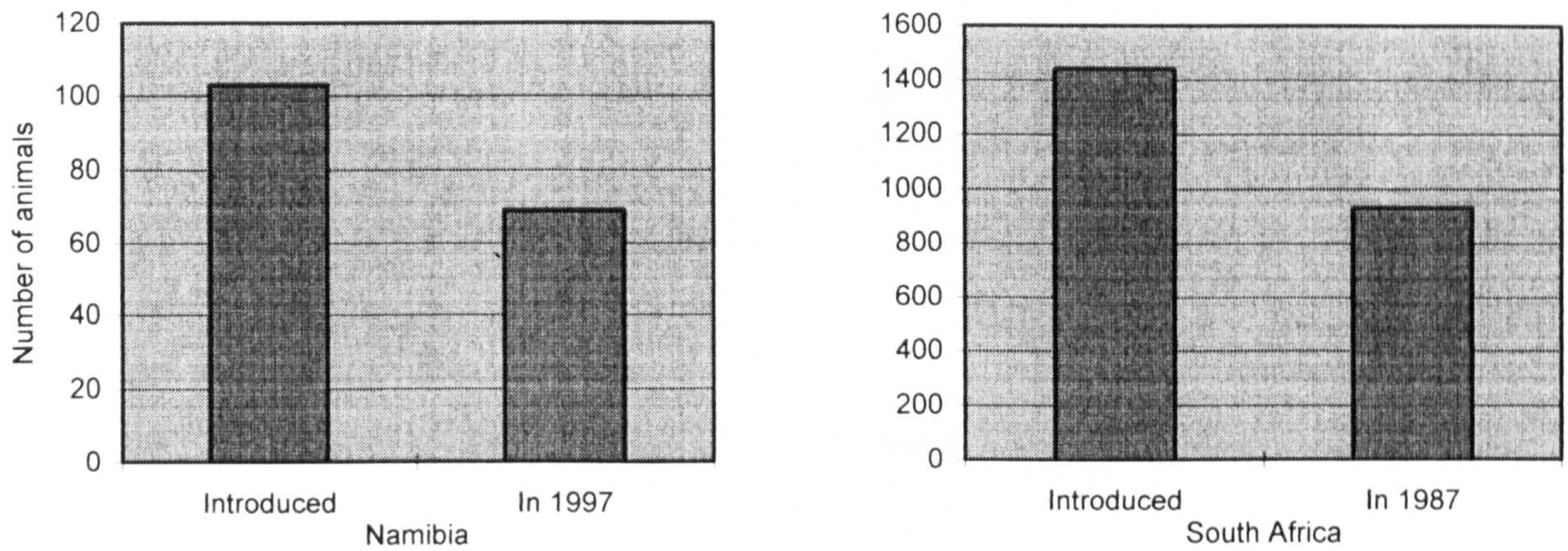


Fig. 2.7 Number of Rhinos Introduced and Existing on Farms 26 Years after the Initial Release

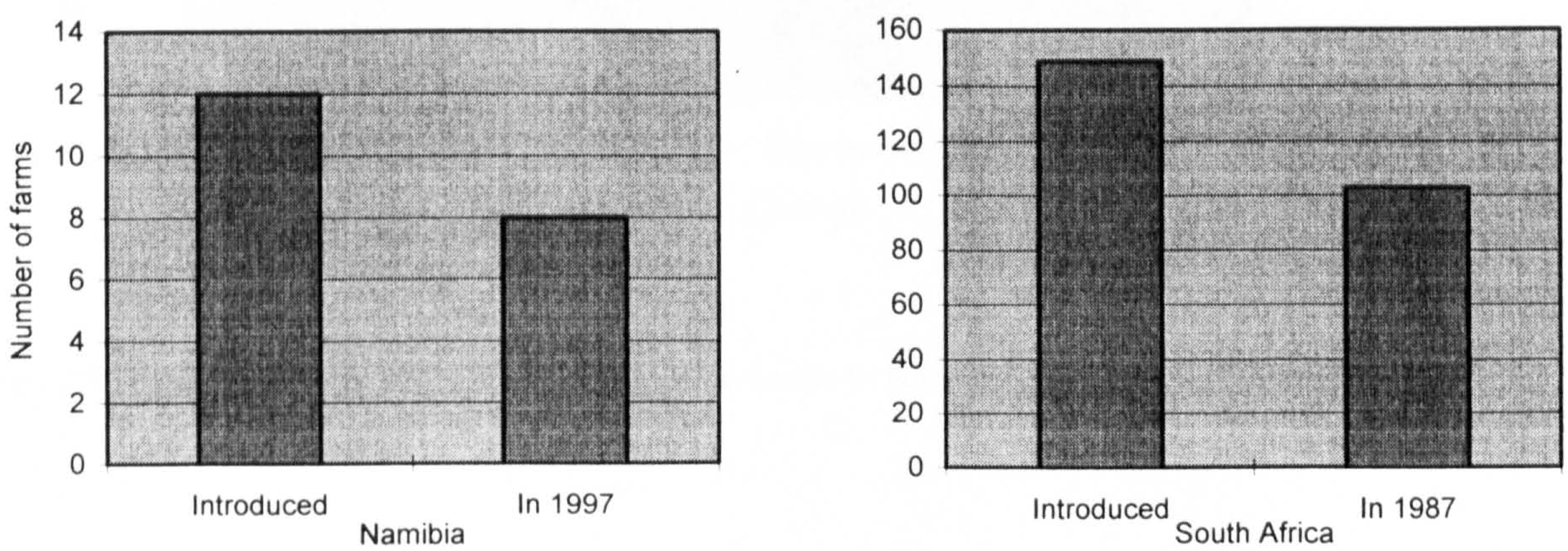


Fig. 2.8 Number of Farms which Introduced Rhinos, and those Supporting Populations 26 years after the Initial Introductions

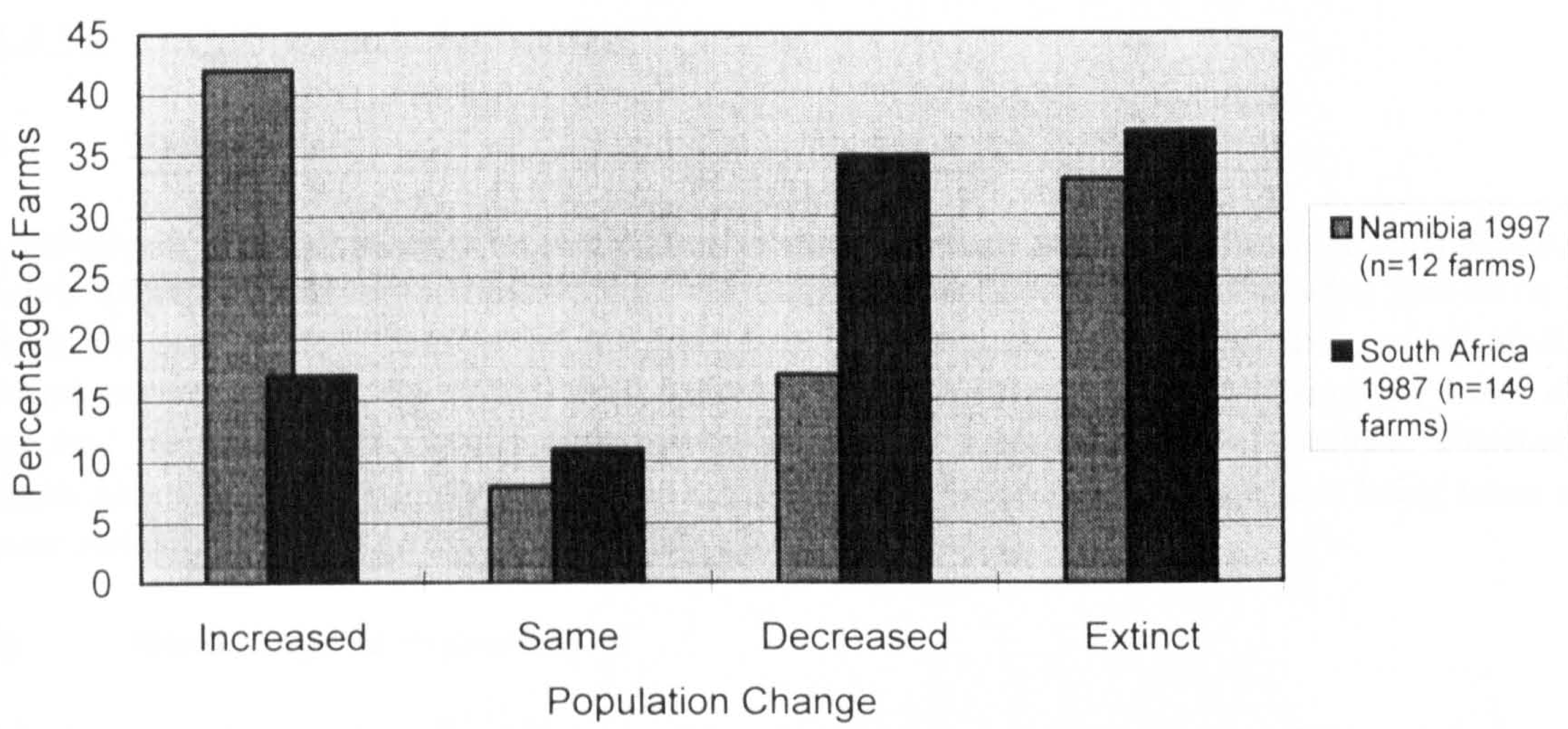


Fig. 2.9 Relative Success of Populations on Game Farms in Namibia and South Africa over 26 years

It would appear that the percentage of populations which had increased in Namibia was far greater than that in South Africa. However, these data are distorted since four of the early Namibian introductions involved large numbers of individuals (16 or 18 animals) and two of these populations are now extinct, causing the loss of many individuals. Since the late 1980's and early 1990's, the number of animals in each introduction has been considerably smaller, but many of these groups have produced one or two calves.

Buijs and Papenfus (1996) conducted another survey in South Africa in 1994, which found a substantial increase in the numbers of both individual rhinos and farms with populations. This was attributed to higher prices for live animals, which had provided an incentive to increase breeding stock, also hunting rates had dropped to about 3% per annum. Between 1987 and 1996 an annual increase of 6.7 % was found in rhino on farms in South Africa which compares with an annual increase in Namibia of 0.9% between 1987 and 1997. Unfortunately this 1994 survey changed the basis of inclusion of farms and counting of animals and no longer provided the number of rhino initially released. This prevented further valid comparison with the 1997 Namibia survey.

2.4.3 Main Factors Influencing the Success of Introductions

2.4.3.1 Anthropogenic Influences

i) Management

Management in Namibia has been inconsistent in the past which generally reflects the early situation in South Africa. Following their survey in 1987, Buijs and Anderson (1989) concluded that 'Even if no rhino had been hunted, there would still have been a net decrease in the population, which obviously throws severe doubt on the ability of most landowners to manage rhinos to enhance the status of the species.' However more recently the situation appeared to have improved in Namibia. Similarly, in South Africa Buijs & Papenfus (1996) stated that the need for conservation was now being taken much more seriously, possibly due to the increased value of the animals.

ii) Monitoring and Protection

Monitoring and protection of privately owned white rhinos is entirely the responsibility of the owner or manager of the game farm. In the past, ineffective or non-existent monitoring and security has led to the loss of numbers of individuals but more recently this situation has improved. Advice on protection techniques is provided in Namibia by the MET and PRU, however the considerable size of most farms and wandering movements of rhinos make effective security difficult and expensive. Attitudes towards the threat of poaching continue to be relaxed although awareness appears to be increasing.

iii) Motivation

During the 1980's the purchase price of a rhino was relatively low at R20,000 or less. Consequently many farms buying during this period were mainly interested in profiting from trophy hunting, not conservation or even sustainable utilisation (Adcock & Emslie 1994; Buijs & Anderson 1989). This trend was observed in Namibia since early introductions declined through unknown causes, most probably trophy hunting. However when prices increased this situation changed and farmers are now increasingly interested in sustainably managing their rhinos.

iv) Utilisation

Hunting can provide a financial return from rhino ownership and may encourage ownership of larger overall populations (Adcock & Emslie 1994). In the past trophy hunting has provided a strong motive for purchase and the introduction of large groups of rhino. Increased animal prices have encouraged owners to manage rhinos for sustainable utilisation and trophy hunting has now become relatively uncommon in Namibia. When recruitment is successful and provided ethical hunting practices are followed, in conjunction with a reasonable understanding of the groups social structure, it should have no detrimental effect upon a population.

In the 1987 South African survey of white rhinos on private land, Buijs & Anderson (1989) described excessive hunting which accounted for 54% of rhino mortalities, with the actual total probably being much higher. Adcock and Emslie (1994) found that trophy hunting of privately owned animals had dropped from approximately 10.5% per year to approximately 3% per year after the value of animals increased in 1988.

At auction from Otjiwa in 1995, animals were reaching N$ 50,000 each which was similar to the values reached for live sales in South Africa (Buijs & Papenfus 1996).

Some live sales have probably occurred in the past and these could possibly be promoted since they encourage farmers to breed with their animals. However, no farms other than Otjiwa and Mt. Etjo have sufficient animals to carry out live sales and the sale of only a few animals often results in small founder populations.

A trial 'eco-hunt', in which two rhinos were darted for capture, was carried out at Otjiwa. One of the animals subsequently died of an infection. Other eco-hunts identified problems with this procedure including the necessity of the presence of a qualified vet and approximately a 5% chance that the rhino will die (Chilvers 1993). It would appear prudent to remain cautious of this alternative until techniques have been better established.

2.4.3.2 Habitat Suitability

i) Indicators of Suitability

All game farms in Namibia are enclosed by a game fence and since there is generally insufficient natural water, artificial water holes are provided. The low rainfall combined with periodic droughts usually results in insufficient natural graze to sustain animals throughout the year. Overgrazing was found to be common and supplementary feeding was regularly needed.

Supplementary feeding has been provided at some time on seven of the nine farms surveyed, therefore approximately 22% of farms apparently never fed their rhinos. On South African farms in a similar survey but with a sample size of 68 farms, Buijs and Papenfus (1996) found that 65% advised that they never fed, with the remaining farms feeding every winter or only during droughts. No farms in South Africa were providing feed for over half of the year, as with Otjiwa in Namibia. These results may be expected since in Namibia the natural environment is far more arid and is subject to periodic droughts.

A total of ten deaths on game farms were attributed to drought, mostly in the 1970/80s. It is considered that these were generally related to inadequate management and monitoring, since the regular provision of supplement feeding and water normally prevents this being a major problem. With so few farms in the survey, variations in the time since the initial release combined with different management, founder group size and sex composition, an assessment of habitat solely on the recruitment history was not possible.

ii) Local Environmental Factors

Most of Namibia is semi-arid with a low and unpredictable rainfall, except for a part of the centre and the Caprivi Strip in the north. Many of the introductions to Namibia were to areas with rainfall below the 400mm rainfall isohyet which Pienaar (1994a) suggested as an important boundary beyond which introductions should be approached with caution. In these circumstances management support to ensure the persistence of a population becomes increasingly important.

Within these areas, owners described their rhinos as preferring riverbeds and open, short grasslands. They considered that the animals appeared to have few problems with slightly rocky areas, but they did avoid very hilly and rocky terrain.

2.4.3.3 Population Composition

i) Initial Population Size

In Namibia, initial populations of less than ten animals accounted for eight out of the twelve introductions. Of these, only 38% decreased in size or became extinct, compared with 70% of similar South African populations (Buijs & Anderson 1989). Risks associated with small populations especially those with low reproductive rates are discussed in the overall discussion.

ii) One-Male Populations

Two pairs of rhinos were introduced on Namibian farms, and in both cases breeding was good or excellent. These cases contradict the conclusions of Blaszkiewitz (1991) and Bertschinger (1994), who found that breeding pairs do not reproduce in captivity also that there is definitely a minimum group size necessary for efficient reproduction.

In Namibia, three groups of rhinos were introduced with one male (including the two pairs above) and overall it appeared that reproduction was not adversely affected. This is also not compatible with a study on captive rhinos by Lindemann (1982), who commented that the breeding success in populations of females with only one male is significantly lower than that in populations with more than one male. Survey results of Buijs and Anderson (1989) on South African game farms confirmed this observation of lack of recruitment, as of the 25 populations with a single male, only nine recorded the production of calves (and it was possible that these females could have been pregnant before relocation). Buijs and Papenfus (1996), were unable to draw any conclusions with a small number of observations, but they commented that apparently poor reproduction could be due to the fact that pairs are often bought as immature animals.

iii) Male Aggression

Within the limited sample size in Namibia, deaths due to aggression appeared unusually common, especially in populations with only one male. Buijs and Papenfus (1996) recorded only two calves killed by bulls, out of 62 deaths from known causes on game farms in South Africa. Hostility between the adult bull and young was noted by Player and Feely (1960) and Grzimek *et al.* (1972), who commented that the male is only tolerant of the young as long as they do not approach him too closely. They added that a calf accompanying a female on heat is in continual danger and if it remains too close to its mother, may be killed by the bull. It is possible that in situations where there are only a few rhinos on a farm, sub-adults or calves are reluctant to leave their mothers as there are no other rhinos to establish a group with.

Territorial conflicts between males as a result of competition for water at water holes at the end of the dry season, caused a significant increase in adult male mortalities in Kruger National Park (Pienaar 1994b). Du Toit (1994) indicated that dominant bulls fighting may account for about 50% of mortalities. The results in Namibia may suggest that where a lone bull is placed on a farm and territorial aggression between bulls therefore removed, this may increase the likelihood that he will direct his aggression on other members of the group.

2.4.3.4 Additional Factors

i) Size Of Farm

In Namibia the mean farm size was 14,230ha with a median of 10,000ha. Buijs and Papenfus (1996), found that of the 140 ranches surveyed, the average farm area was 4,984ha, with a median area of 2,950ha, which is several times smaller than the average farm in Namibia. However it was often the case, particularly in Namibia, that a very large farm may offer a poor habitat due to aridity and very low grass density.

The frequent provision of supplementary feeding in Namibia can reduce competition for resources and the success of a rhino population may therefore be less related to the farm size and grazing area. White rhinos are also social animals and only the dominant bulls will divide the available territory. The six rhinos on Oropoko have bred in an enclosure of only 1,000ha, however compared with the considerably smaller enclosure size of animals kept in a zoo environment, these limitations are possibly not significant.

ii) Disease

Two farms have recorded cases of Anthrax in white rhino, providing confirmation that rhinos are susceptible to the disease. General awareness of this problem appeared to be good, since animals in affected areas have generally been immunised. On private land in Namibia there have been no deaths attributed to other diseases.

In South Africa, Buijs and Anderson (1989) noted that 10% of natural deaths were attributed by private rhino owners to disease, although this has never been recorded as a cause of death by the National Parks Board, Natal Parks Board or other conservation agency. Subsequently, one mortality due to Anthrax was recorded on a game farm in the 1996 survey results (Buijs & Papenfus 1996). It was therefore possible that disease may be used as an explanation for a death if the rhino owner does not know or prefers not to reveal the actual cause. However this was not the case in Namibia where all Anthrax cases were confirmed. Anthrax is a factor which should definitely be considered prior to future releases to determine whether precautionary measures should be taken.

iii) Breakouts

The highest risk of breakout is after a release, therefore new owners should plan for this eventuality since organising the animals recapture and return may be expensive. Large herbivores may also break out of a farm if grazing conditions are inadequate to fulfil their ecological requirements and their natural dispersion is prevented by physical boundaries. This problem can be avoided with a sound fence, good management and reasonable awareness of the animals ecological requirements.

Chapter 3

White Rhinos in National Parks

3 White Rhinos in National Parks

3.1 Introduction

3.1.1 Background

National Parks in Namibia are managed and maintained by the Ministry of Environment and Tourism (MET). They cover approximately 13.6% the country's total surface area and are maintained to conserve the natural habitat, flora and fauna. Management techniques, in particular for monitoring and protection, have been developed primarily for conservation. Consequently, animals are not normally provided with supplementary feed as this practice is not natural and is not a viable long-term management option. As a result, introduced populations are more directly influenced by the available habitat and have the potential to provide a better indication of the inherent suitability of a semi-arid environment.

3.1.2 Previous Research

Studies in South Africa have included investigations into the behavioural ecology of white rhinos in the Umfolosi-Hluhluwe Reserve (Owen-Smith 1973), habitat use in the Pilanesberg Game Reserve, Bophuthatswana (Borthwick 1986) and the species landscape preference in the Kruger National Park (Pienaar *et al.* 1992, 1993a&b). Condy (1973) studied the population status, social behaviour and activity patterns of white rhino in Kyle National Park, Rhodesia (now Zambia and Zimbabwe). No published research has been completed to date on white rhinos in Namibian National Parks other than a brief description of the history of introductions by Joubert (1996).

3.1.3 Aims

This chapter studies the introductions of white rhino to National Parks in Namibia, with the following principal aims:

i) To establish the current status and to assemble the history of all introduced white rhinos on National Parks in Namibia.

ii) To identify the main factors which have influenced the success of introductions with respect to management and habitat suitability.

The results are then compared with the study of white rhino on game farms in Namibia in the overall discussion, chapter 7.

3.2 Methods

Information on the white rhinos in National Parks was collected using the same survey as that used for game farms in Chapter 2. The MET Chief Control Warden or research staff were contacted for information relating to the introductions and existing rhinos and all sources have been named. Information relating to the Etosha National Park and Kaross was collected personally with the assistance and permission of MET. Monitoring of the rhinos on Waterberg Plateau Park (hereafter Waterberg) was carried out personally during one week living on the plateau.

The results were analysed to provide information on the following:

i) The current status of the white rhino on National Parks in Namibia and the history of the populations;

ii) The main factors which have affected the success of the introductions in terms of anthropogenic influences through management, habitat suitability and population composition.

3.3 Results

Background details of each relevant National Park are included as case studies in Appendix V. Locations of the National Parks in Namibia are illustrated in Fig. 3.1. Little information could be found on Mangetti, consequently it is only briefly described.

3.3.1 Status of White Rhino and History of Populations

Details of the initial release of white rhinos to National Parks in Namibia and the present population is provided in Table 3.1. The history of population numbers and the present population is illustrated in Fig. 3.2.

Waterberg forms the dominant result, with an initial introduction in 1975 and a subsequent large increase in the population. Initially the release of rhinos at Waterberg comprised 50% more females than males, but subsequently the sex ratio has become almost even. The Etosha National Park introduction has been too recent to draw any conclusions. In Kaross, the white rhinos have been studied in more detail and the results are provided in Chapter 5, including information on the relocation of the dominant bull to Mangetti.

Table 3.1 History of Releases and Existing Numbers of White Rhinos on National Parks in Namibia.

Park Name	Release Year(s)	Numbers Released (m:f)	Numbers existing in 1996/1997 (m:f:unknown)
Waterberg	1975-1990	14[1] (5:9)	44 (21:22:1)
Etosha	1995-1997	11 (6:5)	11 (6:5)
Kaross	1994	7 (2:5)	4 (1:3)
Mangetti	1996	[1][2] (1:0)	1 (1:0)
MET total		**32 (14:19)**	**60 (29:30:1)**

Notes:

(1) This figure does not include the seven deaths from capture related stress at Waterberg (see Table 3.3 below) although most of these deaths occurred after release.

(2) The introduction to Mangetti was the translocation of a male from Kaross.

The history of rhino population numbers for each year since the initial introduction is detailed in Table 3.2, with approximate figures given in brackets. These results were used to calculate an overall annual increase of 7.5% in the number of rhinos in National Parks between 1987 and 1997.

i) Mortalities

Overall 18 deaths were recorded on National Parks as detailed in Table 3.3 and Fig. 3.3. Waterberg recorded the highest number of mortalities, which were attributed to a variety of causes. No mortalities are known to have occurred in Etosha or Mangetti.

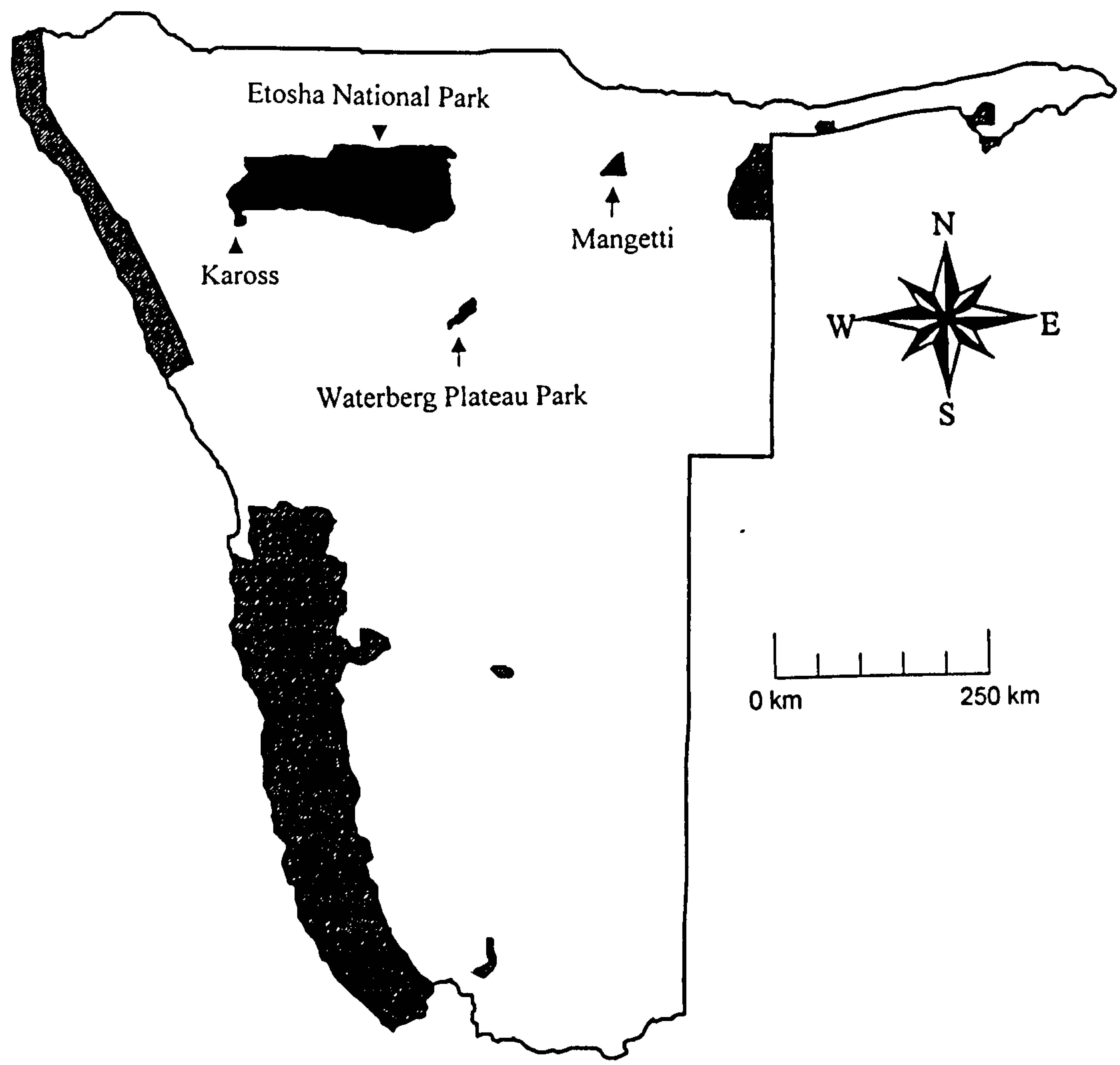


Fig. 3.1 Map of National Parks in Namibia

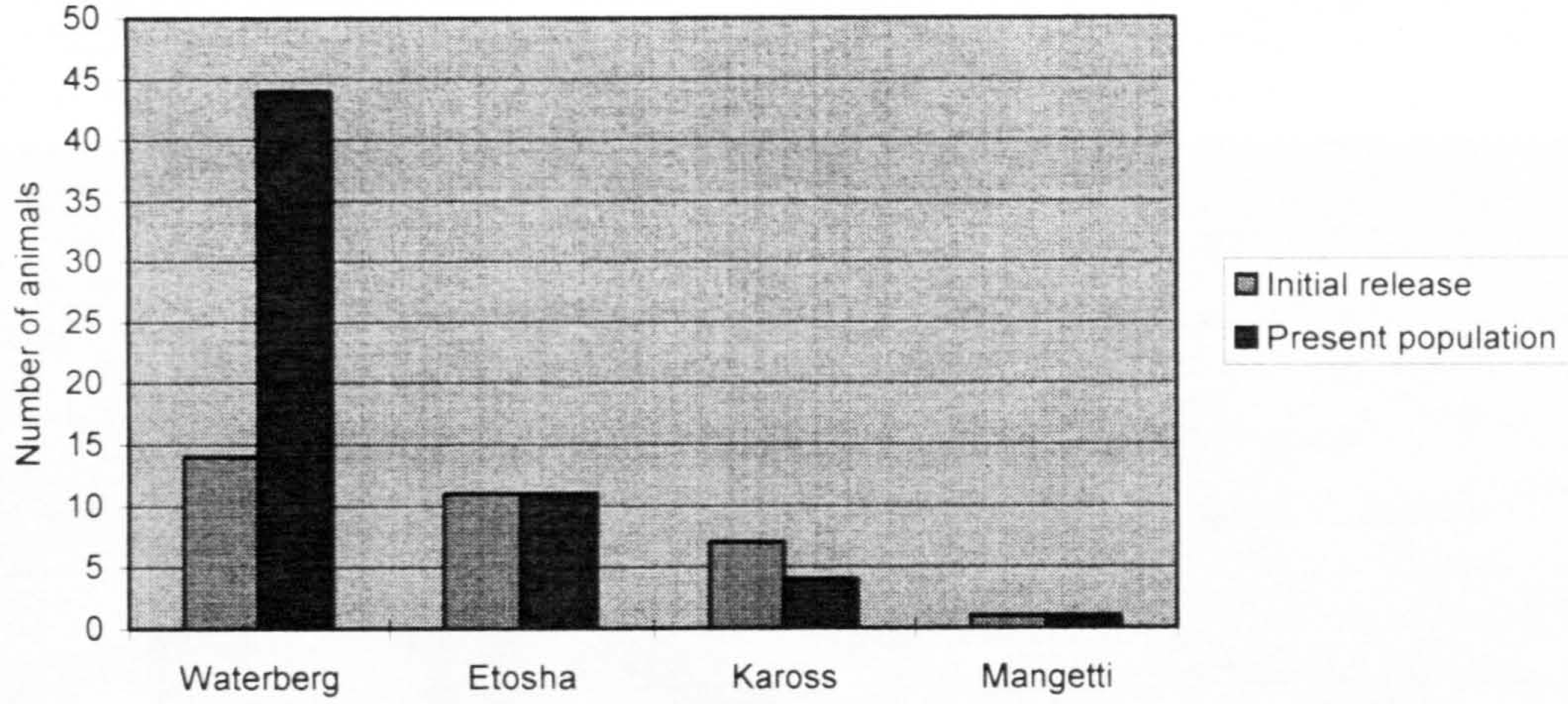


Fig. 3.2 Numbers of Introduced and Present White Rhinos

Table 3.2 History of White Rhino Population Numbers in National Parks

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Waterberg	12	?	?	?	?	?	16	18	20	21	25	28	29	32	31	36	39	?	?	(42)	?	44	(44)
Kaross																					6	5	4
Etosha																					10	10	11
Mangetti																						1	1
Total													29							42		60	60

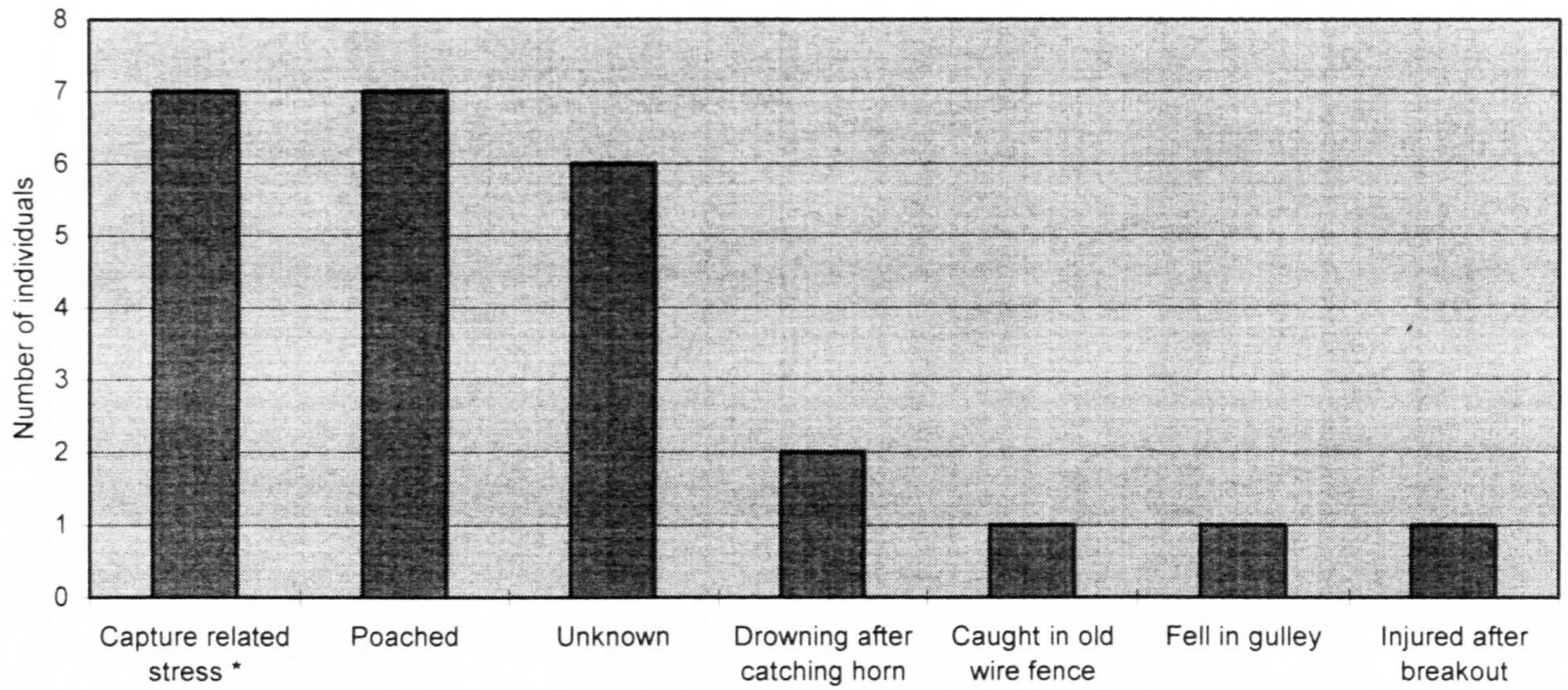


Fig. 3.3 Causes of Death

* These deaths due to capture related stress are not counted as deaths in National Parks since they were caused by capture and transport conditions, and occurred before effective introduction.

Table 3.3 Causes of Death.

Cause of Death and Location	Number of rhino
Capture related stress. The initial release of rhinos from Natal resulted in three stress related deaths after the long journey. During a second introduction in 1990 from Kruger, stress due to initial capture problems caused all the rhinos to refuse to eat or drink in bomas, forcing an early release. This resulted in the deaths of two rhinos which fell from the cliffs, one died in the bomas and one became wedged between rocks. (Waterberg 7)	7
Poached (Waterberg 7)	7
Unknown (Waterberg 4; Kaross 2)	6
Hooked his horn in the water trough in boma and drowned before release (Waterberg 1)	1
Drowned after catching its horn in water hole in park (Waterberg 1)	1
Entangled in wire fence (Waterberg 1)	1
Fell into a gully (Waterberg 1)	1
Broke out of park, caught but injured, later died (Waterberg 1)	1

ii) Recruitment Assessment

Recruitment on each park was assessed and is detailed in Table 3.4. On Waterberg the precise numbers of births and deaths was not certain until September 1993, at which time individuals were identified with a system of ear notches. Consequently it was not possible to model population growth. A cow from Kruger National Park which was introduced in 1990 had her first calf in 1993.

Relating the number of animals released overall to the present population and allowing for 16 recorded deaths, shows that at least 45 rhinos have been born since the releases. Considering that at the time of release most animals were sub-adults, this overall increase in numbers was rated as good.

Table 3.4 Recruitment Ratings.

National Park	Birth Details	Recruitment Rating
Waterberg	Discussed above.	Good
Etosha	Released in 1995, very low density, no recorded births and sightings are infrequent.	Too early
Kaross	Seven individuals released in 1994 and no recorded births (see Chapter 5).	None / poor
Mangetti	One bull introduced in 1996.	Not possible

3.3.2 Main Factors Influencing the Success of Introductions

3.3.2.1 Management

All National Parks in Namibia are managed by the MET who have developed techniques and working practices from years of experience. Management staff all have experience and training (academic or practical) in nature conservation, while regular meetings and workshops encourage discussion and comparison of experiences. The MET Head Office is based in the capital city, Windhoek and regional offices provide links to remote management and research stations in the National Parks. Specialist skills in management and research co-ordinate activities and provide a sound basis for decisions. Two management posts have been established with specific responsibilities for black and white rhinos in Namibia. One post is a research scientist is based in the EEI and the other is a qualified vet responsible for co-ordinating management throughout the country.

National Parks in Namibia are managed to maintain the environment in its natural state, which includes introducing species which historically occurred in the area. Introductions are not expected to bring any financial benefits. However, ownership can provide a financial return. In Waterberg, the population has succeeded to the point where it is thought to be reaching the carrying capacity of the plateau and it is possible that the sale of individuals may occur in the future.

3.3.2.2 Monitoring And Protection

Protection and monitoring are organised independently in each park. Levels of protection are generally high because of the presence of the endangered black rhino as well as white rhino.

The financial resources available to protect animals in National Parks is relatively stable with funding normally available through the government, from tourism and from foreign aid. This has enabled the establishment of properly staffed and equipped teams dedicated to rhino monitoring and protection as detailed in Table 3.5.

National Parks have used various techniques for the identification of individual animals. In Waterberg and Kaross, a sequence of ear notches relating to an individual identity number have been cut in the rhinos ear. This system is sufficiently clear that during the full moon it was possible to identify rhinos visiting water holes. Following fresh rhino footprints (see Chapter 5) to locate an animal enables identification or photography of individuals rhinos. Radio transmitters may be attached to rhinos by horn implants, collars or ear-tags (P. Erb, EEI, MET *pers. comm.*). These have been effective for short term studies such as monitoring rhinos during the weeks after their release but the transmitters rarely last six months. They are also difficult to attach securely, particularly the collars since rhinos have a wide neck which makes the collar vulnerable to slipping back over the head.

Anti-poaching patrols are carried out by either the Wildlife Protection Services (WPS) or Anti-Poaching Units (APU). Teams work on foot, horseback, with vehicles or light aircraft depending upon the local terrain, and communicate through a radio communications network. More recently, additional information on possible poaching activity has been obtained with the co-operation of local communities which have established an information network. Within National Parks, contingency plans have been prepared to provide the necessary security in the event of intensive poaching (Rhinoceros Conservation Plan for Namibia, unpublished report 1996).

Table 3.5 Anti-Poaching and Monitoring Activities.

National Park	Anti-Poaching and Monitoring Activities
Waterberg	Anti-poaching patrols have been carried out regularly since 1989. The rhino monitoring team are well motivated and receive a bonus for clear photographs identifying individual rhinos. All white rhinos were de-horned and individually identified by a series of ear notches late in 1993. Regular de-horning is expected in future. The rhino population is presently monitored by an annual aerial survey and regular water hole counts for up to 72 hours over the full moon period. Poaching has been a problem on Waterberg, however due to the continued efforts of the APU and the rhino monitoring team, appears under control at present.
Etosha	Rhinos are protected by the WPS (previously known as the APU). This is a professional team with the facilities of an aircraft and all-terrain vehicles and is based in Okaukuejo. Regular fence patrols and tracking from water holes are undertaken and protection is assisted by the co-operation of local communities around the park. Regular monitoring is undertaken at water holes during the full-moon period. Before release of the rhinos, radio transmitters were attached to five ear tags and one collar for monitoring purposes.
Kaross	The area is patrolled regularly by the Wildlife Protection Service for Etosha. All the rhinos here are de-horned regularly. When they were released they were marked with ear notches and radio transmitters were attached to collars.
Mangetti	Unknown

3.3.2.3 Habitat Suitability

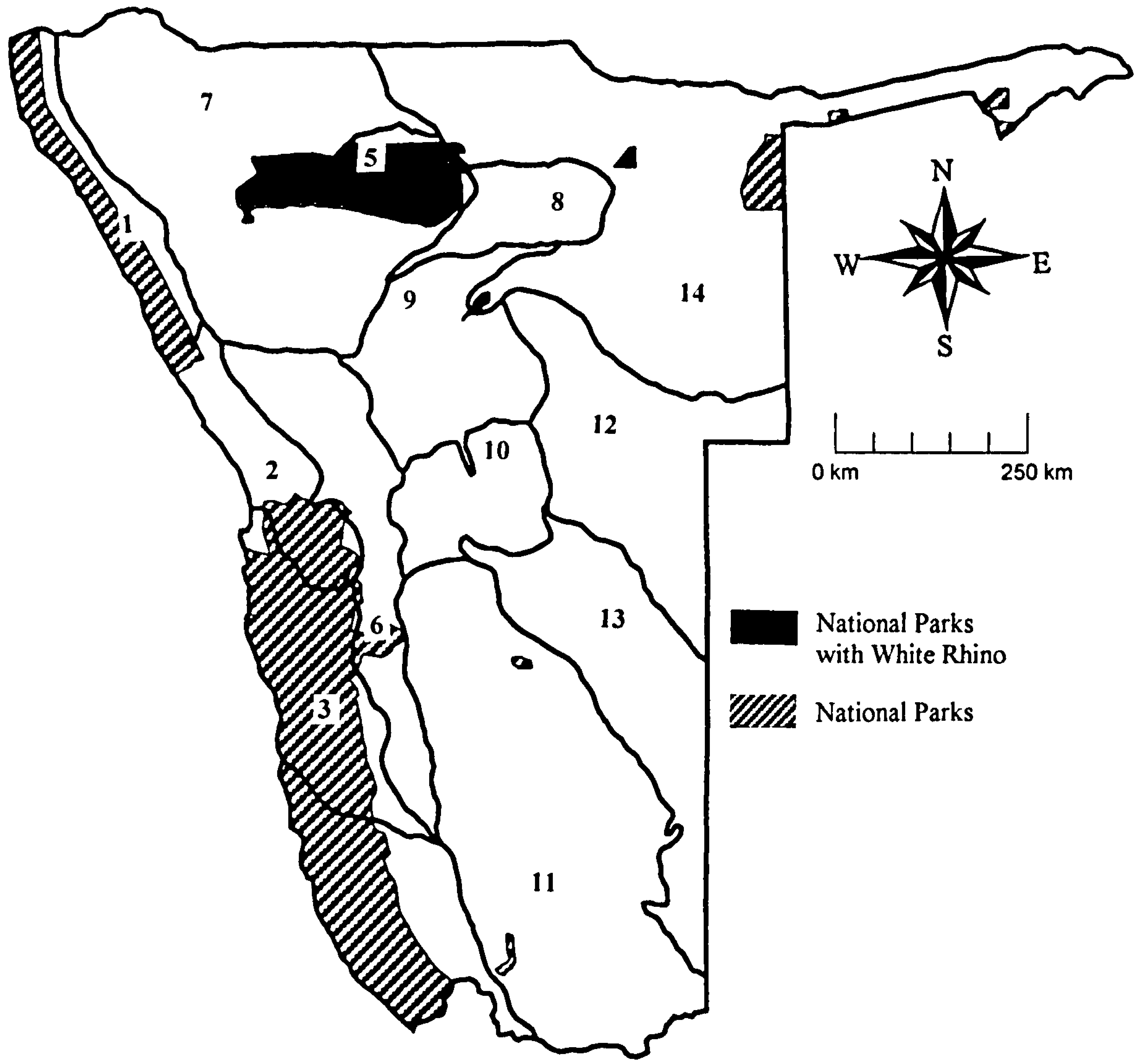
i) Indicators of Suitability

Providing additional food to supplement the diet of the rhinos has not been necessary on any of the National Parks included in this survey. Other factors which might indicate habitat suitability include recruitment success, rhino condition and any mortalities due to drought. Apparently no rhino deaths due to drought have been recorded, although deaths have been attributed to unknown causes. Recruitment success on Waterberg was rated as good. The physical condition of the white rhinos in Waterberg (personal observation) and Etosha (management and research staff, EEI) is reported to have remained good at all times. The condition of the rhinos in Kaross has improved greatly since they were relocated to this area and is described in detail in Chapter 5. It is difficult to assess the grazing situation in any of these parks, however research would tend to indicate that at present Etosha is not nutritionally limiting the numbers of grazing animal (Gasaway *et al.* 1996).

ii) Local Environmental Factors

a) Habitat Types and Utilisation

Habitat types across Namibia were broadly classified by Giess (1971) (Fig. 3.4), and subsequent research has described many of these areas in greater detail, see Table 3.6. The main vegetation type in Namibia is generally classified as sweet-veld but some areas are classified as sour-veld including the Waterberg plateau. These conditions are caused by a high level of leaching of nutrients through the sandy soils of the plateau leaving the grasses mainly unpalatable, except in the river valleys and rocky areas. The soil has a very low pH and is deficient in phosphate, potassium and magnesium. On Waterberg, bonemeal and salt licks are used by rhino to supplement their diet.



Number	Vegetation type
1	Northern Namib
2	Central Namib
3	Southern Namib
4	Desert and Succulent Steppe
5	Saline Desert with Dwarf Shrub Savanna
6	Semi-desert and Savanna Transition Zone
7	Mopane Savanna
8	Mountain Savanna and Karstveld
9	Thornbush Savanna
10	Highland Savanna
11	Dwarf Shrub Savanna
12	Camelthorn Savanna
13	Mixed Tree and Shrub Savanna
14	Tree Savanna and Woodlands

Fig. 3.4 National Parks Habitat Types (Giess 1971)

Table 3.6 Habitat Types.

Location	Habitat description
Waterberg	Tree savanna and woodland (Giess 1971). T. Cooper (Waterberg Plateau Park, MET *pers. comm.*) described the area as broad-leafed woodland savanna or deciduous woodland and vegetated Kalahari sand dunes.
Etosha	Giess (1971) first described the area as *Mopane* savanna and semi-desert with dwarf shrub savanna. Le Roux *et al.* (1988) subsequently identified thirty vegetation types (Fig. 3.5). A vegetation classification system based on the height of woody vegetation has been compiled with the aid of satellite mapping (Sannier *et al.* 1998).
Kaross	*Mopane* savanna was described as the vegetation type by Giess (1971). The habitat in Kaross was described by Le Roux *et al.* (1988) as *Mopane* treeveld and Kaross granitic *Mopane* veld. Habitat was further classified by Sannier *et al.* (1998). A comprehensive habitat survey was carried out as part of this study, see Chapter 4.
Mangetti	Giess (1971) classified the area as tree savanna and woodland.

Habitat preferences were described based upon sightings of the rhinos and are summarised in Table 3.7. Whenever possible this was confirmed during this study by personal observations.

Table 3.7 Habitat Preference.

Location	Habitat Preference
Waterberg	Rhinos were not thought to demonstrate any significant habitat preferences in this area. However fewer sightings were made in thick bush, possibly due to limited visibility. Consequently, more observations occur on the short grass lawns which are grazing areas. It was noticed that rhinos tend to lie on hill ridges under shade trees, where they are also kept cool by the wind.
Etosha	Habitat preference not known, sightings depend upon vegetation type and most sightings were on grassland due to good visibility. Also observed in *Mopane* areas east of Halali.
Kaross	Discussed in Chapter 6.

b) Rainfall

Accurate rainfall figures are available in National Parks as rain gauges are generally located around the park. In addition, twice daily readings are taken for national monitoring purposes at some locations. Average rainfall values for each location have been compared with ratings of Van Der Merwe (1983) (Fig. 3.6), in Table 3.8.

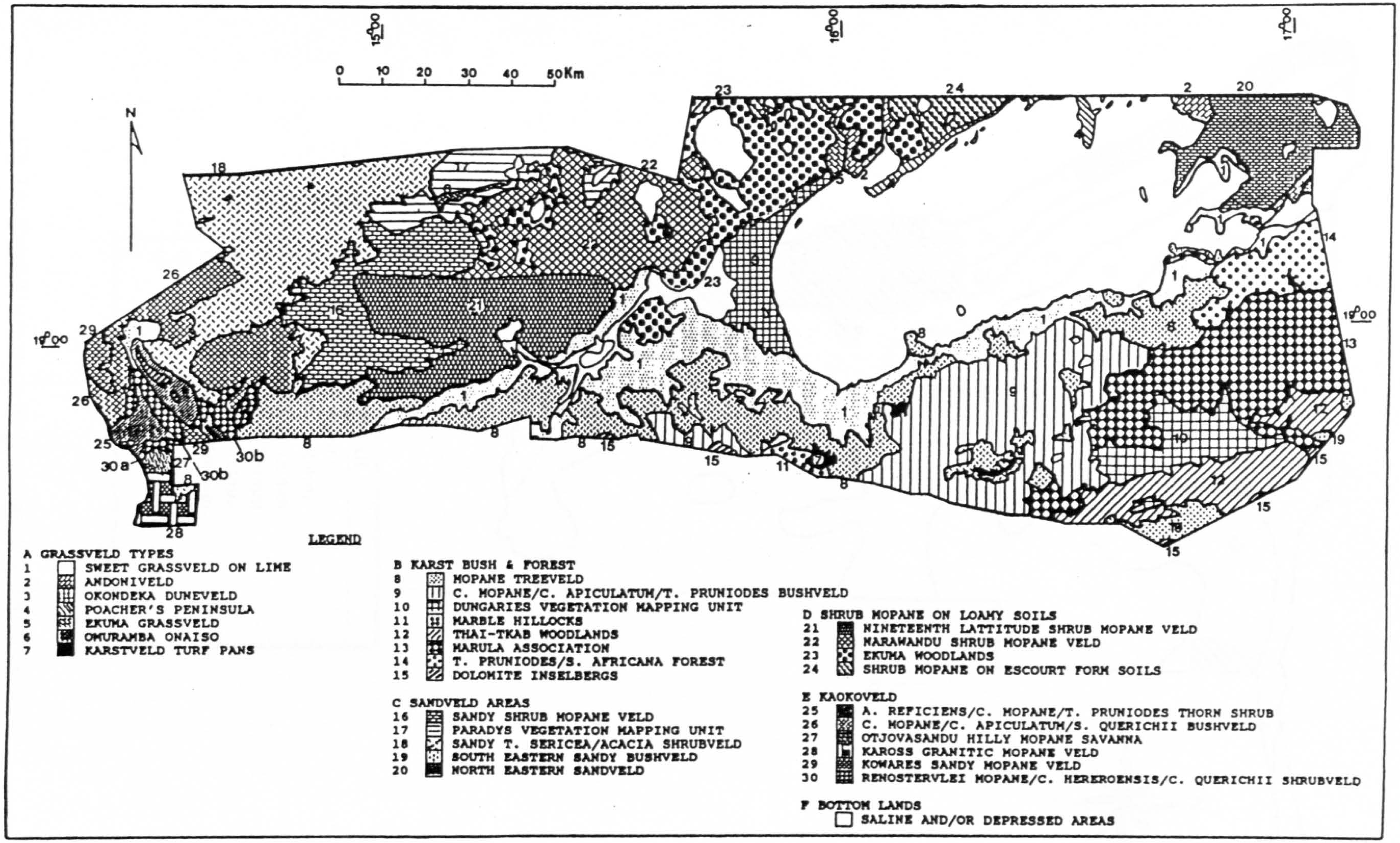
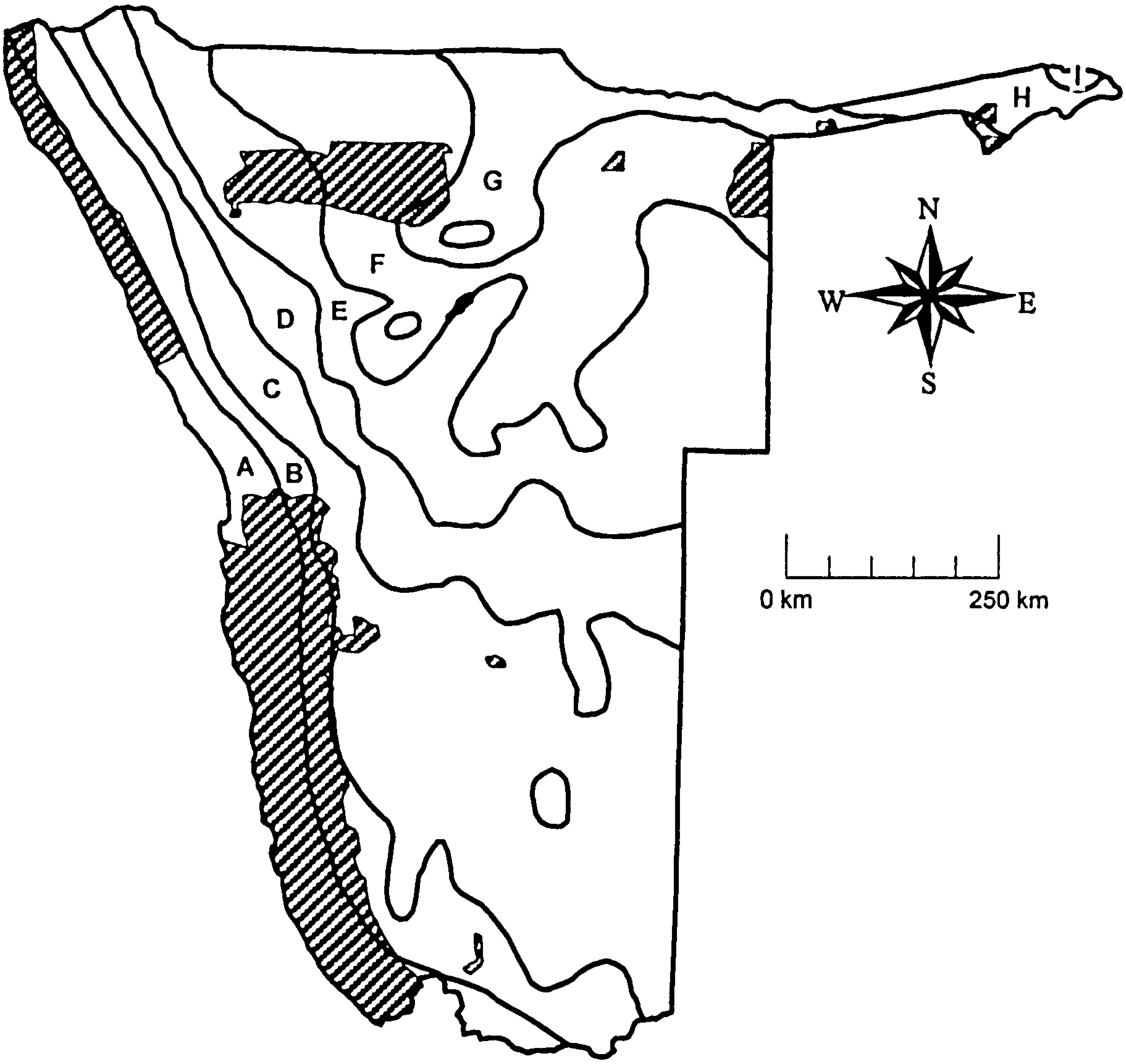


Fig. 3.5 Vegetation Map of Etosha National Park (from Le Roux *et al.* 1988)



Number	Rainfall
A	< 50mm
B	50 - 100mm
C	100 - 200mm
D	200 - 300mm
E	300 - 400mm
F	400 - 500mm
G	500 - 600mm
H	600 - 700mm
I	> 700mm

Fig. 3.6 Rainfall Isohyets on National Parks (Van Der Merwe 1983)

Table 3.8 **Average Annual Rainfall Figures.**

Location	Actual Rainfall (mm)	Rainfall Class (mm)*
Waterberg	Between 1977 and 1992, there was an average of 471mm. Recent years rainfall was not known.	350-450
Etosha	Average from 1966 to 1996; at Namutoni (far east) 431mm, Halali 369mm, Okaukuejo 372mm and Otjovasandu (far west) 366mm. During the season of 1996 to 1997 Namutoni received 642mm, Halali 479mm, Okaukuejo 418mm and Otjovasandu 348mm.	300-550
Kaross	Average of 366mm between 1966 and 1996. During the season of 1995 to 1996, Otjovasandu recorded 348mm.	275 -375
Mangetti	Unknown	400-500

* According to Van Der Merwe (1983)

3.3.2.4 Population Composition

Waterberg's original introduction was large, and benefited genetically from the addition of further animals from a geographically distinct source. In Etosha, only eleven rhinos have so far been released, which is a very low density of animals in relation to the large area of the park. Further introductions are planned in the future.

3.3.2.5 Additional Factors

i) Size of Area Occupied by Rhinos

The total area of each National Park and the area available to the rhinos (i.e. not excessively rocky) are noted in Table 3.9.

Table 3.9 **Total and Available Area for Rhinos.**

Location	Area
Waterberg	41,800ha of which approx. 38,000ha is accessible to the rhinos.
Etosha	2,230,000ha of which over 20% is saline pans (Sannier *et al.* 1998).
Kaross	15,000ha
Mangetti	48,000ha

Note: 1ha = 100m x 100m; $1km^2$=100ha.

ii) Disease

Rhinos have occasionally been inoculated against Anthrax on Waterberg, but at present it is not considered necessary. White rhino were also inoculated against Anthrax before release in Etosha.

3.4 Discussion

3.4.1 Past and Present Status

To date the introductions of white rhino to National Parks in Namibia has not been on a sufficiently large scale to permit any statistical analysis, but a number of conclusions may be drawn. Waterberg has received 14 animals since 1975. The three other parks have only received a total of 18 animals since 1994. The number of rhinos on Waterberg has increased by a factor of three to 44, but introductions to other parks have to date been unproductive. Due to the lack of information on Mangetti, it is not possible to discuss the single, recent introduction.

3.4.2 Comparison between National Parks in Namibia and Southern Africa

Owen-Smith (1973) described the history of white rhinos in the Umfolosi-Hluhluwe reserve South Africa, where a founder population of just 120 animals in 1929 steadily increased to reach approximately 2000 animals in 1970. To accommodate this population increase, rhinos have been extensively introduced to National Parks elsewhere in Southern Africa since the 1960's. Overall these introductions have been highly successful. In Kruger National Park, a 12 year introduction programme in the 1960's and early 1970's relocated 345 white rhinos. By 1993 their numbers had increased to 1,875 (Pienaar 1994a&b).

These statistics show how successful white rhino introductions can be when the habitat and circumstances are favourable. The scale of these introductions is much greater than those to National Parks in Namibia, therefore valid numerical comparisons cannot be made. The most significant factor being that Namibia is generally more arid and has a lower average rainfall than other countries in the region (Owen-Smith 1973; Pienaar *et al.* 1992, 1993a&b).

3.4.3 Factors Influencing Success of Introductions

i) Management, Protection and Monitoring

Rhino management in National Parks is aimed at conservation of the species, normally without the financial constraints and rewards that apply to game farms. Consequently the parks are generally well fenced and patrolled, which significantly deters poaching. The losses of rhino to poaching in Waterberg occurred before 1990 and improved security measures have since been established.

Routine monitoring of animals after release is also important. This demands considerable manpower which is not always available, but overall the National Parks are more able to provide this than game farms. To assist monitoring it has been found that ear notches provide the most simple and effective method of identifying individual rhinos. Radio transmitters enable individuals to be located and tracked but this technique is difficult, expensive and has a limited life span.

ii) Habitat Suitability

No supplementary feed has been provided for the white rhinos in National Parks in Namibia, therefore it is possible to observe populations which are primarily dependent on the Park's natural habitat for their ecological requirements. These populations therefore have the potential to provide an indication of the inherent suitability of Namibian veld. Long-term recruitment success in Namibia cannot be assessed at present since there are insufficient spatial and temporal data.

Waterberg Plateau is northern Kalahari sandveld, which has sandy, heavily leached soils, resulting in its sour-veld status. To compensate for potential mineral deficiencies on the plateau, bonemeal and salt licks are used by the rhinos. Bothma (1989) recommended providing salt licks to provide a phosphate supplement in sour-veld areas. He also commented that game species are less sensitive to phosphate deficiencies than livestock. This is probably due to the fact that game species utilise natural licks better and are able to select plant material with a higher nutritional value. Rhinos in the Umfolosi were observed licking termite mounds (Owen-Smith 1988), which is a natural source of salt and minerals. White rhinos on the plateau have shown good recruitment to date, despite the high number of deaths. This would imply that sour-veld areas such as Waterberg can provide suitable habitat for white rhino.

At the time of the introduction of white rhinos to Etosha there was considerable discussion over whether the habitat was entirely suitable due to the uncertain historical distribution. If the rhinos survive but fail to reproduce this may indicate that the habitat is only marginally suitable, although the very low density of animals provides an advantage. Previous studies in Etosha tested the theory that food availability was the reason for the persistent low densities of plains ungulates (Gasaway *et al.* 1996). A visual assessment of physical condition did not indicate any cases of typical starvation during drought and late dry season periods, which indicates that nutrition was not limiting the number of grazing ungulates. This implies that as large grazers, rhinos will probably not be nutritionally constrained in Etosha, despite the fact that this area is not necessarily within their historical distribution.

iii) Additional Factors

a) Size Of Park

National Parks normally provide large enclosed areas where relatively large populations of animals may be introduced. Kruger and Etosha National Parks are both approximately the same size while most other parks in Southern Africa are smaller. The carrying capacity of herbivores in a National Park is a function of the total grazing area and the long term quality of the herbaceous layer. Relatively small areas can maintain significant numbers of rhino if the habitat is favourable, whereas much larger areas are needed if the natural habitat is poor.

b) Disease

Due to the size of some parks, rhino deaths may not be noticed for weeks, which usually prevents the cause being established. Anthrax is endemic to certain regions in Namibia and is a regular seasonal cause of death of ungulates and occasional black rhino in Etosha (Lindeque 1991). Several white rhino and occasional black rhino mortalities on game farms in Namibia have been identified as Anthrax, confirming the species susceptibility to the disease. Consequently, introductions to areas with endemic Anthrax should be approached with caution due to the practical problems of inoculating wild animals in National Parks. Within the survey period no other disease has been identified as causing rhino mortalities in the National Parks.

Chapter 4

Mapping the Habitat in Kaross

4 Mapping the Habitat in Kaross

4.1 Introduction

4.1.1 Background

Kaross is an enclosed area of 150km^2 (15,000ha) located in the south-west corner of Etosha, and is managed as a sanctuary for rare and endangered species (Fig. 4.1). Elephants (*Loxodonta africana*) and lions (*Panthera leo*) are normally excluded from the area and the rhinos are regularly de-horned to deter poachers. Its topography is a transition between the flat plains of Etosha and the mountainous regions of Koakoland to the west.

Seven white rhino were introduced into Kaross in 1994 and there has subsequently been no recruitment. Various factors may be responsible, but the area is reputed to be marginal white rhino habitat, receiving an average annual rainfall of 366mm between 1966 and 1996. This element of the study was intended to establish and map herbaceous species and habitat available in Kaross to enable habitat utilisation of the white rhino to be assessed.

4.1.2 Previous Research

Namibia's vegetation types were first detailed by Giess (1971) who described Kaross as *Mopane* savanna. Subsequently, a detailed vegetation map of Etosha was constructed in 1988 (Le Roux *et al.* 1988) which classified Kaross as mainly Granitic *Mopane* veld (similar to Kaokoveld) and *Mopane* tree veld (See Fig. 3.4). More recently, remote sensing (Sannier *et al.* 1998) has been used to classify the area according to the height of the woody vegetation.

The grasses of Namibia were classified by Müller (1984) and the grasses of Southern Africa by Gibbs-Russell *et al.* (1991). The tree species of Etosha were described by Berry (1980) in sufficient detail for this study.

Parameters perceived as important in habitat evaluation to identify and define homogenous units, were defined by Bothma (1989) and Du Plessis (1992). To supplement field observations, details of topography were obtained from a Geological survey map (Geological Survey of SWA/Namibia 1979), hereafter referred to as the topographical map.

The soil was described by Le Roux *et al.* (1988) as medium sandy loam, possibly derived from granite, interspersed with quite large granite intrusions. Du Plessis (1992) described the area as geologically heterogeneous, including granite, quartzite, shale, sandstone, dolomite and calcrete. Subsequently, a detailed soil map was completed by Beugler-Bell (1996) and this was used to obtain soil data.

4.1.3 Aims

In order to establish rhino utilisation patterns, the individual characteristics of the herbaceous layer and habitat across the area had to be surveyed and mapped. Wherever appropriate, previous research was incorporated, including vegetation classification (Sannier *et al.* 1998), habitat classification (Du Plessis 1992), soil types (Beugler-Bell 1996) and topographical features (Geological survey of SWA/Namibia).

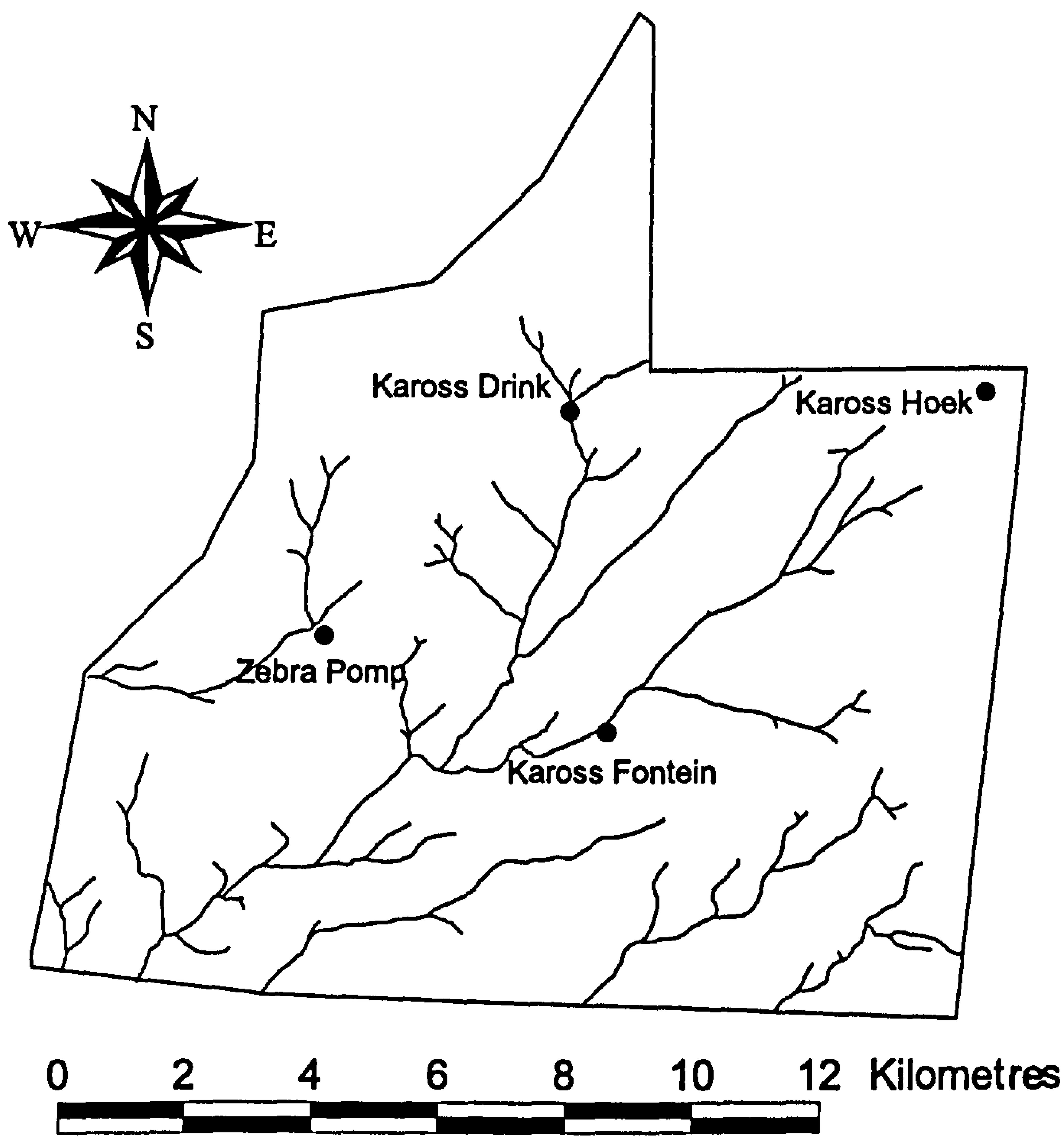


Fig. 4.1 Location of Water Holes and Rivers

The aims therefore are:

i) To produce maps illustrating the distribution of the following environmental parameters:

- **Herbaceous Layer.** With details of the grass layer in terms of species composition, distribution, density and biomass.

- **Habitat.** With details of the habitat in terms of vegetation classification, tree cover and dominant species, rockiness, soil, grazing pressure and utilisation, landscape, rivers and water holes.

ii) To compile the results for each category to construct:

- **Herbaceous Layer and Habitat Maps.** Apply multivariate analysis to the data to identify and describe homogenous areas of herbaceous species and habitat. Refine these maps by including any dominant habitat features including rivers and water holes.

4.2 Methods

A transect was taken to be a specific location from which details of herbaceous layer and habitat were recorded. A regular grid of transects was established over the area of Kaross based upon the topographical map. Following the field survey, the accuracy of certain parameters was enhanced by referring to results from previous studies. Information on all parameters was reclassified where necessary, then analysed by correspondence analysis to identify homogenous regions of herbaceous and habitat types. A Geographical Information System (hereafter referred to as GIS) was subsequently used to map the spatial variability of individual characteristics and to create maps of homogenous areas.

Locating Transects

A copy of the topographical map was divided into a regular grid comprising 257 squares or transects. Position locations (or co-ordinates) for the corners of Kaross were obtained at Etosha Ecological Institute (EEI) and marked on the map. The co-ordinate scale was extrapolated to provide the Global Positioning System (hereafter referred to as GPS) position of each transect, and it was found that they were separated by 0.73km. Each transect location was given an identity number and co-ordinates for its ideal position.

A hand held Magellan GPS 2000 Satellite Navigator was used to locate the transect position. This navigator is reported to have a distance error of ±50 metres. The UTM 33S co-ordinate system was adopted as standard throughout the survey. When the transects were located in the field, it was discovered that the co-ordinates for the corners of Kaross obtained from EEI, were based upon a different grid system, moving personal survey positions approximately 420m to the south. Certain transects were therefore located beyond the boundaries of Kaross and others had to be created to investigate the whole area. Consequently it was necessary to ensure that all maps were on the same standard grid for further analysis.

For each transect the **ideal** way-point was entered into the GPS as a 'GOTO' site and this was located by walking in the direction the GPS indicated. As the direction was followed the GPS calculated the distance to the way-point in 0.1km increments. When the distance to the ideal location was displayed as 0km, the transect location was assumed to have been reached and the **actual** reading on the GPS was recorded. The error between the ideal and actual way-points was later calculated. The figure for the actual GPS position was subsequently used to plot the position of each transect while mapping the data with GIS.

4.2.1 Herbaceous Layer

Identification of grasses was carried out according to the classification system of Müller (1984). Identification of all species was confirmed by the vegetation ecologist in Etosha (W. Du Plessis, EEI, MET *pers. comm.*). A herbarium of the grass species in the area was compiled for future reference in duplicate, one for future research in Etosha at the Otjovasandu herbarium and one for personal use. For recording purposes, the Latin name for grass species was abbreviated and the first two letters of each name used (Table 4.1).

i) Grass Species Occurrence, Distribution and Density

The wheel-point technique (Tidmarsh & Havenga 1955) was used to assess grass species occurrence and distribution across the area. This technique has previously been adapted by Mentis (1981) and Du Plessis (1992), and the basic technique was further developed for the purpose of this study to provide an index of grass density.

Table 4.1 Key to Abbreviations of Grass Species Names

Abbreviation	Species
An Pu	*Anthephora pubescens*
An Sc	*Anthephora schinzii*
Ar Ad	*Aristida adscensionis*
Ar Co	*Aristida congesta*
Ar Ho	*Aristida hordeacea*
Ar Me	*Aristida meridionalis*
Ar Rh	*Aristida rhiniochloa*
Ar St	*Aristida stipitata*
Bare Ground	No herbaceous species within 100cm
Ce Ci	*Cenchrus ciliaris*
Ch Vi	*Chloris virgata*
Cy Da	*Cynodon dactylon*
Cyprus	Sedge
Da Di	*Danthoniopsis dinteri*
En Ce	*Enneapogon cenchroides*
En De	*Enneapogon desvauxii*
En Sc	*Enneapogon scoparius*
Er An	*Eragrostis annulata*
Er An	*Eragrostis annulata*
Er Ec	*Eragrostis echinochloidea*
Er Le	*Eragrostis lehmenniana*
Er Ni	*Eragrostis nindensis*
Er Po	*Eragrostis porosa*
Er Ri	*Eragrostis rigidior*
Er Ro	*Eragrostis rotifer*
Er Su	*Eragrostis superba*
Er Tr	*Eragrostis trichophora*
Fi Af	*Fingerhuthia africana*
He Co	*Heteropogon contortus*
Me Re	*Melinus repens*
Mi Ca	*Michrocloa caffra*
Mo Lu	*Monolytrum luederitzianum*
Pa Co	*Panicum coloratum*
Pa Ma	*Panicum maximum*
Po Fl	*Pogonarthria fleckii*
Sc Ka	*Schmidtia kalihariensis*
St Hi	*Stipagrostis hirtigluma*
St Ho	*Stipagrostis hochstetteriana*
St Na	*Stipagrostis namaquensis*
St Un	*Stipagrostis uniplumis*
Tr Mo	*Tricholaena monachne*
Tr Ra	*Triraphis ramosissima*
Unidentified	Grazed / damaged beyond identification
Ur Br	*Urochloa brachyura*

The wheel-point apparatus resembles a bicycle wheel with spikes at the edge instead of a rim (see Fig. 4.2). While being pushed, a marked spike hits the ground at regular intervals which became the sample points. The diameter of the spike was 1cm. At each transect, the wheel-point apparatus was used to record 100 sample points. From the starting location a route of walking thirty points to the east, five to the north, thirty to the west, five to the north and thirty back to east, was taken. A hand-held counter was used to ensure that the correct number of observations was taken in each direction and overall.

The wheel-point apparatus was used for all initial transects and its use was continued where subsequent transects were easily accessible. The apparatus proved impractical for use in rocky areas and in situations where the transect was located far from the nearest road. This was because pushing the apparatus to and from the sampling sites and over rocky areas was excessively time consuming. Consequently, a variation of the technique of Du Plessis (1992) was used, which made completion of transects considerably quicker. An assistant walked straight ahead on the transect line taking three steps between sample sites. Instead of the apparatus, he carried a stick (with a 1cm diameter) and at each sample site, without looking, he placed it at arms length to his right. At no time were obstacles avoided, except for trees. All transects were visited and completed irrespective of the type of area. Only once did a transect have to be re-routed due to a steep fall from a kopje (or rocky outcrop).

Records were made of:

a) The **species of plant** under the marked spike or nearest to the spike, but within a maximum range of one metre (expanding upon the technique of Tidmarsh & Havenga (1955)). If a grass had been grazed and the remaining stem was not identifiable, a record of 'unidentified' was recorded.

b) The **distance** between the spike and the plant recorded above. In the case of a direct strike where the marked spike hit living basal cover (i.e., when the point fell within the circumference or rooted area of a living plant), a distance of 0mm. was applied. If a strike was not recorded, the distance between the marked spike and the nearest grass was measured. Initially distances were accurately ascertained with a tape measure, until it became possible to accurately estimate the distance visually. Subsequently, only distances over 500mm. were measured. If there were no herbaceous species in the one metre radius of the spike, a record of bare ground was made.

Forbs are broad-leafed herbs (Riney 1982) or non-grass herbaceous species (Du Plessis 1992). These were not recorded as an herbaceous species during the survey, but where they were clearly abundant in a transect a note was made of their presence. The sedge *Cyprus* was included in the survey as it had been recorded as eaten by rhinos.

Basal cover is the percentage of ground covered by the base of plants at ground level, which indicates the amount of grass in an area. It is usually calculated as the number of strikes per 100 records (Mentis 1984; Tainton *et al.* 1980). Because basal cover was obviously low in Kaross, the number of strikes at each transect was very low (less than five strikes in each transect). However, basal cover was considered as important since it could potentially exert a significant effect upon rhino activity. Therefore this technique was varied to calculate an index of plant density, which provided a more accurate indication of the amount of grass cover. To provide this index of density, for each transect the mean distance found in (b) above was calculated. Bare ground was recorded a distance of 1000mm.

ii) Forage Factor

Forage factors have been assigned to each grass species occurring in Etosha by Du Plessis (1992). Factors range from 1 (minimum) to 10 (maximum) and represent the perceived sustainable forage production potential of a species, i.e. their potential to produce acceptable forage for grazers (Trollope 1990).

Fig. 4.2 Wheel-Point Apparatus (from Tidmarsh & Havenga 1955)

For each transect, the forage factor for every grass species was multiplied by the number of occurrences and the total summed (Du Plessis 1992). Bare ground was allocated a value of zero. This provided an assessment of the total forage quality of each transect.

Du Plessis (1992) had classified ratings of the overall forage score obtained at each transect. This technique has been repeated, however the resulting scores were not comparable between surveys as the sampling criteria was slightly different. This was due to the presence of unidentifiable grass species and *Cyprus* which were not classified as an herbaceous species by Du Plessis (1992) therefore, they were not allocated a forage score. Consequently, it was only possible to refer to the overall forage score within the context of this study.

iii) Herbaceous Standing Crop

The standing crop of grass was recorded using a Disc Pasture Meter (DPM) (Bransby & Tainton 1977). The DPM (Fig. 4.3) consists of a central rod with a marked scale which is held vertically and the bottom placed on the surface of the ground. A weighted disc surrounds the pole and is dropped from a given height, to fall and settle on the herbaceous layer below. The level of the meter reading provides the height in centimetres that the disc has settled above the ground. Calibrating the DPM involves harvesting the material within the cylinder created between the ground and the disc. It had been found that there was a strong correlation between disc settling height and the biomass of grass. The DPM has been calibrated for use in Etosha (Fig. 4.4, Table. 4.2) by Kannenberg (1992) and Du Plessis (1997) to give the relationship between disc settling height and the dry mass of grass under the disc. Shrubs were not incorporated in the measurements.

The DPM apparatus was too cumbersome to carry in the field on a daily basis. Consequently, before the survey, repeated personal estimation of biomass ratings were undertaken, followed by actual measurements, until personal estimation of biomass was 95% accurate on trial transects.

Table 4.2 **Assessment of Grass Standing Crop with a Disc Pasture Meter (Kannenberg 1992; Du Plessis 1997).**

Biomass Rating	Disc Settling Height	Dry Mass of Grass (kg/ha)
EL	less than or equal to 0.5cm	less than or equal to 100
VL	0.6-1.5cm	101-500
L	1.6-2.5cm	501-1,200
M	2.6-4.5cm	1,200-2,000
H	4.6-7.5cm	2,001-3,300
VH	7.6cm or higher	higher than 3,300

iv) Confirming Continuity

Calibration and quality control of data obtained was confirmed every month to ensure that estimations continued to be accurate. This included:

a) Identification of grass species was confirmed by reviewing the compiled herbarium.
b) The distance between the spike of the DPM and the nearest grass species was measured following estimation.
c) Basal cover estimation was reconfirmed by repeated utilisation of the DPM.

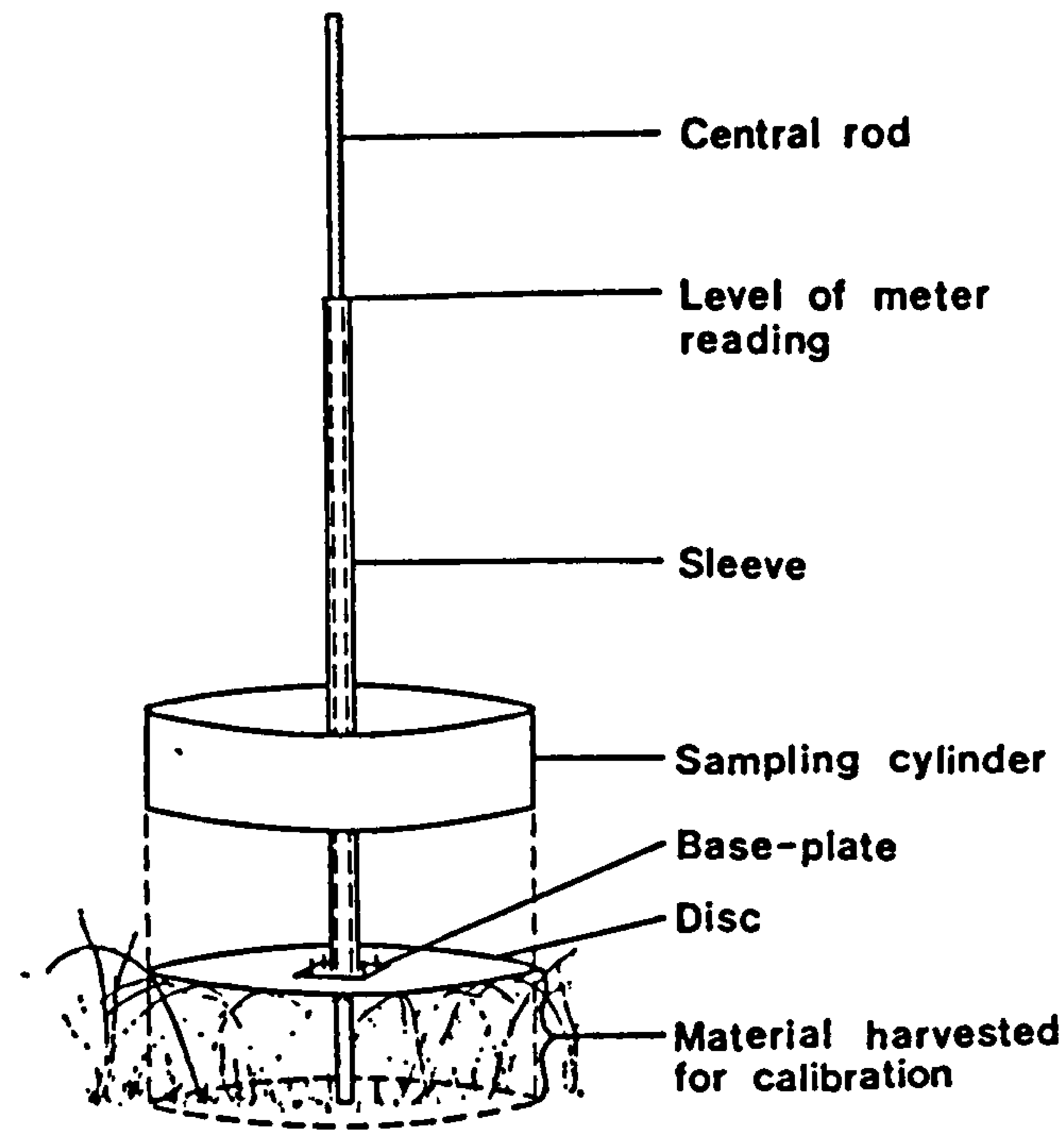


Fig. 4.3 Disc Pasture Meter (from Bransby & Tainton 1977)

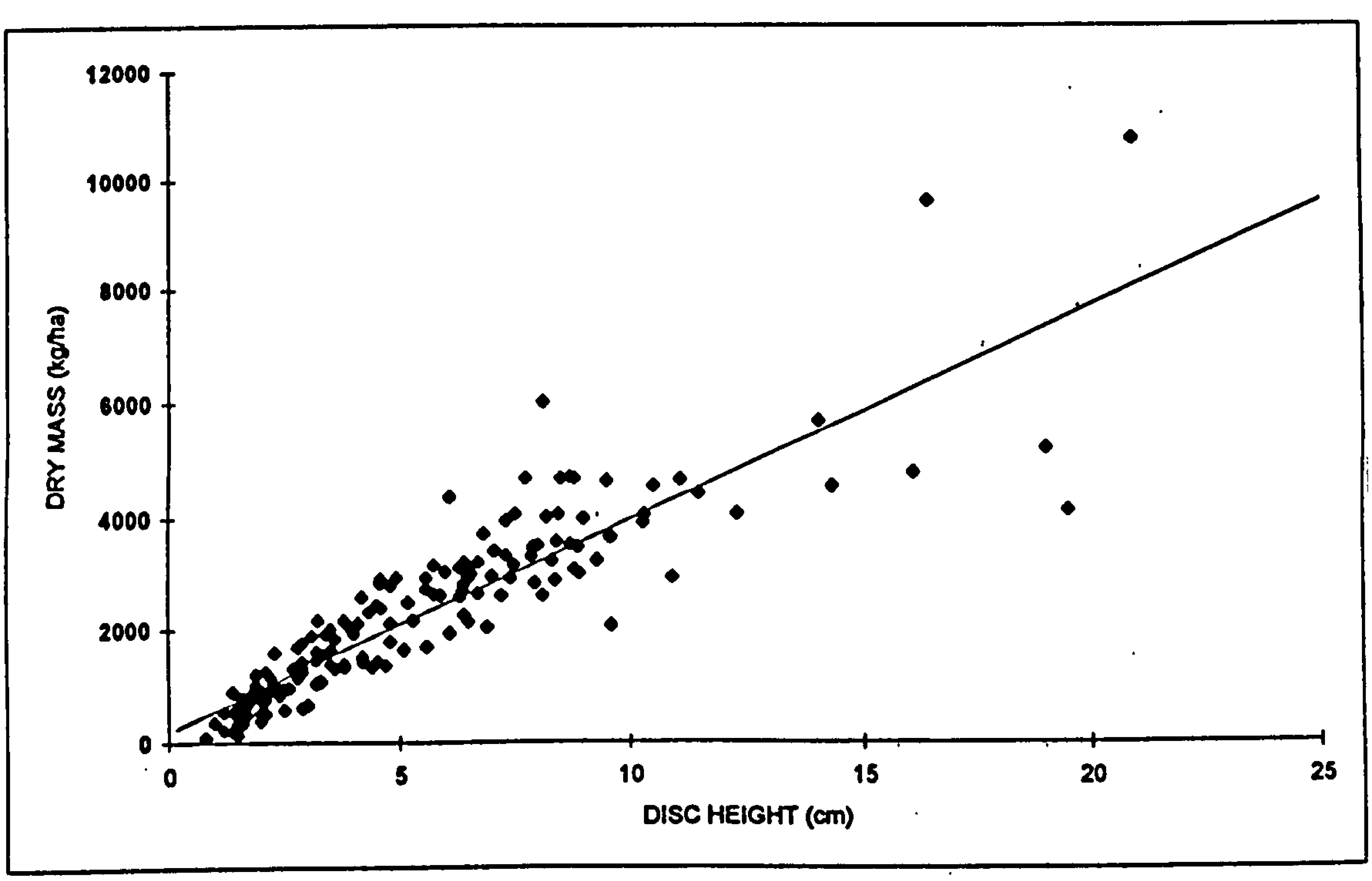


Fig. 4.4 Correlation Between Dry Mass of Grass and Disc Settling Height During Calibration of Disc Pasture Meter to Etosha (from Kannenberg 1992)

v) **Grass Collection**

Samples of all the grass species were collected at one time of year. In addition the main five species (*Anthephora schinzii, Eragrostis nindensis, Eragrostis porosa, Schmidtia kalahariensis* and *Stipagrostis uniplumis*) were sampled during all three seasons. These were collected for use as reference samples and against the possibility of future chemical analysis to assess nutritional qualities.

vi) **Visual Assessment**

Any general observations on the condition and availability of grazing in Kaross were recorded throughout the year. In addition, observations on the difference in grazing between the study area and surrounding locations (Koabendes, Etosha, Hobatare, neighbouring farms called Kaross and Ermo) were also noted.

4.2.2 Habitat

Where appropriate, photographs have been included to illustrate specific parameters.

4.2.2.1 Vegetation Classification

A seven-class habitat classification system has been devised for use in Etosha, including Kaross, to identify habitat types (Sannier *et al.* 1998). This classification relates to a habitat map of Etosha created by satellite remote sensing methods. This classification is based on the structure (i.e. density and height) of the vegetation, according to the categories in Table 4.3 and as described in Fig. 4.5. During the habitat survey, vegetation class was assessed visually following personal calibration which involved assessing canopy to gap ratios (see 4.2.2.2 below).

According to Du Plessis (1992), trees are defined as woody perennial plants taller than 2m which include shrub *Mopane* (*Colophospermum mopane*) taller than 1.25m. Shrubs were defined as woody perennial plants between 0.3 and 2m, or shrub *Mopane* between 0.3m and 1.25m.

Table 4.3 Vegetation Classes assigned by Satellite Remote Sensing Techniques of Sannier *et al.* (1998).

Vegetation Class	Trees and Shrub Cover and Height
Savanna woodland (SW)	Areas with >5% canopy cover of shrubs and trees. Most trees >10m high.
High tree savanna (HTS)	Areas with >5% canopy cover of shrubs and trees. More than 5% of trees >5-10m high.
Low tree savanna (LTS)	Areas with >5% canopy cover of shrubs and trees. More than 5% of trees >2-5m high.
Shrub savanna (SS)	Areas with >5% canopy cover of shrubs. Shrubs ≤ 2m high. Trees ≤ 1% canopy cover.
Grass savanna (GS)	Areas with very low canopy cover (>1-5%) of shrubs and trees.
Steppe (ST)	Dwarf shrubs with >1% canopy cover. Canopy cover of trees and shrubs ≤ 1%. Subdivisions by location.
Grassland (G)	Trees, shrubs and dwarf shrubs with extremely low canopy cover (≤1%) and > 100kg/ha of dry herbaceous biomass.
Bare ground (BG)	Trees, shrubs and dwarf shrubs with extremely low (≤1%) canopy cover and ≤ 100kg/ha of dry herbaceous biomass.

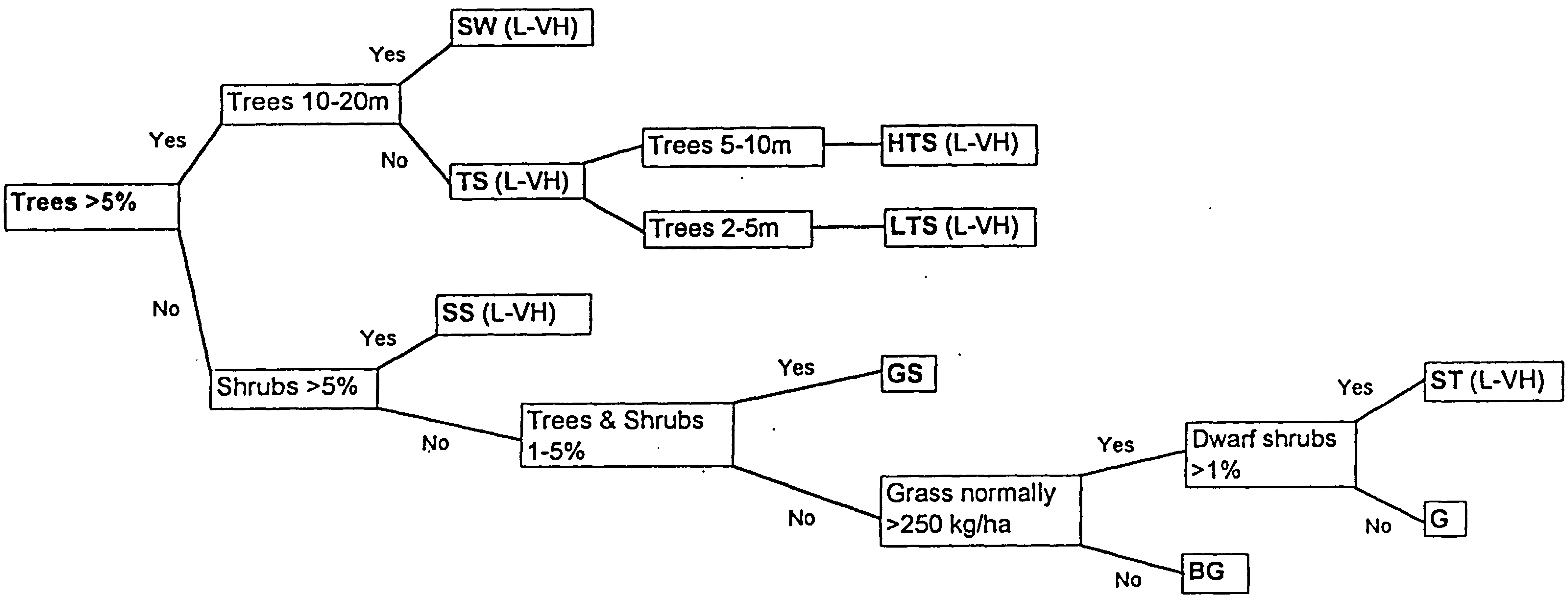


Fig. 4.5 Vegetation Classification in Etosha (from Sannier *et al.* 1988)

Classification does not provide information on species composition, consequently the species of woody plants is unknown. In addition, no description of the grassland is obtained. At present the classification system of Sannier *et al.* (1998) is thought to be 80% accurate.

The satellite habitat classification map of Sannier *et al.* (1998) (Fig. 4.6) was compared with results obtained during the habitat survey. Classes on the satellite image had a pixel size of 25m x 25m. The actual GPS positions obtained in the field were located in a single pixel and the habitat class datum for this location was extracted. In addition to this centre pixel, the eight surrounding squares were queried and these data were used to provide a mode average class for all nine pixels. This query was completed by a programme which was written in TURBO PASCAL (R. Middleton. Dept. of Geography, University of Hull). Once the values had been extracted, several random transect positions were manually visited on the satellite image and the identity of each square confirmed the accuracy of the programme. Comparison between personal observations, the specific pixel identified on the satellite image and the nine pixels in that area (i.e. the mode classification from the centre pixel and surrounding eight pixels) was done visually and statistically by Chi Square analysis.

4.2.2.2 Tree Species and Cover

In order to assess the tree cover the following information was gathered at each transect location:

i) Canopy-to-Gap Ratio. An approximation of the tree density was found by looking at the canopy (or crown)-to-gap ratio. The canopy-to-gap ratio is defined as the mean gap between crowns divided by the mean crown diameter (Walker *et al.* 1988), i.e. the number of times the average canopy diameter fits into the gaps. The calculation takes points 20m. apart and picks the nearest example of woody vegetation to each point (shrub/tree then called A). It was important that at each point none of the shrubs included in the previous transect were included. The next example of woody vegetation from A was identified and referred to as tree/shrub B. An imaginary line was drawn between A and B. While standing at a position perpendicular to this line at a reasonable distance, the number of times the width of shrub B, fitted into the gap between A and B was counted. This was then repeated at the next point and the average of all the ratios calculated. The percentage tree cover classes were then provided using Table 4.4.

For this investigation, the effects of canopy cover were of minor importance. It was however necessary to be able to assess tree and shrub density to derive the correct vegetation class according to Sannier *et al.* (1998) and calculation of the ratio provided greater accuracy. This information was initially calculated and thereafter it was estimated.

Table 4.4 Canopy Cover Density Classes according to Sannier *et al.* (1998).

Canopy Cover Rating	Canopy-to-Gap Ratio	Density of Trees and Shrubs
Very high (VH)	<0.1	>75%
High (H)	0.35-0.1	50-75%
Moderate (M)	0.9-0.35	25-50%
Low (L)	3.3-0.9	5-25%
Very low (VL)	8.5-3.3	1-5%
Extremely low (EL)	>8.5	<1%

ii) At each transect, tree species were identified and briefly described. No further detail of species present was regarded as necessary as it was thought the height and density of tree cover were the main factors influencing rhino selection, rather than individual species. The presence of *Acacia* species, *Mopane* (either tree or shrub size, shrubs being under 1.25m), *Combretum* species and

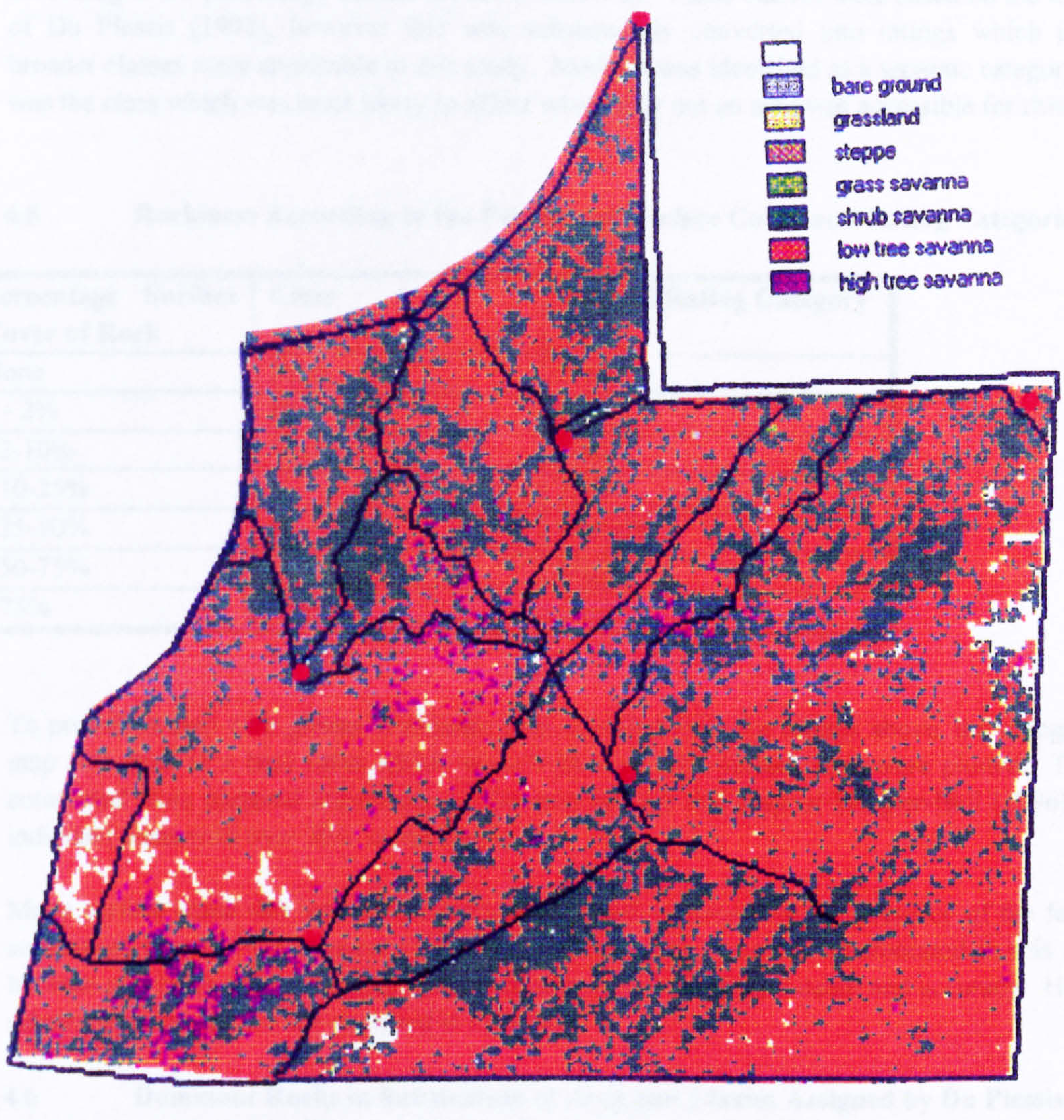


Fig. 4.6 Seven-Class Vegetation Classification of Kaross (from Sannier *et al.* 1998)

Terminalia species were also recorded. *Boscia* species and *Catophractes* were also included, but later only referred to for tree distribution analysis.

iii) One survey of the whole area was completed to determine which tree species were present (genus and species).

4.2.2.3 Rockiness

Rockiness was described in two ways.

i) During the habitat survey, rockiness was subjectively assessed and classified into rating classes according to the percentage surface stones (Table 4.5). These classes were based on the technique of Du Plessis (1992), however this was subsequently converted into ratings which provided broader classes more applicable to this study. Medium was identified as a separate category as this was the class which was most likely to affect whether or not an area was accessible for rhinos.

Table 4.5 Rockiness According to the Percentage Surface Cover and Rating Categories.

Percentage Surface Cover of Rock	Class	Revised Rating Category
None	None	None
0 - 2%	EL	Low
>2-10%	VL	Low
>10-25%	L	Low
>25-50%	M	Medium
>50-75%	H	High
>75%	VH/EH	High

ii) To provide a map with greater resolution than obtained from the ratings above, the topographical map was used as a base upon which areas with over 60% surface rock were plotted. This was completed from personal knowledge of the area and the soil map of Beugler-Bell (1996), which indicated areas with over 70% surface rock.

iii) Mean surface stone size was subjectively determined by recording the presence of the following substratum types in the transect (Table 4.6). These data were not incorporated in this analysis because rockiness ratings and topographical maps provided greater detail and accuracy. However, substratum descriptions are analysed in Chapter 6.

Table 4.6 Dominant Rocks in Substratum of Area and Classes Assigned by Du Plessis (1992).

Substratum Type (Personal Description)	Substratum Class from Du Plessis (1992)
Dusty	Not recorded
Sandy	0 Varying
Gravely	1 (5-20mm)
Pebbles	2 Small stones (>20-50mm)
Small rocks	3 Medium stones(>50-100mm)
Rocks	4 Big stones (>100-250mm)
Boulders	5 Very big stones (>250-500mm)
Sheet rock	6 Rocks and rocky sheets (>500mm)

4.2.2.4 Soil

During the survey a description of the colour and texture of the soil was compiled. Subsequently, this information was discarded as the comprehensive soil maps compiled by Beugler-Bell (1996) (Fig. 4.7) were considerably superior. Four classes of soil were identified by Beugler-Bell (1996). For the purpose of this study these were divided into the five categories, described in Table 4.7. Actual transect positions and reference numbers were plotted on the soil map and the soil type at each location was extracted.

Table 4.7 Soil Classes Identified by Beugler-Bell (1996).

Type	Soil Origins
A	The soils of the Highveld and the Otavi mountains.
B	The soil of the Koabendes mountain and hill zone.
C:	The soils of the Kaross Granite zone (dominant type - subdivided into:)
C1	Dystric Leptosols and Cambisols.
C2	Lithic/Dystric Leptosols.
D	Soils from fluvial sediments.

4.2.2.5 Grazing Pressure/Utilisation

Grazing intensity was subjectively estimated by observing the quantity of grasses retaining their seed heads and the quantity of grass present. A description of ratings is given in Table 4.8.

Table 4.8 Ratings of Grazing Pressure

Rating	Appearance of grass
None	No grazing evident
VL	Very little grazing, under utilised.
L	Low pressure, lightly utilised.
M	Moderate pressure, moderately utilised.
H	High pressure, highly utilised.
VH	Very high pressure, for example around water holes, very highly-utilised.

4.2.2.6 Landscape

A description of the landscape was recorded in terms of rivers, water holes, roads, kopjes, valleys, plains, riverbeds, drainage areas, bottom of hills, hill slope (mid-slope) and hill crests. This information was later discarded as recording these parameters was considered to be excessively subjective, since knowledge of the presence of or distance from these features varied depending upon visibility. Instead, important landscape parameters, including water holes and rivers were accurately mapped from the topographical map, as described below:

i) **Rivers.** The topographical map of the rivers did not distinguish between main channels (>10m across) and small gullies. For the purpose of this study, these smaller gullies were not important and only rivers which were known to have associated riverine vegetation (either distinct grass or tree species, or tree density, although this was also influenced by the substratum) were marked on

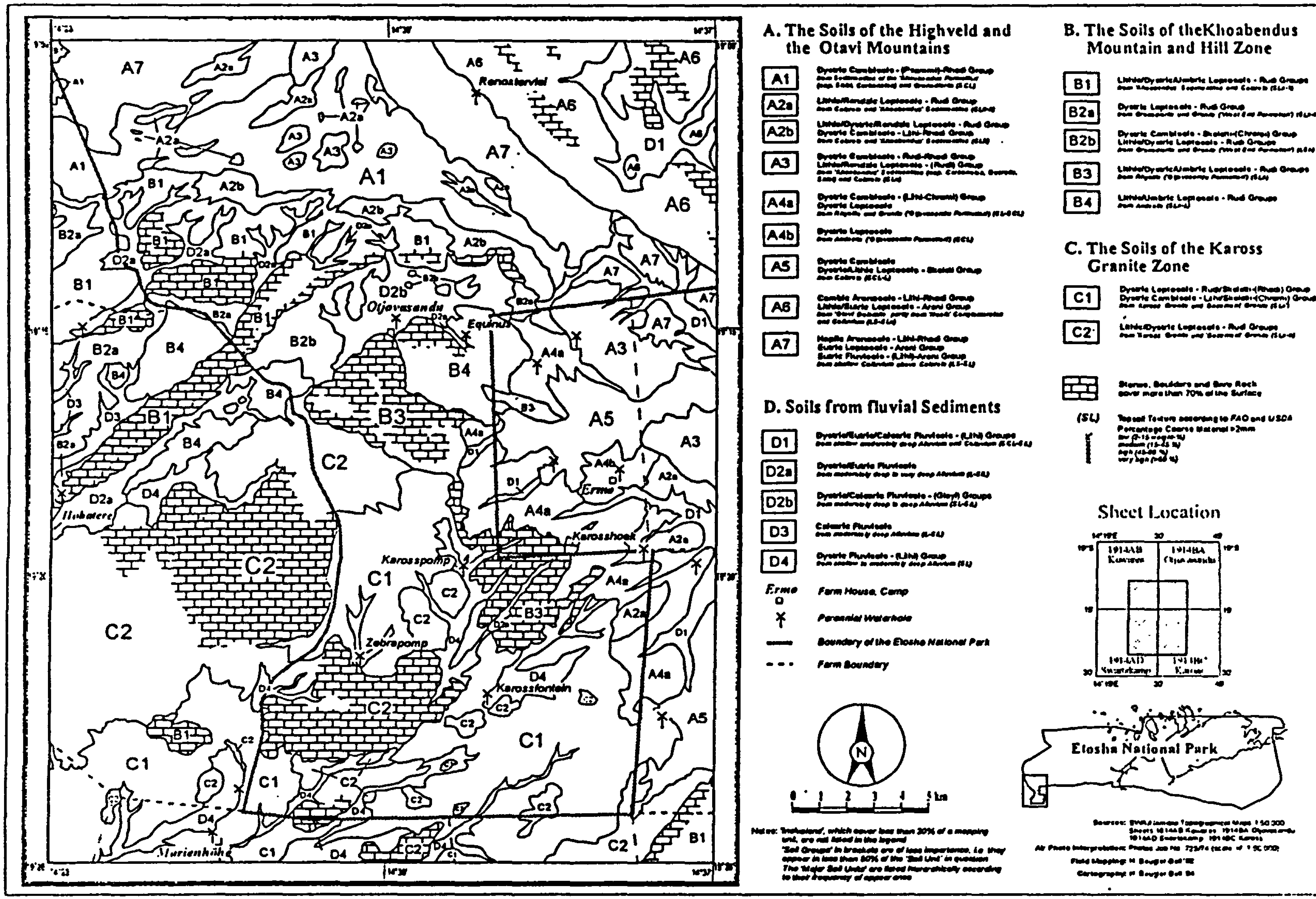


Fig. 4.7 Soil Classification System of Beugler-Bell (1996)

the map. This was to prevent the smaller tributaries and drainage channels becoming confused with areas with distinctly riverine vegetation.

ii) **Water holes** in an arid environment are frequently visited by most animals and consequently the habitat is greatly influenced by high trampling and grazing pressure. This creates a unique landscape type.

iii) **Slope.** The slope was estimated subjectively according to the classes of Du Plessis (1992) as described in Table 4.9. Initial ratings were subsequently redefined to provide broader categories as it was found that there was little difference between certain categories as initially defined. For rhino movement the initial ratings continued to be used as they provide additional accuracy.

Table 4.9 Classification of Slope According to the Classes of Du Plessis (1992).

Slope	Initial Ratings	Subsequent Ratings
0-3 degrees	None, slight, gentle	Slight
3-10 degrees	Noticeable	Reasonable
10-20 degrees	Reasonable	Reasonable
20-45 degrees	Steep	Steep
>45 degrees	Extreme	Steep

iv) **Topography.** The topography was described in terms of aspect, related to the direction the slope was facing as a compass bearing (Du Plessis 1992). It was not possible to record the aspect when the area was variable or flat. In addition, the aspect at each transect location was generally only applicable to a small area, and not suitable for extrapolation to the larger area each transect represented. Consequently, although aspect does influence plant growth and grass palatability (Bothma 1989), this information was discarded.

4.2.3 Analysis

Data were processed by correspondence analysis to identify associations between similar transects and to define homogenous grassland, habitat and tree species regions. Several multivariate analysis techniques were employed to compare data obtained at each transect and to identify relationships (Gauch 1982).

4.2.3.1 Ordination Analysis

The results were presented as an ordination plot which recognised the data as a continuum and produces a series of dots, which may then be divided to find habitat patterns (DECORANA, described by Hill 1979a). This technique arranges transects with similar species composition along axes which may represent environmental gradients. Sites were separated according to their species component attributes (Q mode analysis) which was the most applicable technique to describe variances in the species data. Ordination analysis was used to plot grass species and tree species with respect to habitat variables.

4.2.3.2 Cluster Analysis

Cluster analysis results were presented as a dendrogram which forced groupings between transects with similar attributes, according to robust trends. Analysis was carried out to compare MVSP (MultiVariate Statistics Package) and TWINSPAN (Two-Way INdicator SPecies ANalysis (Hill 1979b)) techniques. The TWINSPAN technique usually uses more than one species to divide the data set and the transects are classified in addition to the species. The resulting dendrograms were divided at an appropriate accuracy level to define classes of transects according to their grass species composition and habitat parameters (Q mode). The composition of each class identified was subsequently analysed to define its characteristics, in terms of species composition and habitat parameters (R mode analysis).

When homogenous areas had been identified, their characteristics were defined by counting the frequency that each grass species or habitat rating category occurred within each class. Each class was then quantified as follows:

$$\text{Percentage Occurrence} = \frac{\text{Number of observations in each class}}{\text{Total number of observations in class}} \times 100$$

Following the identification of homogenous transects, the classes assigned to each transect were spatially analysed by the assign proximity function of GIS. Water holes and rivers were superimposed on these maps as separate habitat types.

i) Grass Species

The transect number and the percentage occurrence of each grass species was analysed. Ordinations were plotted for the site numbers and grass species. Results of cluster analysis using both techniques were critically compared, with approximately four grass classes being formed wherever possible.

ii) Habitat Types

Factors determining and describing habitat type parameters were assigned ratings, usually from one to three, as described below. Ratings were merged into three classes since the majority of observations generally fell into two to three classes and the occurrence of rare or extreme ratings were infrequent or non-existent. By grouping these extreme ratings, the influence of categories with a small number of observations, which may disrupt analysis, is minimised.

Forage factor and herbaceous standing crop were incorporated in the correspondence analysis of habitat types because herbaceous layer analysis was solely on the basis of grass species occurrence. These parameters were regarded as important factors to be incorporated in habitat analysis, because herbaceous layer and habitat are inter-related. Herbaceous layer parameters were also thought to provide a good indication of the soil and substratum characteristics.

a) Vegetation class

Table 4.10 describes the classes assigned to specific vegetation types. There was only one observation of shrub savanna, which was included in the grass savanna category as these vegetation types both had a very low tree density. Observations next to water holes were also classified as grass savanna, although this vegetation type had been created by heavy utilisation and trampling. In addition, areas within specified distances from water holes were later marked on the maps.

Table 4.10 MVSP Classes Assigned to Vegetation Categories.

Vegetation Categories	MVSP Class
Grass savanna (GS) & Shrub savanna (SS)	1
Low tree savanna (LTS)	2
High tree savanna (HTS)	3

b) **Tree Cover**

Canopy cover density classes were assigned MVSP ratings as described in Table 4.11.

Table 4.11 MVSP Classes Assigned to Canopy Cover Density Ratings.

Canopy Cover Rating	MVSP Class
None, Very Low & Extremely Low	1
Low	2
Moderate	3

c) **Rockiness**

Rockiness ratings were assigned MVSP classes as described in Table 4.12. The rating 'none' was included with the other low rockiness ratings as they all represented areas which were most similar.

Table 4.12 MVSP Classes Assigned to Rockiness Ratings.

Rockiness Ratings	MVSP Class
None, Extra Low, Very Low & Low	1
Medium	2
High, Very High & Extra High	3

d) **Soil**

Soil classes identified by Beugler-Bell (1996) were assigned five MVSP classes (Table 4.13). This was because soil types A, B and D occurred highly infrequently, while the very dominant group C could be subdivided into two types, C1 and C2, which occurred with reasonable frequency across the area.

Table 4.13 MVSP Classes Assigned to Soil Types.

Soil Type	MVSP Class
A	1
B	2
C	
C1	3
C2	4
D	5

e) **Grazing Pressure**

Grazing pressure ratings were assigned MVSP classes as described in Table 4.14.

Table 4.14 MVSP Classes Assigned to Grazing Pressure Ratings.

Grazing Pressure Rating	MVSP Class
High & Very High	1
Medium	2
None, Very Low & Low	3

f) Slope

Slope ratings were assigned the MVSP classes described in Table 4.15.

Table 4.15 MVSP Classes Assigned to Slope Ratings.

Slope ratings	MVSP Class
Flat, Gentle & Slight	1
Noticeable & Reasonable	2
Steep	3

g) Grass Biomass

MVSP classes were assigned to grass biomass as described in Table 4.16.

Table 4.16 MVSP Classes Assigned to Grass Biomass Ratings.

Grass Biomass	MVSP Rating
Bare Ground, Extra Low & Very Low	1
Low	2
Medium, High & Very High	3

h) Grass Density

Classes assigned to distance rating for MVSP analysis are shown in Table 4.17.

Table 4.17 MVSP Classes Assigned to Grass Density.

Mean Distance between Spike and Grass (Index of Density)	MVSP Class
0 – 10cm	1
10 – 20cm	2
> 20cm	3

i) Forage Factor

Classes assigned to forage factor scores for MVSP analysis are shown in Table 4.18.

Table 4.18 MVSP Classes Assigned to Forage Factor.

Forage Factor Score	MVSP Class
0 - 250	1
250 - 350	2
> 350	3

iii) Tree Types

The six predominant tree species were recorded on a presence or absence scale. These binary data were incompatible with the habitat ratings and consequently were analysed separately. Tree species characteristic of each class were identified by calculating the percentage occurrence of each species, as in the habitat section.

4.2.4 Geographical Information Systems (GIS)

i) Map Input

Digitising techniques were used to input maps of the roads, fence, rivers, rocky areas and soil types. Common reference points between all maps were the locations of water holes since several position fixes had been taken. The root-mean-square error provides an indication of the error between digitised reference points and was given as 196.4 and 183 metres between water hole positions, which was regarded as reasonable. Standard base maps produced by EEI were based on a different grid system, therefore these were also input by digitisation.

ii) Analysis

GIS facilitated the analysis of three dimensional data. For the purpose of this study, ArcView v.3 was used primarily because of its spatial analysis facilities. With the spatial analyst function, layers were converted into grids, for which a resolution of 50m x 50m was assigned. This resolution was considered appropriate for mapping purposes in relation to the limitations in the accuracy of GPS positions. Following conversion to a grid and classification of regions according to categories, it was possible to obtain the number of pixels contained within any class. Since 4 pixels equals 1 hectare it was possible to measure area and the number of observations per hectare.

Spatial interpolation assigns values to intermediate points between transect positions with a specified value. The boundary fence of Kaross was defined as the limit (or mask) to the extent of the interpolation. Analysis included:

- Interpolation of continuous data between transect points was completed with the Spline function. This is a useful general purpose interpolator that fits a minimum curvature surface through the input points. Following an interpolation, the image was reclassified to provide distinct ranges of applicable values. This classification was applied to continuous data, for example where values ranged between 0 and 100 as with the grass species.

- The assign proximity function allocated grid cells a value identical to that obtained at the nearest transect. This function was used when values to be analysed were represented by a few classes or contained figures for presence or absence. Appropriate data were obtained from habitat ratings.

- Buffer zones were generated around a feature according to appropriate distance classes. This was applicable for allocating distances from rivers and water holes.

- Map calculator was used to add layers together. Maps of homogenous regions identified following correspondence analysis were enhanced by creating additional classes of rivers (with 100m buffer) and water holes (with 150m buffer), which took precedence over original classes. Rivers and water holes are important landscape features which had herbaceous layer and habitat characteristics unique to the surrounding area. To create these maps, relevant map layers were added together and then reclassified.

4.3 Results

The survey of Kaross was carried out between June and August 1996 and a total of 257 transects were completed. Each transect took about 20 minutes to complete plus 10 to 15 minutes to walk between transects. Their positions have been mapped with respect to the fence and roads in Fig. 4.8. Typically, the morning was spent tracking rhinos and approximately six habitat transects were completed in the afternoon.

The significance of interpolated maps of individual parameters is limited since the influence of landscape and other factors is unknown. Consequently, homogenous areas were identified with correspondence analysis to provide a clearer indication of associations between parameters. Trends in rhino utilisation with respect to individual parameters and homogenous areas are discussed in Chapter 6.

4.3.1 Herbaceous Layer

i) Grass Species Occurrence, Distribution and Density

The occurrence of each grass species in Kaross is plotted in Fig. 4.9. Details of occurrence and percentage of the total are given in Appendix VI, Table 1. The most common species was *Schmidtia kalahariensis* at 31%, followed by *Stipagrostis uniplumis* at 27%, *Eragrostis nindensis* at 14% and *Aristida adscensionis* at 6%. All other species occur at below 5% abundance. Bare ground was recorded at 324 of the 25,800 samples, and 277 grass samples were too damaged to be identified.

The percentage occurrence of five grass species were interpolated and the results detailed in Table 4.19 together with the mean occurrence of the species present within two grass genera. The *Aristida* family were are all known to be spiky and undesirable species, whereas *Eragrostis* species were either intermediate or undesirable (Bothma 1989; Bester unpublished document).

Table 4.19 Distribution of Grass Species.

Species	Details of Distribution
Schmidtia kalahariensis	Reasonably evenly distributed. Low abundance in north, south-east, south-west and central regions. (Fig. 4.10).
Stipagrostis uniplumis	Reasonably evenly distributed. More common in the south-eastern quarter. (Fig. 4.11).
Eragrostis nindensis	Most abundant in north-west and south-east areas. (Fig. 4.12).
Aristida adscensionis	Patchy distribution, but more common in north, north eastern and central areas. (Fig. 4.13).
Eragrostis porosa	Infrequent in most areas. (Fig. 4.14).
Aristida species	Patchy distribution in the northern, north-eastern and central areas. (Fig. 4.15).
Eragrostis species	More common in the north and western areas. (Fig. 4.16).

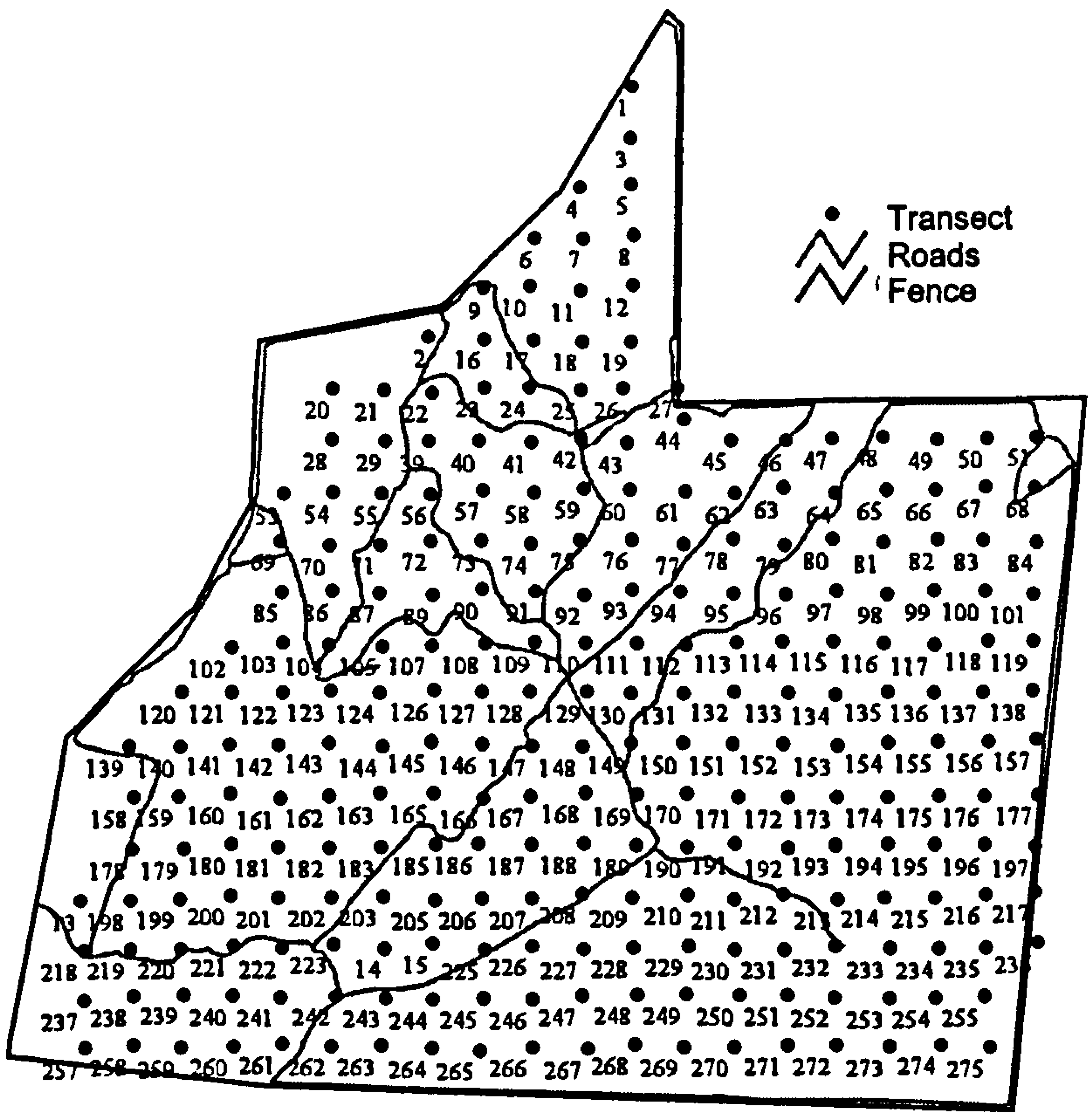


Fig. 4.8 Location of Transects with Roads

Fig. 4.9 Occurrence of all Grass Species in Survey of Kaross

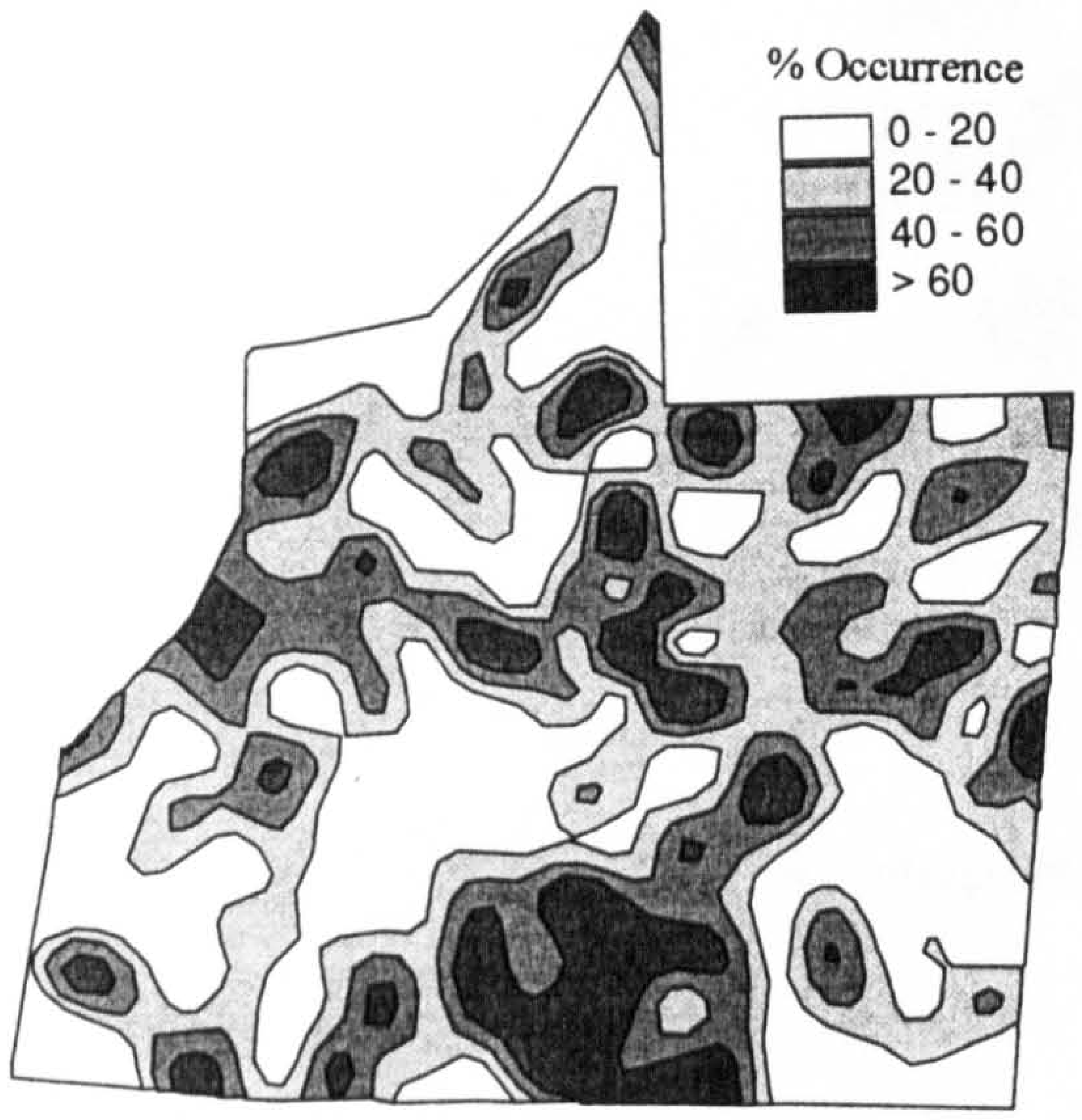


Fig. 4.10 Interpolated Distribution of *Schmidtia kalahariensis*

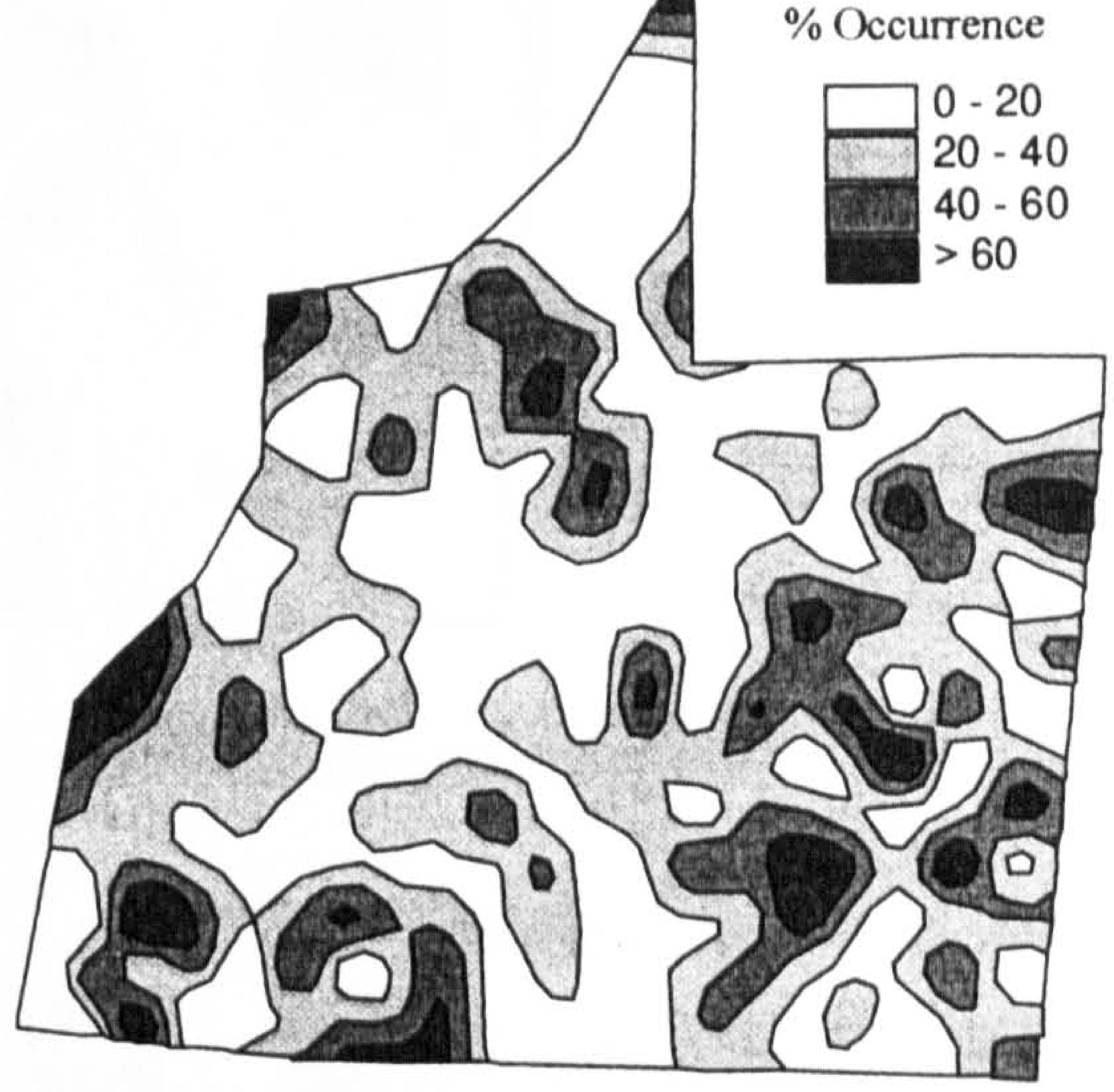


Fig. 4.11 Interpolated Distribution of *Stipagrostis uniplumis*

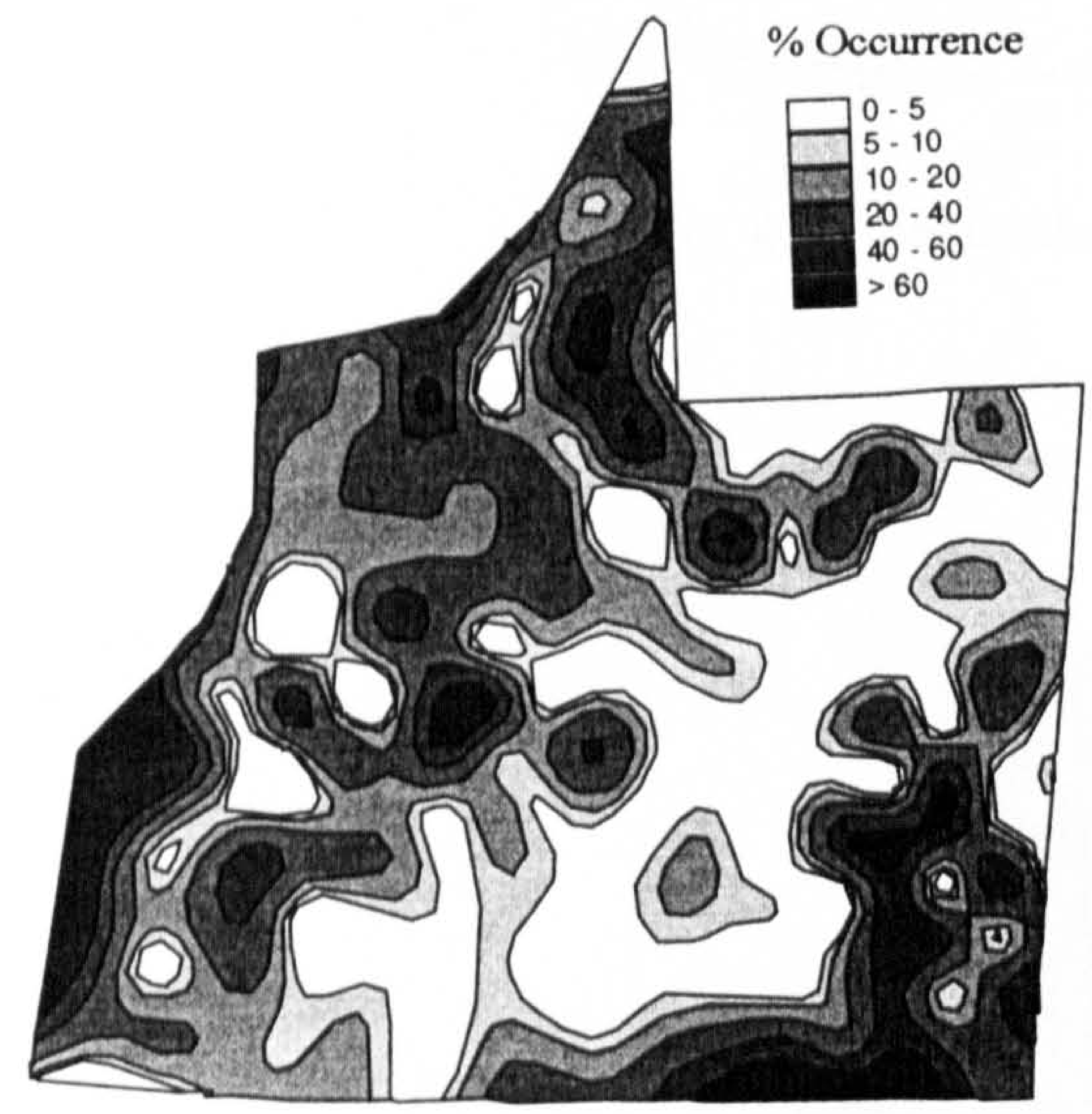


Fig. 4.12 Interpolated Distribution of *Eragrostis nindensis*

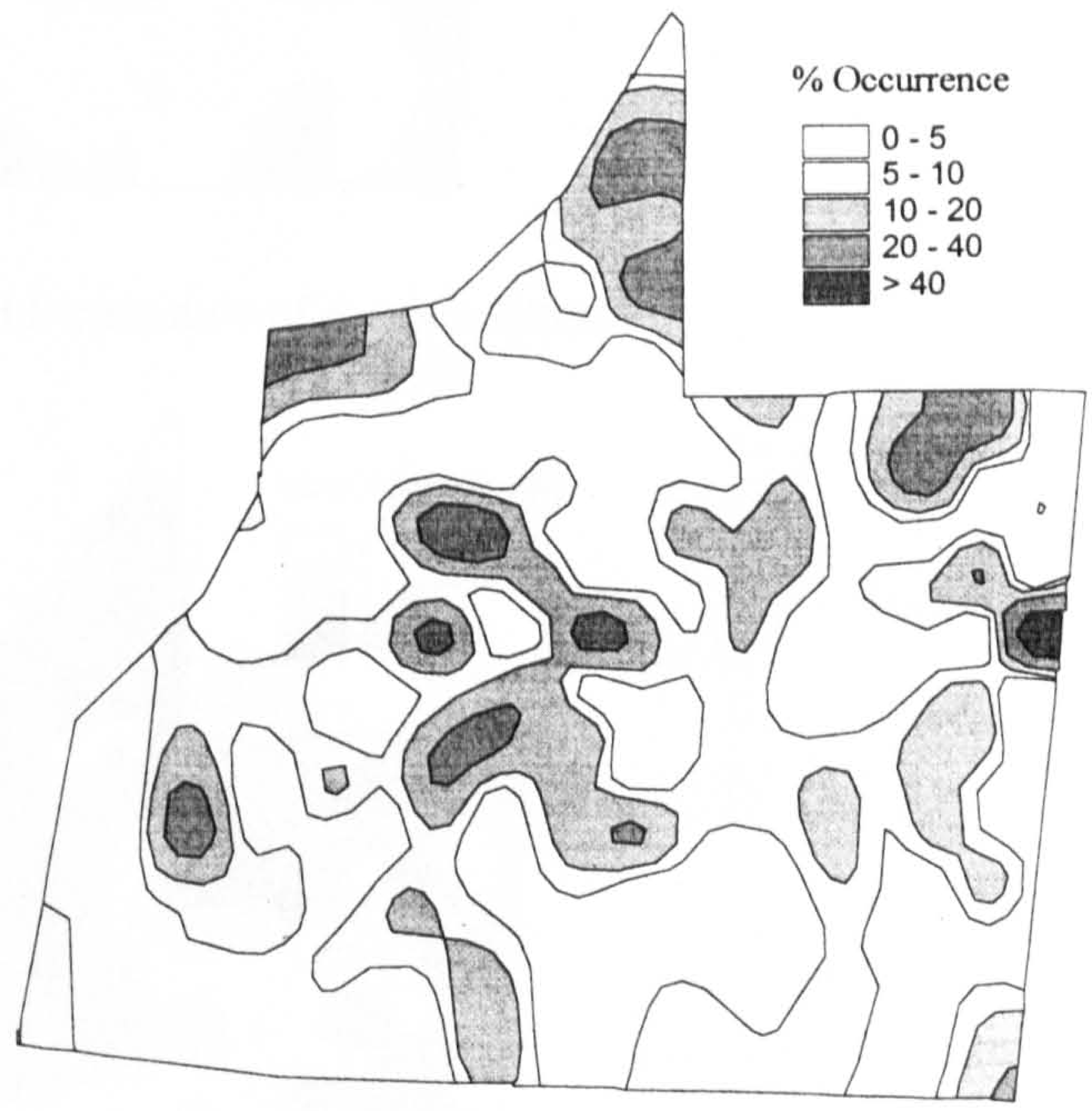


Fig. 4.13 Interpolated Distribution of *Aristida adscensionis*

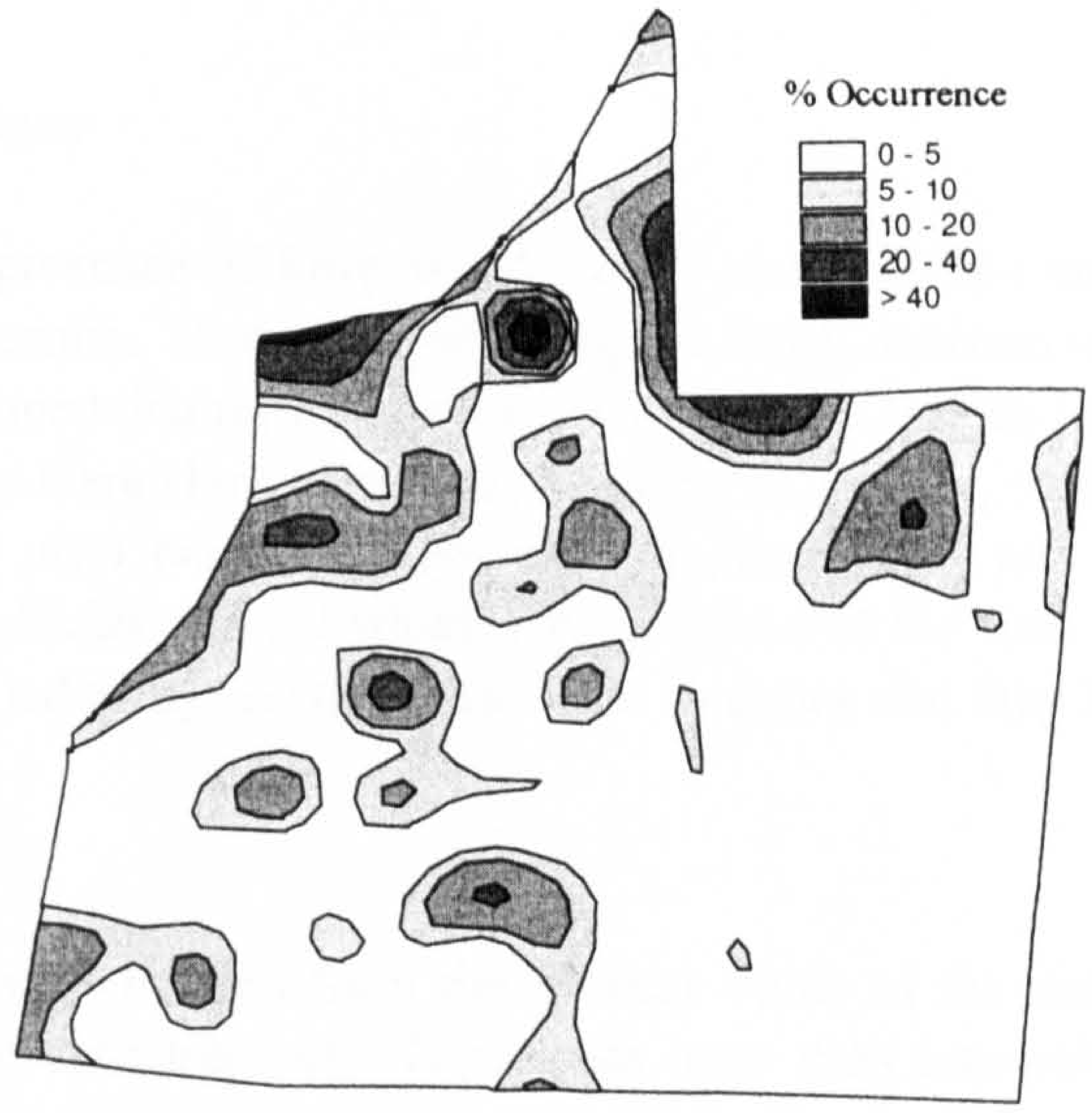


Fig. 4.14 Interpolated Distribution of *Eragrostis porosa*

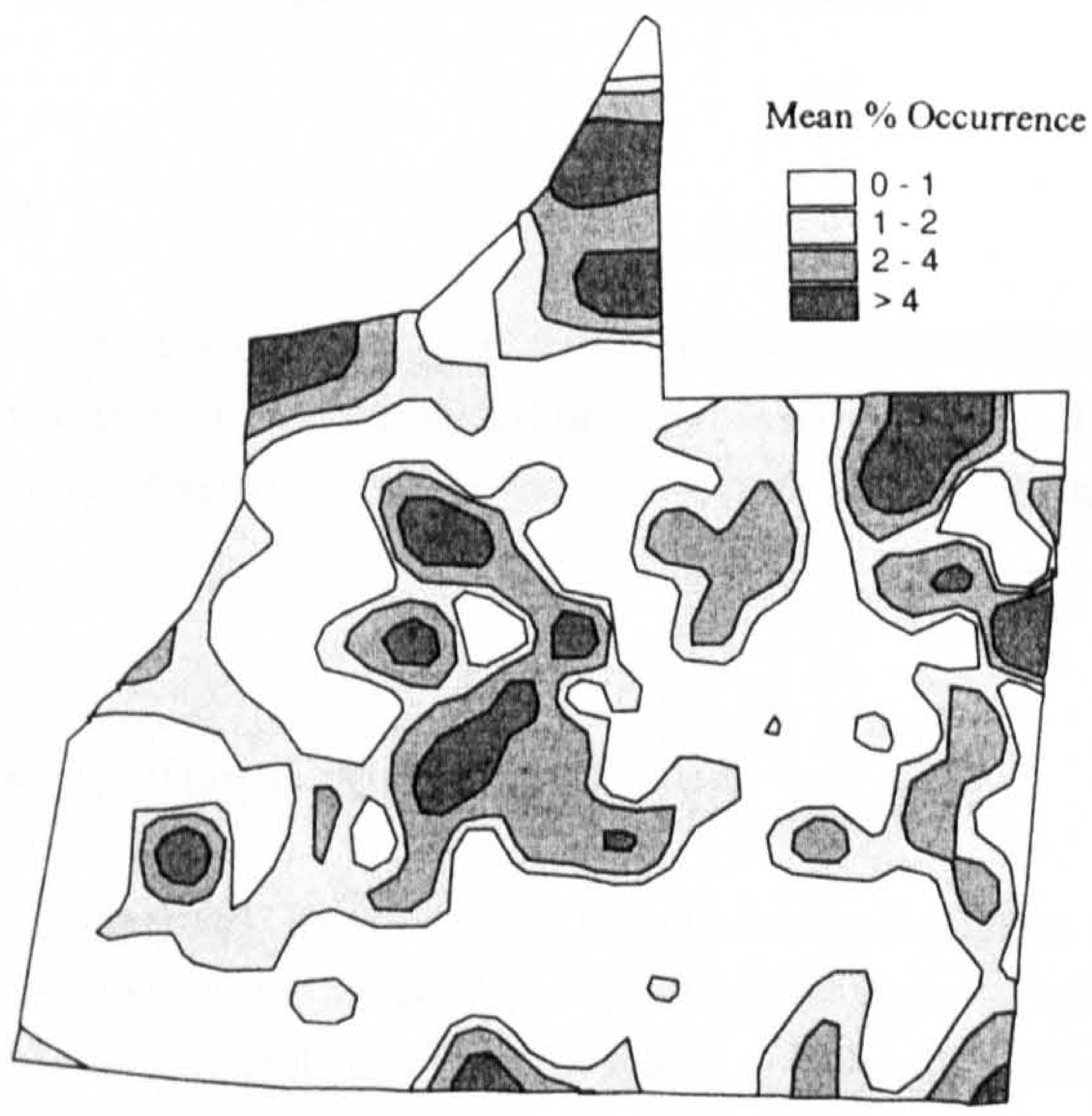


Fig. 4.15 Interpolated Distribution of *Aristida* species

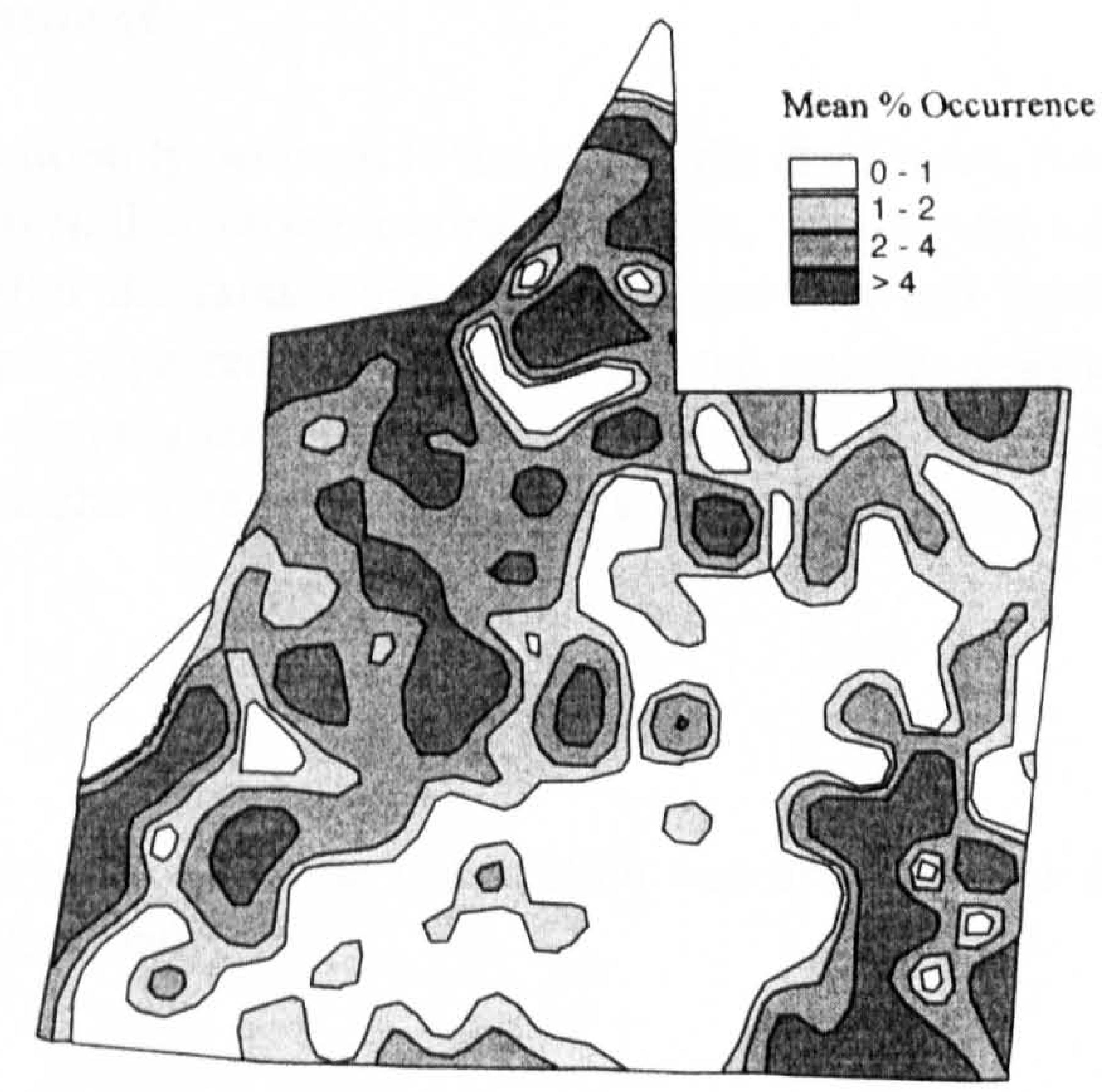


Fig. 4.16 Interpolated Distribution of *Eragrostis* species

a) Forbs and Sedges

During the survey, the presence of forbs was found in transects 261 and 201 in sufficient abundance to justify inclusion in the results. However, following the initial decision to ignore their presence, they were not recorded. It was noticed that during the rainy season there was an increase in the number of forbs but many of the forb species were short lived and disappeared quickly, to the point that it was impossible to find indications of their prior existence. For example, in January and February there were many small yellow thorn flowers *Tribulus zeyheri* which were obvious at the time, but after they had flowered, the leaves and stems shrivelled away and there was little evidence that they had ever existed.

b) Grass Density

A grass density index was obtained from the average value of the distance between the spike and the nearest grass species for each transect. These data were then interpolated and reclassified (Fig. 4.17). Overall, the grass density index varied considerably over the whole area, with an average distance between the spike and the nearest grass species of 154.2mm. A few areas had densities of more than 300mm distance and in these regions, grass cover was very sparse.

ii) Forage Factor

The forage factor for each species occurring in a transect was summed to provide the total forage score for the transect. These points were interpolated and reclassified as in Fig. 4.18. Most of the central, north and north-eastern areas have low forage scores. The average forage factor for the whole area was calculated as 299.8.

iii) Herbaceous Standing Crop

Ratings of biomass were analysed by the assign proximity function and are mapped in Fig. 4.19. Generally, the grass biomass was low, with some areas of medium or very low. Extra low ratings were recorded near water holes. In general, the further away a transect is from a water hole, the higher the biomass rating.

iv) Visual Assessment

The grass biomass had noticeably declined at the end of the dry season, however, the availability of grass remained reasonable. Utilisation varied according to area, with certain valleys and riverbed areas being well grazed, especially after the rains when grass was growing and flowering. At the end of the dry period, surrounding farms appeared to be under greater grazing pressure than Kaross, although to differing extents. When visually comparing the grass biomass in Etosha with Kaross it was considered that the eastern areas of Etosha were generally under greater grazing pressure.

4.3.2 Habitat

For each habitat parameter, the available information was assessed and the most appropriate maps for investigating utilisation identified.

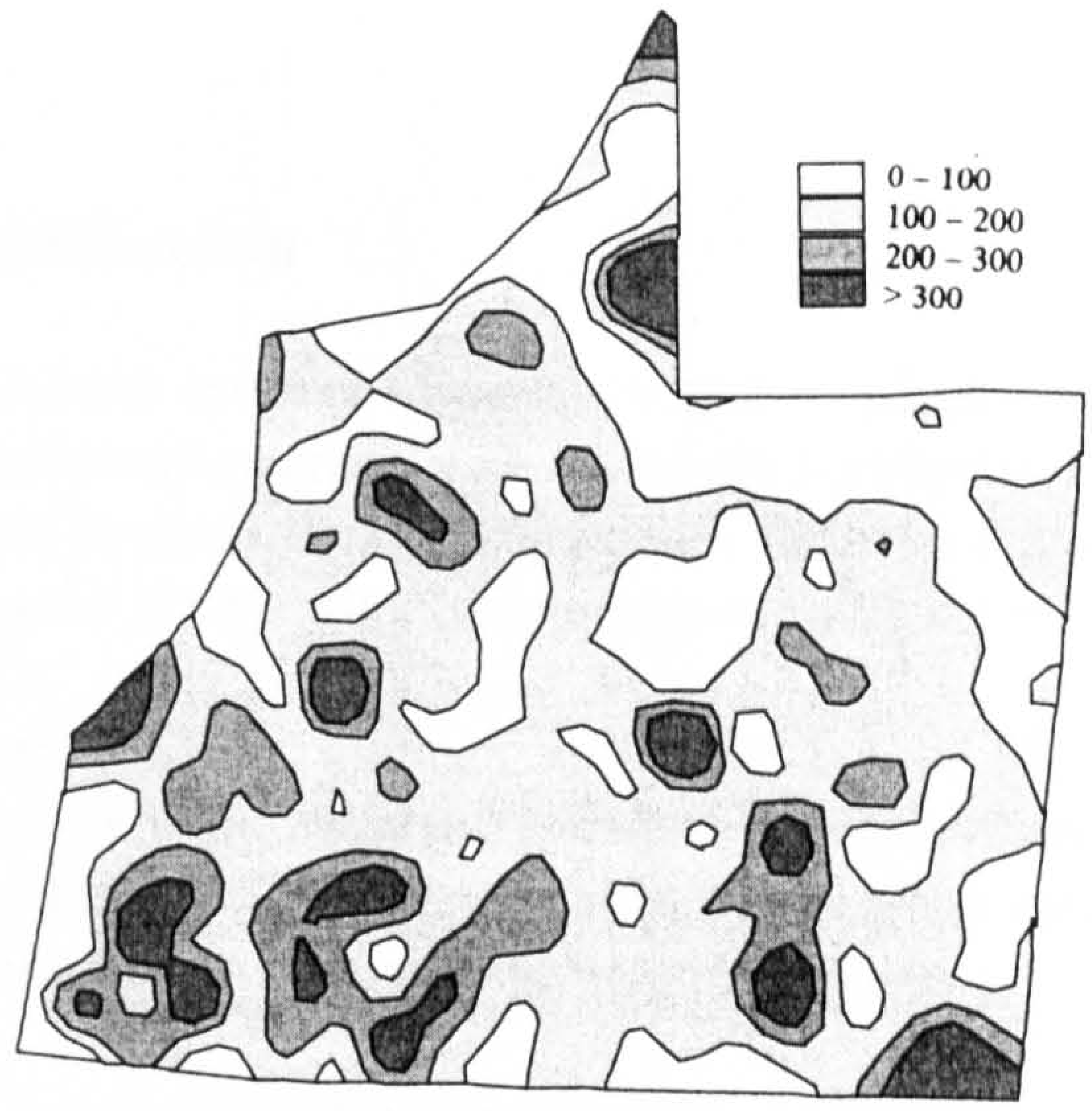


Fig. 4.17 Interpolated Average Grass Density (mm)

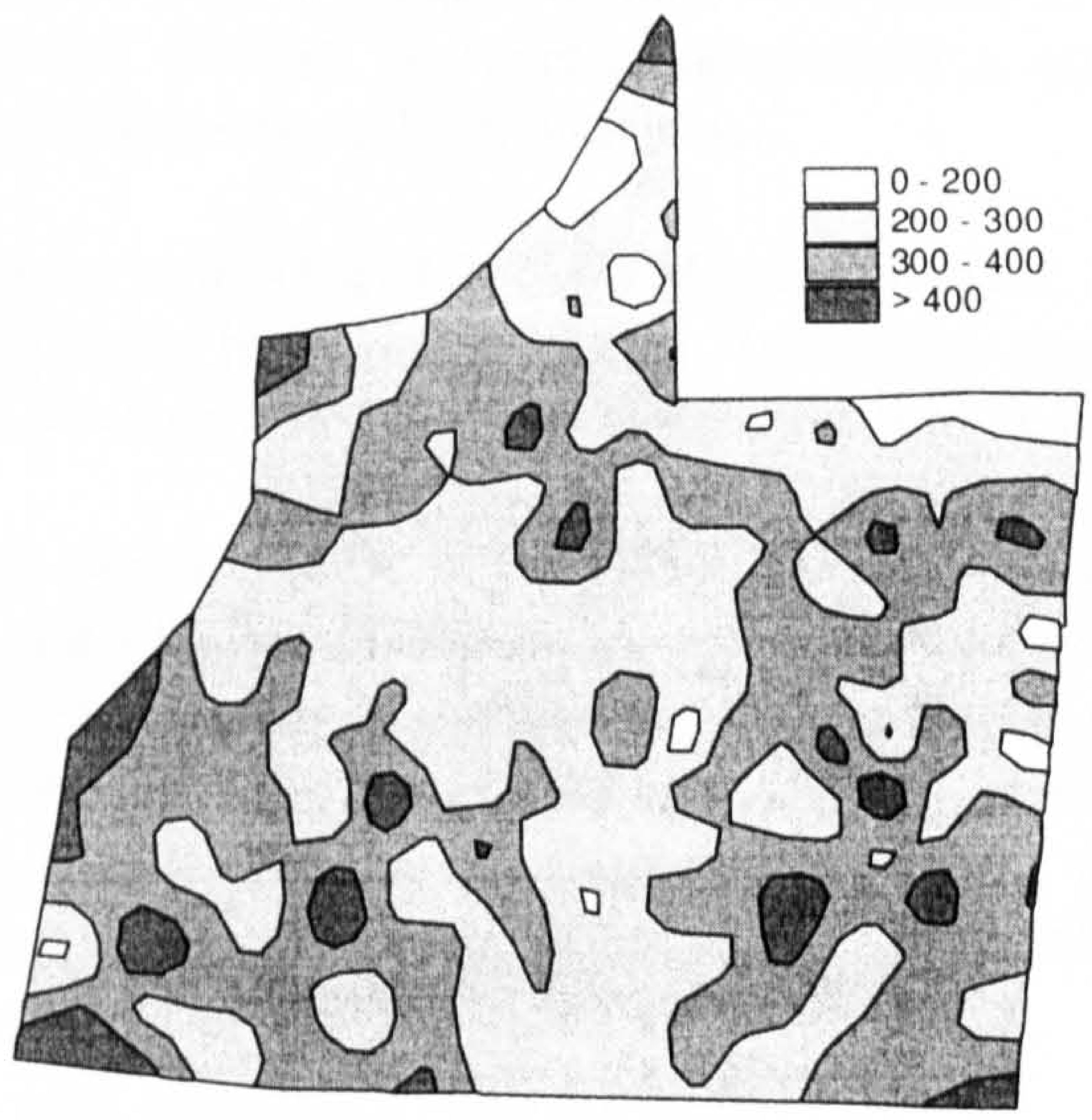


Fig. 4.18 Interpolated Forage Factors with Assigned Ranges

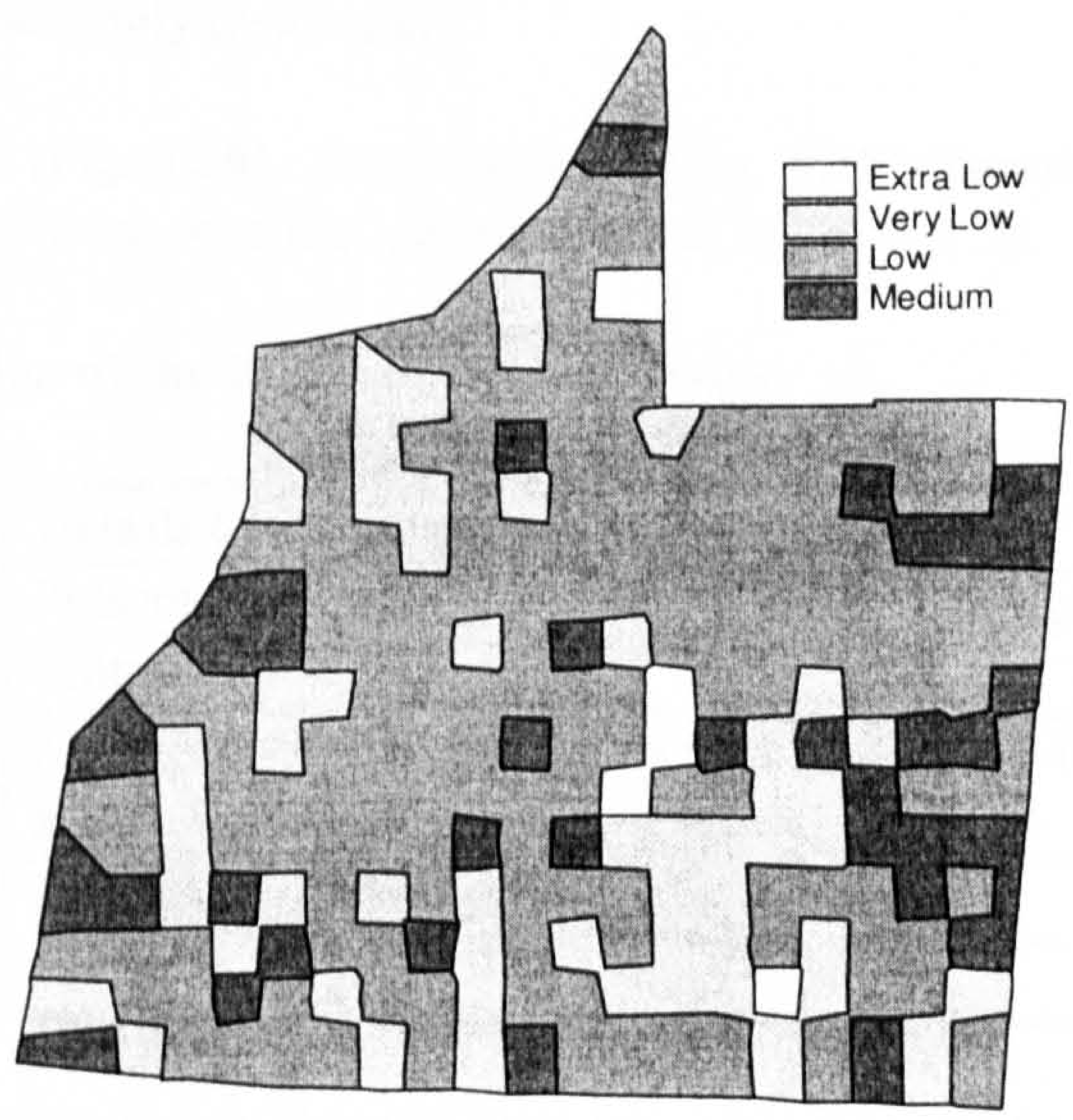


Fig. 4.19 Ratings for Grass Biomass

i) Vegetation Classification

Fig. 4.20 shows typical grassland savanna towards the end of the dry season. Clumps of the stemmy species *Stipagrostis uniplumis* were apparent, with *Schmidtia kalahariensis* less obvious between clumps. *Acacia* species form low tree savanna in the distance as a drainage channel leads to a river. Fig. 4.21 shows a typical low tree savanna habitat with random *Mopane* after the start of the rainy season.

Low tree savanna was identified as the dominant vegetation type in Fig. 4.22. High tree savanna was associated with riverine areas and was observed infrequently. Grassland savanna was mainly found in heavily utilised areas near water holes or rivers. In situations where an area consisted of one or more vegetation types, the dominant type was selected as the overall class.

To confirm the personal vegetation classification, the individual pixels on the satellite-derived classification map of Sannier *et al.*, (1998) (Fig. 4.23) were used to construct maps for comparison. These maps were similar as the majority of the vegetation in both was low tree savanna, however shrub savanna was evident in the maps of Sannier *et al.* (1988) which has replaced what had been personally classified as grass savanna. Overall, no direct visual correlation appeared to exist between areas of high tree savanna or savanna with grass, and shrub savanna.

Comparing the nine pixel result (Fig. 4.24) with the central pixel, it is possible to see that fewer areas receive no classification rating in the one pixel map. In addition, the satellite image included a significant number of pixels with no value which were not included in the statistical analysis.

Statistically there was also a significant difference between the areas covered by vegetation classes identified personally, and with the satellite image values for the centre and surrounding nine pixels $\chi^2_8 = 134.1$, $P<0.01$. While the accuracy of the satellite classification is not doubted, it clearly deviates from vegetation classes identified during the present study. Consequently, it was decided to apply personal observation of habitat classification for this study as these results were known to be applicable to each location and were a component of the other habitat parameters recorded.

ii) Tree Species and Cover

Tree cover density across the region is shown in Fig. 4.25. Generally tree cover was rated low or medium, but overall it was randomly distributed.

The distribution of *Mopane* (Fig. 4.26), *Acacia* species (Fig. 4.27), *Terminalia* species (Fig. 4.28) and *Combretum* species (Fig. 4.29) was mapped and is described in Table 4.20.

Table 4.20 Distribution of the Dominant Tree Species.

Tree Species	Details of Distribution
Mopane (tree and shrub)	Present over almost the whole area, although less is found in the central region.
Acacia species	Scattered distribution, especially present in the central and eastern areas.
Terminalia species	Patchy distribution across most of area.
Combretum species	Patchy distribution across most of area.

Over the whole area a brief assessment identified the following tree species as present *Colophospermum mopane* (trees and shrub), *Terminalia pruinoides, T. sericea, Combretum apiculatum, C. hereroense, C. imberbe* (in riverbed), *Dichrostachys cinerea, Grewia bicolour, Commiphora pyracanthoides, Acacia reficiens, A. mellifera, A. newbrownii, A. erubescens, A. hebeclada, A. senegal, A. erioloba, Boscia foetida, Boscia albitrunca, Albizia anthelmintica* and *Ziziphus mucronata.*

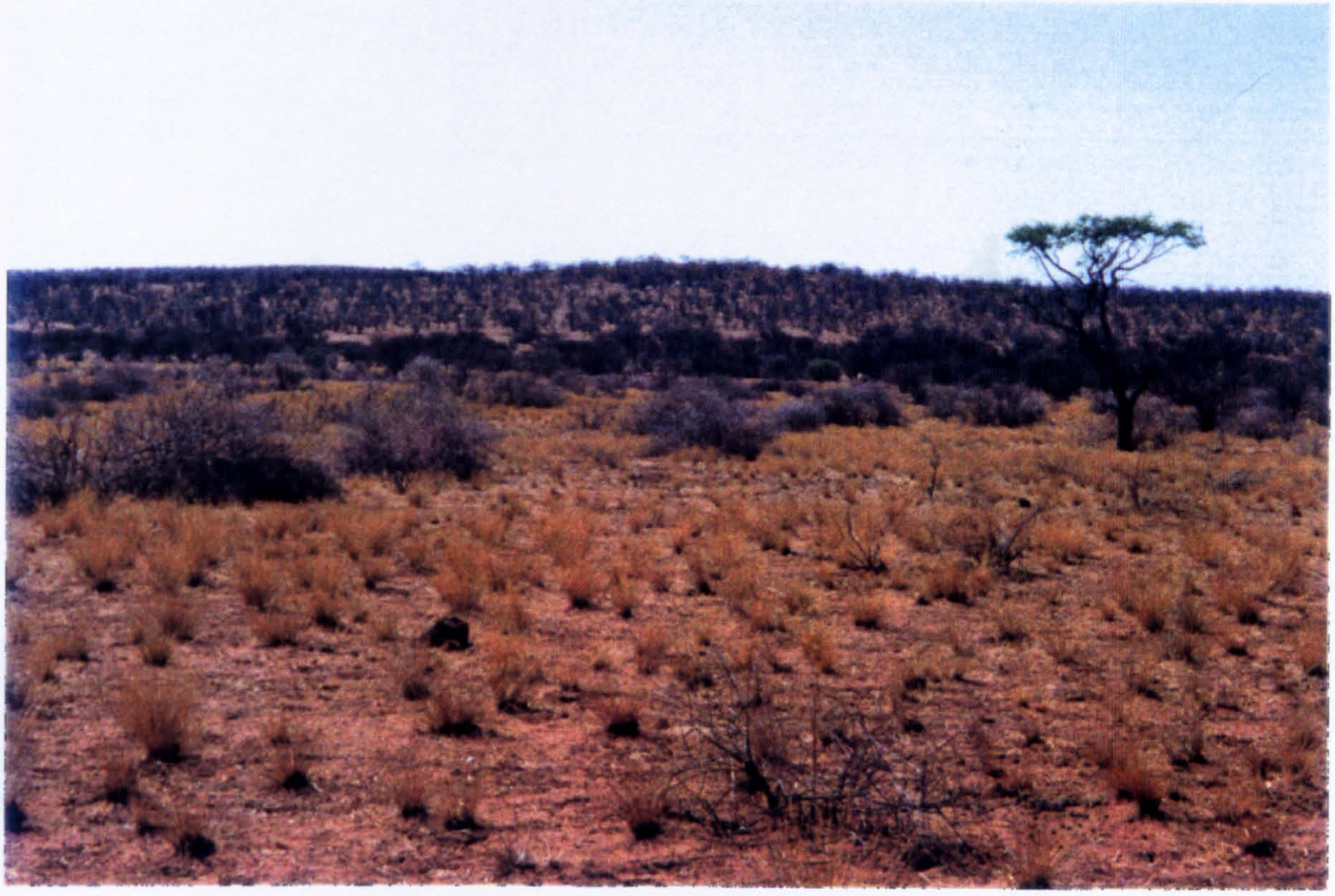


Fig. 4.20 Grass Savanna with Low Tree Savanna in Distance

Fig. 4.21 Low Tree Savanna During the Rainy Season

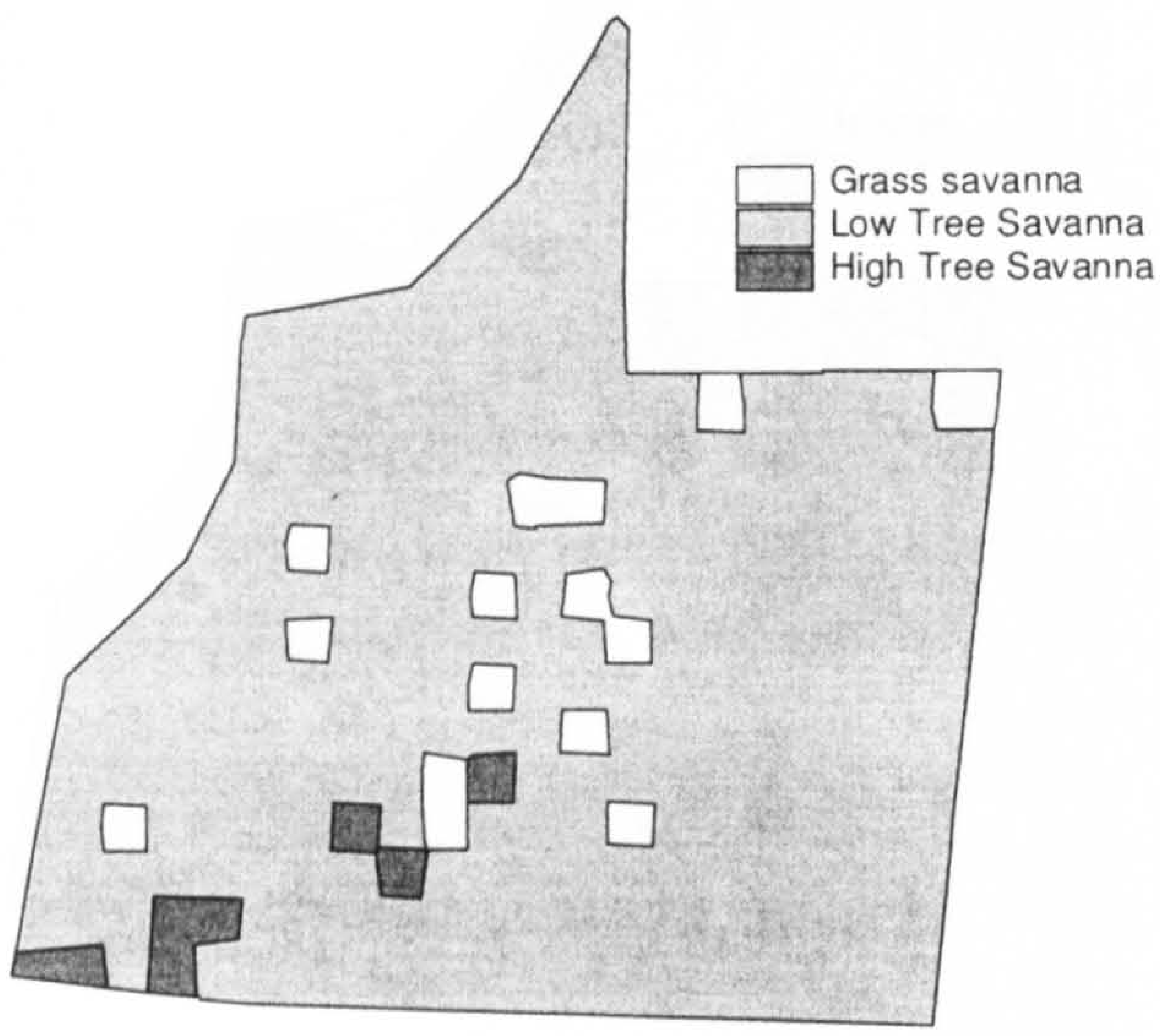


Fig. 4.22 Vegetation Classification from Personal Observation

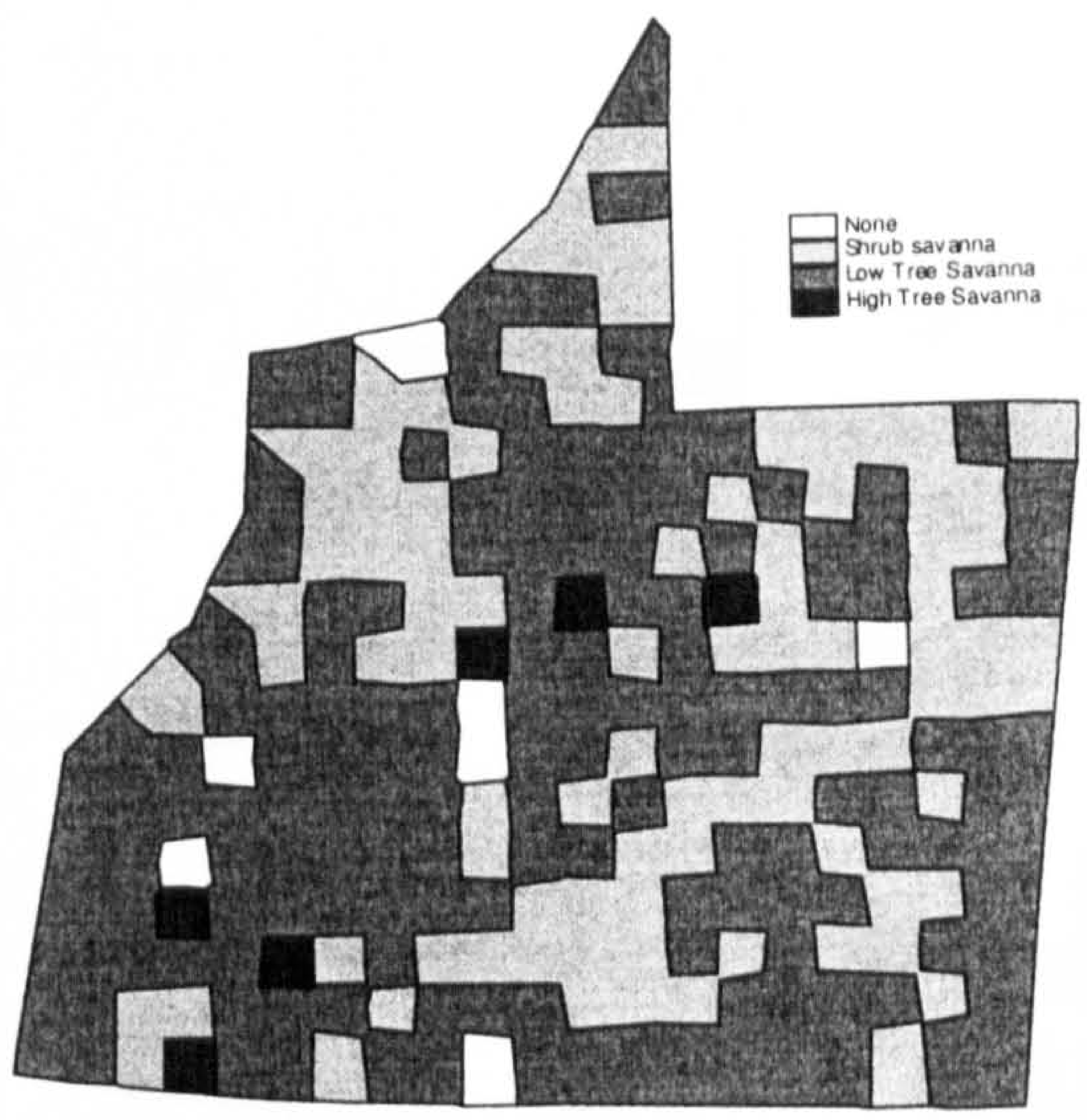


Fig. 4.23 IDRISI Image Pixel Relative to Transect Covered in Survey

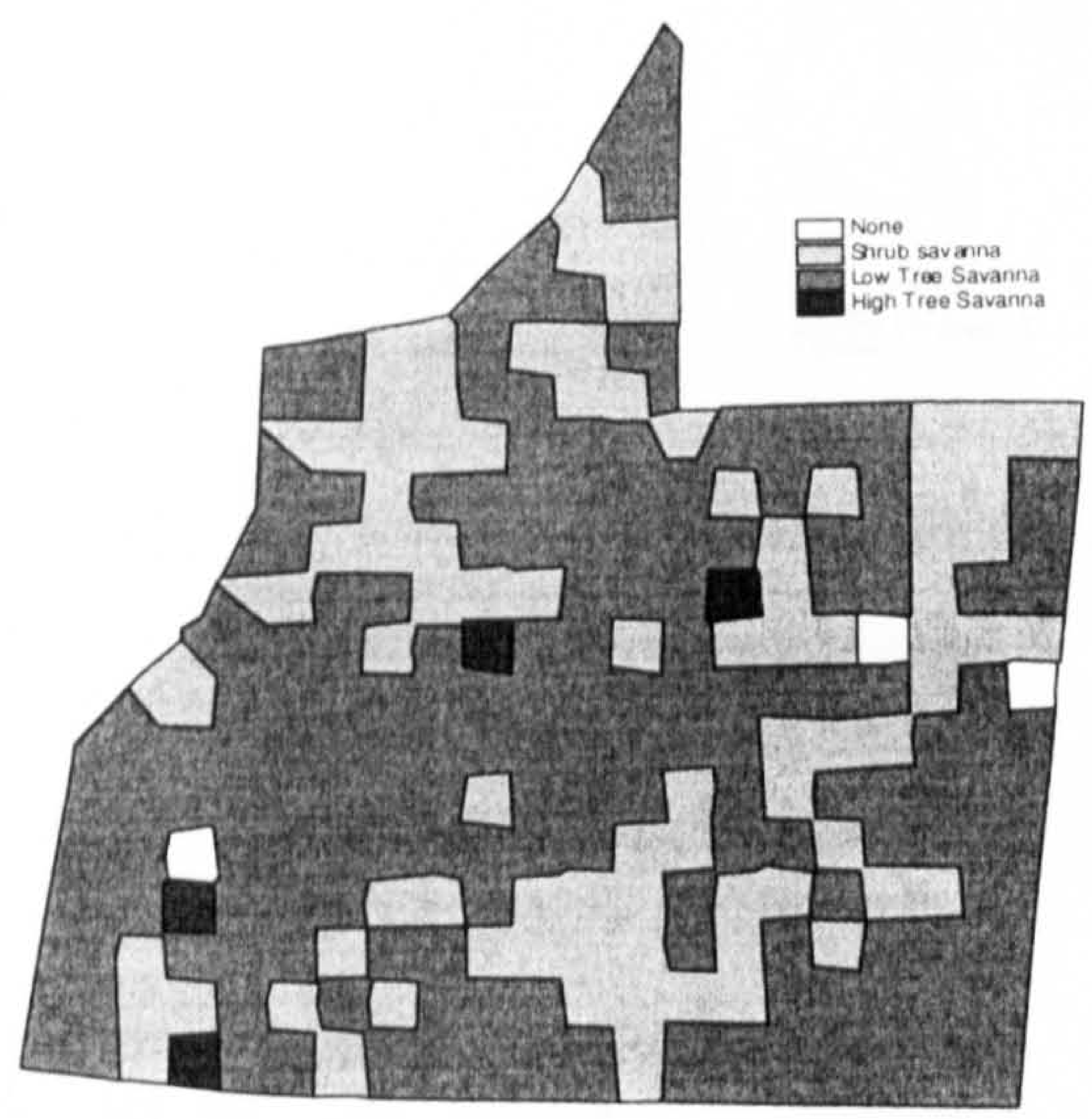


Fig. 4.24 IDRISI Image Average of Nine Pixels in Area of Transect

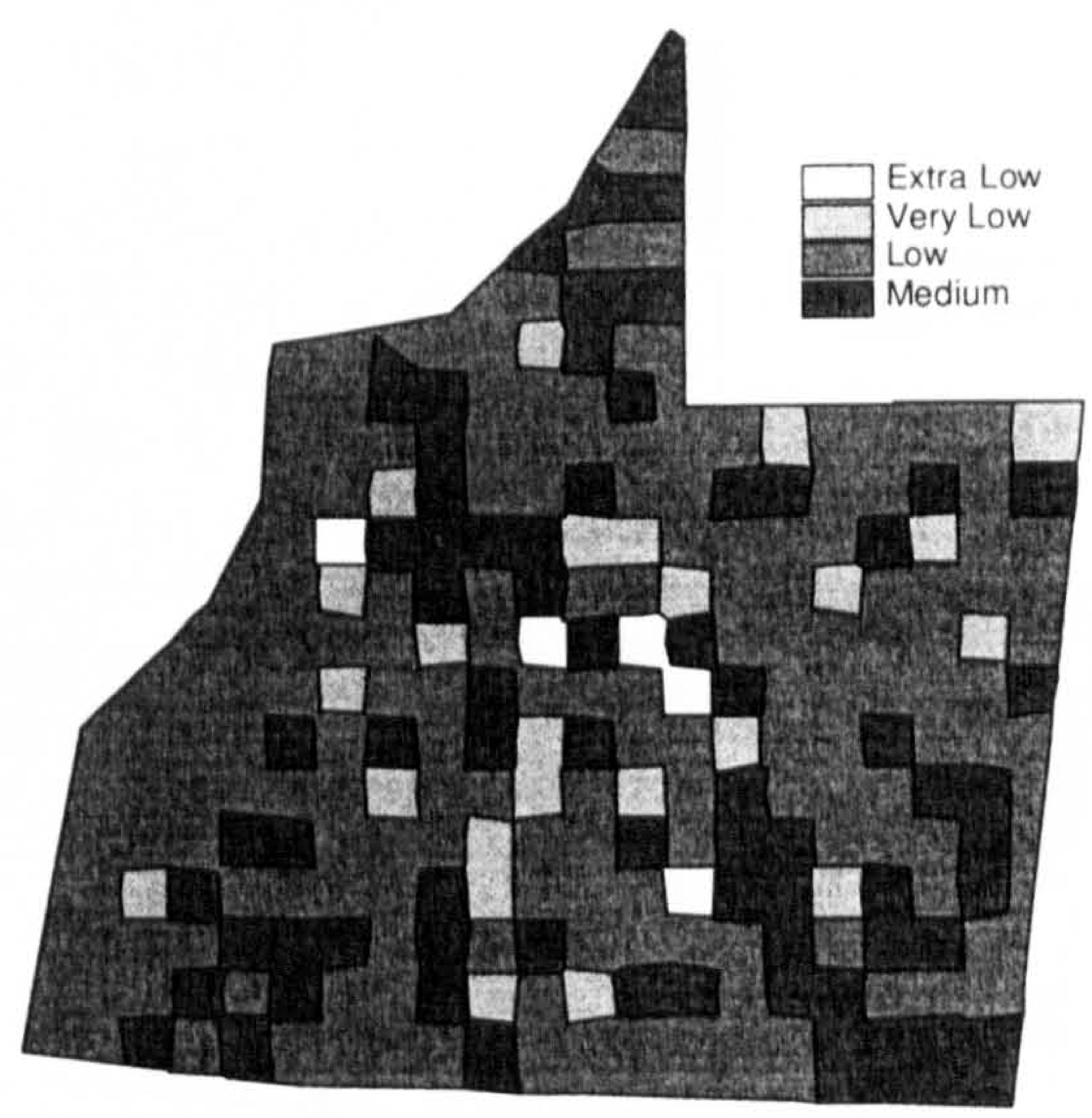


Fig. 4.25 Ratings for Tree Cover

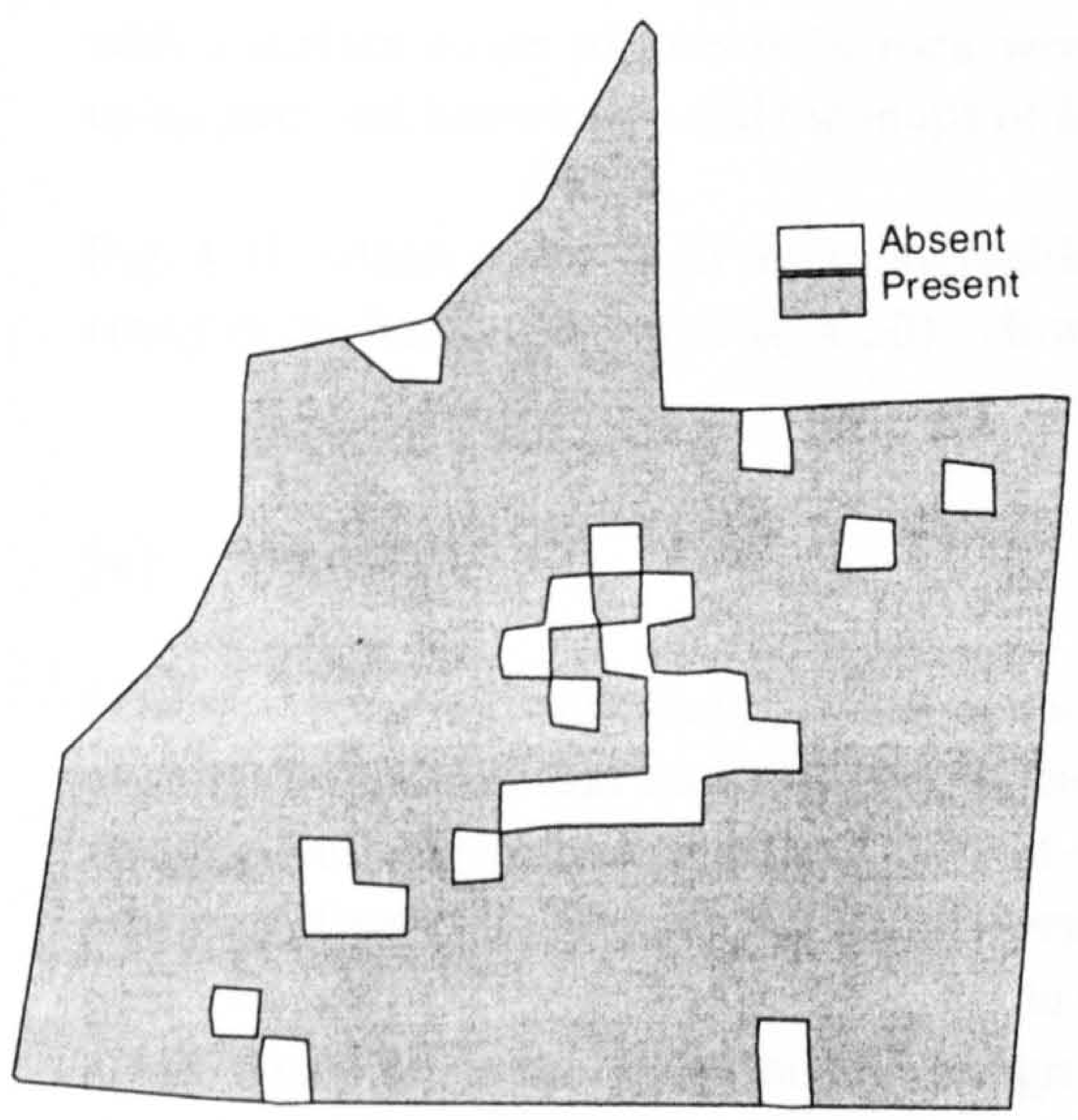


Fig. 4.26 Presence or Absence of *Mopane* Trees or Shrubs

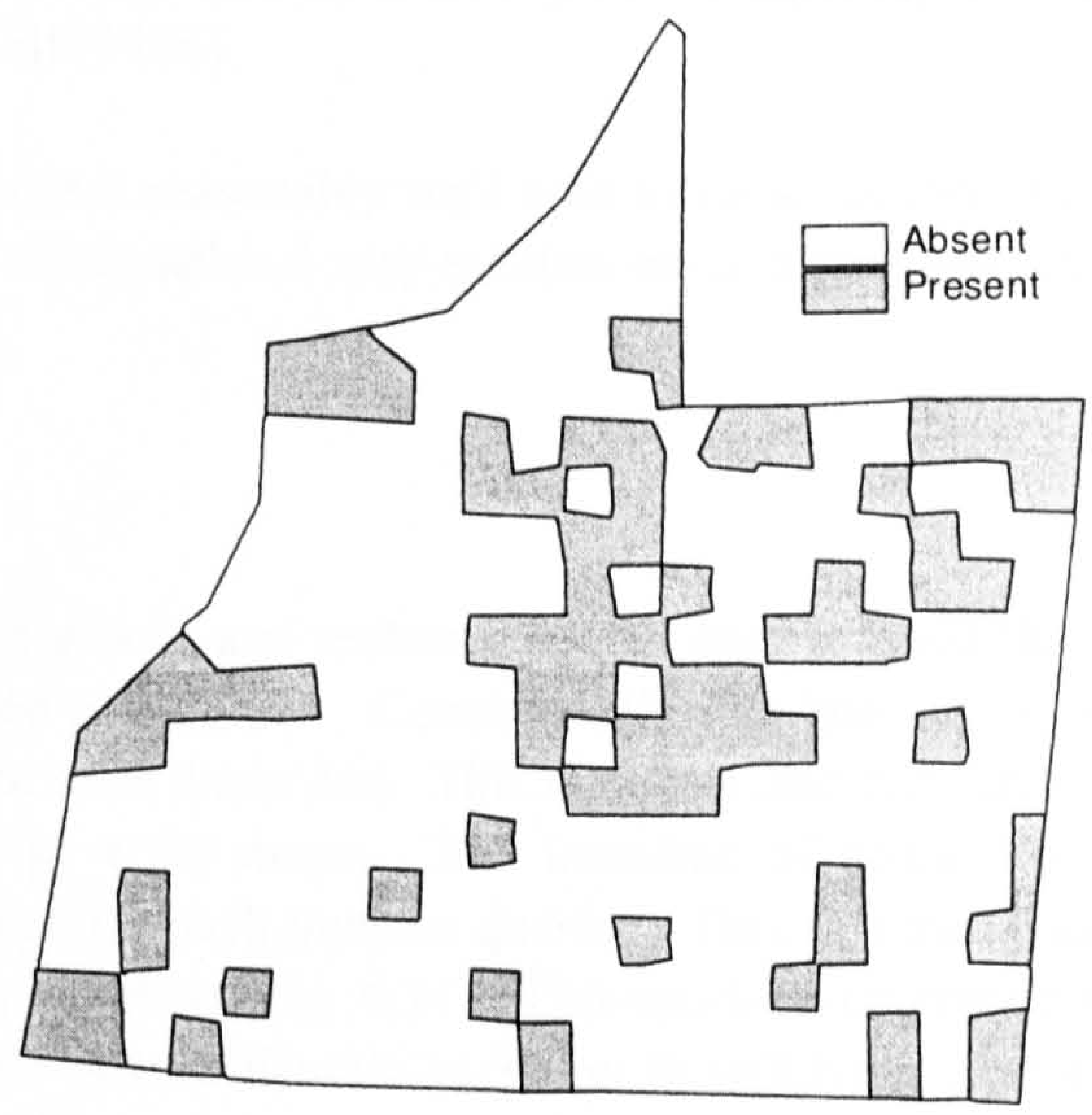


Fig. 4.27 Presence or Absence of *Acacia* Species

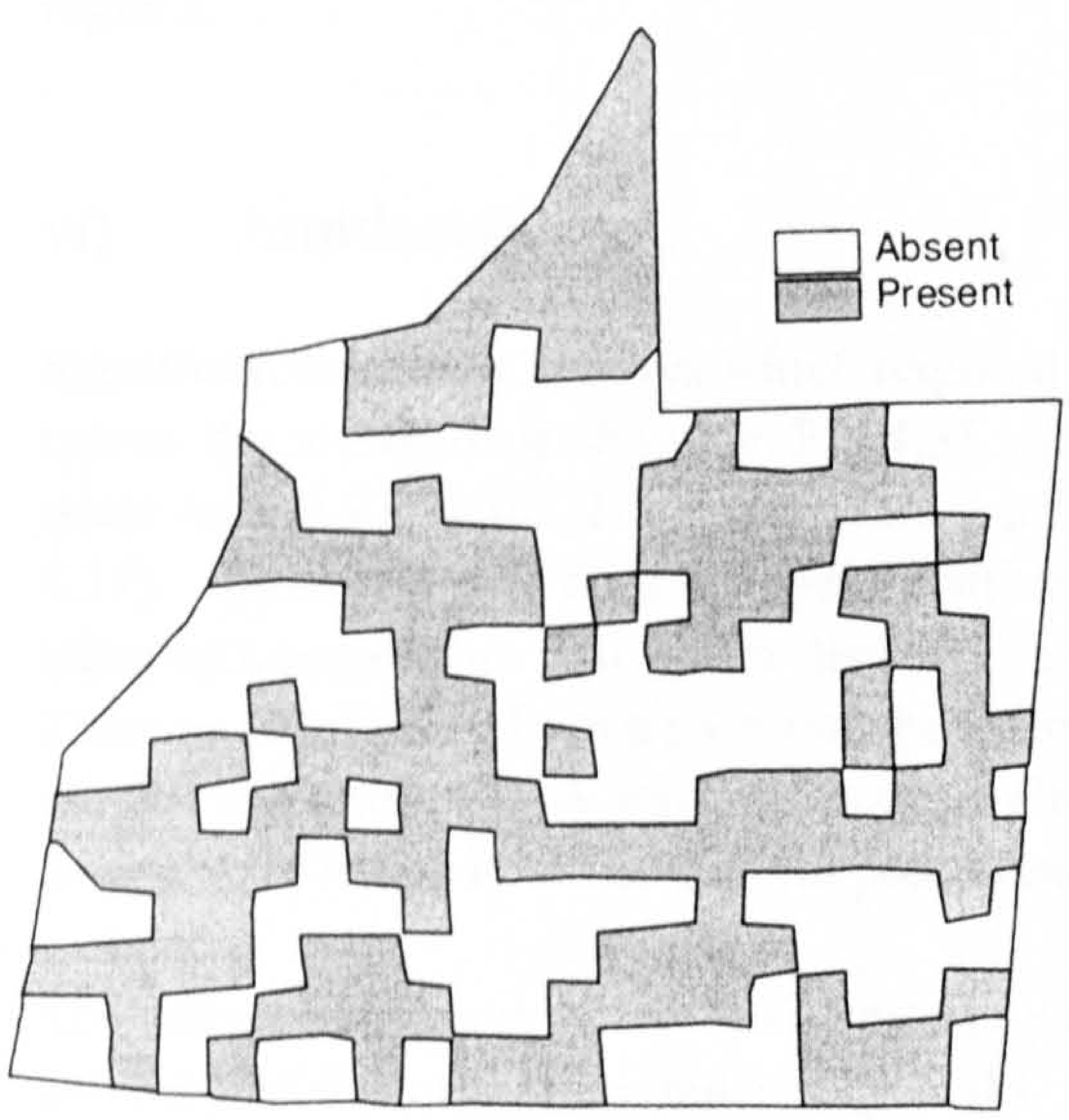


Fig. 4.28 Presence or Absence of *Terminalia* Species

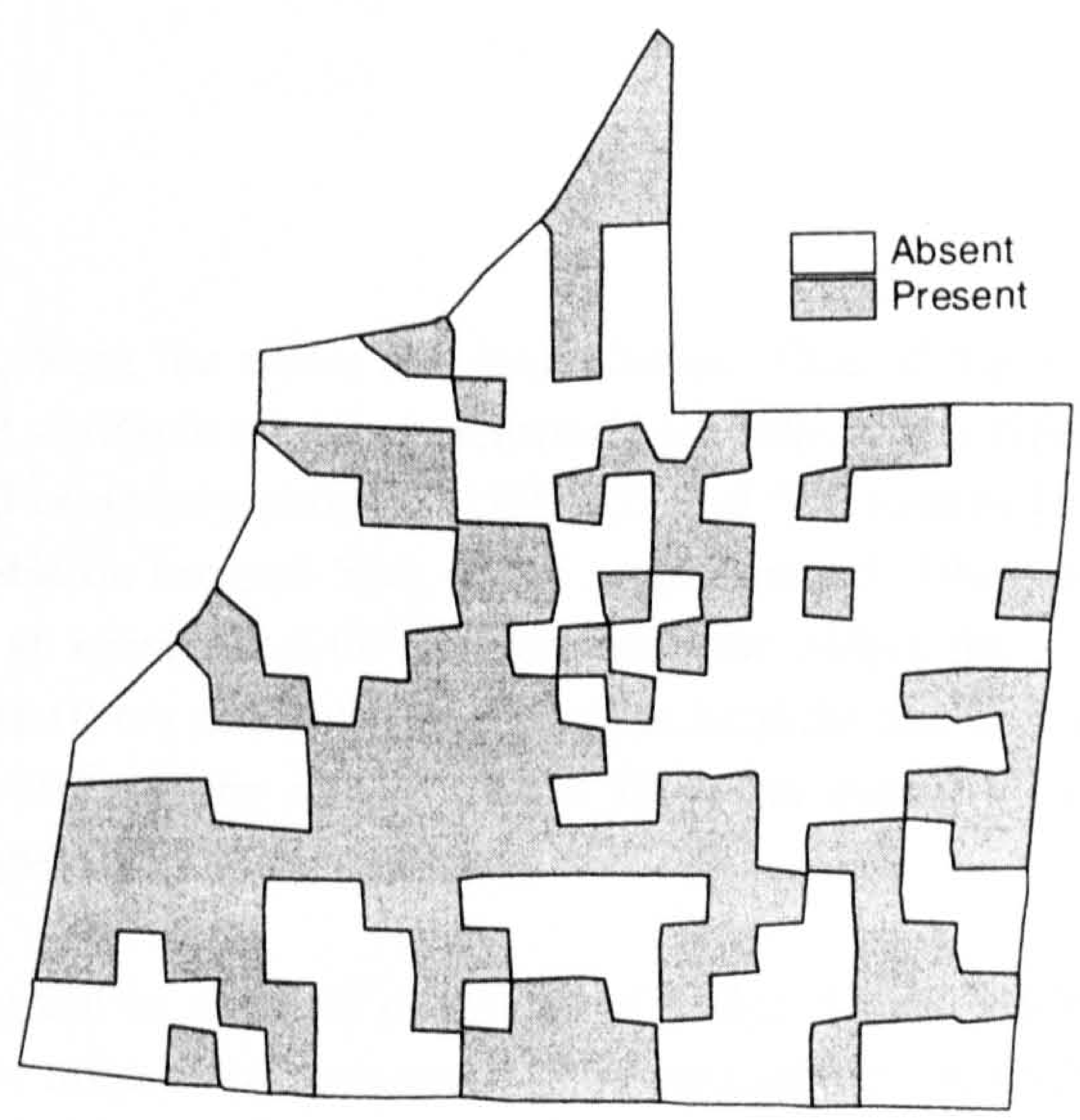


Fig. 4.29 Presence or Absence of *Combretum* Species

iii) Rockiness

Rockiness was quantified by the percentage of ground surface covered by rocks and is illustrated in Fig. 4.30. There were few rocks over most of the area of Kaross, however mixed levels of rockiness existed in a distinct band between the south-west and north-eastern corners and in the south-eastern corner. Areas with a surface cover of over 60% rock were plotted in Fig. 4.31 by referring to the topographical map, using personal knowledge and the maps of Beugler-Bell (1996).

Fig. 4.31, which is based on the topographical map relates reasonably well with those areas identified as rocky in the habitat survey (Fig. 4.30). However, the topographical map exhibits much higher resolution.

iv) Soil

During the survey, soil was assessed according to its colour and texture. It was later realised that the position of the sun had an influence on the perceived soil colour. Consequently the detailed maps of Beugler-Bell (1996) were used and the soil colour data were discarded. This map was then reproduced to represent five-class (Fig. 4.32) and eleven-class (Fig. 4.33) maps. The locations of actual transect positions were placed on the soil maps, and the soil type for each transect queried. This was then used to create a map of Kaross using the GIS assign proximity function (Fig. 4.34). This was then compared with the original five-class map. It was apparent that there is considerable variation in soil types across the region.

The dominant soil types were C1 and C2, Dystric/Lithic Leptosols from the Kaross granite zone. Several other soil types also occur infrequently, for example regions with soil class D were associated with riverine areas.

v) Grazing Pressure and Utilisation of an Area

Grazing pressure was not mapped as readings varied slightly over the months that the survey was conducted. However, results were utilised in correspondence analysis to form homogenous habitat regions.

vi) Landscape

Significant landscape features which required mapping were the rivers and water holes. One of the main typical dry riverbeds is shown in Fig 4.35 and also the concrete trough at KarossHoek which is a typical water hole in Fig 4.36. The main rivers were assigned boundary zones of 100, 250 and 500 metres (Fig. 4.37). Although rivers do not generally influence vegetation beyond 50m of the main channel, 100m was taken as a reasonable first buffer distance, to tolerate an element of GPS error. Habitat within the zone 250m to 500m away from a river may be affected by the rivers presence, by acting as a catchment area for rainfall and nutrients. A separate analysis allocated a buffer zone of 100 metres from the main rivers to form a layer which could be superimposed onto the maps of homogenous areas.

The influence of water holes was assessed by assigning buffer zones at distances of 150m, 500m, 1,500m and 3,000m from the water holes (Fig. 4.38). All water holes were presumed to be permanent. A further map was created with a buffer of 150m allocated to each water hole to be superimposed onto maps of homogenous areas.

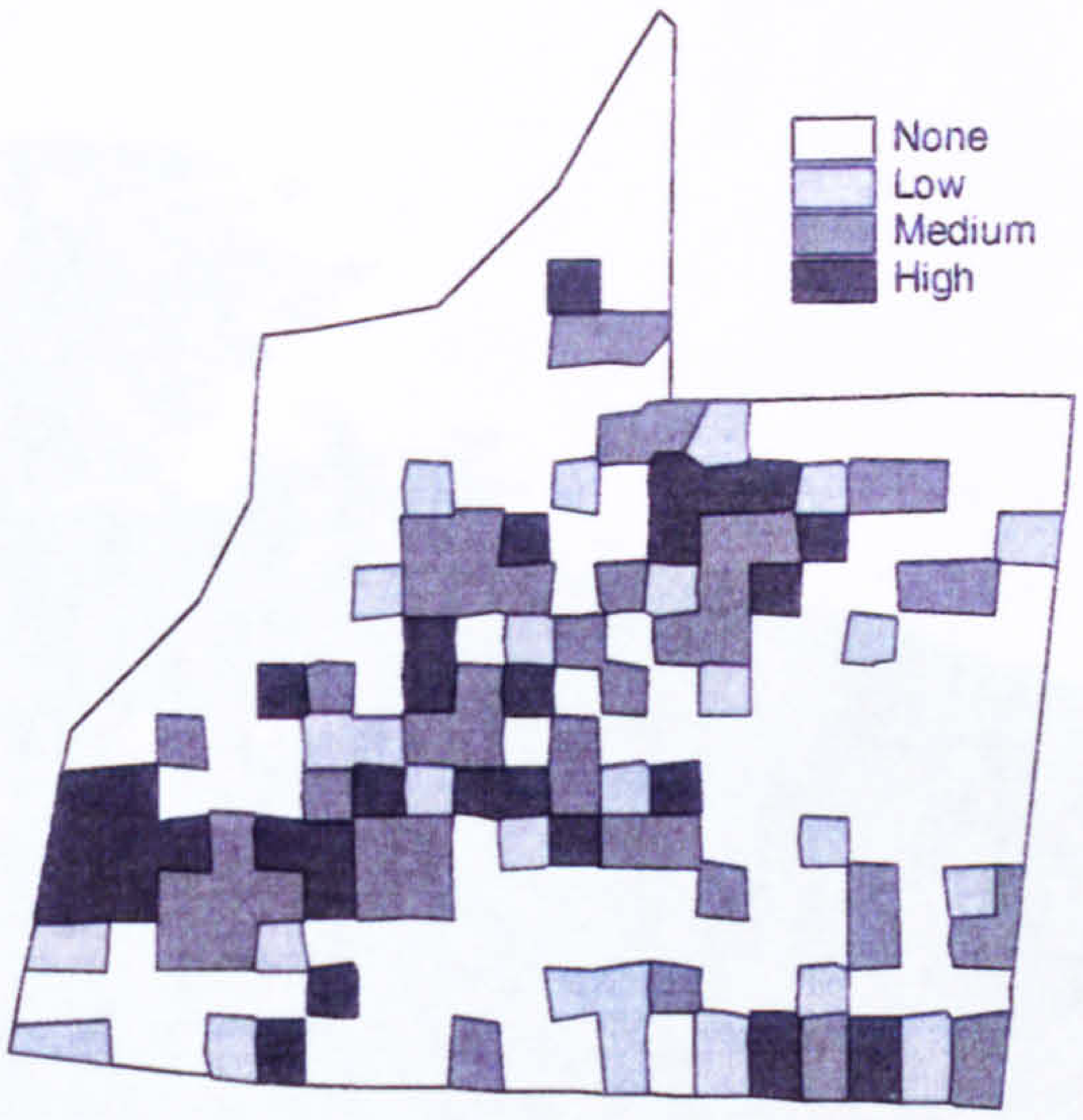


Fig. 4.30 Assessment of Surface Cover of Rocks

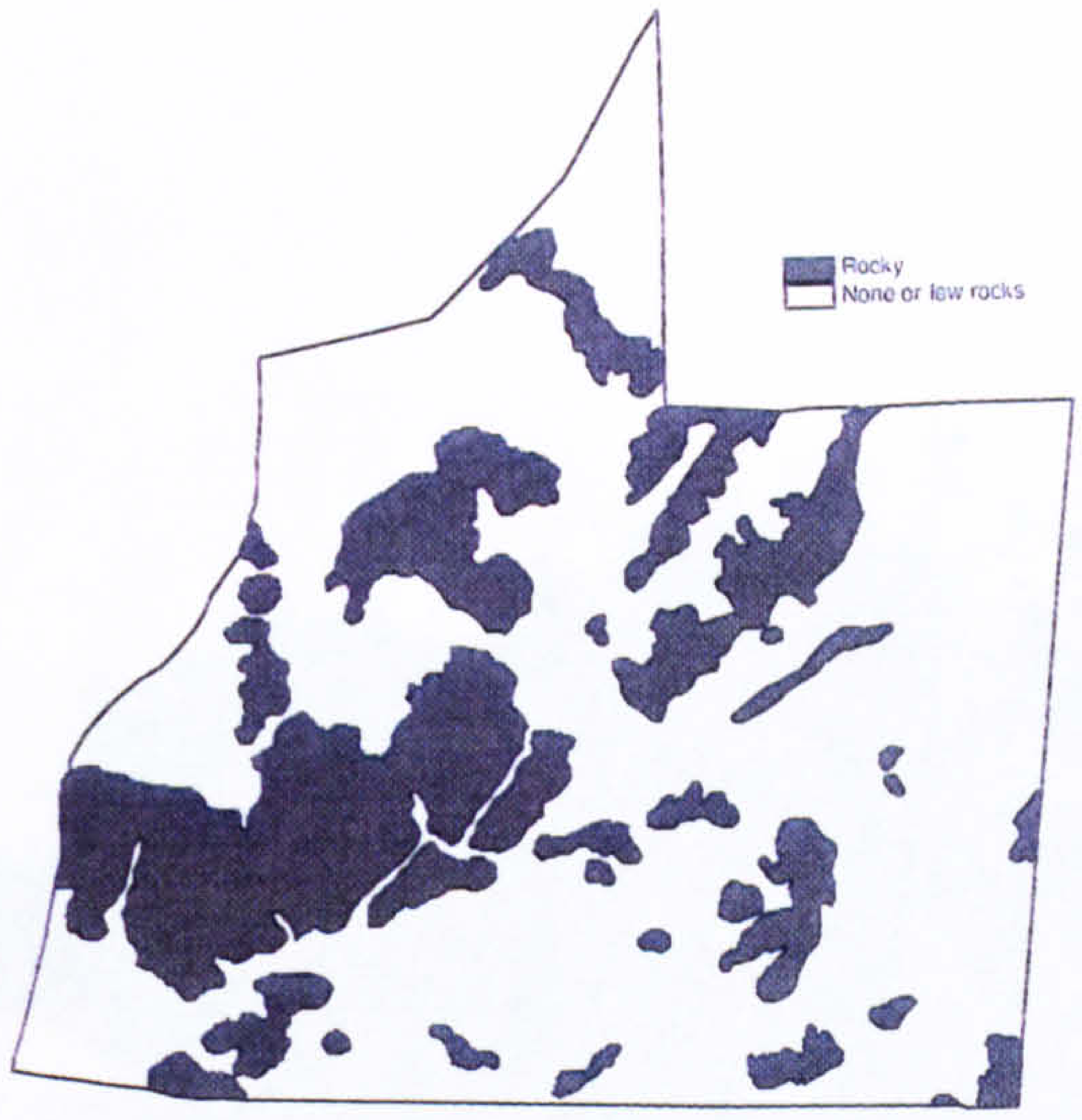


Fig. 4.31 Areas with Over 60% Surface Rock derived from Topographical map

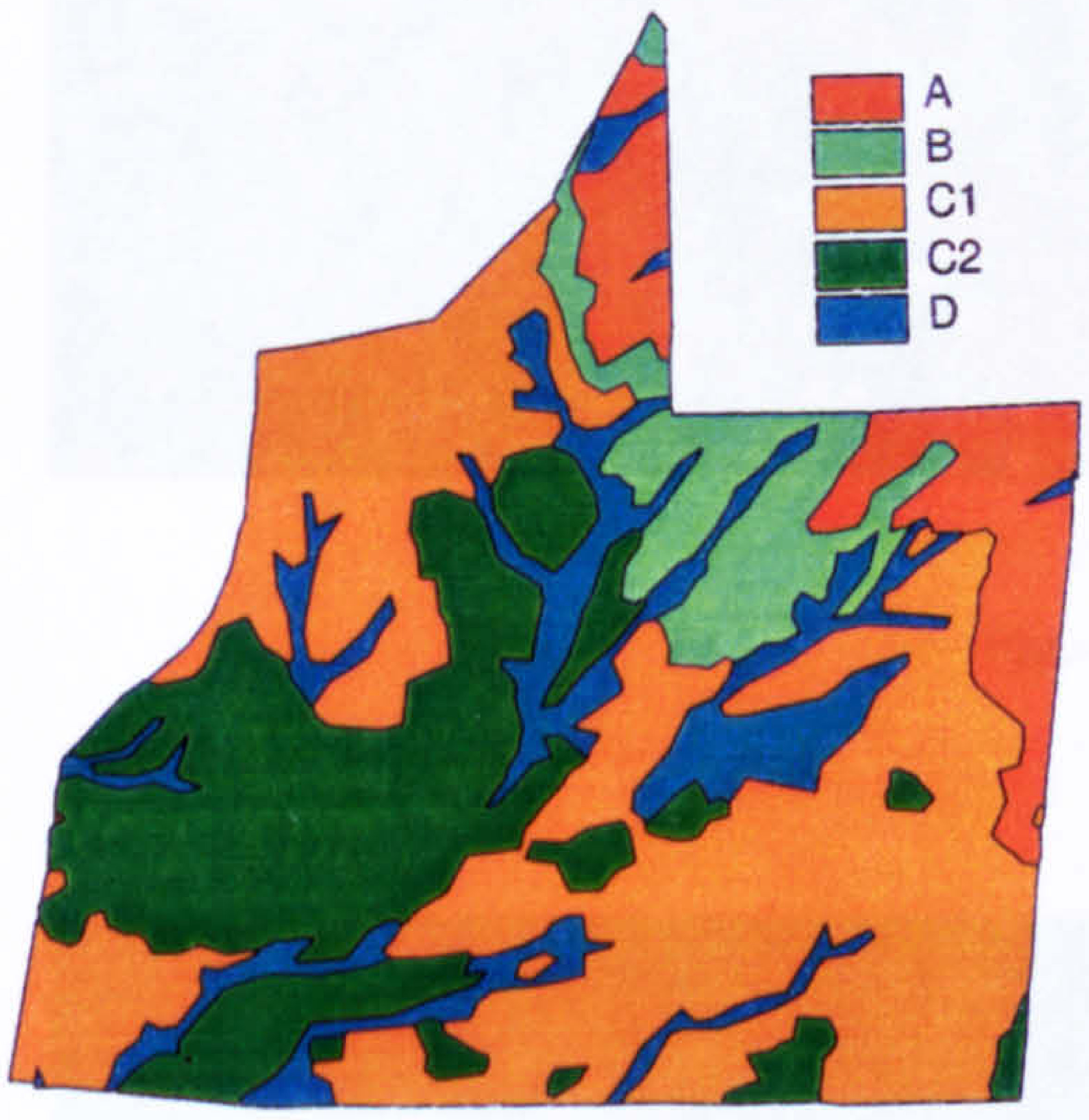


Fig. 4.32 Five-Class Soil Map (from Beugler-Bell 1996)

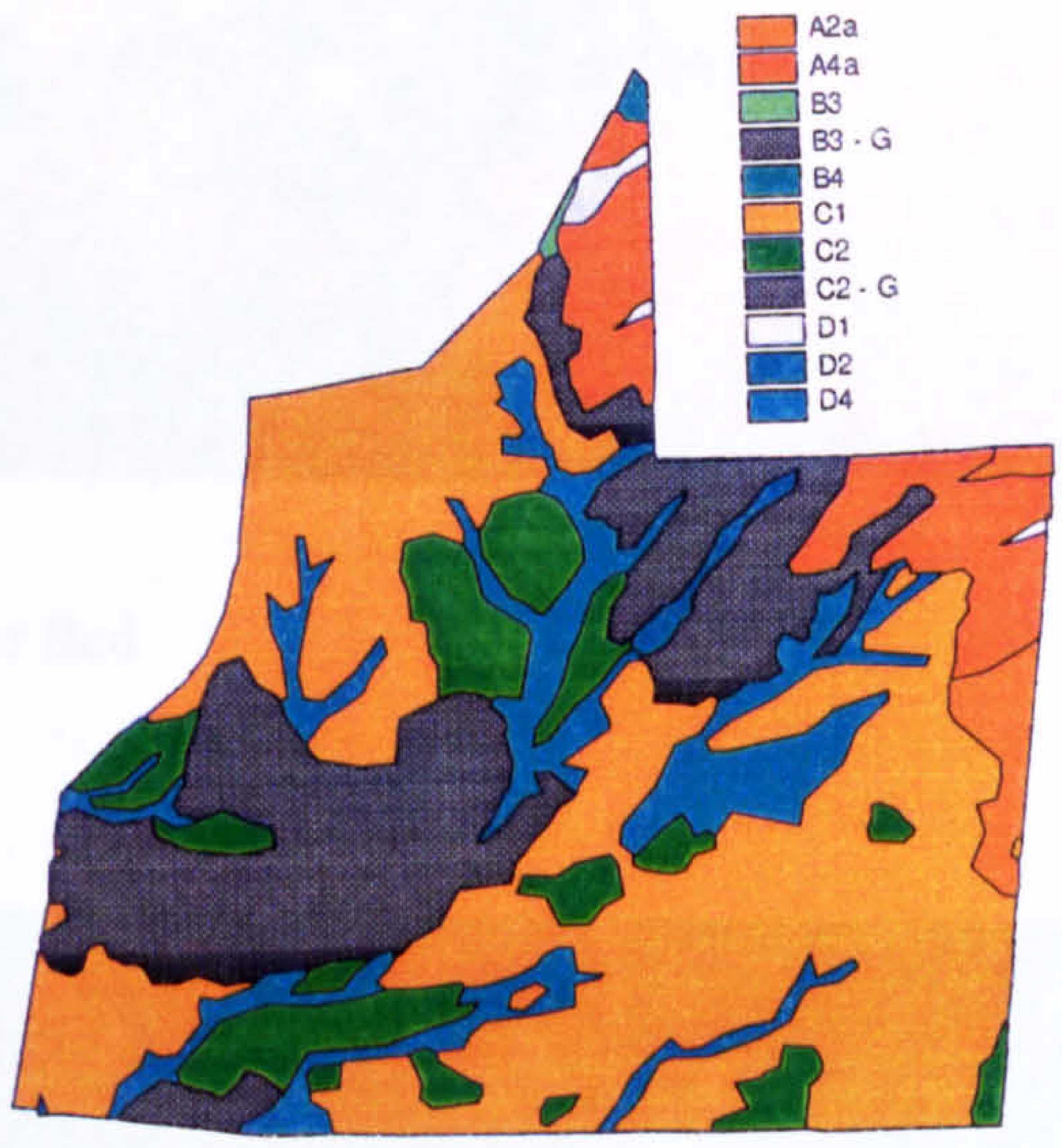


Fig. 4.33 Eleven-Class Soil Map (from Beugler-Bell 1996)

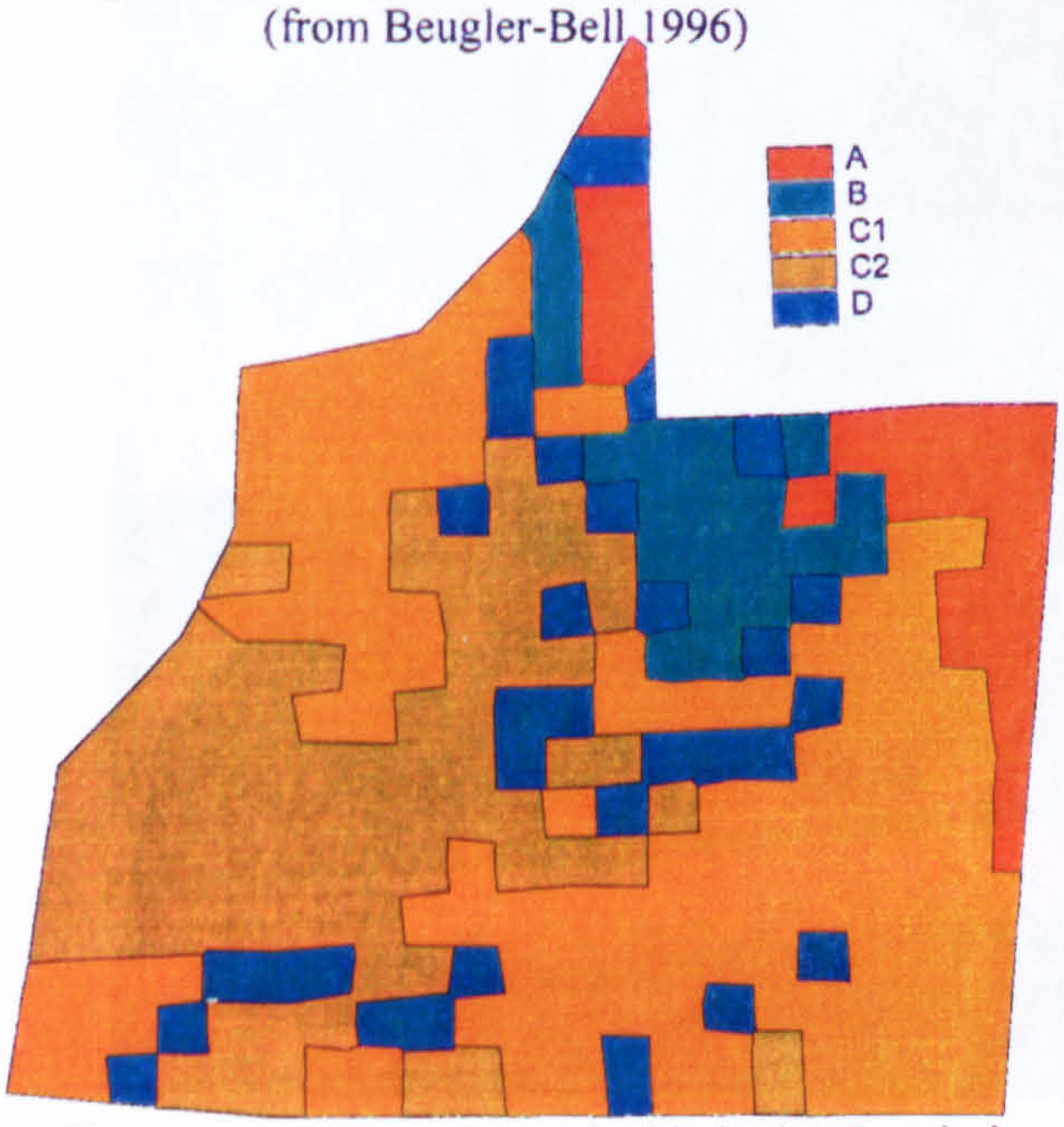


Fig. 4.34 Soil Map Created with Assign Proximity Function (from Beugler-Bell 1996)

Fig. 4.35 Dry River Bed

Fig. 4.36 KarossHoek Water-Hole

Fig. 4.37 Rivers with Assigned Distance Boundaries

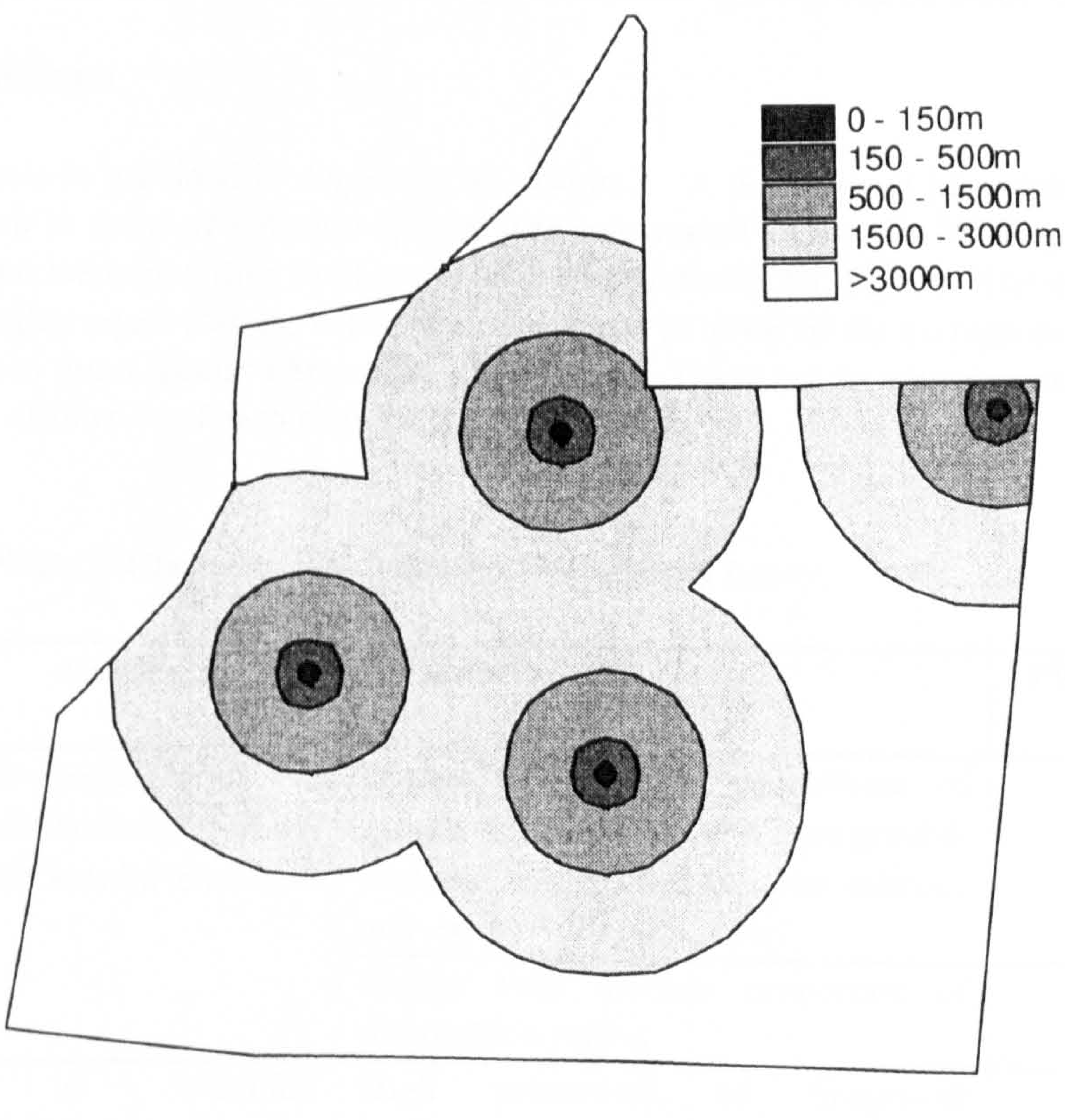


Fig. 4.38 Locations of Water Holes with Assigned Distances

4.3.3 Homogenous Grass, Habitat and Tree Areas

Inter-relationships between grass, habitat and tree parameters were analysed and discussed. Two cluster analysis techniques were applied to analyse herbaceous species data. This comparison identified MVSP as the most appropriate method of analysis since it displayed a strong capacity to identify unusual or unique transects as different classification categories.

4.3.3.1 Grass Species

i) Visual Comparison

The grass species distribution maps (Fig's. 4.10 to 4.14) were visually compared. No significant visual correlation between distribution patterns of different species could be identified.

ii) Ordination

Ordination analysis describes the spatial separation between transects according to the occurrence of their component grass species. In Appendix VI, Table 2 shows the species occurrence and Fig.1 is the ordination plot. The ordination plot shows a close correlation between most transects. This indicates that the majority of the transects were of a reasonably similar species composition. A few outlying points were identified, which represented increasingly different or extreme habitat.

iii) Cluster Analysis

Two cluster analysis techniques were used to force groupings, and the results were compared. Analysis was primarily intended to identify associations between transects (Q mode). Species indicating each identified class were described according to their average occurrence in the group (R mode analysis).

a) TWINSPAN

The output of the analysis is provided in Appendix VI, Table 3. A dendrogram identifying associated sites and describing them in terms of indicator species was constructed (Appendix VI, Fig. 2)(Q mode). Grass species associations were identified by R mode analysis (Appendix VI, Fig. 3). The transects were split to provide four roughly equal classes, which were described in terms of the average occurrence and standard deviation of each grass species (Appendix VI, Table 4). These results are summarised in terms of the dominant species distinctive of each class in Table 4.21.

Table 4.21 TWINSPAN Classes of Homogenous Herbaceous Layer

Herbaceous Layer Description		TWINSPAN Class
High proportion of *Eragrostis nindensis* and *Aristida adscensionis*. Low proportions of *Schmidtia kalahariensis* and *Eragrostis porosa*.	Higher than average proportions of *Enneapogon cenchroides*, bare ground, *Melinus repens*, *Triaphis ramosissima* and *Anthephora pubescens*.	1
	Higher than average proportion of *Microchloa caffra*.	2
High proportion of *Schmidtia kalahariensis* and *Eragrostis porosa*.	High proportion of *Eragrostis nindensis*, *Aristida adscensionis* and *Eragrostis rotifer*.	3
	High proportions of *Stipagrostis uniplumis* and *Antephora schinzii*.	4

Fig. 4.39 maps the homogenous areas of herbaceous species. This shows that classes 3 and 4, mainly occur in southern, south-eastern and north-western areas. Classes 1 and 2 were more associated with rocky areas. This map was enhanced with additional classes of rivers and water holes in Fig. 4.40.

b) MVSP

The dendrogram in Appendix VI, Fig. 4 was split into a three and eight-class system. Several unique transects were evident on the left side of the diagram, which would have been expected from occasional transects near water holes, over-utilised regions, eroded ground, riverbeds or highly rocky areas. The eight-class system accommodated these infrequent classes to a greater extent than the three-class system.

Average values of the main grass species and their standard deviation from this mean are shown in Appendix VI, Table 5. These results are summarised in Table 4.22.

Table 4.22 Three-Class MVSP Analysis of Homogenous Herbaceous Layer

MVSP Class	Description of Herbaceous Layer
1	Higher than average levels of *Eragrostis nindensis*, *Anthephora schinzii*, *Aristida adscensionis* and less *Eragrostis rotifer*, slightly less *Stipagrostis uniplumis*.
2	Higher than average levels of *Schmidtia kalahariensis*, *Eragrostis rotifer*, *Cenchrus ciliaris*, *Eragrostis annulata* and *Eragrostis echinochloidea*. There may also be *Chloris virgata* present.
3	Higher than average levels of *Stipagrostis hochstetterana* and *Triaphis ramosissima*. Low levels of *Schmidtia kalahariensis*, *Eragrostis nindensis*, *Microchloa caffra*, *Anthephora schinzii* and *Eragrostis porosa*. This class only contains seven transects.

Average values of grass species according to the eight-class system are given in Appendix VI, Table 6. The first four classes contain the majority of the transects. All classes are described in Table 4.23.

Table 4.23 Eight-Class MVSP Analysis of Homogenous Herbaceous Layer

MVSP Class	Description of Herbaceous Layer
1	High levels of *Anthephora schinzii* and *Aristida adscensionis*. Low levels of *Cenchrus ciliaris*.
2	High levels of *Eragrostis nindensis* and *Aristida adscensionis*.
3	High levels of *Schmidtia kalahariensis*, *Cenchrus ciliaris*, *Eragrostis porosa*, *Chloris virgata* and *Eragrostis echinochloidea*.
4	High levels of *Stipagrostis uniplumis* and *Stipagrostis hochstetterana*. Low levels of *Cenchrus ciliaris*.
5	High levels of *Eragrostis rotifer*, *Eragrostis annulata* and unidentified grasses.
6	High levels of *Stipagrostis uniplumis*, *Triaphis ramosissima* and *Melinus repens*. Low levels of *Schmidtia kalahariensis* and *Eragrostis nindensis*.
7	Exceptionally high levels of *Stipagrostis hochstetterana*. Low levels of *Eragrostis nindensis*.
8	Exceptionally high levels of *Eragrostis nindensis*. High levels of *Eragrostis rotifer*.

Fig. 4.39 Homogenous Herbaceous Layer Classes Identified by TWINSPAN

Fig. 4.40 TWINSPAN Four-Class Grass Map with Rivers and Water Holes

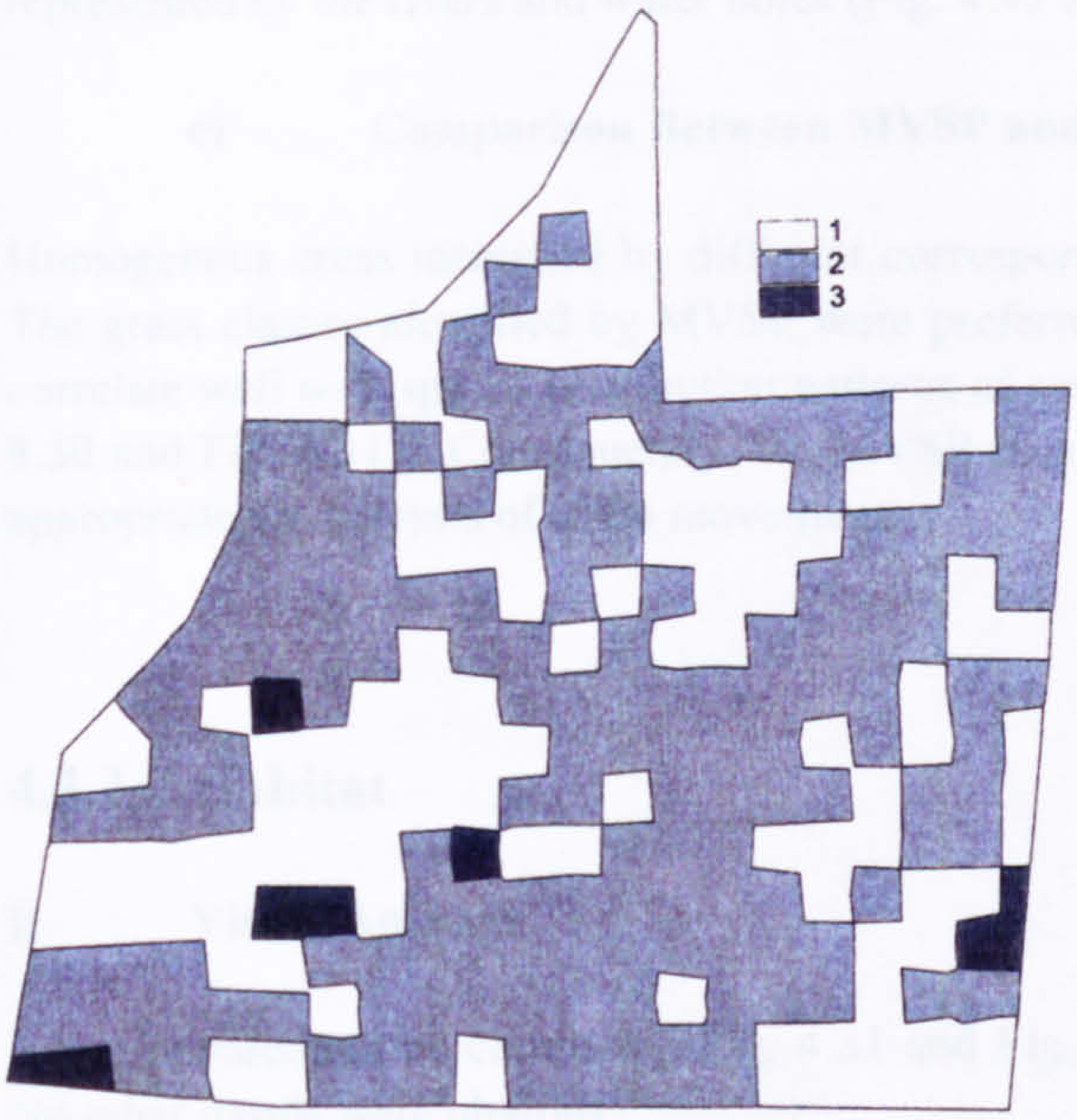


Fig. 4.41 Three Homogenous Herbaceous Layer Classes Identified by MVSP

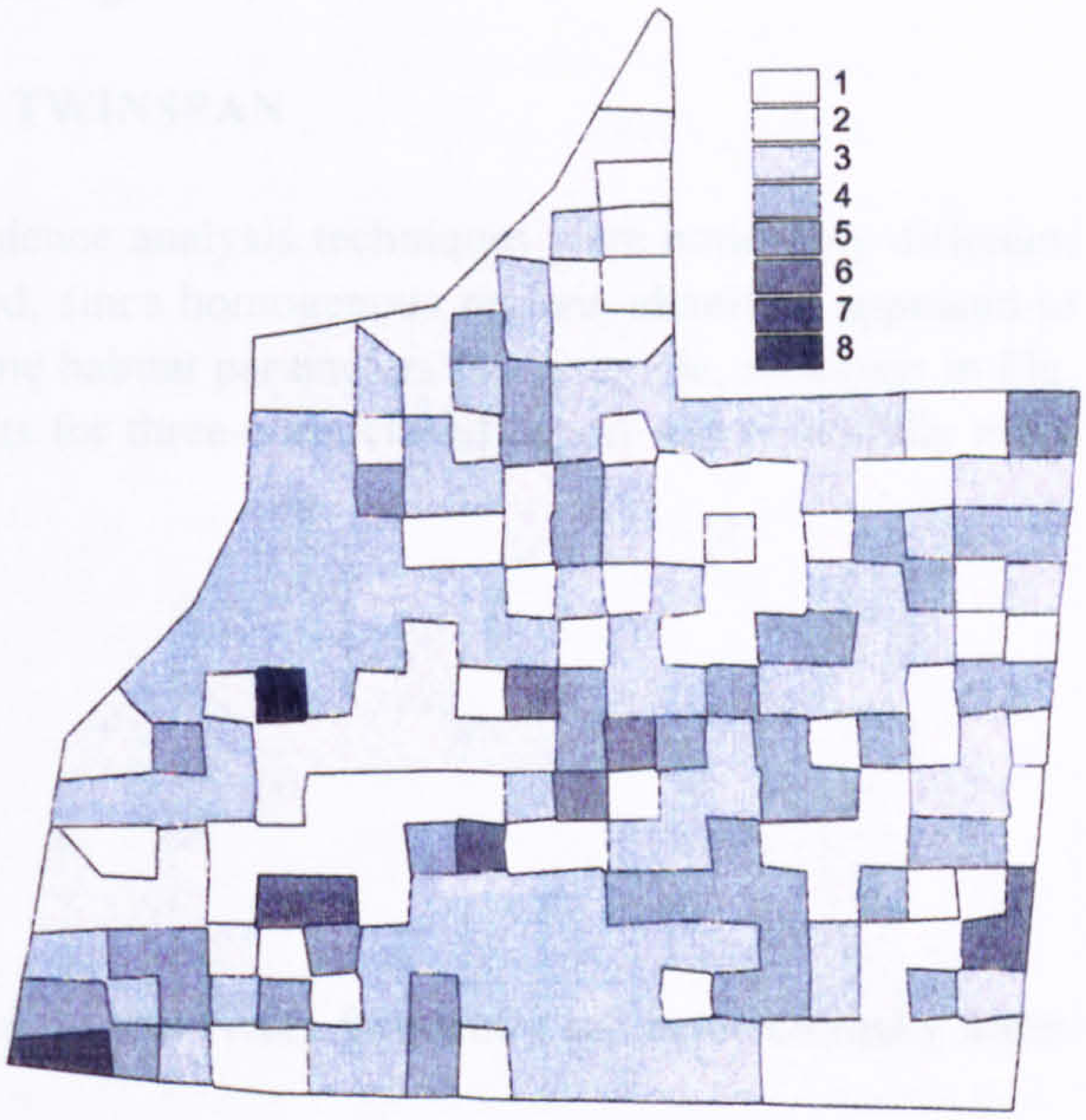


Fig. 4.42 Eight Homogenous Herbaceous Layer Classes Identified by MVSP

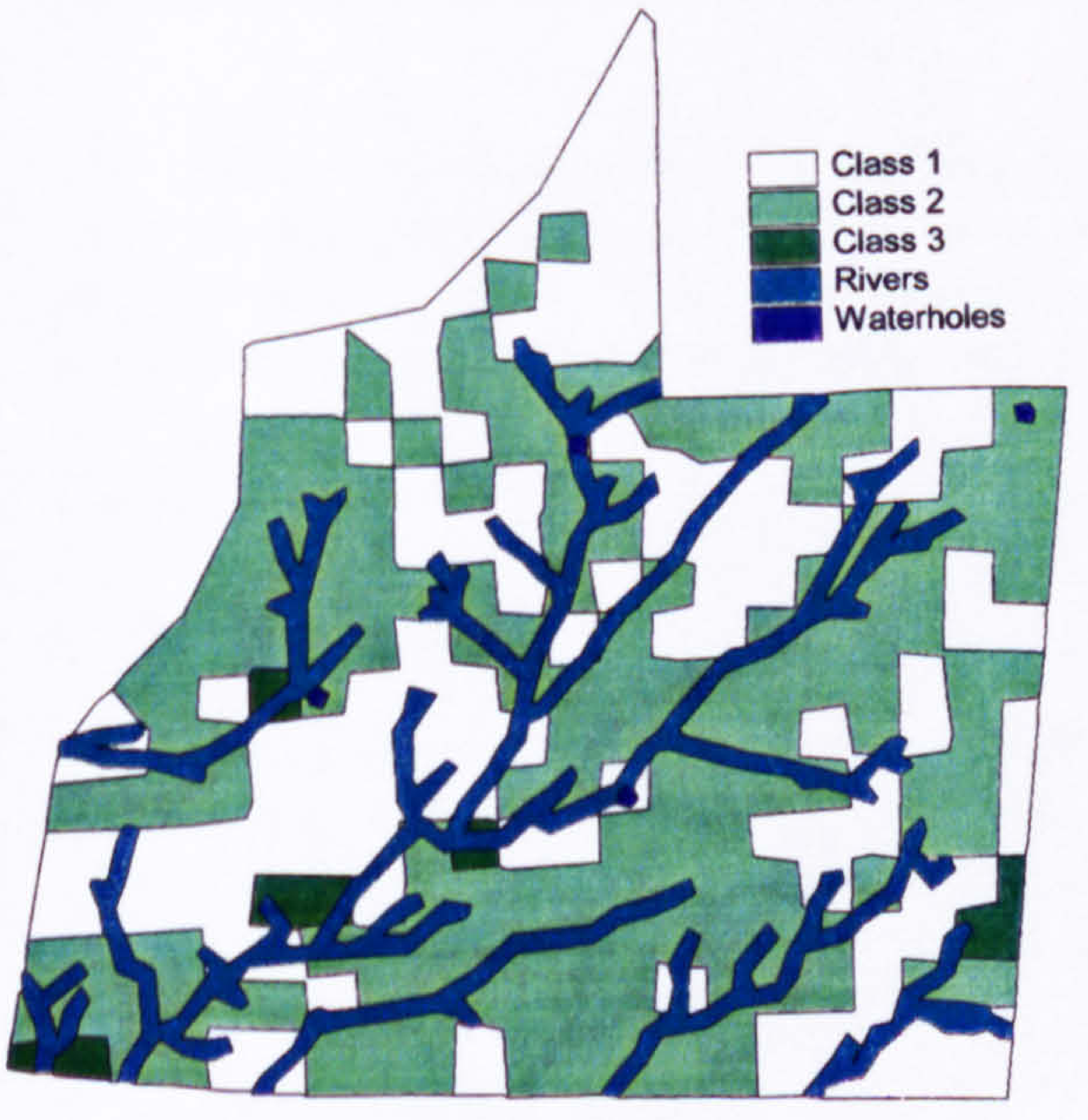


Fig. 4.43 MVSP Three-Class Grass Map With Rivers and Water Holes

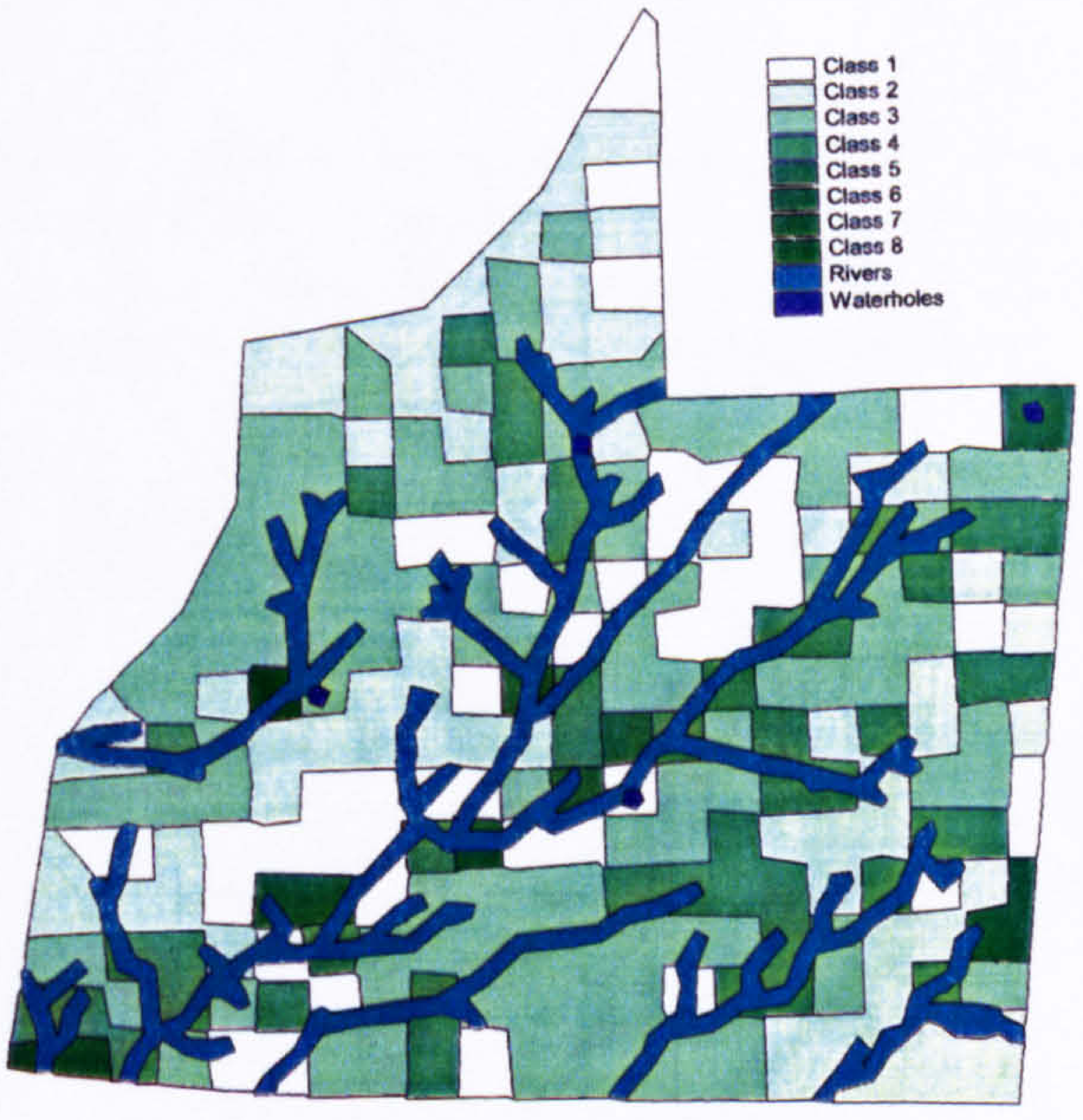


Fig. 4.44 MVSP Eight-Class Grass Map With Rivers and Water Holes

The resulting maps are presented in Fig. 4.41 under the three-class classification, and in Fig. 4.42 under the eight-class classification. The three-class system was preferable as it did not introduce as many rare classes as the eight-class system. These maps were then produced showing additional habitat classes represented by the rivers and water holes (Fig. 4.43 and Fig. 4.44).

c) Comparison Between MVSP and TWINSPAN

Homogenous areas identified by different correspondence analysis techniques were noticeably different. The grass classes identified by MVSP were preferred, since homogenous regions identified appeared to correlate well with spatial distribution patterns of some habitat parameters (for example, rockiness in Fig. 4.30 and Fig. 4.31). Consequently, the MVSP results for three-class classification was potentially more appropriate for analysis of rhino movements.

4.3.3.2 Habitat

i) Visual Analysis

It was apparent when comparing Fig. 4.31 and Fig. 4.37 that rivers frequently ran between rocky areas. No other trends were obvious.

ii) Dendrograms

Habitat ratings were analysed by MVSP and the results given in Appendix VI, Table 7. The dendrogram of the results is shown in Appendix VI, Fig. 5. Characteristics of each class were analysed by indicating what percentage of all observations were in each MVSP class and the results are given in Appendix VI, Table 8. The description of each class is discussed in terms of ratings in Table 4.24.

Table 4.24 **Habitat Classes Identified by MVSP Analysis Described in terms of Ratings.**

MVSP Class	Description of Habitat
1	All low tree savanna. Tree canopy cover mainly low or sometimes moderate. Generally little or no rocky cover, although sometimes medium or high levels of rockiness. Soil classes were all types A or B. Grazing pressure generally high or very high, although sometimes moderate. Slope usually slight, but may also be reasonable or steep. Grass biomass generally low. The grass density index was generally below 10cm, which relates to high basal cover. Forage factors were usually in the medium to low range. These areas include the plateau areas in the north and east.
2	All low tree savanna. Tree cover was variable, but mainly low. Predominantly little or no rocky cover. Soil type mainly C1, but also C2, D or B. Variable grazing pressure, but mainly high or very high. Slope generally slight, occasionally reasonable. Grass biomass was variable, but mainly low. Grass density index was generally between 10 and 20 cm which indicates slightly low basal cover. Forage factors were usually in the middle to upper end of the range. These areas incorporate the undulating plains and open valley areas.
3	Predominantly low tree savanna, occasional grass savanna or shrub savanna. Tree cover mainly low or moderate. Characteristically medium, high or very high rockiness. Soil type dominantly C2, but also C1 or D. Grazing pressure predominantly very high or high. Slope usually reasonable, but often steep and occasionally slight. Grass biomass variable but mainly low. Grass density variable, but generally between 10 and 20 cm. Forage factors were generally in the middle of the range. These characteristics were typical of the rocky areas.
4	Mainly grass savanna or shrub savanna, although may include low tree savanna. Tree cover extremely low, very low or low. Either low or medium rocky cover. Soil type mainly C1, but also A and B. Grazing pressure generally non-existent or low, although sometimes medium. Slope always slight. Grass biomass generally very low or bare ground. Grass density index varied, but was generally less than 10cm. Forage factor classes were consistently low. Only seven transects. These unusual vegetation types were generally found in heavily grazed areas around water holes, or where sheet erosion is a problem.

The resulting distribution map of the habitat classes (Fig. 4.45) correlated well with differing habitats identified from personal knowledge of the area. Class 1 related to the north and north-eastern plateau areas and class 2 generally represented the undulating plains. Rocky areas were generally class 3. This map was subsequently improved by superimposing maps of the water holes and rivers, Fig. 4.46.

4.3.3.3 Trees

i) Visual Analysis

Mopane trees and shrubs were the dominant species in the area and occurred in the majority of the transects (Fig. 4.26). In the areas where *Mopane* was absent, *Acacia* species were often present (Fig. 4.27). *Terminalia* and *Combretum* species were often found together. In areas where *Terminalia* (Fig. 4.28) and *Combretum* (Fig. 4.29) species were present, *Acacia* was generally absent.

ii) Dendrograms

Occurrence of the six tree species was analysed by correspondence analysis and the results are detailed in Appendix VI, Table 9. Four homogenous areas were identified following correspondence analysis of the transects (Appendix VI, Fig 6). Each class was described in terms of their percentage of presence or absence values for each tree species in Appendix VI, Table 10. A description of each class is provided in Table 4.25.

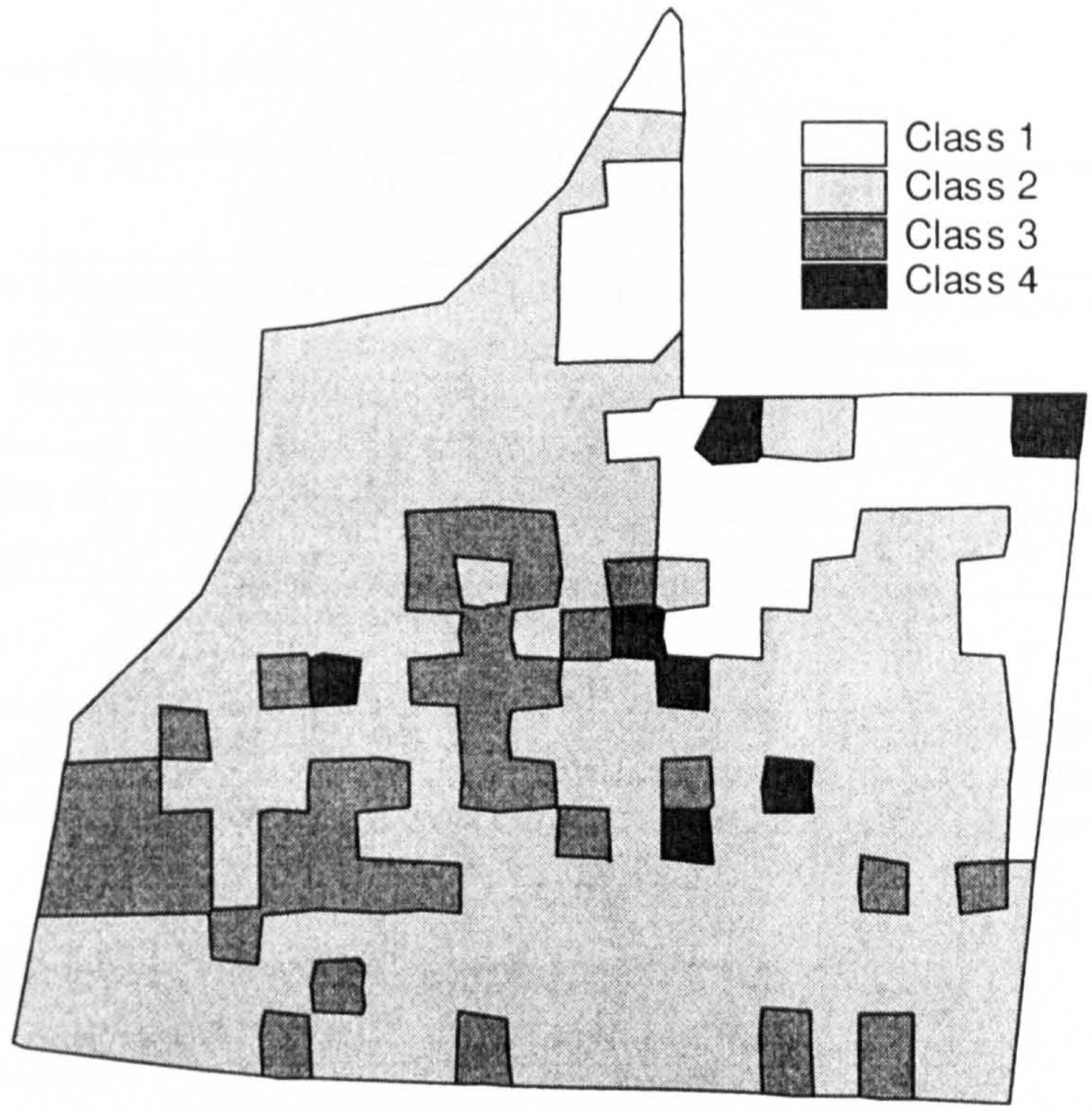


Fig. 4.45 Homogenous Habitat Classes Identified by MVSP

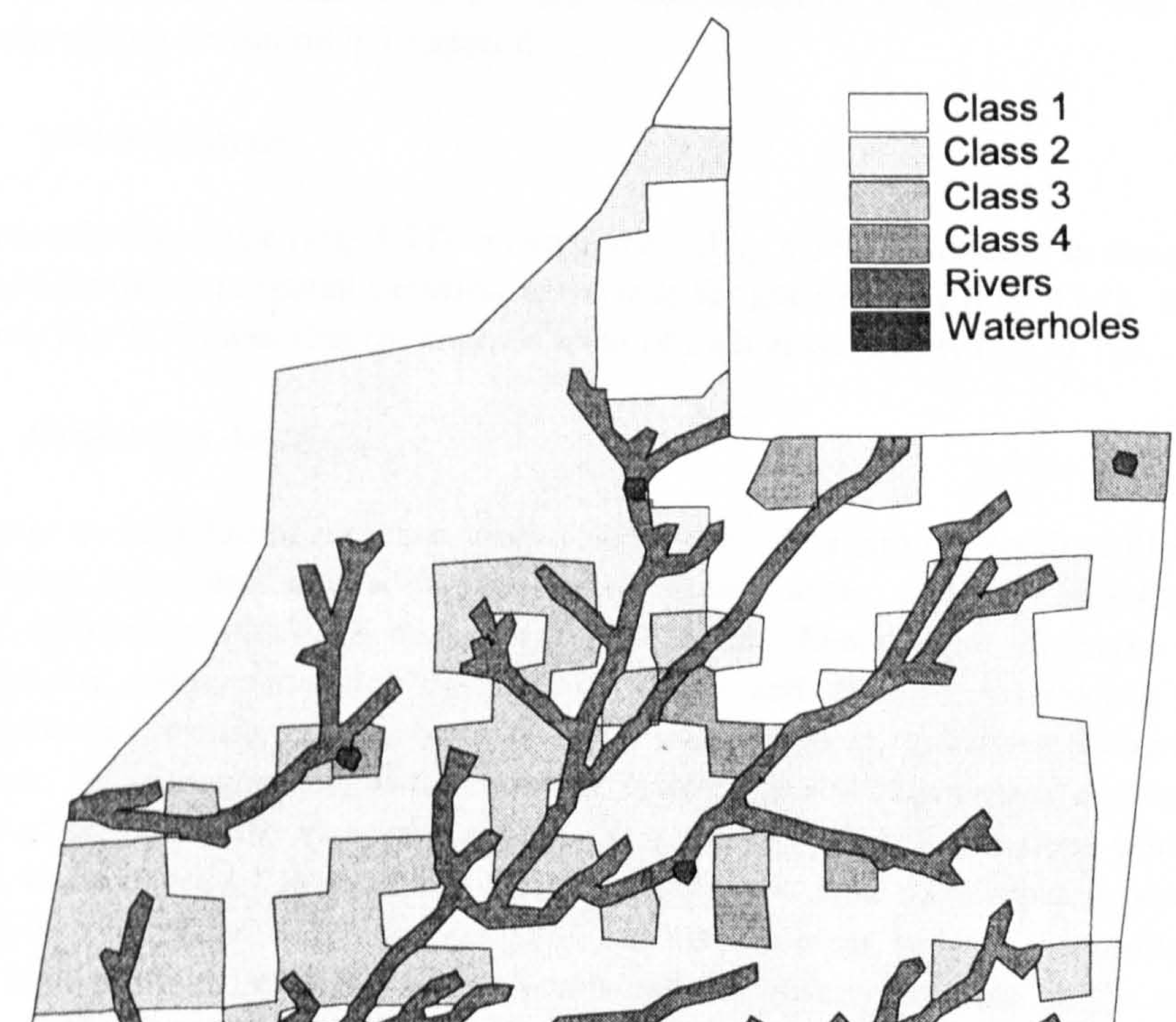


Fig. 4.46 MVSP Habitat Classes Map with Rivers and Water Holes

Table 4.25 **Tree Classes Identified by MVSP Analysis.**

MVSP Class	Description of Tree Species
1	Generally a *Mopane* area, however *Catophractes*, and occasionally *Boscia* were present.
2	*Mopane* was the dominant species, with other species usually absent.
3	*Mopane, Terminalia, Combretum, Acacia* and *Boscia* were all generally present.
4	*Combretum* and *Boscia* were occasionally present and the other species were generally absent. This class was represented by six transects and were generally located in areas with low tree cover.

The distribution of these tree groups across the area are shown in Fig. 4.47. Homogenous areas identified were more random than other maps of homogenous areas and it was not possible to identify any trends at this stage. This map was enhanced with additional classes of rivers and water holes in Fig. 4.48.

4.3.3.4 Relationships between Grass, Habitat and Trees

i) Grass and habitat

Comparing the three-class MVSP map of herbaceous layer (Fig. 4.41) with habitat class (Fig. 4.45), it was apparent that classes which occurred infrequently (representing only a few transects), were not in the same locations. There was a reasonable visual correlation between the classes, however in some areas no similarities between different classes were evident. Consequently, these classes will be considered separately to analyse rhino utilisation in Chapter 6.

a) Visual Analysis

Grasses were generally less dense (Fig. 4.17) in rocky areas (Fig. 4.31). Variations in forage factors (Fig. 4.18) indicated similar trends in spatial variation as the map for grass density (Fig. 4.17). It would appear that grass biomass (Fig. 4.19) was slightly lower in areas of high grass density (Fig. 4.17).

b) Ordination Analysis

Ordination analysis was conducted on grass species and habitat data and the result is illustrated in Fig. 4.49. Grass species associated with rocky, generally sloping areas, include *Fingerhuthia africana, Melinus repens, Aristida stipitata, Enneapogon cenchroides, Enneapogon desvauxii* and *Aristida congesta*. *Eragrostis echinochloidea, Pogonarthria fleckii* and *Eragrostis annulata* appear to be associated with grazing pressure. *Stipagrostis hochstetterana, Cenchurus ciliaris, Eragrostis superba, Eragrostis rigidior, Heteropogon contortus, Urochloa brachyura* and *Stipagrostis uniplumis* vary with the forage factor of grasses in the surrounding area. The quantity of rock and slope were very closely related, which is to be expected as generally the more rocky the area the steeper it becomes. These parameters are inversely related to grazing pressure, because as areas become increasingly rocky and steep, they also become more inaccessible for animals and the grazing pressure on the area decreases. None of these physical parameters are related to the forage factor or index of grass density.

Of the dominant species, *Schmidtia kalahariensis* (Fig. 4.10) has a tendency to avoid rocky areas (Fig. 4.31). *Eragrostis nindensis* (Fig. 4.12) was found in increasingly rocky areas (Fig. 4.31). In areas where *Eragrostis nindensis* was common, *Anthephora schinzii, Aristida andscensionis* and *Enneapogon desvauxii* were often present.

Fig. 4.47 Homogenous Tree Species Classes Identified by MVSP

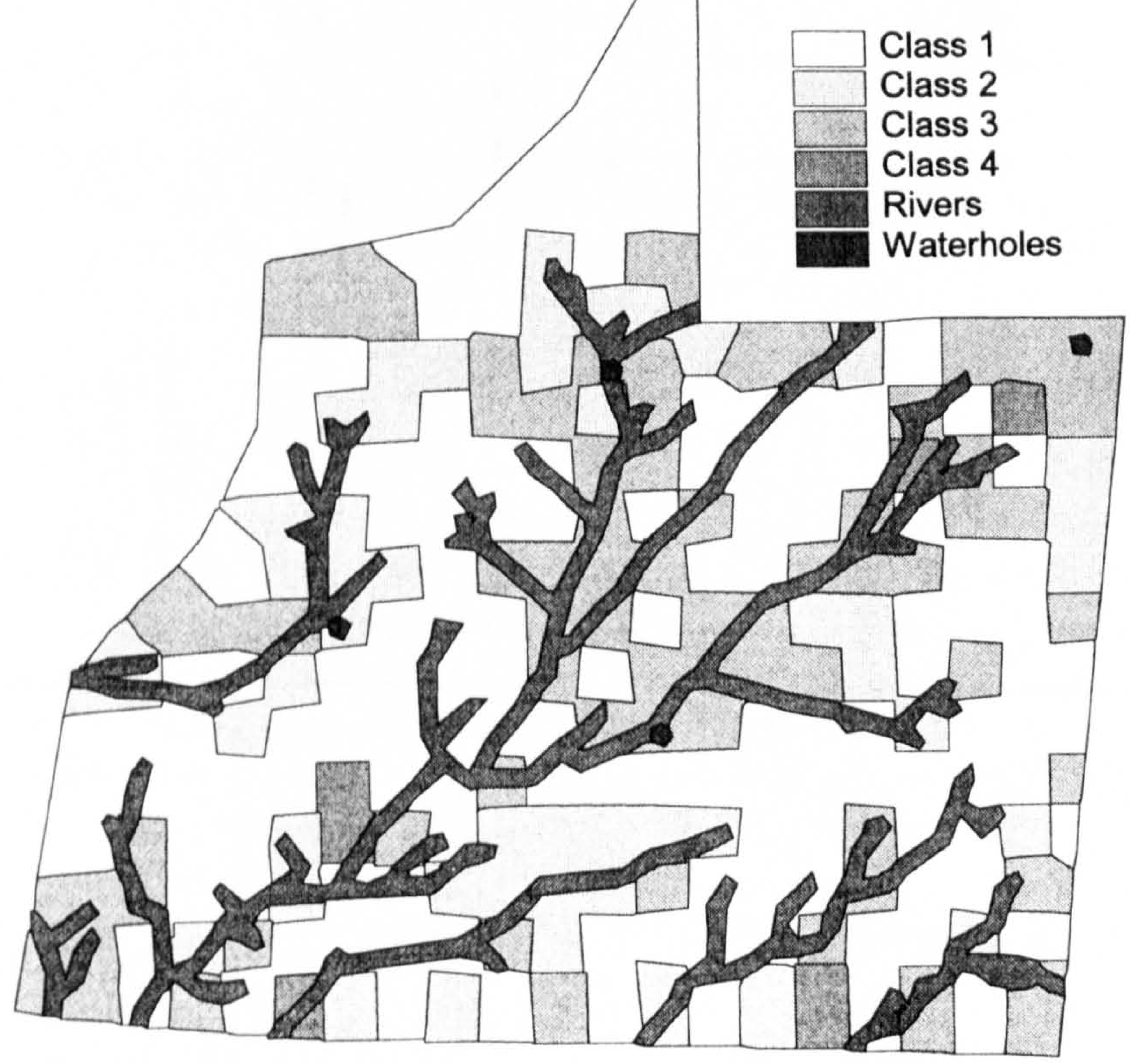


Fig. 4.48 MVSP Tree Species Classes Map with Rivers and Water Holes

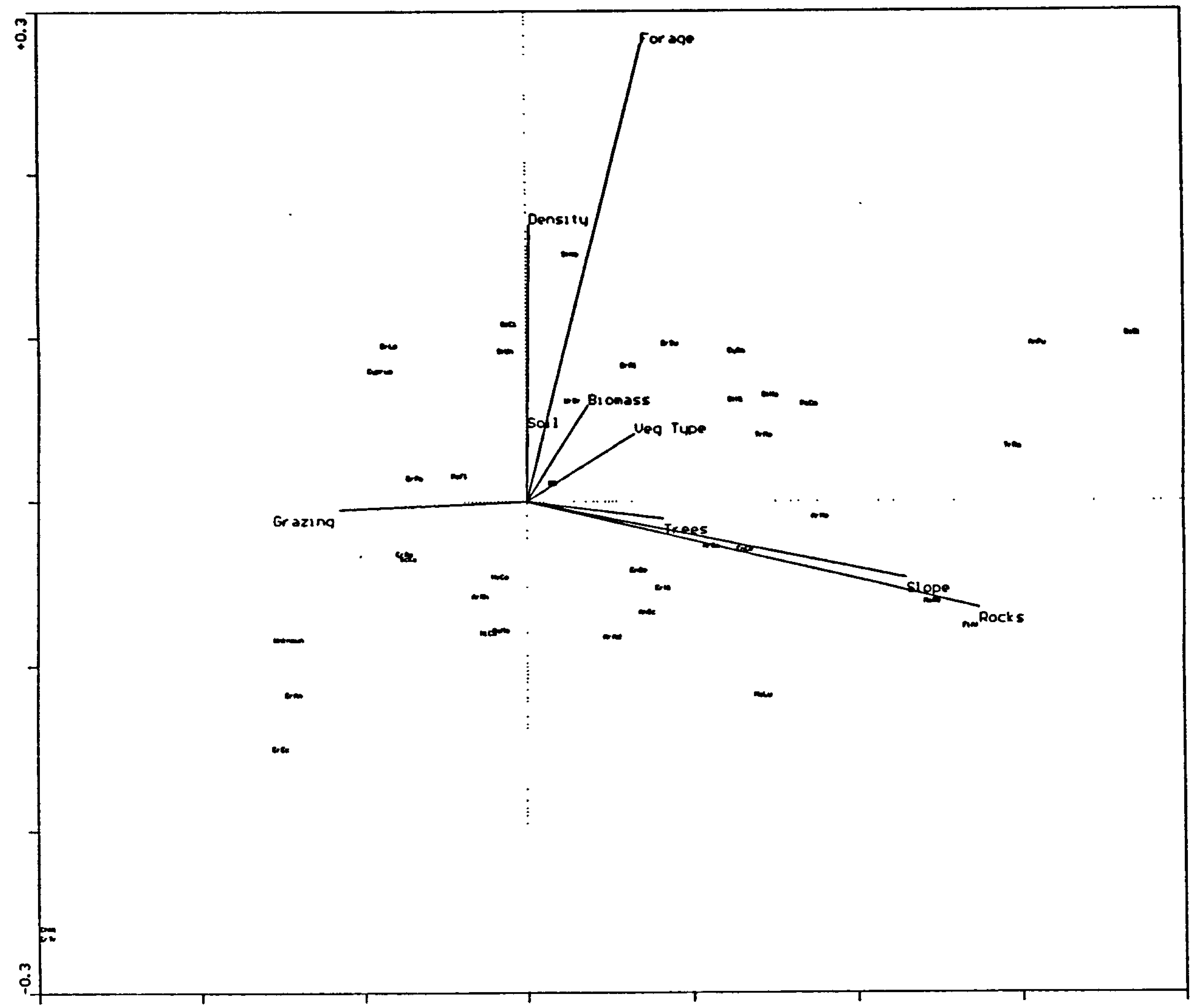


Fig. 4.49 Ordination of Grass Species and Habitat Data

ii) **Grass and Trees**

Comparing three-class grass map (Fig. 4.41) and the tree class map (Fig. 4.47), there appears to be little spatial correlation between classes.

iii) **Habitat and Trees**

Ordination analysis was completed and the result is illustrated in Fig. 4.50. However tree presence was recorded on a binary scale, which was not ideal for continuous analysis. *Combretum* species preferred areas which are slightly associated with rocks and slope. *Acacia* species were apparently associated with grazing pressure, which may be expected as it is often also found in drainage areas near to rivers.

Comparing the map of the tree classes (Fig. 4.47) with habitat classes (Fig. 4.45), no similarity in the spatial distribution of classes was apparent.

4.3.4 Limitations

i) The area of Kaross was calculated in this study as 15,066ha using the EEI map, but was calculated as 14,901ha from the map of rockiness which was based on the topographical map. This was because the rockiness map was digitised separately and the boundary fence locations varied slightly, reducing the apparent total area enclosed.

ii) Following the mapping of the habitat survey it was found that additional transects along the western boundary of the area should have been completed (Fig. 4.8).

iii) Although 257 transects were considered sufficient for this investigation, if the locations of many smaller features including rivers, water holes and rocks were required to be plotted, a significantly higher density of transects would have been necessary, possibly separated by 25 metres or less.

iv) Interpolating herbaceous and habitat data between transect locations using GIS had several limitations. The resolution was insufficient to show gradients, or to indicate that a particular transect was unique in a particular area. Interpolated results lose accuracy towards the boundaries of Kaross as the technique continues the trend observed in the marginal transects, therefore often creating an unusually high or low score in these areas. This was especially evident on the western side of the area.

v) The standard error of the Magellan hand-held GPS was reported as ±50m. It was noted that while remaining stationary, with 3 dimensional resolution, there were fluctuations in the fix location. This was quantified to assess the significance in three ways:

- The standard deviation of the co-ordinates obtained for all the water holes on different occasions provided an average error of 209.2m, see Table 4.26, which was much higher than expected.
- When a transect position was located the discrepancy between ideal and actual GPS values had a mean value of 25m, with a median error of 24m, see Table 4.27. Few errors greater than 60m were recorded (5), the largest error was 293m in transect 44, the second largest was 130m in transect 26.
- Root-mean-square error identified during the preparation of the base maps was given as 183m and 196.4m.

These sources of error could affect any of the GPS locations and therefore it has been estimated that an error of less than 100m could be expected on each transect.

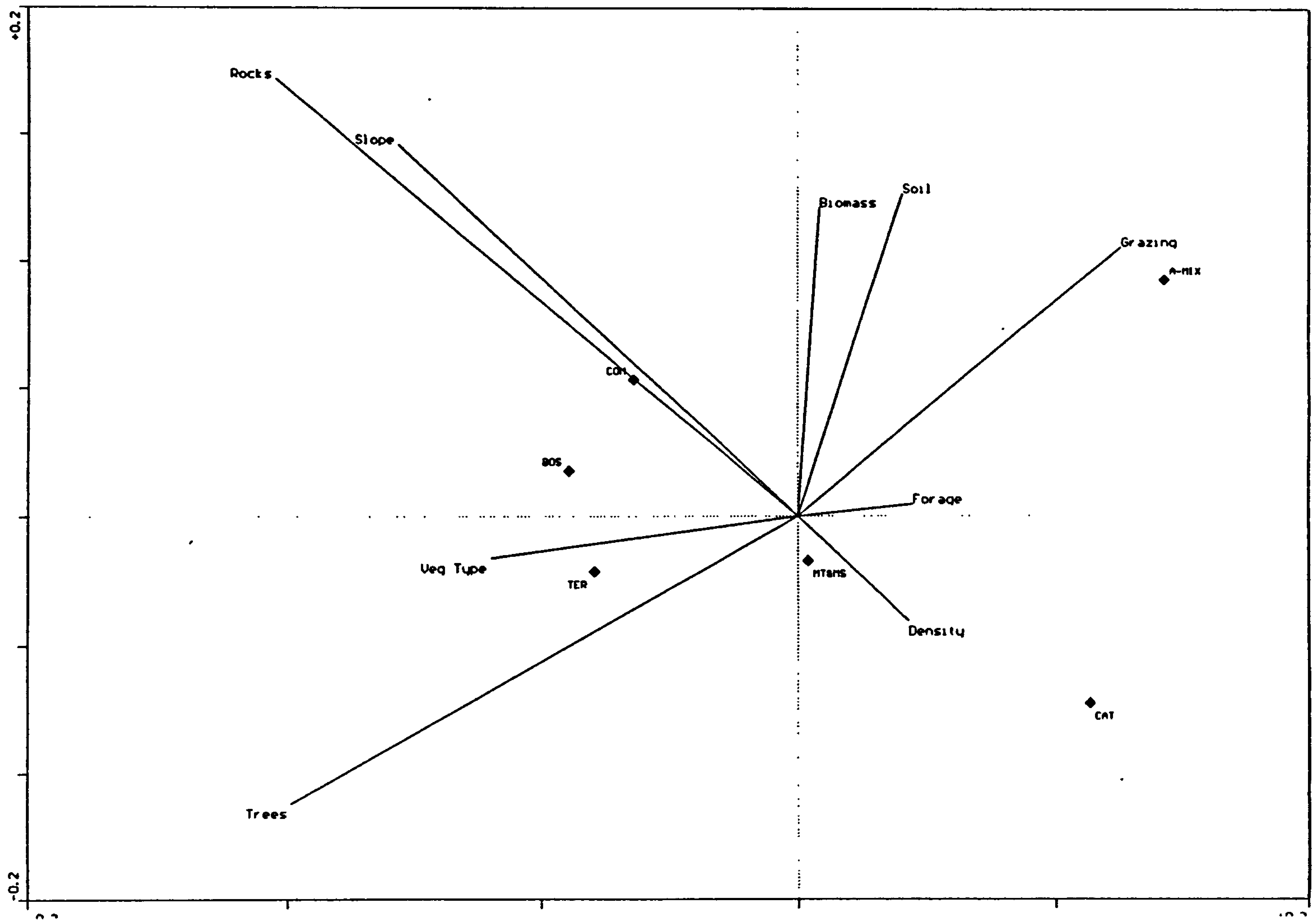


Fig. 4.50 Ordination of Tree Species and Habitat Data

Table 4.26 Standard Deviation of GPS Error on Water Hole Fixes

Water Hole	Number Fixes	Mean Co-ordinate	Standard Deviation of Co-ordinates	Average Standard Deviation
KarossHoek	9	456836	39.7	51.5
		7862495	63.3	
KarossFontein	5	450884	180.0	155.7
		7857111	131.3	
KarossDrink	4	450288	354.1	550.2
		7862191	746.3	
ZebraPomp	4	446424	48.1	79.5
		7858648	111.0	

Table 4.27 Discrepancy between Ideal and Actual GPS Values

Value	Result (Metres)
Mean	25
Median	24
Maximum	18
Standard Deviation	293

vi) To minimise error when digitising the maps, base reference points for GIS would preferably have been on or beyond the boundary of the study area. However no such positions were available, therefore the water hole positions were used. Several fixes were recorded for all water hole locations during the survey. This problem arose since it was originally thought that co-ordinates were identical to those used by EEI, and would therefore be compatible. However the grid systems were found to be different. In retrospect, it would have been preferable to have determined GPS positions of the corners of the area to use as reference points. This would have provided greater accuracy since they are at a greater distance apart than the water holes.

vii) This habitat survey was conducted over three months, being completed in August. As time progressed, there was an increase in the number of grasses that could not be identified. This may have been caused by grazing over the period.

4.4 Discussion

Kaross has a varied landscape with hills and valleys, and distinct plateau regions in the far north and east of the area. Towards the southern and western regions, rocky valleys line wide dry river beds. In the south there are undulating plains dotted with kopjes, and riverbeds which stretch for kilometres. A similar landscape is found in the north-western area.

This survey represents the first intensive assessment of the habitat in Kaross. It was carried out by establishing a regular grid of 257 transects covering the whole area, and investigating individual herbaceous layer and habitat parameters across these. Homogenous areas were identified by correspondence analysis and enhanced by superimposing rivers and water holes as additional classes. Multivariate associations between dependent variables (e.g. grass species and density) and independent variables (e.g. vegetation type, soil type and rockiness) were established. All of these parameters were then detailed on spatial maps. Rhino utilisation will be analysed with respect to these maps in Chapter 6.

4.4.1 Herbaceous Layer

Field techniques used during this survey were adapted from standard procedures designed by vegetation ecologists to assess veld condition, monitor vegetation change (Dankwerts & Teague 1989) and assess quantity of biomass before burning (Du Plessis 1997). The principles of these monitoring techniques have been established (Tidmarsh & Havenga 1955; Bransby & Tainton 1977) and are widely applied across southern Africa, although the basic methods have been varied and adapted for specific studies (Dankwerts & Teague 1989; Foran *et al.* 1978; Walker 1970). This study aimed to establish the main factors influencing rhino selection of habitat and grazing area and was not part of a veld monitoring programme. Consequently, where appropriate, basic techniques were adapted to meet this goal and also accommodate the conditions of a semi-arid environment. A brief appraisal of each technique and explanations for any adaptations has been provided below.

i) Grass Species Occurrence, Distribution and Density

While studying the distribution of grass species it was also important to consider their characteristics. The most dominant species in Kaross (31%) was *Schmidtia kalahariensis* which is an annual grass. It was described by Bothma (1989) as an undesirable grass species, often used for veld reclamation in arid areas. The second most common grass (27%) is the perennial species, *Stipagrostis uniplumis* which is also used for veld reclamation in arid areas (Bothma 1989). This grass has been described as highly desirable (Bester *unpublished*). Other grass species include *Eragrostis nindensis* (14%) which is a perennial grass. *Aristida adsensionis* (6%) an annual which has been described as an undesirable grass species (Bothma 1989). Finally, *Eragrostis porosa* (3%) which is also an annual grass.

The occurrence of grass species was often localised depending on the habitat. Near riverbeds, certain species including *Cenchrus ciliaris*, *Cynodon dactylon* and *Cyprus* were particularly common. On areas which were heavily trampled, for example near water holes or where sheet erosion has washed away the top soil, other species were present, the most common being *Acacia* thorn bushes. Distinctly rocky areas, particularly those with a sloping surface, favoured species such as *Anthephora pubescens* and *Fingerhuthia africana*. On the rolling plains the most common species was *Schmidtia kalahariensis* and *Stipagrostis uniplumis*, while the plateau areas in the north and east of Kaross often had predominant *Eragrostis nindensis* and *Anthephora schinzii*.

To carry out the survey, a wheel-point apparatus was used. This basic technique was first described by Tidmarsh & Havenga (1955) and was subsequently adapted to the step-point method (Mentis 1981) and the 'rod method' (Du Plessis 1992). In Kaross the wheel-point system was selected as the main technique, however where appropriate it was adapted to a combination of the methods of Du Plessis (1992) and Mentis (1981). A grid system of transects was introduced, using GPS guidance to their locations to provide an additional element of uniformity. The sampling grid provided a fairly crude level of resolution as demonstrated by the rockiness and soil parameters mapped in the habitat section. This limitation is a recognised result of spot sampling. The basic requirement of systematic location points well distributed over the area was of primary concern.

It was decided that approximately 250 transects across the area would provide a reasonable frequency and distribution of locations. A previous study by Du Plessis (1992) investigated the herbaceous species in Kaross as part of a larger study of the vegetation in Etosha. His survey incorporated 66 transects from visually identified variations in vegetation, reflecting biotic and abiotic factors. It would be possible to compare the results of these surveys to identify changes in the herbaceous layer over the years as part of a veld monitoring investigation.

In each transect 100 sampling points were taken to be sufficient for this research objective, which generated some 25,700 sampling points overall. This sampling frequency was recommended by Hardy and Walker (1991) as adequate in terms of the minimal requirement for coarse management scale investigations, whereas for monitoring purposes they advised sampling 200 points in each transect.

Criticisms of recording solely the nearest plant to point (Snyman *et al.* 1990), led Du Plessis (1992) to first record the nearest species and then, if this was not a perennial, continue to note the nearest perennial species to the spike. Du Plessis adopted this technique since in arid areas the abundance of annual plant species fluctuates greatly in comparison with perennials, especially after the rains. In addition, the perennial component of grassland is more stable therefore providing a more accurate reflection of the long-term stability of a community (Muellor-Dombois & Ellenberg 1974). This factor may be an important consideration for long term monitoring but was not considered necessary for studies on rhino grazing.

Grass species were rarely recorded beyond 400mm distance from the spike, although the limit assigned to grass presence was 1000mm. Where the closest grass did occur beyond 400mm it was generally in areas of high surface rock, or where sheet erosion (removal of layers of top soil) was severe. In the study by Du Plessis (1992), grass species were only recorded within 400mm circumference of the point. By recording species beyond this limit, additional information was provided for the index of grass density.

Forbs were described by Riney (1982) as nutritious and forming part of the diet of grazing animals. However, Du Plessis (1992) did not regard forbs as an important food resource for most grazers in Etosha. As a result they were ignored, although a note was made of their presence if seen in a transect.

Low ground cover of grass in Kaross was clearly evident, with the average distance between the spike of the wheel-point apparatus and the nearest grass species being 154mm. Consequently, although basal cover can be calculated from the number of strikes recorded in each transect (Tidmarsh & Havenga 1955), the results would have been less accurate due to the low number of strikes. Mentis *et al.* (1980), considered that deriving basal cover from the number of strikes was inaccurate and time consuming. Accuracy levels using this technique improved the calculation of grass density in arid grasslands (rainfall < 400mm), with repeatable estimates of density being obtained with as few as 80 sample points (Stuart-Hill, *unpublished data*, reported in Danckwerts & Teague 1989). However, for the purpose of clearly mapping variations in the density of vegetative cover, it was decided that averaging the overall distance between the spike and the grass was the preferred technique to establish an index of density.

ii) Forage Factor

Forage factors have been assigned to each grass species occurring in Etosha by Du Plessis (1992). He adapted the rating technique of Trollope (1990), to incorporate an assessment of the potential of a species to produce acceptable material for intermediate or bulk grazing animals in Etosha. However, forage factors do not indicate the amount of forage or the density of grasses available at any instant in time (Du Plessis 1992; Mentis 1984).

Overall the average forage factor calculated for all the transects in Kaross was 299.8. Du Plessis (1992) used the following scores to represent a general condition for the area: very low 0-110, low 111-220, medium 221-330, high 331-440, very high 441-550 and extra high >500. Kaross therefore falls in the medium range for condition score. However the survey technique of Du Plessis (1992) which formed the basis of these classes differed from the method used in this study. Du Plessis (1992) included forbs and more detailed recording of perennials. This survey included *Cyprus* and unidentified grass species, both of which had unknown forage factors. Consequently, although the use of Du Plessis condition scores is not strictly valid, occurrence of the factors representing any discrepancy were minimal and would have had little effect on the overall score.

iii) Herbaceous Standing Crop

Bransby and Tainton (1977) described the Disc Pasture Meter as a simple inexpensive instrument which provides estimates of standing forage, forage intake, utilisation and grazing patterns. It has been used in Etosha to monitor grazing pressure and assess the suitability of the veld for burning (Du Plessis *in press*). When it was found possible to reliably estimate DPM measurements, it was considered not necessary to carry the apparatus in the field, and rapid estimates of biomass ratings were possible. During this study it was used to provide an indication of available biomass of grass in particular areas which may influence rhino grazing activity.

iv) Visual Assessment of Veld Condition

Grazing pressure was noticeably greater in valleys and riverbed areas because these areas have access to water for slightly longer periods and they act as a run off trap for nutrients from surrounding areas and riverbeds (Bothma 1989). In certain valleys, overgrazing and trampling were readily apparent. According to Bothma (1989), this may result in reduced veld capacity, bush encroachment and soil erosion.

Comparing Kaross with adjoining farms clearly indicated that Kaross was experiencing less grazing pressure than these outlying areas. An excess of animals which may cause overgrazing has occurred in the past, for example in the late 1970's the more sensitive species such as Roan antelope were in poor condition and dying of malnutrition. As a result a number of grazers were removed during a culling operation (A Cilliers, c/o MET Head Office, Windhoek *pers. comm.*). During 1996, the removal of many more grazers took place and it is planned to remove more animals in the future, possibly for sale at auction.

Controlled burning of the veld has been recognised as being very important in maintaining the current vegetation communities (Du Plessis 1997). The last burn in Kaross was in 1994 in the north-western corner, mainly covering the area north of Zebrapomp to the main gate.

4.4.2 Habitat

i) Vegetation class

The vegetation classification scheme adopted for this survey utilised the same classes as the satellite monitoring technique which was used to map vegetation types in Etosha (Sannier *et al.* 1998). This technique, based on assessing the structure of the vegetation, was also generally applicable to this study and easily repeatable in the field. However, this classification scheme identified the majority of Kaross as low tree savanna. Although applicable to the vast area of Etosha, it was not sufficiently sensitive to identify the distribution of vegetation classes in Kaross.

The maps of vegetation classification created by satellite monitoring techniques (Sannier *et al.* 1998) did not correlate well with classes identified personally. Consequently, for the purpose of this study it was decided that personal assessment of vegetation classification was preferred, as this was known to be accurate and ratings correlated with other habitat parameters collected at each transect.

ii) Tree Species and Cover

Following the survey it was readily apparent that the dominant tree species in the area is *Colophospermum mopane. Acacia* species were common in well utilised areas by rivers, drainage channels and near water holes. Tree species were included in analysis as an indication of habitat types which may subsequently influence rhino utilisation.

iii) Rockiness

From the survey it was established that almost half the area of Kaross contained some degree of rocks. To analyse rhino movements a rockiness map with high spatial resolution was essential, therefore one was created from the topographical map. Rockiness data were used for correspondence analysis.

iv) Soil

To assess the soil personally, using a relatively rapid technique but without experience or assistance, was considered not feasible within the duration of the survey. The research of Beugler-Bell (1996) produced detailed maps of soil types, within and beyond the area of Kaross and these maps provided good accuracy. Soil type D was distinctly related to riverine areas. Soil types also correlated well with areas of homogenous grass and habitat which were identified by correspondence analysis.

v) Landscape

Certain features of the landscape, particularly rivers and water holes have a very marked effect on the habitat and herbaceous layer. Consequently the accurate inclusion of these areas in the map of the region was very important. It was recognised that the resolution of the survey grid was too coarse to locate these features precisely, however the topographical map provided valuable data. The accuracy of the topographical map was excellent, with landscape features providing good references to locate exact positions of water holes and rivers.

4.4.3 Homogenous Areas, Habitat and Tree Areas

In Kaross, visual comparison, ordination and correspondence analysis have identified several relationships between geological formations, soil types and plant communities. For example, the index of forage factor complements the index of grass density since it is often found that in inaccessible areas (e.g. rocky and steep), grass species have a higher forage factor but are sparsely distributed.

Visual analysis between maps, to identify any trend or correlation between individual parameters was relatively unsuccessful. The high level of small scale variation in habitat across this area was possibly creating too much 'noise' or confusion to enable corresponding parameters to be identified.

The ordination technique was valuable for identifying species or transect associations, particularly since the data were on a two dimensional axis. With an ordination plot, points may be linked by visually circling distinct groups of data. However, appraising the extent of distinct data groups is subjective and would have been difficult due to the close association between the majority of transects in these circumstances.

Consequently, cluster analysis was the preferred technique, since during analysis it divides the variables according to what it perceives as separate classes. Dendrograms were created using two techniques, which used different procedures to force associations between parameters. MVSP was regarded as the most appropriate technique for this analysis, since it identified herbaceous layer communities which correlated well with areas which had been identified as separate communities by Etosha's vegetation ecologist (Du Plessis *unpublished data*). The three-class MVSP classification system identified both dominant and rare combinations of herbaceous species, which were representative of the situation in the field. The eight-class system provided additional detail and identified several unique homogenous areas of grass species which were only found on a few transects. The eight-class classification was not thought appropriate because of the error introduced by these rare transects.

Classification into areas based on tree species presence or absence was completed to identify whether these results were similar to the habitat or grass homogenous areas maps. Although certain homogenous areas were identified as covering similar regions across both maps, no clear trends were identified.

Chapter 5

White Rhinos in Kaross

5 White Rhinos in Kaross

5.1 Introduction

5.1.1 Background

In February 1994, seven adult rhinos (2 males and 5 females) were translocated from the game farm Ohorongo to Kaross. Information on the conditions and management on Ohorongo which led to their relocation, are described in Chapter 2 and in Appendix IV.

Since their release, the rhinos have been infrequently monitored. It was thought that no calves had been born and two animals were found dead of unknown causes in early December 1995. These remaining individuals were marked with ear notches to identify each animal and de-horned to deter poachers. Further information on the history of these animals is included in Chapter 3 and in Appendix V.

This study began in April 1996 and was intended to study the movements and behaviour of the rhinos, primarily to collect information to analyse rhino utilisation in Chapter 6, and also to attempt to identify reasons for the lack of successful recruitment. The study group comprised five rhino including two males (numbered one and two) and three females (numbered one, four and five).

Other species in Kaross included kudu (*Tragelaphus strepsiceros*), blue wildebeest (*Connochaetes taurinus*), red hartebeest (*Alcelaphus buselaphus caama*), mountain zebra (*Equus zebra*), giraffe (*Giraffa camelopardalis*), eland (*Taurotragus oryx*), roan (*Hippotragus equinus*), gemsbok (*Oryx gazella*), black faced impala (*Aepyceros petersi*), black rhino (*Diceros bicornis*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), hyena (*Crocuta crocuta*) and one springbok (*Antidorcas marsupialis*). Smaller mammals include black-backed jackal (*Canis mesomelas*), baboons (*Papio ursinus*), warthog (*Phacochoerus aethiopicus*), porcupine (*Hystrics africae-australis*), honey badger (*Mellivora capensis*) and aardvark (*Orycteropus afer*). Although the area was managed to exclude them, occasional sightings or signs of elephant (*Loxodonta africana*) and lion (*Panthera leo*) have been recorded.

5.1.2 Aims

Although Kaross was considered to be potentially marginal habitat, it had not been necessary to provide the rhinos with supplementary feed since their release. Consequently, their behaviour and movements are primarily a function of the available habitat. The principal objectives of this investigation were:

- To map the movements of each individual rhino with respect to type of activity, during the three climatic seasons of the year.

- To study general activities of the animals, for example the locations and frequency of drinking, mud-wallowing and dust baths and the locations and descriptions of preferred laying or resting areas.

- To try to identify any possible reasons for lack of recruitment success by studying inter-relationships and behaviour patterns between the animals. Details would include whether mating occurs, patterns of associations and behaviour of any paired animals within groups.

- To collect information to enable assessment of rhino utilisation patterns in Chapter 6, by relating rhino activity to herbaceous layer and habitat parameters.

5.2 Methods

5.2.1 Observational Techniques

An initial survey of Kaross was undertaken during November 1995. It was found that the rhinos could often be located by following or tracking fresh footprints or spoor from the water holes. While following spoor it was possible to deduce the activity of the animal, for example whether the rhino was grazing or walking, by the distance between steps and the general direction of movement. The rhinos were usually resting by the time they were sighted. They were very sensitive to the presence of an observer and were easily disturbed. Based upon these characteristics, techniques were devised to collect data using two procedures, designated **indirect** observations and **direct** observations.

i) Indirect Data Collection by Tracking

Searching for the tracks or spoor of rhino began at sunrise, when there was just sufficient light to detect and age spoor clearly. Spoor less than ten hours old, sufficiently recent to be termed 'fresh', was located at water holes, which the rhinos usually visited during the night. Initially, tracking attempted to rotate observations on a daily basis between each individual rhino, however it was not always possible to ascertain which animals had produced the spoor. Consequently, every second day, different water holes were selected and spoor leading from these locations were assigned priority. During the rainy season this technique was varied as rhinos visits to the water holes were less frequent.

Fresh spoor was identified by looking for changes that occur as the imprint ages, primarily due to the effect of wind but also caused by other disturbances. These changes are mainly noticeable in the colour and definition of the creases and outline of the foot. Further estimates of the time since the rhino had passed could also be obtained from the gradual drying of grazed grass and from dung and urine deposits.

While trying to find and employ a suitable tracker for this field work, several different tracking techniques were observed. Some trackers looked for footprints in the near distance and followed the general direction of movement. Others did not waste time examining a criss-cross of tracks in a grazing area; instead they walked in a large circle around the area until they found where the rhino had moved away. When a tracker was eventually selected and employed for this project, he was asked to trace the spoor step by step, independent of the activity of the rhino. This provided a clear indication of whether the rhino was walking or grazing, by assessing the distance between the spoor. Although time consuming, it was possible to see exactly where the rhino had stood and therefore where its head would have been, to look for evidence of the grass species grazed. This technique also facilitated the logging of regular, detailed activity records with events such as defecating and spray urinating. Only in the event that the track was not discernible would the tracker walk around at various distances, radiating out from the point where it was lost. Depending upon the substratum, the spoor might then be found at a later point or lost.

a) Seasonal Variations

Three seasons were used in this study as identified by Berry (1980). These were:

i. the hot and wet season from January to April,
ii. the dry cool season from May to August,
iii. the dry hot period from September to December.

In the **wet season**, fresh water was readily available in the field at mud holes (Fig. 5.1) and recesses in rocks (Fig. 5.2). Since this water was available, the rhinos often did not visit the permanent water holes at night. Consequently at this time of year, searches for spoor were also carried out on the roads, at water

Fig. 5.1 Seasonal Mud Hole in a Natural Depression

Fig. 5.2 Recesses in Rocks, Which Provide Seasonal Water Sources

holes and on foot through the large areas without roads. Areas frequently utilised by the rhinos were identified and these were walked across whilst looking for spoor.

During the **dry season**, spoor was generally followed from water holes (Fig. 4.36), although occasionally it was followed from where the animal was located the previous day or from a track crossing a road. Whenever possible, all the water holes in the area were visited during each days observations. At each water hole a record was made of how many white rhino (if any) had drunk and the directions they had entered from and left towards. Water availability was also noted.

b) Observations

Whenever fresh spoor were found and tracking initiated, recording of observations began. When spoor was lost, data collection was paused and was resumed if and when the track was recovered. Observations were collected at regular time intervals, which related to various distances covered depending upon tracking speed, as follows:

- Every 15 minutes the location was recorded, ie. on the hour (H+00), H+15, H+30, etc.
- Every 10 minutes a note was made of the rhino activity and a grass assessment, ie. at H+00, H+10, H+20, etc.
- Every 30 minutes a complete habitat assessment, grass assessment, location and details of rhino activity were recorded, ie. at H+00, H+30, etc.

ii) Direct Observations

Direct information was collected whenever rhinos were located and they were not disturbed by observer presence. These observations were used to supplement and support the tracker guided records and to provide a background to the associations and behaviour between individuals.

When the rhinos had been sighted, direct observations began and they were continued at 30 minute intervals. As soon as the rhinos lay to sleep, or if they were already in this position when found, they were observed for half an hour before leaving. If at any time the rhinos became aware of our presence, identification was only briefly attempted, if at all, then the rhinos were quickly left to minimise the disturbance to their routine. Disturbed behaviour was evident when the rhinos were encountered in a standing position, characteristic of their defensive posture, or running away. When analysing the results, all observations relating to this disturbed behaviour thought to be a result of the observer's presence were rejected.

Observations included the following information:-

- Rhino identification number and condition, assessed once on each sighting.
- Every half hour, the activity of all the animals, location and habitat.
- Climatic data, recorded on an hourly basis.
- Identification of freshly grazed areas, if the area could be visited without disturbing the rhinos.

iii) General Observations

Other information was compiled primarily from tracker guided and direct observations, as well as other sources. This included the following parameters:-

- Rhino age and mortality information.
- Responses to visual, aural and olfactory stimuli.
- Characteristics of resting locations.
- Water hole visits, drinking frequency, dust baths and mud wallows.
- Home ranges and distances moved.
- Climate, rainfall and rainy season observations.

5.2.2 Data Collection

i) Location

The rhino's location and route were determined with the aid of the Global Positioning System (GPS) (Hurn 1989). Unfortunately, the first GPS receiver used was faulty and had to be replaced. Consequently, maps of rhino movements were plotted with reference to topographical features until June 1996, and then assigned GPS co-ordinates in accordance with a manually drawn grid of the area. In addition, GPS positions were not recorded as frequently as rhino activity locations, since the distances between subsequent GPS locations was too small. Activity observations were therefore assigned intermediate co-ordinates where appropriate.

ii) Rhino Activity

As the spoor was being followed, the tracker analysed and indicated the rhino's activity. His explanations of the observations were frequently queried to assist personal understanding. The appearance of rhino spoor patterns was subtly modified by different activities with respect to the direction of movement, distance between steps and type of steps (either distinct or 'lazy' almost shuffling movement). Observations were recorded in basic terms, based upon direct observations and the descriptions of Owen-Smith (1973) (Table. 5.1).

Table 5.1 Descriptions of Activity and the Codes Allocated to Described Behaviour.

Code	Activity
Gr	Pure grazing, when the rhino is eating intensively, with relatively little change in position and often moving in circles.
Gr/Wa	Grazing, but at the same time walking in a general direction. Small distances between steps.
Wa/Gr	Primarily walking, but taking occasional bites. Possibly chewing.
Wa	Walking generally straight, without eating. Evident due to greater distances between spoor.
Ly	Lying down - resting or sleeping.
Dr	Drinking
Mud	Wallowing in mud holes.
Ru	Running in response to a disturbance. Whether or not observer presence caused the disturbance was noted.

Further observations included rolling in dust, standing stationary and marking territory by spray urinating. Few social interactions between individuals were recorded from the spoor alone, but these included mating which was indicated by heavy scraping footprints, and a fight or confrontation which may disturb the grass, shrubs or bushes in the area.

iii) Individual Sightings and Intra-Specific Interactions

For direct observations, all the rhinos in the Kaross group could be clearly identified by ear notches of different shapes and positions, as shown in Fig. 5.3.

To enable identification of individual rhinos while tracking (indirect observations), it was hoped to detect distinguishing characteristics and patterns which could be related to specific individuals. The pattern of various spoor was therefore mapped with respect to its width and crease patterns. If successful, this

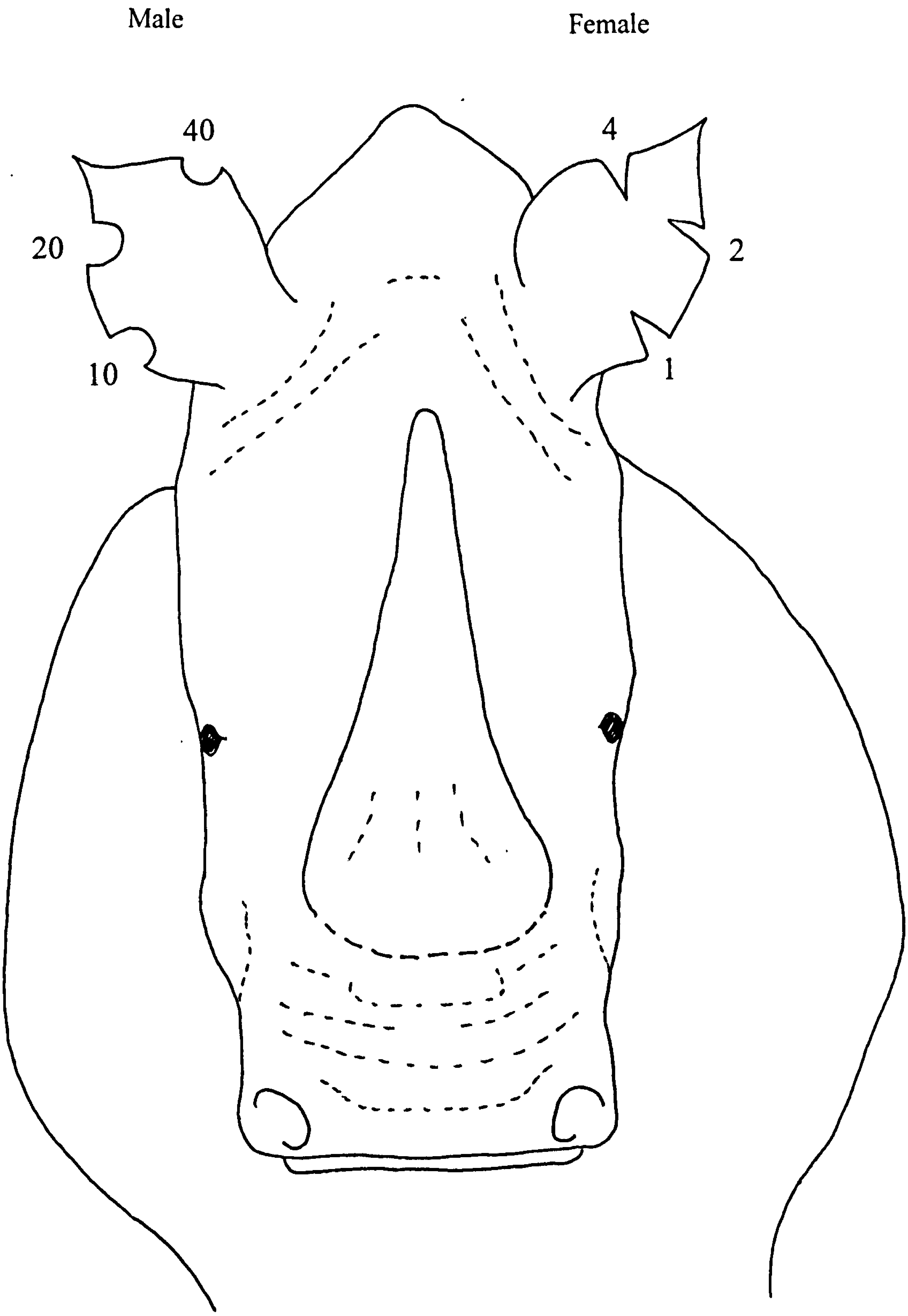


Fig. 5.3 Rhino Identification via Ear Notch Numbering System

technique would reduce disturbance to the rhinos since the pressure to identify individuals when they were sighted would be reduced. It would also allow identification of animals paired for mating and enable dung collection for hormone analysis during tracker guided observations.

Observations recorded included the behaviour of each individual, whether alone or in a group. Details included intra-specific interactions between individuals, including displays of territoriality, mating and confrontations between individuals. Data recorded included both direct observations and any behaviour apparent from tracker guided observations.

iv) Inter-Specific Interactions

Inter-specific interactions, especially with black rhinos, were recorded during direct observations.

v) Condition of the Rhinos and Other Animals

Notes on the physical condition of the rhinos were taken whenever possible, in accordance with the condition categories of Keep (1971).

Seasonal changes and deterioration in the quality and availability of grazing may have been more apparent from the condition of other grazing species in Kaross. Therefore, whenever ungulates were noticeably in poor condition, the species, description of condition and location were recorded. This could provide supporting evidence for any observations of fluctuating condition in the white rhinos.

vi) Rhino Capture

A description of the operation when the dominant bull was captured for removal was included.

vii) Ages and Mortalities

Information pertaining to the probable ages of the rhinos in Kaross was discussed and verified by direct observations. Two white rhino carcasses were found before the study began. The probable cause of death was considered and the age of individuals was ascertained by tooth wear (Hillman-Smith *et al.* 1986).

viii) Response to Stimuli

Details of the rhino's response to disturbance caused by human observers were noted. The rhino's apparent sense of smell, sight and hearing, also reactions to other animal's alarms and disturbed behaviour were described.

ix) Characteristics of Resting Locations

Rhinos were often located while resting and these areas were described in terms of habitat characteristics.

x) Water Hole Visits, Drinking Frequency, Dust Baths and Mud Wallows

Frequency of drinking, dust bathing and mud wallowing throughout the year were calculated. Preferred water holes were also identified.

xi) Home Ranges and Distances Moved

Details of the home range and distance moved by rhinos, also problems encountered with establishing them, were described.

xii) Climate, Rainfall and Rainy Season Observations

Climatic data were recorded on an hourly basis, which included the parameters described in Table 5.2. If relevant, other unusual events, for example rain, were recorded. Rainfall figures over the study period were recorded, as well as the influence the rainy season exerted on rhino tracking activities, water availability, herbaceous species and habitat characteristics.

Table 5.2 Climatic Information Collected During Direct Observations.

Parameter	Details Recorded
Sun	Whether the sun is shining or whether it is obscured by cloud.
Cloud	Recorded in eighths coverage of the sky. For example: 0/8 indicates no cloud, 4/8 indicates 50% cover and 8/8 indicates complete sky coverage by cloud.
Wind strength	Recorded as Beaufort scale measurements. For example: 0 equals calm conditions with no wind; 2 is a light breeze, where wind can be felt on the face and leaves are rustling; 4 is a moderate breeze which raises dust and loose paper, small branches are moved; 6 is a strong breeze moving large branches; 8 is a gale, breaking twigs off trees and impeding progress.
Wind direction	The direction from which the wind is originating relative to magnetic (compass) readings.
Temperature	Recorded in degrees Celsius, in the shade, using a portable electronic thermometer.

5.2.3 Analysis of Movements

Information relating to movements derived from both tracker guided and direct observations were combined and analysed using GIS, with respect to individual animals, activity and season.

A database was established using Microsoft ACCESS and maps were constructed using the GIS programmes ArcView v.2.1b and v.3. All location positions were plotted as dots on base maps which outlined the fences and roads. Any points falling beyond the boundaries of the fence which were a result of GPS error were removed since they could not be related to features within the map. The overall number of observations were counted to indicate the total quantity of data.

5.3 Results

Observations were intensively carried out and recorded from May 1996 to the end of February 1997. The number of days spent in the field compared with days resulting in observations during each season are shown in Table. 5.3. During the months from January to April, difficulties in finding the rhinos resulted in many days spent without collecting any data. Other reasons for fewer days of rhino observations than overall days of field work, relate to occasions when it was not possible to locate any spoor and when game capture operations in the area created excessive disturbance for the rhinos. On days when rhinos were not tracked, the habitat survey was conducted.

Table 5.3 Number of Days Spent in the Field and the Number of these Resulting in either Direct or Indirect Observations.

Season	Field work, total	Direct and Indirect Observation of Rhino
Jan - April	59 days	41 days
May - Aug	59 days	53 days
Sept - Dec	28 days	27 days
Total	**146 days**	**121 days**

The total time spent collecting data was compiled in Table 5.4. The number of hours spent tracking does not include time spent searching for spoor when tracking had become difficult, or time spent walking back to the vehicle after the rhinos had been observed. The number of hours of direct observations does not include time when the animals were disturbed (as shown in Fig. 5.4). Time spent on the habitat survey is also not included in this table.

Table 5.4 Hours Spent Collecting Rhino Data by Tracking and by Direct Observations.

Season	Hours of tracking	Hours of direct observations
January-April	89h 05m	12h 25m
May - August	137h 25m	26h 30m
September - December	28h 55m	15h 25m
Total	255h 25m	54h 20m

5.3.1 Mapping of Rhino Activity and Seasonal Utilisation

i) Activity

While **basic or pure activities** of grazing (Fig. 5.5) and of walking were of primary importance, **combined activities** of grazing with walking also form an integral part of the study. The relationship between pure and combined observations was reviewed to determine how frequent combined observations were, and whether they should be considered separately from the pure observations. Other observations included lying (fig. 5.6) and drinking locations. It should be noted that the number of observations of each activity does not indicate how much time the rhinos occupied on these activities. The following maps illustrate the locations of these observations:

Fig. 5.4 Male 2 Standing in an Alert Disturbed Position

Fig. 5.5 Male 2 Grazing

Fig. 5.6 Male 1 Resting

Locations of grazing, and grazing / walking observations.
Pure grazing observations (n = 516) were far greater in number than when grazing was combined with walking (n = 48) (Fig. 5.7). The locations of grazing positions identify definite regions of intensive grazing which were generally not close to the water holes.

Locations of walking, and walking / grazing observations.
A total of 601 observations of pure walking were collected and 221 observations of walking and grazing (Fig. 5.8). Walking activities were particularly evident around water holes. The fairly high frequency of combined walking and grazing activities implies that this casual feeding while walking provides a significant additional source of dietary intake. Because concentrated grazing was not undertaken in these areas, this was possibly an indication that the grass was not regarded as desirable for eating.

Locations of lying observations.
A total of 47 locations where the rhinos were found sleeping were recorded, which appear to be randomly located across the area (Fig 5.9).

Locations of drinking and mud wallow observations.
A total of 20 sites were located which included water holes and mud holes used for wallowing during the rainy season (Fig 5.10).

ii) Seasonal Variations

Seasonal variations in rhino movements were mapped to indicate seasonal utilisation of different areas. These maps show the positions of all rhinos. The number of observations collected in any one season influences the appearance of each map.

Rhino Locations Between January and April.
During this period, finding the rhinos was often difficult since water was generally readily available from mud holes and holes in rocks, therefore the rhinos very rarely visited the water holes. Altogether 662 locations were recorded during these months (Fig 5.11). Through this season, tracking was slower due to spoor disturbance by rainfall and increased herbaceous layer cover. Slow tracking was evident from the smaller distance between points. It was not easy to distinguish points which overlay on the map, which was a result of rhinos frequently walking the same path. Generally, movements were concentrated near to and south of KarossHoek water hole, along the riverbed between KarossFontein and KarossHoek water holes and occasionally in the southern area. During this season, the rhinos were observed to take one exploratory walk lasting two days through the whole area. It was interesting to note that no observations were recorded in the main riverbed running south-west of KarossFontein, although this was favoured at other times of the year.

Rhino Locations Between May and August.
Intensive monitoring during this cool dry season resulted in 1128 observations (Fig 5.12). Areas of apparently high utilisation occur in the central riverine area between KarossDrink and KarossFontein and along the road which passes through the main river south-west of KarossFontein. It is not clear from these maps whether these routes are simply preferred walking paths or are direct links to grazing areas.

Rhino Locations Between September and December.
Fewer days were spent in the field in the hot dry season, therefore considerably fewer observations (263) were obtained (Fig 5.13). Observations during this season were too few to draw any definite conclusions.

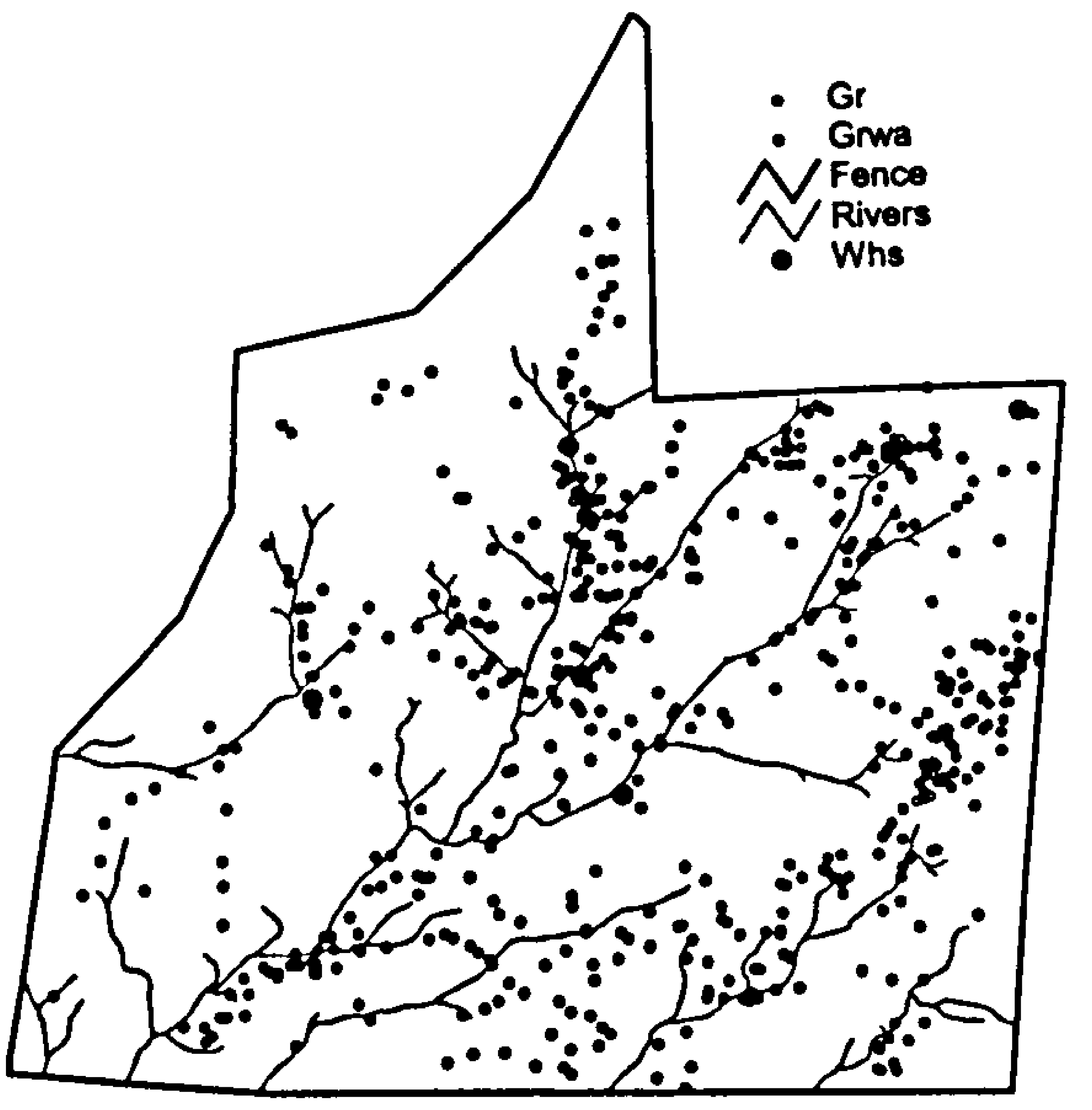


Fig. 5.7 Locations of Grazing, and Grazing/Walking Observations

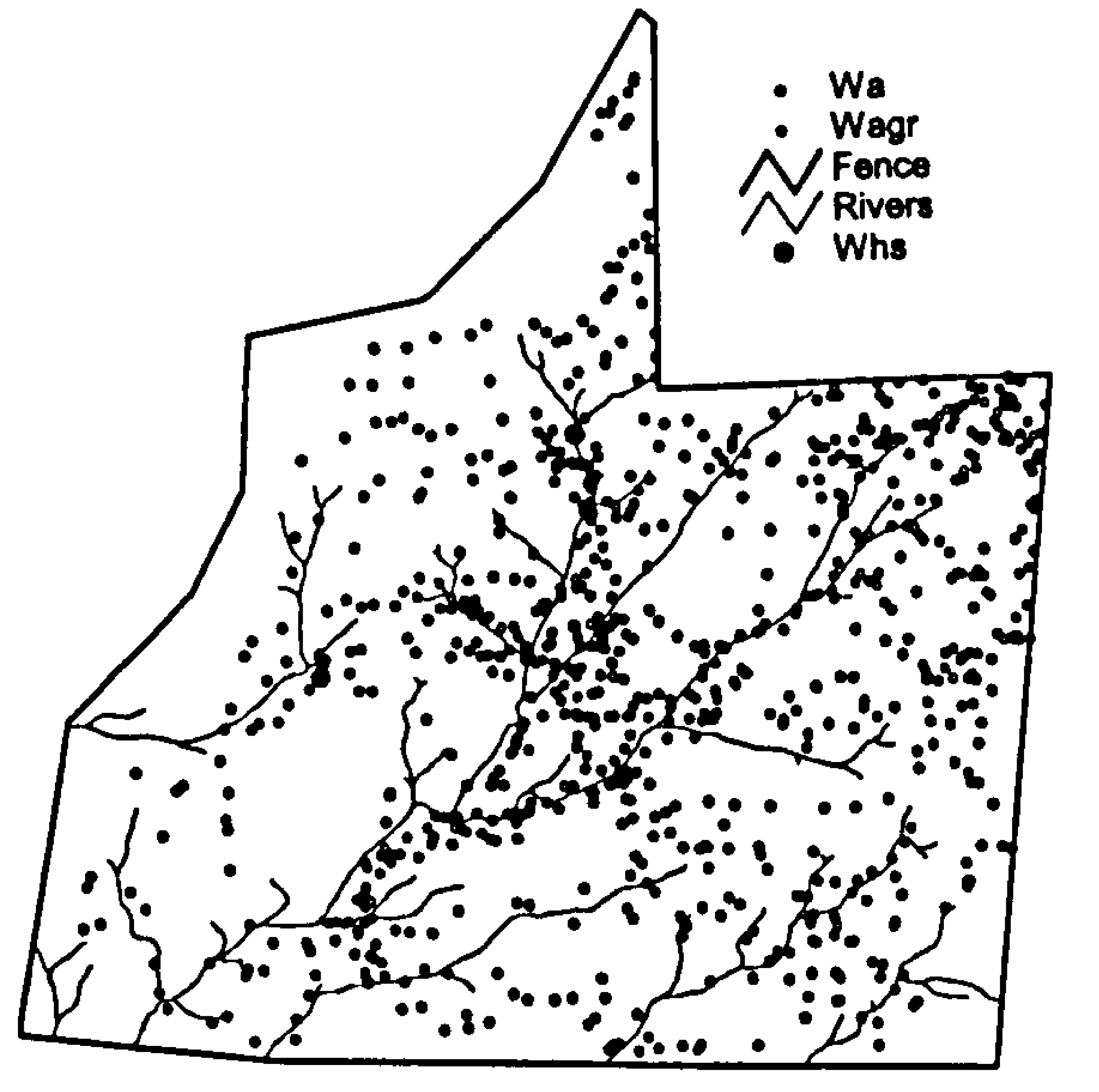


Fig. 5.8 Location of Walking, and Walking/Grazing Observations

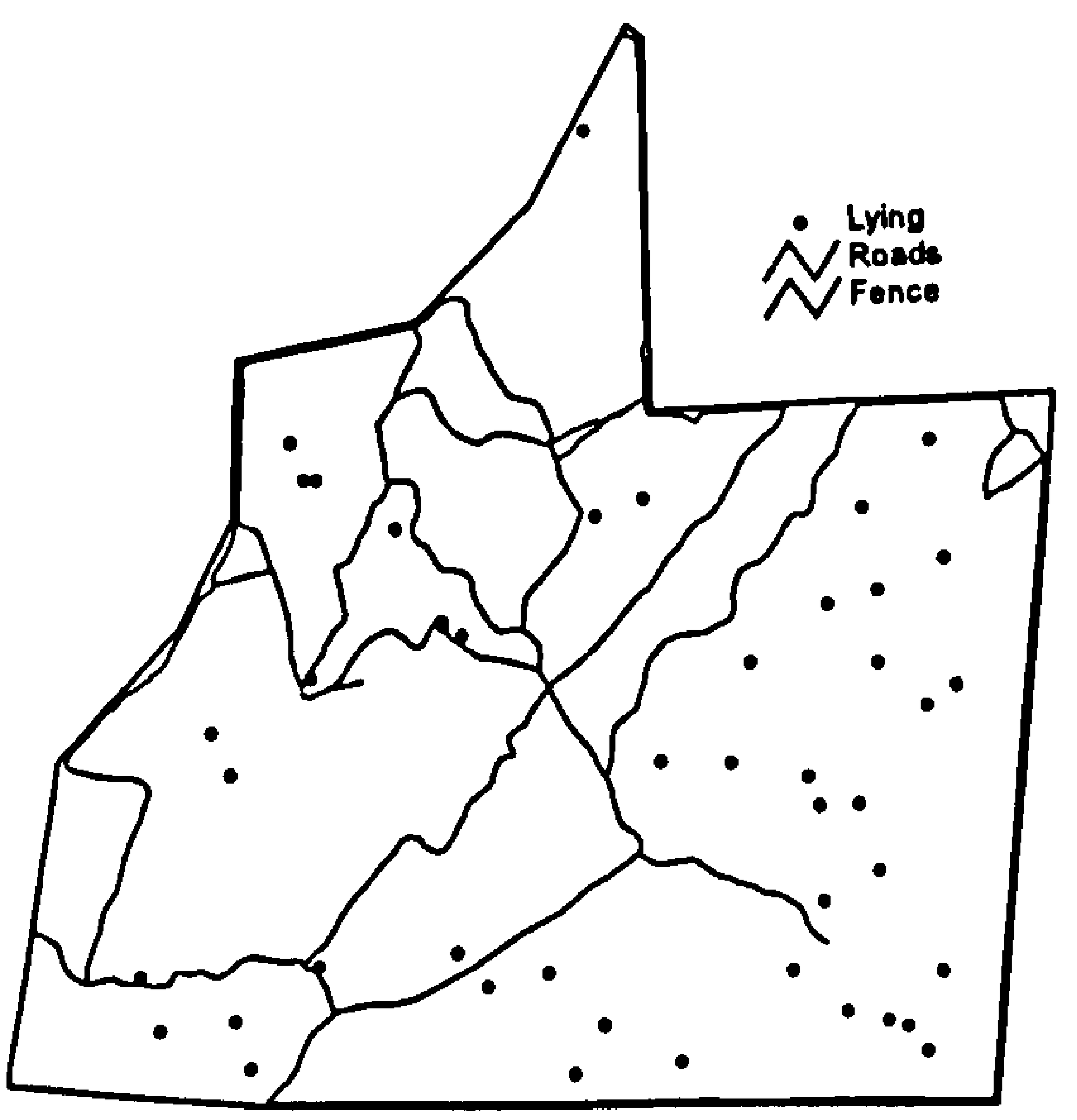


Fig. 5.9 Location of Lying Observations

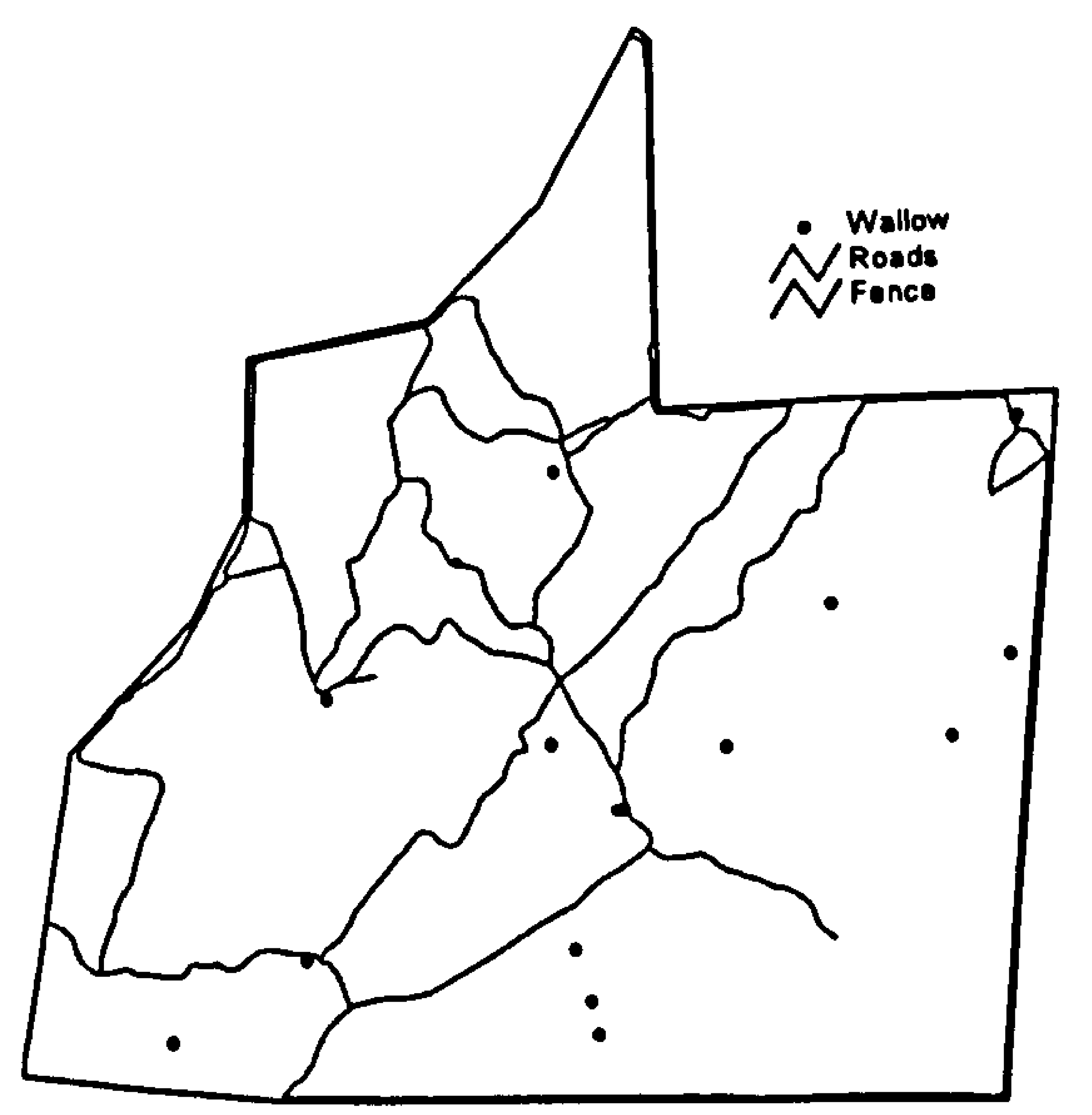


Fig. 5.10 Location of Drinking and Mud-Wallow Observations

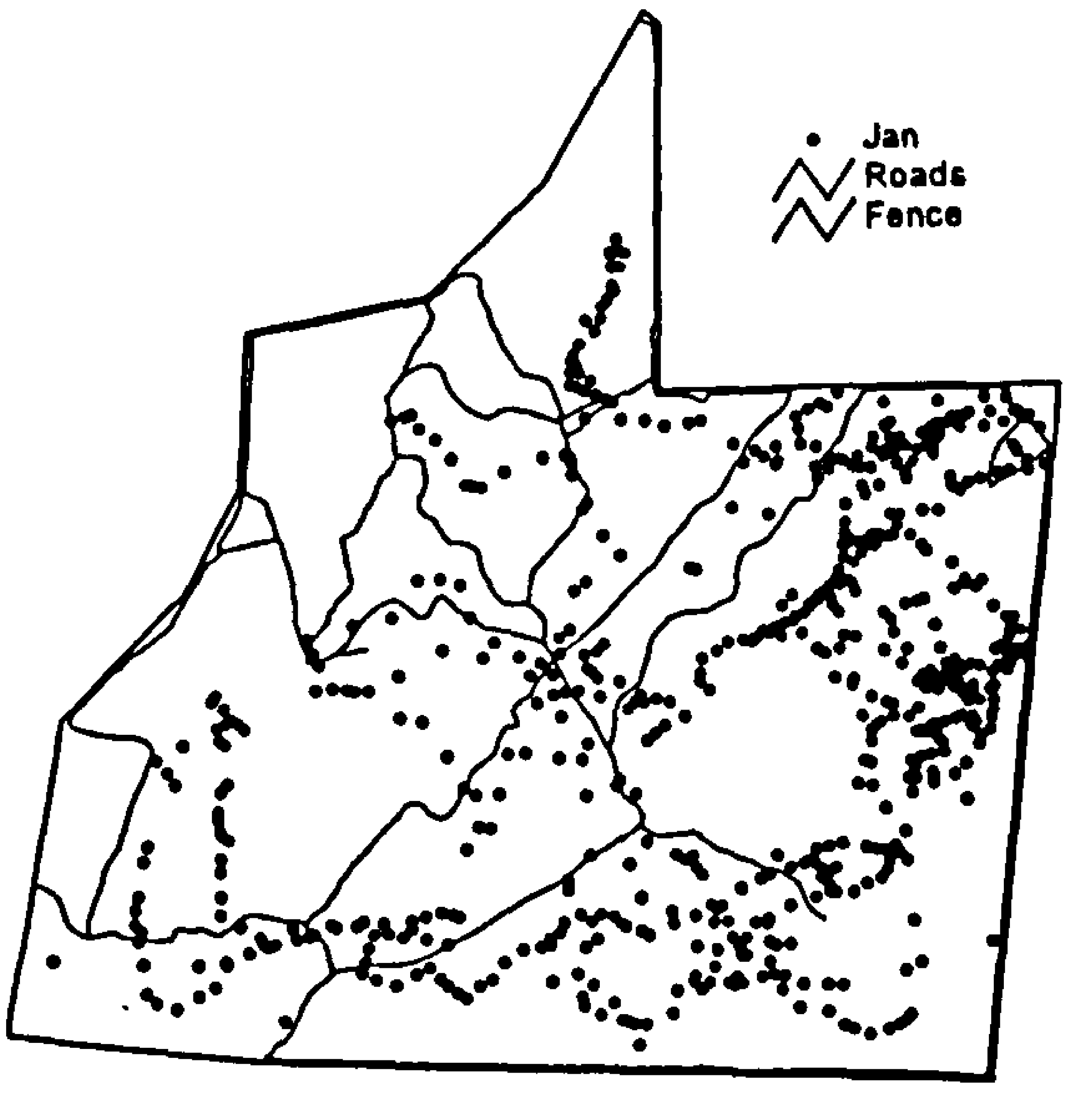


Fig. 5.11 Rhino Locations Between January and April

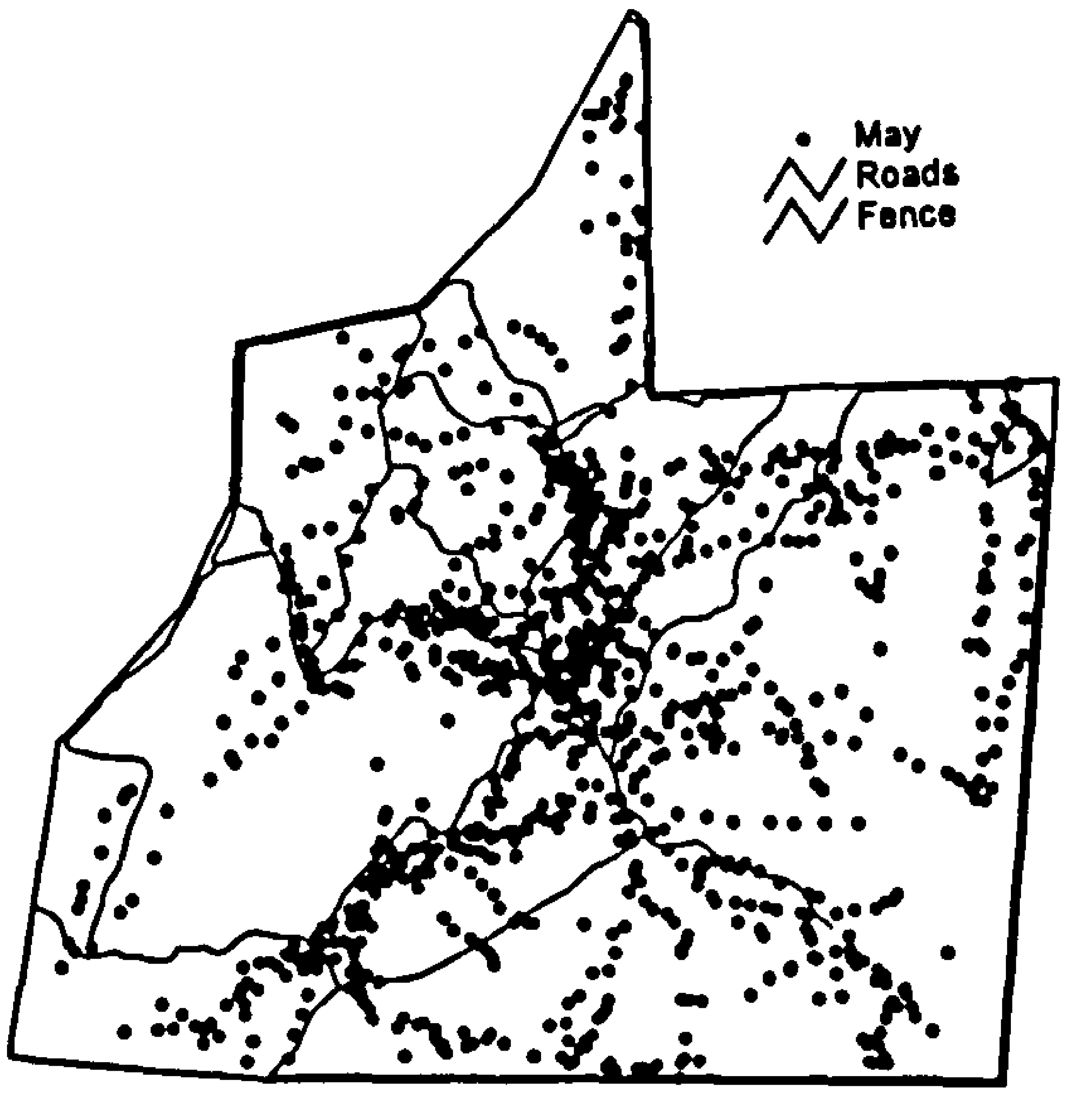


Fig. 5.12 Rhino Locations Between May and August

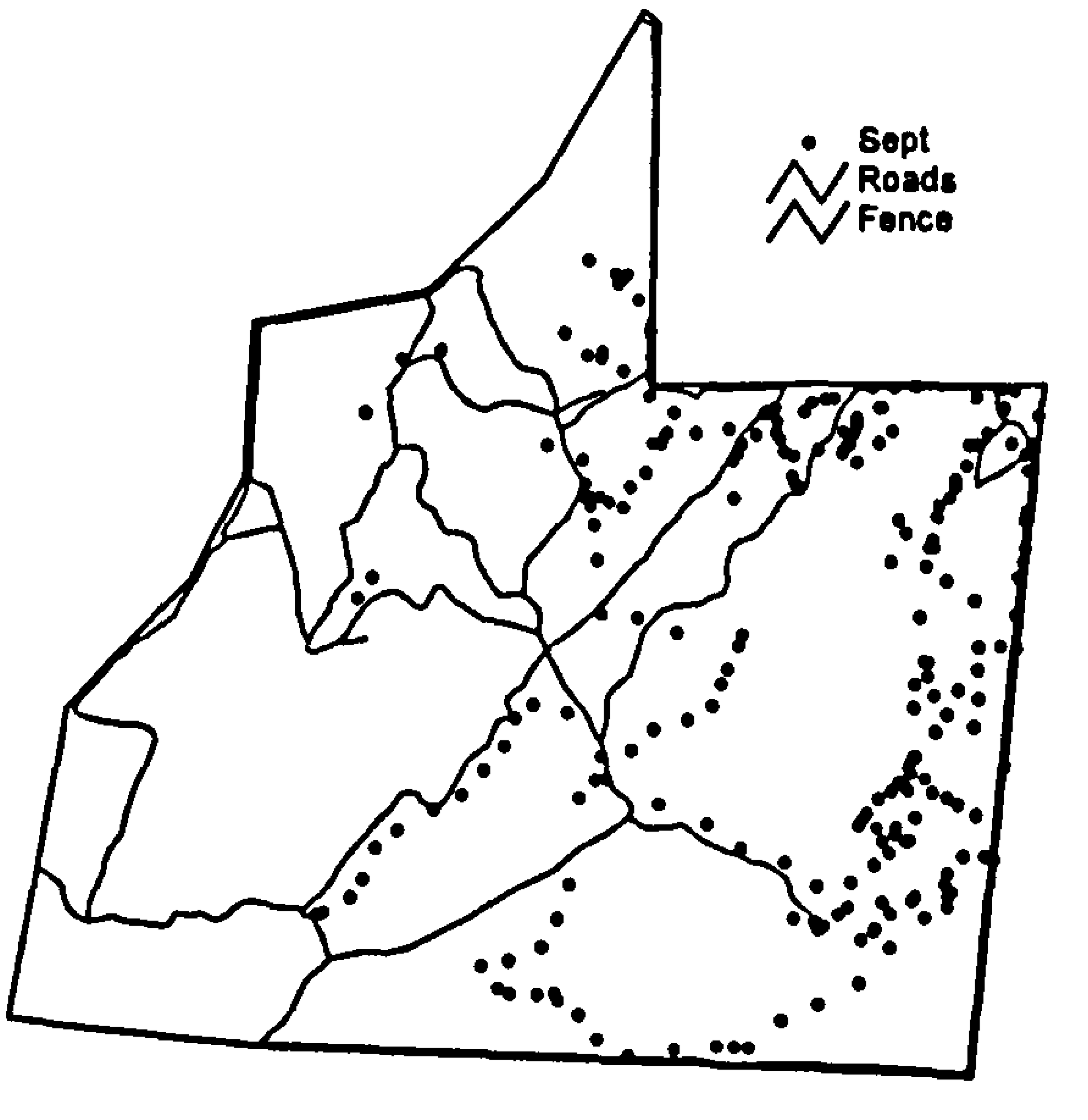


Fig. 5.13 Rhino Locations Between September and December

5.3.2 Individual Sightings and Associations

i) Individual Rhinos

Whenever a rhino was successfully identified by its ear notches after tracking its path, it was possible to definitely associate that track with the individual. Conversely, if the rhino was not identified, the route could not be related to an individual animal. The possibility of mapping and measuring spoor was attempted but proved to be inaccurate due to excessive variation between subsequent measurements due to the area's substratum. There were also occasions when rhino spoor paths crossed causing uncertainty over whether tracking continued on the path of the same rhino. In these circumstances, even if an individual was subsequently identified, these observations were excluded.

Movements of all animals, especially the subordinate bull (male 2) were affected by the removal of the dominant bull, male 1, on the 21st July 1996. Therefore, the movements of male 2 have been described separately, before and after this date.

Movements of Male 1.
A total of 320 locations relating to male 1 were recorded up to the time of his capture for relocation (Fig 5.14). These locations show that he clearly remained in the southern area of Kaross, using KarossHoek and KarossFontein water holes. He frequently patrolled along the territorial boundary which was between KarossHoek water hole and the south-western corner of Kaross. He was also observed on one occasion to walk inside the territory of the other male which lay along the north of the road leading east from ZebraPomp water hole.

Movements of Male 2.
A total of 669 locations were recorded for this individual (Fig 5.15). He appears to have moved across the whole area, however this map does not indicate the influence of the territorial boundary on this individual prior to the removal of the dominant male.

How the movements of Male 2 were affected by the removal of Male 1.
A total of 190 locations of male 2 were recorded while the dominant male was present, and 479 locations were recorded after he had been relocated (Fig 5.16). Prior to the removal of male 1, male 2 regularly patrolled the same route south of KarossDrink to the junction between the main rivers and roads. This was presumed to be his territorial boundary. He then continued to walk west along the road to ZebraPomp and was generally found sleeping in the same area. On two occasions male 2 was recorded within male 1's territory, once at KarossHoek water hole and once east of KarossFontein. After the removal of male 1, it was possible to see that male 2's movements covered the whole of Kaross.

Movements of Female 1 and Movements of Female 5.
These two females were generally found together except on one occasion. This resulted in a total of 956 locations for female one (Fig 5.17) and 953 locations for female five (Fig 5.18). There appeared to be a bond between these females and it is possible that they were related. Their movements were generally within the territory of male 1 and even after his removal, they only occasionally ventured out of this area.

Movements of F1 and F5 during each season.
Records of the movements of these females were used to show seasonal variations in the movements of the rhinos (Fig 5.19). Between January and April, 342 observations were collected, from May to August this increased to 445 and between September and December it decreased to 162. It was possible to identify apparently preferred areas in each season. For example, during January and April, the small river which runs north-east of KarossFontein and the area to the south of KarossHoek and KarossFontein were frequently used. In all seasons, exploratory deviations from preferred areas occurred. Complicating factors which may have affected movements include territorial restrictions imposed by the dominant male up to the time that he was removed.

Movements of Female 4.
This female generally walked alone, at which time she covered greater distances than when walking with the other females (Fig 5.20). 631 locations were recorded. Female 4 also moved mainly within the territory of male one until he was removed.

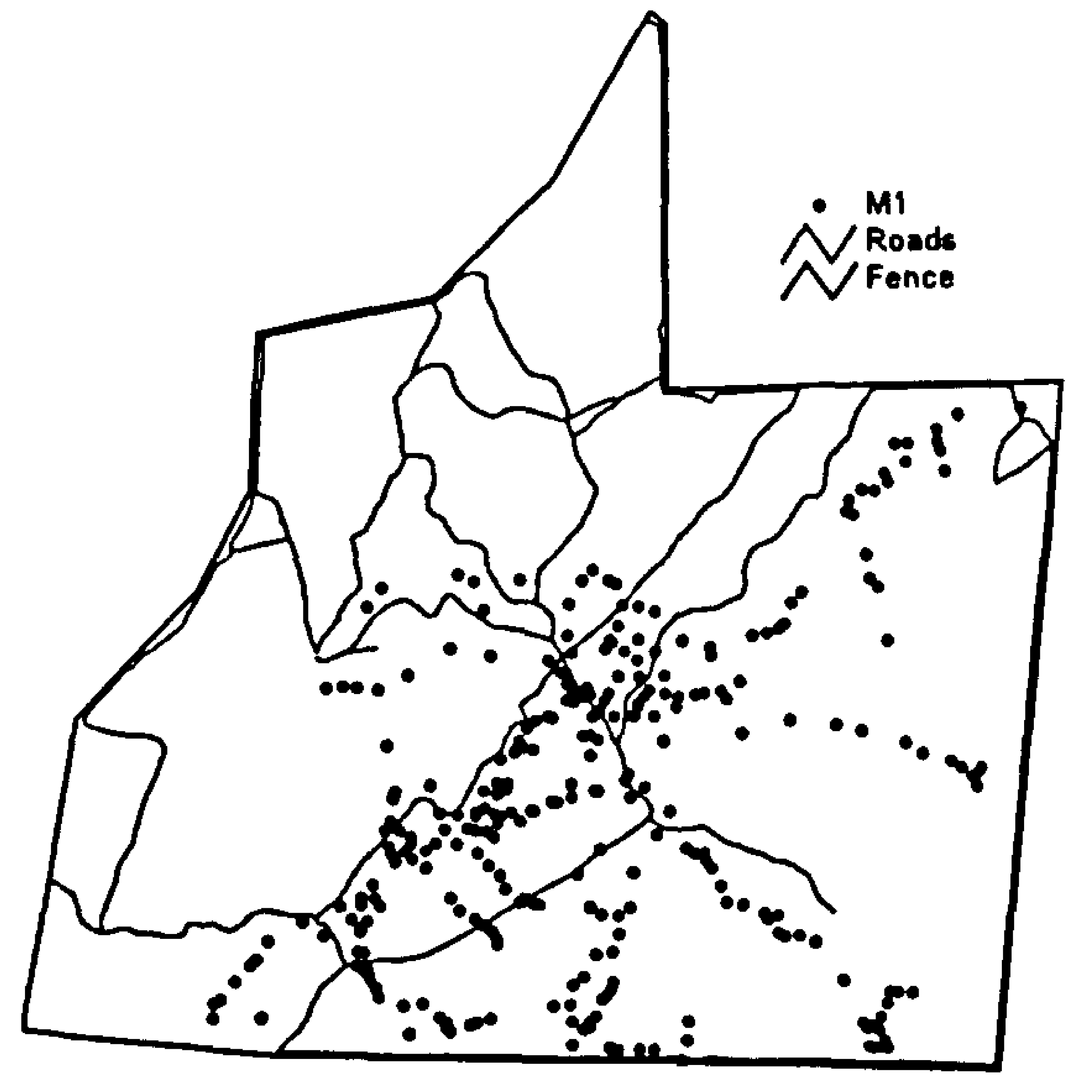


Fig. 5.14 Movements of Male 1

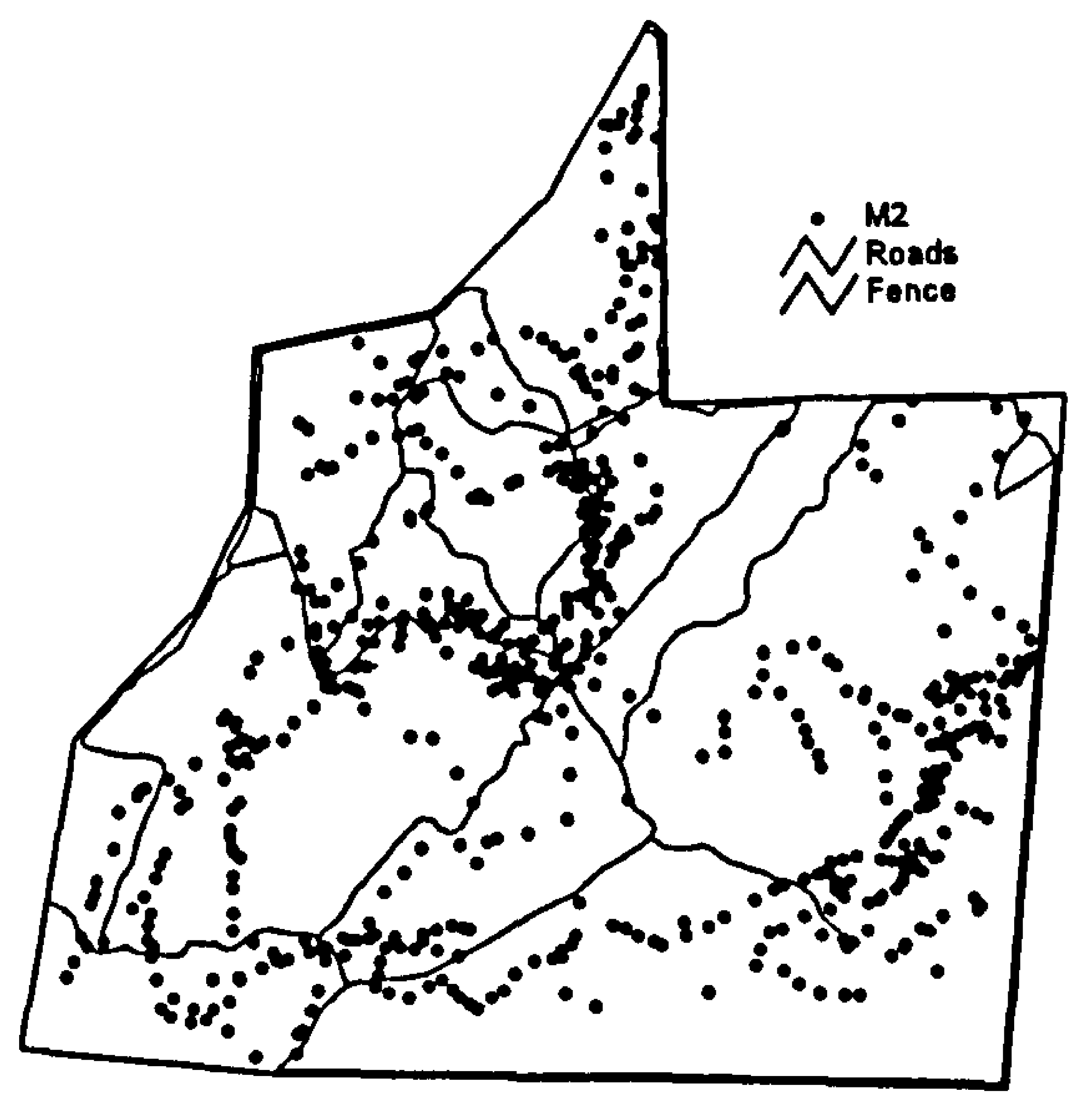


Fig. 5.15 Movements of Male 2

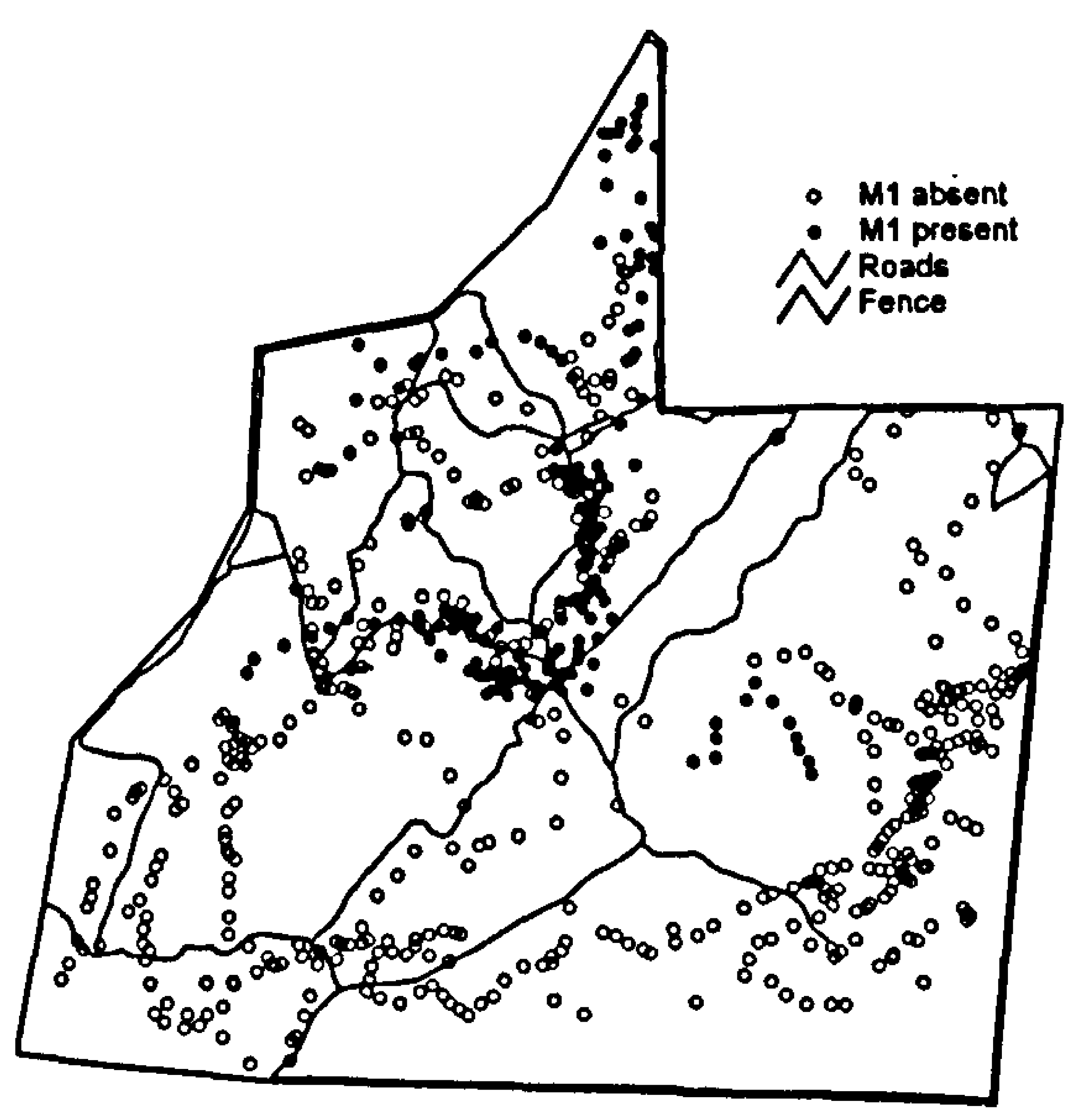


Fig. 5.16 How the Movements of Male 2 were Affected by the Removal of Male 1

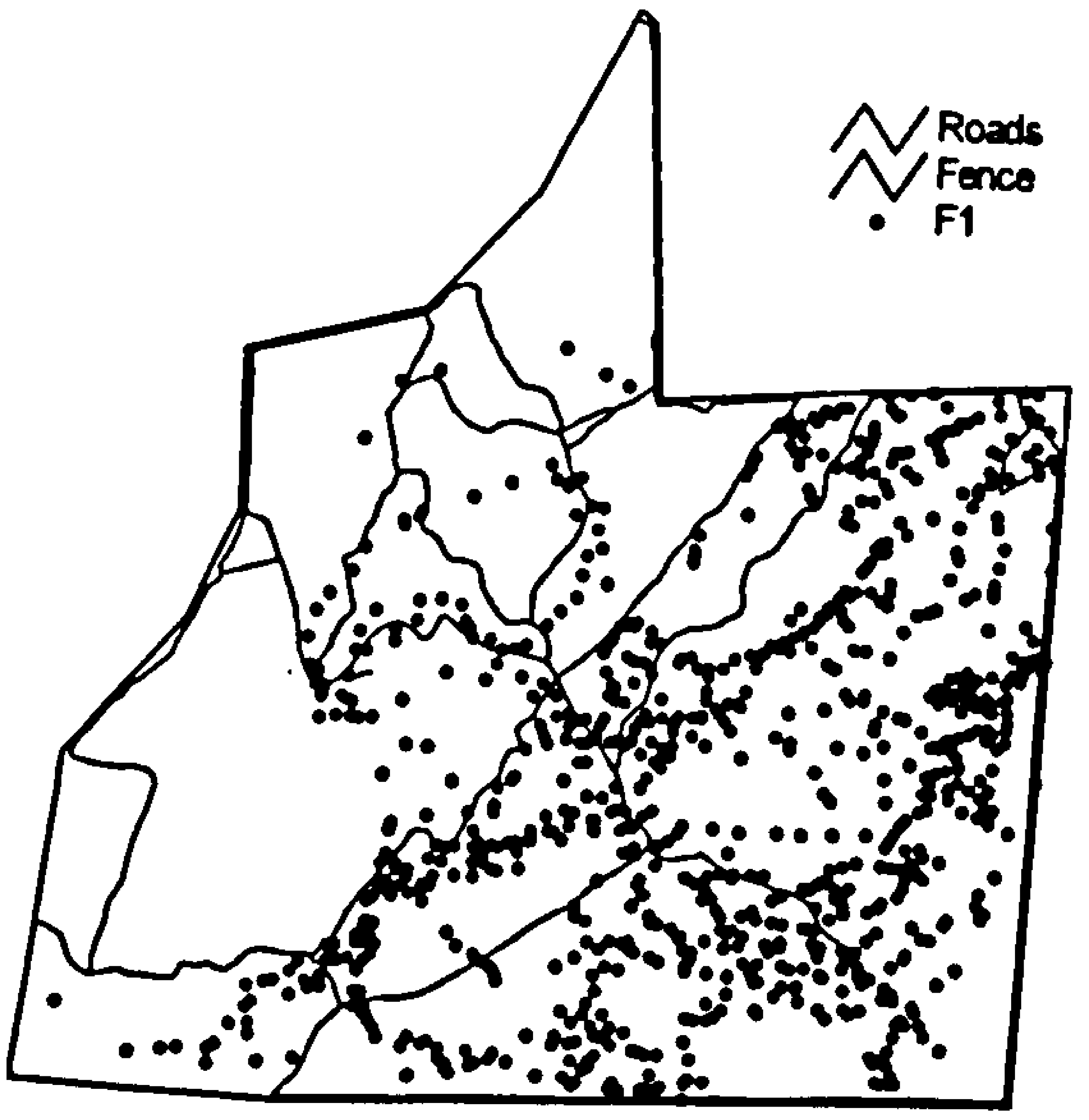


Fig. 5.17 Movements of Female 1

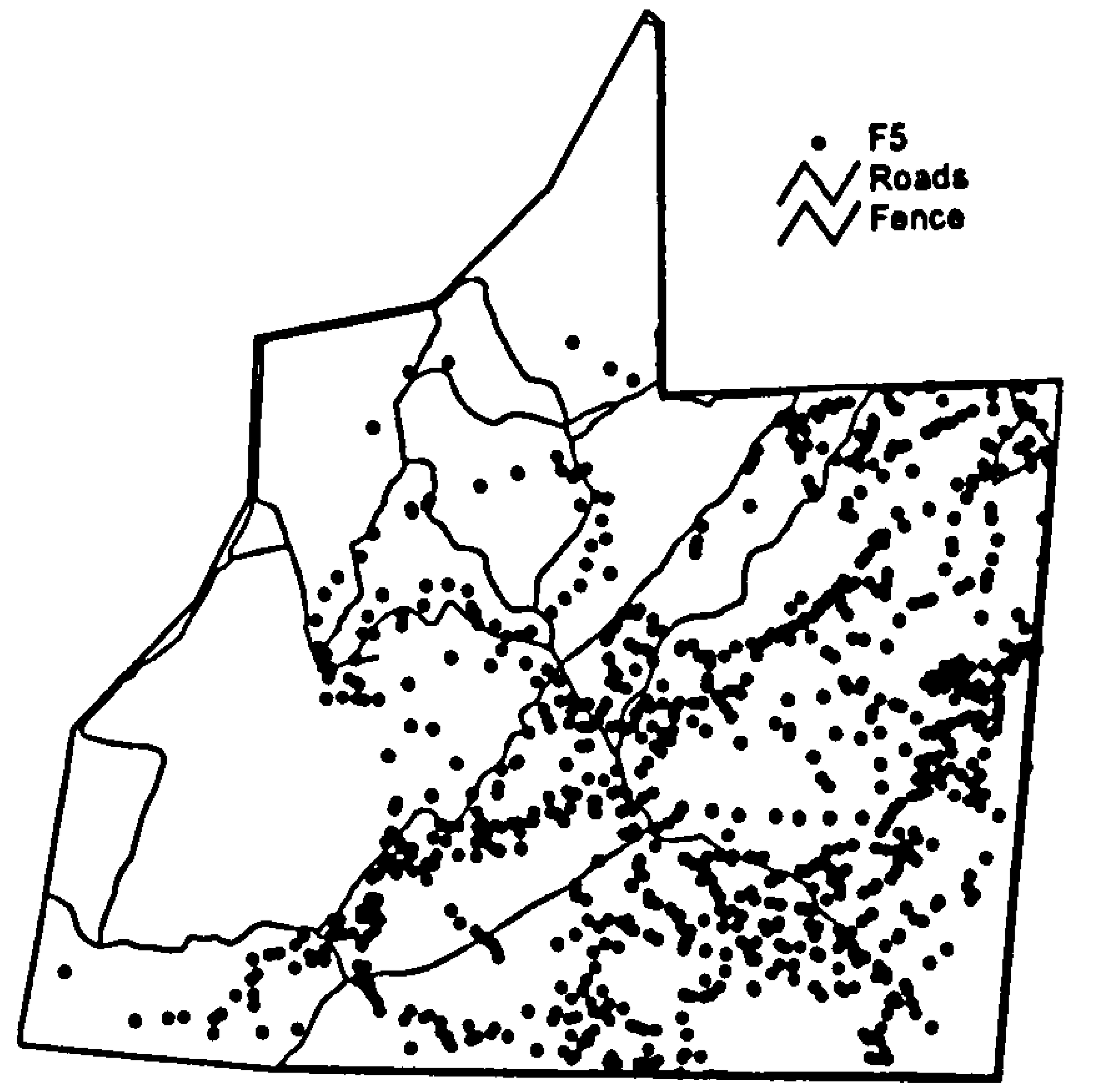


Fig. 5.18 Movements of Female 5

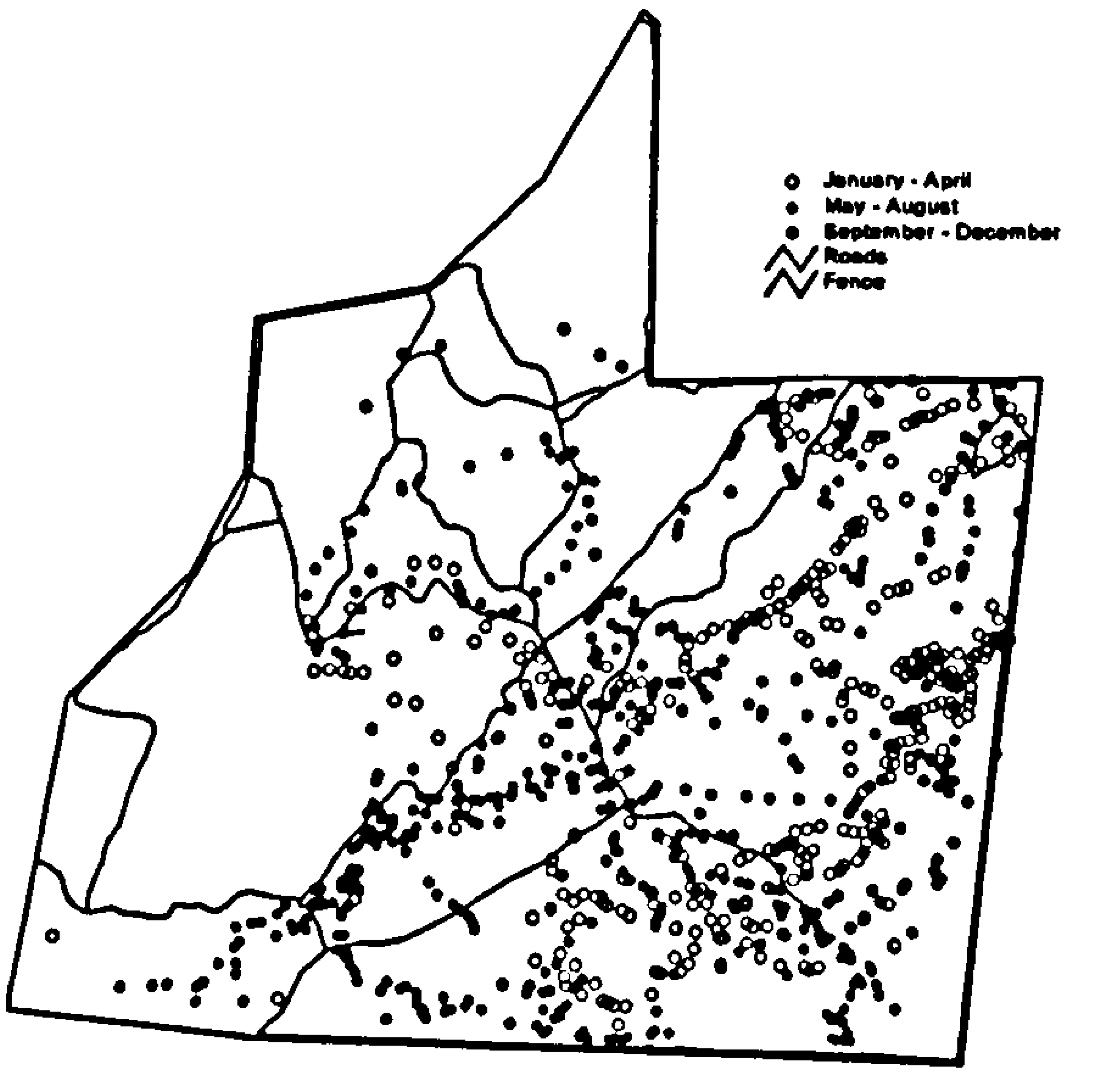


Fig. 5.19 Movements of Females 1 and 5 During Each Season

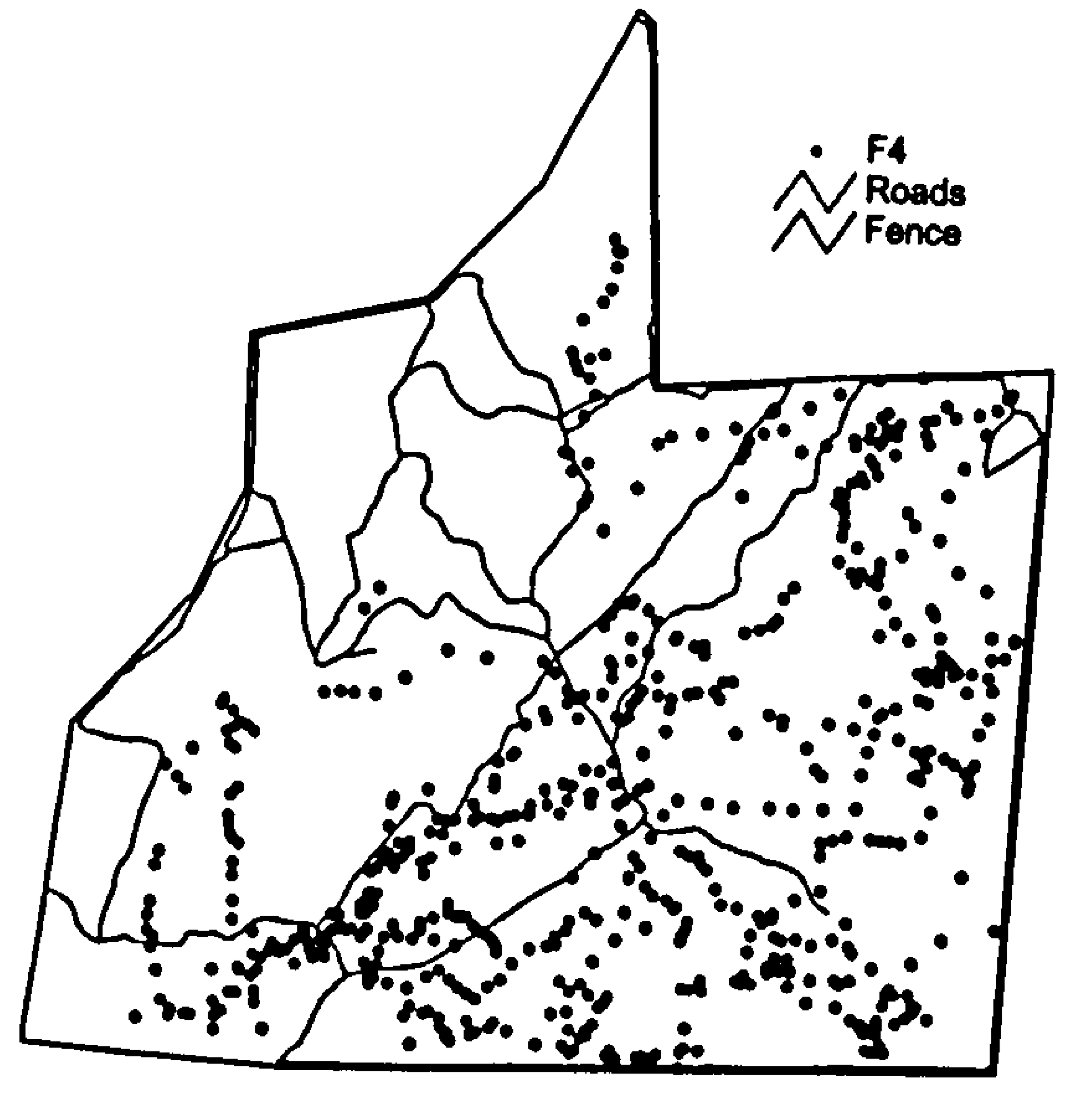


Fig. 5.20 Movements of Female 4

ii) Individual Sightings and Intra-Specific Interactions

The number of times each individual was positively identified throughout the year is shown in Table 5.5.

Table 5.5 Number of Observations of Each Individual.

Season	Male 1	Male 2	Female 1	Female 4	Female 5
January - April	4	18	22	18	21
May - August	18	22	28	19	28
Sept - December	N/A	12	18	11	18
Total	22	52	68	48	67

A pattern of associations between individuals appeared and is summarised in Table 5.6. Maps of the movements provided earlier give additional information on these associations.

Table 5.6 Associations between Rhinos as Indicated by Sightings.

	Male 2	Female 1	Female 4	Female 5
Male 1	0	16	15	15
Male 2	*	28	21	28
Female 1	*	*	34	67
Female 4	*	*	*	33

* Repeated data.

At the start of the project two bulls were present and it was possible to distinguish the territorial boundary between their ranges. They were never sighted together and interactions between them were primarily related to territoriality. The dominant male, number 1, mainly walked south of KarossFontein, accompanying the females. He occasionally separated from this group to maintain the boundary to his territory especially at the cross roads north of KarossFontein and the road north-east of this point down the valley (called Vlak Vark Vlei), while occasionally walking south of ZebraPomp. The subordinate male, number 2 walked across the northern half of Kaross, covering the area from Nordhoek to ZebraPomp. On one occasion (27^{th} May 1996) there was an indication that the bulls had met at the entrance to Vlak Vark Vlei, and a small fight had ensued. Grass clumps and soil had been disturbed and nearby bushes damaged.

Females 1 and 5 were regularly sighted together and on approximately half of these occasions female 4 was also present. Female 4 was normally difficult to locate, possibly being more independent and she was often sighted alone. She regularly walked large distances and ran much further than the other rhinos if disturbed by our presence. Prior to the removal of the dominant bull, the females were most frequently sighted within the boundaries of his territory. During the rainy season they preferred the area in the south, leaving it only for occasional excursions.

It is not possible to comment on the number of sightings of the females with the bulls, as the removal of male 1 disrupted the results. Interactions between the males and females were mainly established by direct observations. The dominant or only male was often found accompanying one or more of the females. This association was generally amicable, although the bull usually remained at a reasonable distance from the females and often walked behind them. Females 1 and 5 had been observed being particularly intolerant of the presence of either male. In the event of his approach to within 10m of either of the females, female 1 chased him away by charging in his direction and bellowing. The male then backed away defensively. This behaviour was also described by Owen-Smith (1988). The other females seemed more tolerant of his presence, however if all the females were together then they were observed to defend each other in the manner described (n = 4).

The original dominant bull was directly observed attempting to mate with female 4 (n=1). At around this time, tracker guided observations indicated that mating had occurred or was attempted during the previous two nights activity. After the removal of the dominant bull, the subordinate bull regularly accompanied the females, however no mating was reported.

5.3.3 Inter-Specific Interactions

White rhinos tend to ignore other animals around them, however they generally responded to their alarm calls by becoming more restless or standing in an alert position. At water holes they were occasionally observed chasing other species away (n=2), although most of the time they were ignored. The white rhinos were never observed walking with black rhinos, although they were often located in the same vicinity. On one occasion, nose to nose contact was observed between an inquisitive black rhino and a white rhino.

5.3.4 Condition of Rhinos and Other Animals

Whenever possible, the physical condition of the rhinos was assessed visually (Table 1.1). The condition of the rhinos at the end of the dry season was generally good. However, on two occasions at the end of the dry season it was thought that the condition of one individual may only be described as fair. After the rainy season had begun the animals could all be described as in very good condition, developing good deposits of fat. See Fig. 5.21 of female 4 and Fig. 5.22 of male 2 in good condition. It was found that visual assessment of rhino condition became more reliable and accurate following repeated direct observations.

The condition of ungulates in the area was also recorded. Roan (*Hippotragus niger*) a grazer, are particularly sensitive to the condition of the veld. Their condition remained consistently good even at the end of the dry season. The condition of Eland (*Taurotragus oryx*) a browser, noticeably deteriorated at the end of the dry season, a change which was especially visible in pregnant females but also seen in some of the bulls. This trend was apparent over the whole area, however animals sighted north of KarossDrink seemed in worse condition than animals in the south.

5.3.5 Rhino Capture

One possible explanation for the lack of recruitment was that the dominant bull was infertile and was preventing the subordinate bull access to the cows. Consequently, the Ministry of Environment and Tourism decided to relocate the dominant bull on 21st July, 1996. He was spotted from the air, immobilised by a dart and collapsed a short time afterwards (Fig. 5.23). During the capture exercise, although sedated his head remained above ground and he was breathing rapidly or sniffing the air. This condition of muscular shaking is evidently common in white rhinos and other related species when they are immobilised (L. Geldenhys, MET, Windhoek, *pers comm.*). Limited measurements were taken (Fig. 5.24) due to the rhinos condition, these included a spine length 2800mm and head circumference behind second horn of 1550mm. When the antidote was initially administered it had no affect, however following a further dose he eventually stood up and was pulled into the crate. He appeared to be perspiring heavily. Once loaded into the lorry he was transported to Mangetti.

Fig. 5.21 Female 4 in Good Condition

Fig. 5.22 Male 2 in Good Condition

Fig. 5.23 Male 1 Immobilised for Capture

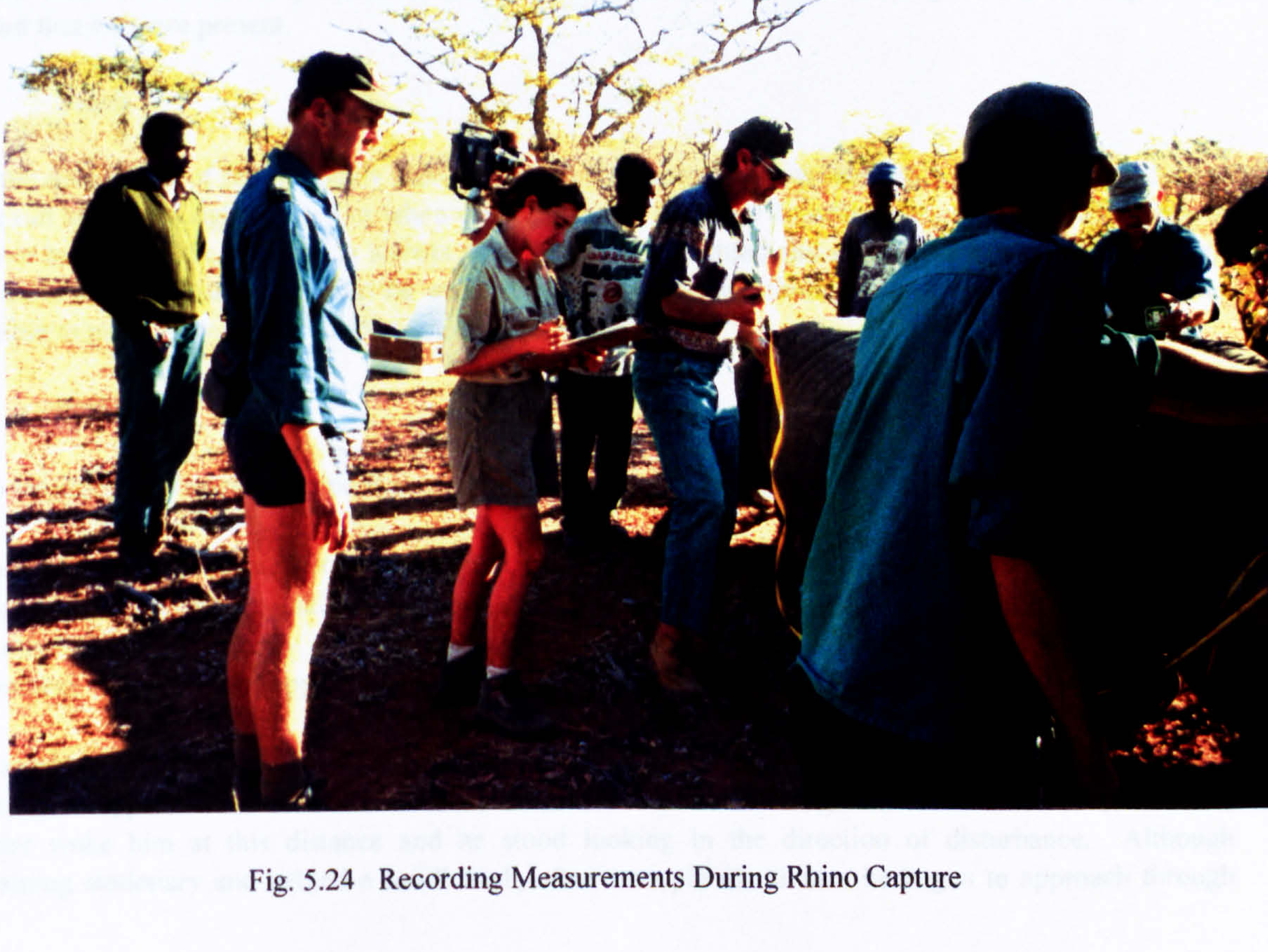


Fig. 5.24 Recording Measurements During Rhino Capture

5.3.6 Ages and Mortalities

Personal estimation assessed that all the Kaross rhinos were in an 'older' age category, but it was not possible to age them more precisely without the assistance of dental impressions (Wucher 1994). However, in terms of fitness as indicated by activity, female 4 was the most active individual. P. Du Preez (MET, Katima Mulilo, Namibia, *pers. comm.*) estimated the ages of the rhinos in 1994, as male 1, 25 or more; male 2, between 14 and 20; female 1, 23 or older and the remaining females between the ages of 14 and 25. H. Winterback (Game Capture Division, MET, Windhoek, *pers. comm.*) described the rhinos as ageing adults although only one of the rhinos was thought to be from the population which was originally delivered to Ohorongo.

Two females died during late 1995 to early 1996. The first carcass was found in early December 1995 in the valley to the west of KarossHoek and was thought to have died several weeks earlier. The skull is now stored at Etosha Ecological Institute (EEI), numbered CS 96/03/19.01 VM. Fig. 5.25 shows the dental wear on this skull. It was aged at 25 to 32 years according to dental wear classes which indicate distinct age categories according to Hillman-Smith *et al.* (1986).

The second carcass was sighted from the air by the game capture team in mid March 1996, located on a rocky hill near the ridge about 2km north-west of the previous carcass. It was also aged at 25 to 32 years and is now in the EEI collection, number CS 96/03/19.01 HW. Fig. 5.26 shows the dental wear on this skull. It was not possible to determine when death occurred, but it was probably over 2 months earlier. Both carcasses were found with the horns still attached and the causes of death were not established. Samples were taken for the determination of Anthrax, but the results are unknown.

5.3.7 Responses to Stimuli

The response of the rhinos to disturbance and other stimuli was noted. Because the study area was not open to tourists, the rhinos were easily disturbed by human presence or vehicular noise. Throughout the project their reaction to our presence remained consistent and at no time did they resume feeding if they sensed that we were present.

a) Smell

Rhinos acute sense of smell quickly alerted them to our approach if we were up-wind. They would often have run before we sighted them or when we approached, regularly detecting our presence at a distance of 50m or more. Wind conditions in Kaross were frequently unsettled and gusty, and when these conditions existed it was necessary to remain far away during direct observations. With a favourable wind it was possible to move to within 12 to 15m without disturbing them.

b) Sight

Two incidents demonstrate the poor eyesight of rhinos, particularly with slow moving objects.

On one occasion, the observer was standing in the shadow of a tree when the rhinos started to come closer. While initially maintaining a stationary position, as the rhinos approached to a distance of 10m, the observer moved slowly towards the tree. Although their attention was briefly attracted to the movement, they remained apparently unconcerned but altered their path to pass by.

On another occasion four rhinos were located sleeping in very favourable wind conditions and it was possible to approach the bull to a distance of 12m without disturbing him. The noise of the camera shutter woke him at this distance and he stood looking in the direction of disturbance. Although remaining stationary and behind a small bush, after a couple of minutes he began to approach through

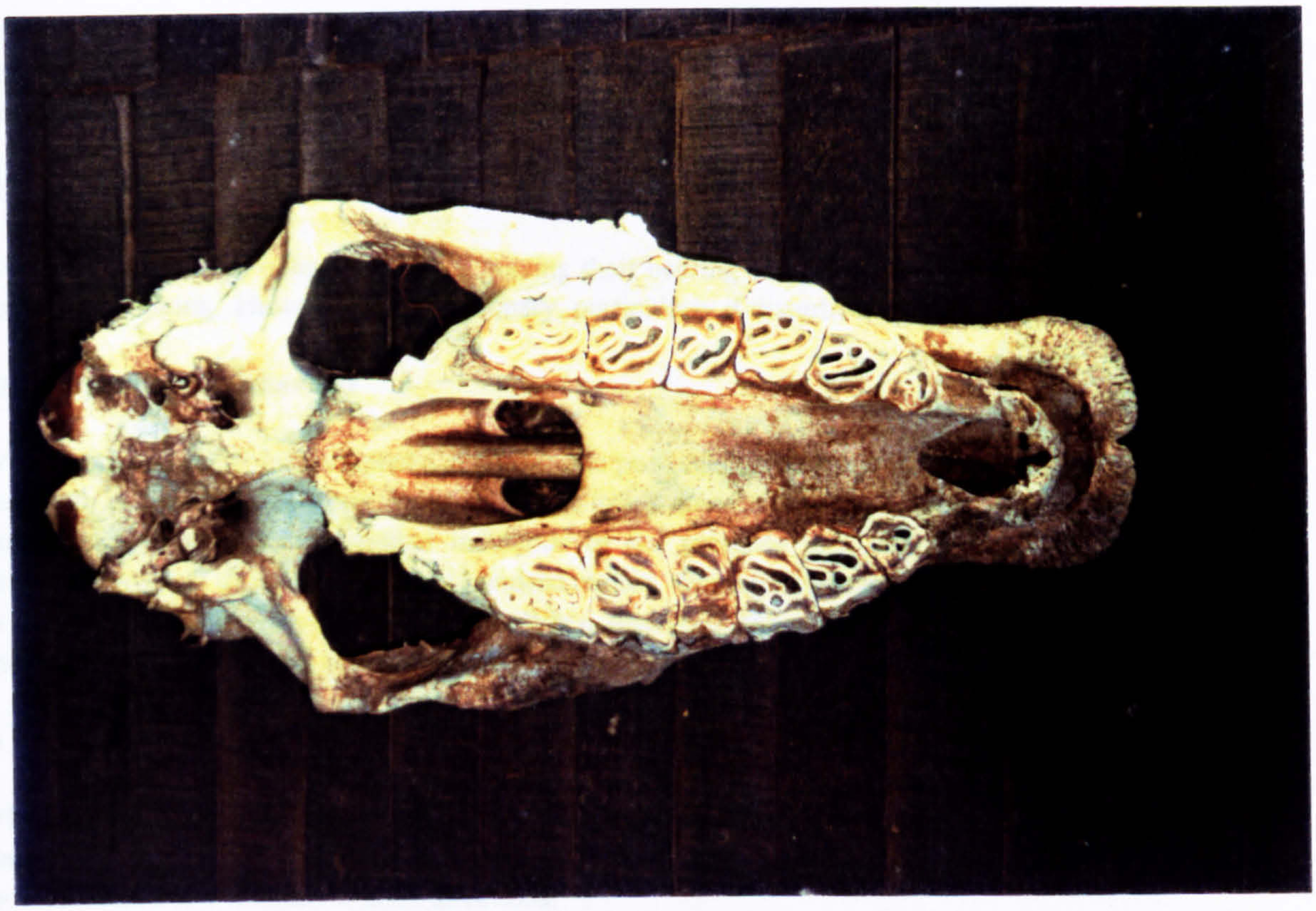


Fig. 5.25 Dental Wear of Skull, CS 96/03/19.01 VM

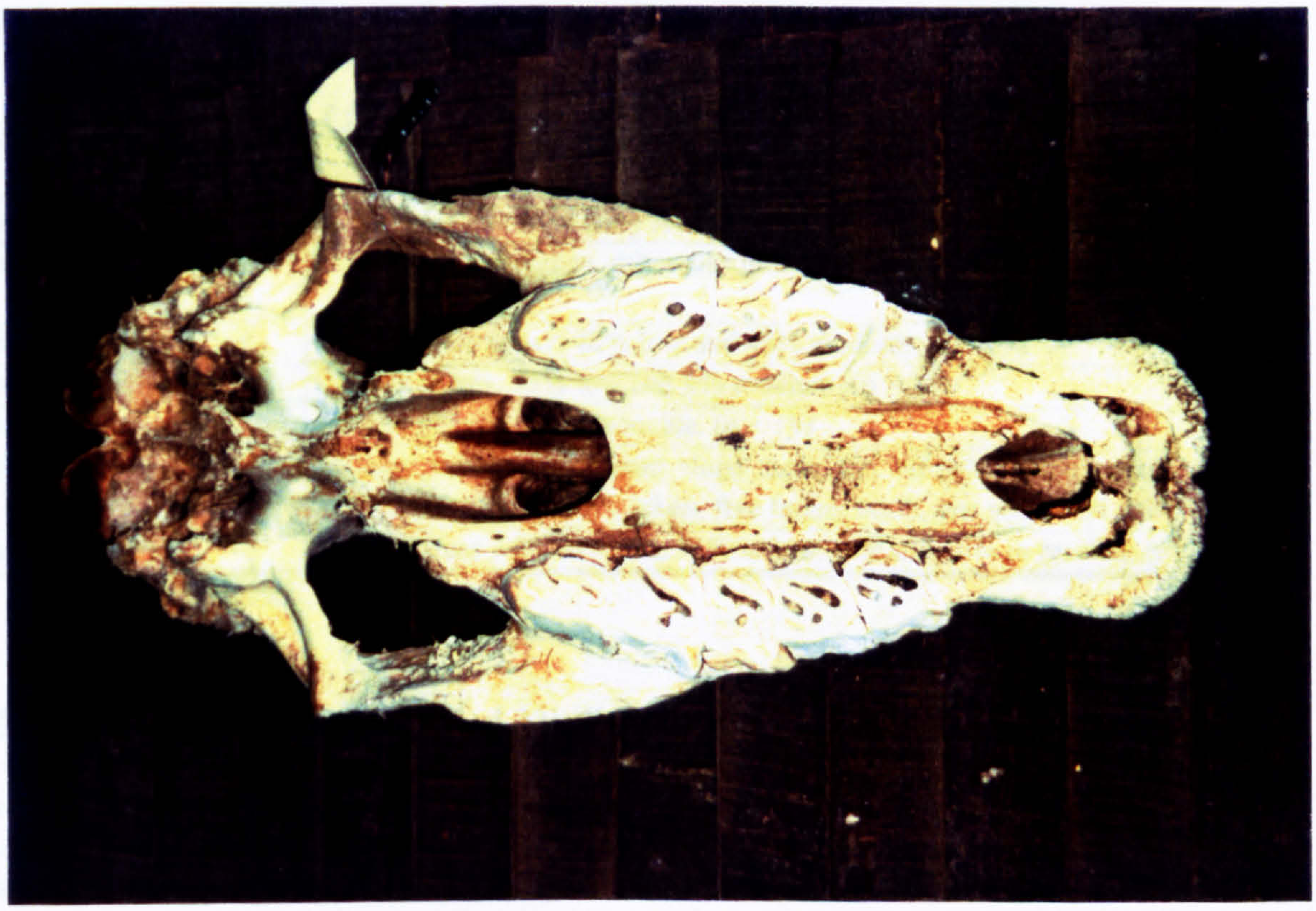


Fig. 5.26 Dental Wear of Skull, CS 96/03/19.01 HW

curiosity. As the observer crept backwards he seemed uncertain of the movement and remained stationary looking in the direction of the disturbance. He later lay down again and slept.

c) Hearing

When the rhinos were either walking or grazing their hearing was poor, possibly due to the noise of their eating and walking. However, when stationary, particularly if disturbed, their hearing was excellent.

d) Disturbed behaviour

When disturbed, the rhinos adopted a characteristic position standing with their rumps together and facing outwards in opposite directions. They held their heads above the ground while their ears were scanning for noise. If they received another indication of our presence they would run off at a steady pace, generally covering distances of several hundred metres. Sometimes however, they only ran a few metres, or on other occasions several kilometres. When disturbed and running the rhinos never intentionally headed in our direction and consequently could not be described as attempting to charge.

e) Other animals

When we were observing the rhinos, if other animals detected our presence and ran away using their alarm calls, this caused a temporary disturbance to the rhinos. However, the rhinos were never distracted for more than a few minutes in these situations.

5.3.8 Characteristics of Resting Locations

The characteristics of areas where rhinos were found sleeping and not disturbed were recorded (Table 5.7). Rhinos often changed position to remain in the shade of a tree as the sun moved.

Table 5.7 Characteristics of Areas where Rhinos were found Lying Down.

Parameter	Characteristics of Lying Area
Vegetation Class	92% low tree savanna, otherwise grass and shrub savanna. (n = 26)
Tree Cover	8% very low cover, 48% low and 43% medium. (n = 23)
Total Grass Biomass	18% very low, 73% low and 9% medium. (n = 22)
Slope	95% slight and 5% reasonable. (n = 19)
Orientation	If there was no significant slope there was no orientation, consequently only seven records were taken, five facing north, one south and one west.
Rockiness	35% in areas with no rocks, 55% in low rock and 10% in medium (n = 20).

n = number of observations

5.3.9 Water Hole Visits, Mud Wallows and Dust Baths.

There were four main water holes in Kaross and utilisation of these was found to depend upon water availability as well as rhino preference. Table 5.8 indicates the average frequency the rhinos visited the water holes, which was calculated from the days when all the water holes in Kaross were visited. This indicates that on average the rhinos visited water holes approximately once every two days during the dry season. Table 5.9 indicates the number of rhinos which had drunk at each water hole (if it was visited) to indicate the rhino's preferences between these water holes. On one occasion the number of rhinos visiting KarossFontein was unknown because the spoor was too confused to count the number of individuals. When referring to these figures it should be noted that rhinos often acted in groups. In addition, it is possible that the same rhino visited more than one water hole per night, or it may have visited the same water hole more than once.

Table 5.8 Average Frequency of Rhino Visits to Water Holes.

Season	Average drinking frequency	Number of observations made (days)
January - April	Frequent visits to seasonal water sources. Generally more than once per night.	8
May - August	1.9 days	10
September - December	2.0 days	11

Table 5.9 Numbers of Rhino Visiting Main Water Holes within Previous 24 Hours.

Numbers of rhino	KarossHoek	KarossDrink	KarossFontein	ZebraPomp
0	15	27	35	10
1	10	39	14	5
2	10	5	7	1
3	6	3	13	1
4	3	2	9	0
5	0	0	3	0
Unknown	-	-	1	-
Number of samples, i.e. observations at water hole	44	76	82	17

KarossFontein was the most frequently visited water hole over the study period. Water availability at KarossFontein was generally good, although it ran dry for several days around the 6th of September. Also, during the rainy season (5th February onwards), water flow was reduced to conserve the underground water level. Water availability at KarossDrink was always good and this water hole was used on a daily basis by the subordinate bull before the dominant bull was removed. Subsequently his visits to this location decreased. In the far corner of the area, KarossHoek water hole always had water and may have been preferred by the rhinos because it sometimes had an adjacent mud hole. Water availability was always poor at the ZebraPomp water hole. The pump stopped working on 8th May, although very limited quantities of water were pumped from 18th October for several weeks. Subsequently, the concrete trough only acted as a trough for collecting rainwater during the rainy season. The rhinos very rarely visited ZebraPomp water hole as it was generally dry, except during the wet season when it held rain water.

During the rainy season water collected in temporary catchments which included holes in rocks, at Sills Dam (located 500m south of ZebraPomp) and in occasional mud holes. These seasonal water supplies were readily used by the rhinos and during this period, spoor was only seen infrequently around the main water holes.

Throughout the dry season dust baths were common, and this was recorded at times when mud holes were both available and dry. Visits to temporary mud holes were common during the rainy season. After they had wallowed, the rhinos often rubbed their bodies against trees, tree stumps, termite mounds, or other objects of suitable size. On one occasion during the rainy season two rhinos were followed to a seasonal mud hole where they spent just over half an hour wallowing in the muddy water. It was not possible to establish exactly how many dust baths or mud wallows the rhinos had during any 24 hour period, because the complete route taken by rhinos during this time was very rarely followed.

5.3.10 Home Ranges and Distances Moved

Calculating home ranges was not appropriate since the rhinos were confined by the boundary fence which restricted their selection of home range. In addition, the study period was concentrated over one year and the removal of the dominant bull further complicated any deductions. It was noted that the area was shared almost equally between the bulls before the removal of the dominant bull.

The rhinos frequently walked over 5km after leaving water holes, but a calculation of the average distance moved over a 24 hour period was not possible due to insufficient repeated days observations of the same individual. In addition, the random grazing path of individual rhinos complicated measurement.

5.3.11 Climate, Rainfall and Rainy Season Observations

Temperature was the only climatic parameter for which sufficient observations were collected to enable comparison with activity observations. The temperatures at which rhinos were recorded as actively grazing, or lying and resting, varied throughout the year, and the results with 95% error bars are shown in Fig. 5.27. As expected, cloud cover was greater during the rainy season with an average cover of 3/8. Throughout the rest of the year cloud cover varied between 0 and 0.5/8.

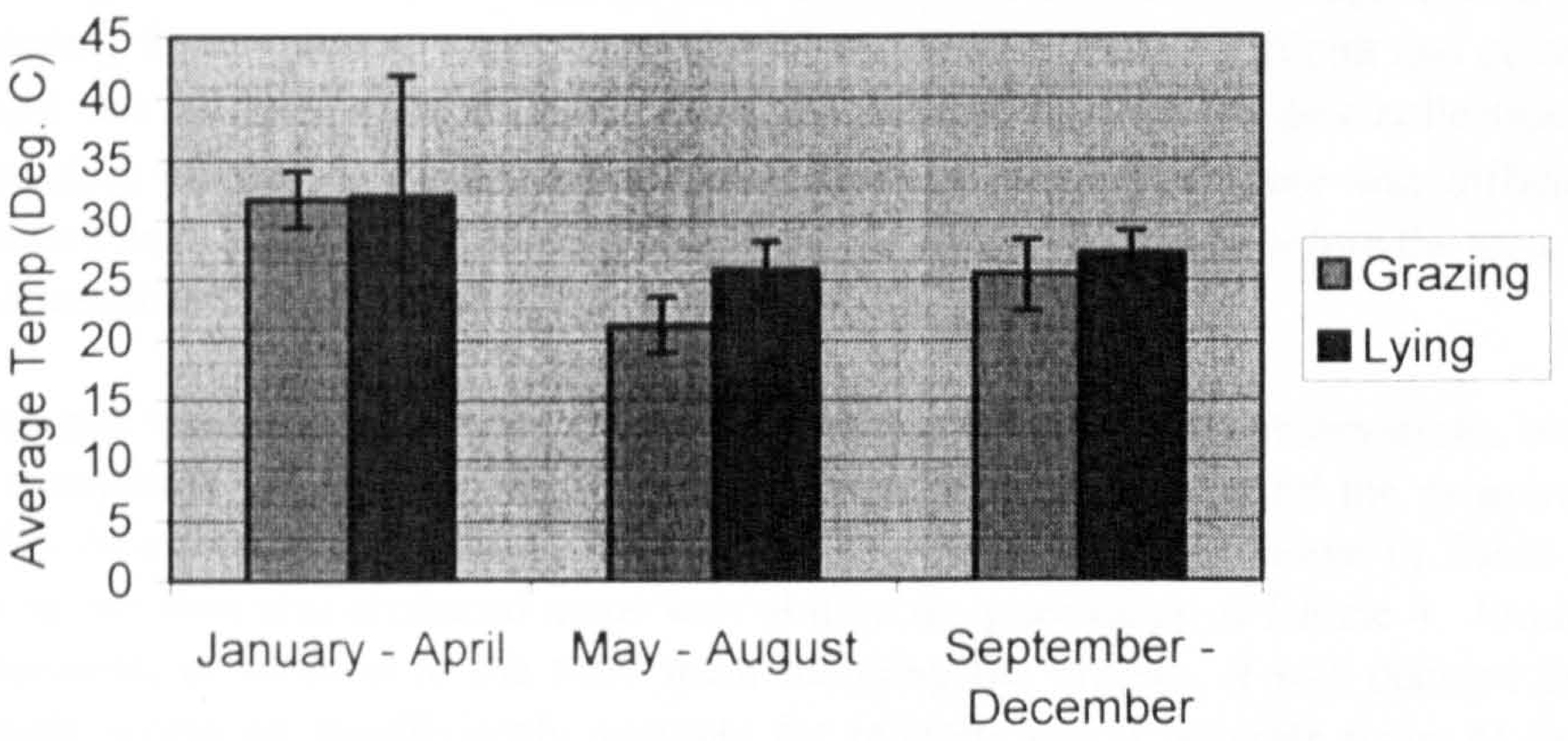


Fig. 5.27 Average Temperatures Recorded with Respect to Activity Through the Year

Rainfall values for Otjovasandu, which is approximately 10 km north of Kaross, from 1966 to 1996 averaged 366mm, and for the rainy season 1996 to 1997 totalled 348mm.

During January, the early part of the rainy season, it was difficult to find the rhinos since they no longer visited permanent water holes and any rain made their tracks impossible to age. Locating the rhinos involved searching for spoor along roads or walking across areas where they might have passed. As the rainy season progressed, the grass became more abundant, making it even more difficult to see spoor while walking through areas or when driving along the roads. Therefore, whenever they were found, rhinos were followed on subsequent days from the place they were last seen, until it rained again. Also, the locations of preferred mud holes and temporary water sources in rocks which were frequently visited became known and these often provided a reliable starting point for tracking. During the rainy season, tracking involved covering greater distances since the rhino's route over the past 24 hours was covered. With the dry season technique, only the route from the water holes was followed.

5.3.12 Limitations

i) GPS

The standard error of a GPS, as established earlier, must be considered as it can have a significant effect on the location of the spoor. An additional error was introduced when directly observing the rhinos, since animals were observed at a distance of 20m to 40m, and the GPS location was taken at the point of observation.

Due to a faulty GPS satellite receiver, before the 11th June 1996 rhino positions were plotted on a map of the area. Subsequently, these were converted to assumed GPS positions according to a grid of co-ordinates superimposed on the map. Additional assumed positions were also assigned to activity observations (recorded every 10 minutes) taken between GPS locations (recorded every 15 minutes). These positions were found by interpolating between intermediate GPS locations. Fig. 5.28 indicates the locations of the actual and assumed GPS locations. (Actual GPS locations = 813, assumed GPS locations = 1240) It is possible to identify routes followed when no GPS was available. This map indicates that there are no significant discrepancies and that the assumed GPS positions may be justifiably used.

Following GIS analysis, a few activity locations were found to be situated outside the boundaries of the area due to random GPS error. For the purpose of producing maps, these observations were deleted as they were technically not possible and it would not be valid to 'move' them inside the fence.

ii) Tracking

After strong winds or rain it was not possible to track spoor as the fresh appearance of the tracks rapidly disappeared. Some types of substrata resulted in tracking becoming difficult and occasionally the track of the spoor was completely lost. It was then not possible to continue data collection and an incomplete days tracking resulted. Also in certain areas accurate ageing of spoor was difficult and occasionally spoor over one day old was mistakenly followed for varying distances before the error was recognised. In these circumstances the observations were ignored.

Mapping and measuring spoor to identify individuals, without direct observations, was tested on male 2. Good measurements of the width of spoor of each foot were taken and the measurement repeated two days later in a similar substratum. The change in measurements is shown in Table 5.10. Mapping the creases in one foot also produced maps very similar to spoor maps of female 4. From these variations in measurements, in addition to the time spent mapping the creases, it was decided that identification of individuals would be insufficiently accurate for reliable use. If accurate maps of the spoor could have been generated then it would have been possible to identify which rhino was being followed whenever a clear print was visible.

Table 5.10 Trial Spoor Width Measurements for Identification of Individuals.

Male 2, foot-	Initial width measurement	Width measurement two days later
Right back	260mm	255mm
Right front	300mm	290mm
Left back	270mm	270mm
Left front	300mm	290mm

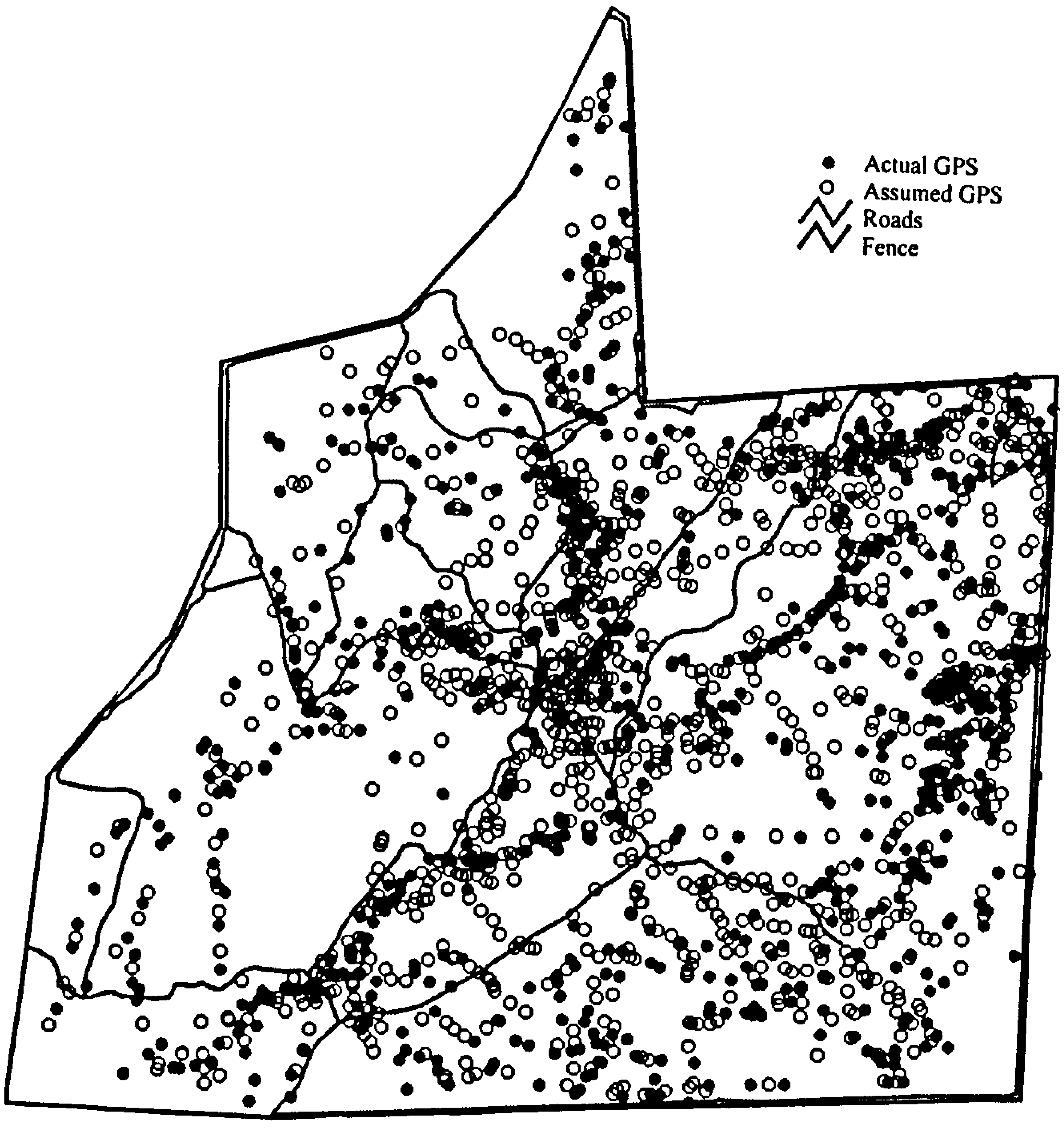


Fig. 5.28 Positions of Actual and Assumed GPS Locations

iii) Incomplete Coverage

On most occasions rhinos were tracked from a water hole, avoiding the path of the rhino the previous evening when on its way to water. Consequently, to provide data for complete 24 hour periods of activity and movement, on several occasions the complete path was followed from where the rhinos were left the previous day. Tracking 24 hours of activity proved very time intensive since the rhinos would often walk long distances. After they were located, generally around 13:00 to 14:00hrs, it was still necessary for us to return to the vehicle. Although tracking continued through the mid-day period on most days, it was not practical to track 24 hours of rhino activity on a regular basis. In addition, it was sometimes found that the spoor was becoming old after this time and tracking often resulted in lost spoor.

5.4 Discussion

Observations were assessed to provide an insight into the social ecology and behaviour of the rhinos in Kaross. Although the rhinos were apparently managing well and were visually in good physical condition, the lack of recruitment in the last three years requires consideration of possible explanations.

5.4.1 Rhino Observations

i) Mapping of Rhino Activity, Individual Sightings and Intra-specific Interactions

During the period that the two males were present, male 1 was the dominant bull. The area of Kaross was divided approximately equally between the bulls, although not all of the area within each territory was used. It was found that when tracking along the path of a male, it was obvious which individual was being followed, since their home ranges were clearly non-overlapping. Territorial boundaries were regularly patrolled and marked by spray urinating and dung scattering. Defence of individuals territory was also clear from the evidence of a night time fight, which was apparent in the spoor the following day. These observations of territoriality agreed with the description of Owen-Smith (1972 & 1975). However, both bulls were recorded on at least one occasion outside the borders of their area. Also, male 2 was occasionally found to be covering large distances.

Female 4 was often located with the other females, although she frequently walked independently, and over longer distances than other females. Females 1 and 5 were generally always found together, and the close association between these individuals remained consistent throughout the study. The reason for this association is unknown. Owen-Smith (1988) attributed similar pairings between two individuals as generally being a cow accompanying a calf and it is possible that these individuals did have this relationship. However, groupings of females without calves and sub-adults have also been recorded, although these relationships are not usually permanent since cows separate to give birth and care for their young. White rhino cows usually responded neutrally to each other, as was described by Owen-Smith (1988).

Although the cows were found to tolerate the presence of the bull, he was often only allowed to follow them at a distance behind, as has been observed by Owen-Smith (1992). The bull sometimes remained with a cow for more than 24 hours which was regarded as an indication of the cow coming into oestrus by Owen-Smith (1992). However, mating was infrequent before the dominant bull was removed and not observed after his removal. When the two males were present, the females remained in the territory of the dominant bull. After he was removed the movements of all the rhinos became far more unpredictable, extending across more of the available area.

ii) Seasonal Utilisation

Seasonal changes in movements highlight the effect of the rainy season on the rhinos. Rhinos took advantage of the areas which were the first to produce new grass and to find these they appeared to carry out exploratory walks across the area. During the rainy season the rhinos made less use of the main riverbed areas, indicating that these areas were more important during the late dry season.

iii) Condition of Rhinos and Other Animals

It was found that the condition of the rhinos was good all year round, although at the end of the dry season there may have been a very marginal loss of body fat. H. Winterback (*pers. comm.*) advised that when the rhinos were captured and relocated to Kaross they were all in very poor condition, but following their release, their condition rapidly improved. Subsequently, their condition has remained consistently good to excellent (also P. Erb comment, *rhino researcher in Namibia*).

It was observed that the rhinos in Kaross appeared well nourished during the rainy season when plentiful fresh grass was available. Build up of body fat when grazing is plentiful has also been noticed by other authors. Owen-Smith (1988) described increased body mass as an adaptation to compensate for extreme fluctuations in seasonal food availability. This observation was based on the finding of Bell (1971), that larger animals lose condition more slowly on a sub-maintenance diet than do smaller animals. Lindstedt and Boyce (1985) showed that stored fat reserves become a greater fraction of body mass as size increases. The ability of white rhinos to build up deposits of subcutaneous fat to aid their survival through the dry season was described by Selous (1899), Owen-Smith (1988) and Smithers (1983).

Roan antelope are a grazer and are particularly sensitive to the condition of the veld, being one of the first animals to reflect a deterioration in the quality of grazing. In Kaross, the condition of these animals remained consistently good, even at the end of the dry season. However, the condition of some Eland noticeably deteriorated at the end of the dry season, although because they are browsers, this observation does not reflect grazing conditions. A variety of factors may have caused this observed effect in Eland, including territorial instincts which may result in animals going hungry or even starving. Also, following the birth of a calf, many cows are known to lose condition.

These results would indicate that at present, rhinos are not nutritionally limited in Kaross and that the habitat was therefore inherently suitable.

iv) Rhino Capture

During the capture of the dominant bull, he appeared to be sweaty, which was particularly noticeable in the crate after loading. Owen-Smith (1973) described this sweaty appearance as often evident following a prolonged chase before capture or after a long fighting session. The immobilising drug used was Etorphine hydrochloride (M.99) and the antagonistic drug was (M.285). It took longer than expected for the antagonistic drug to take effect, an observation also recorded by Owen-Smith (1973) during his field observations with NPB's capture team.

v) Ages and Mortality

Personal observations are supported by the records of Du Preez (unpublished) which categorised the rhinos as in the 'older' age category. From the assessed ages of the carcases found it is likely that these individuals are now aged between 25 and 32 years. It is unfortunate that the actual ages, and more details of the reproductive history of these animals before they were moved to this area, were not known. In addition, because the carcasses of the females which died were found some time after their deaths, it was not possible to make any observations on possible causes of death. The longest-lived wild white rhino was believed to be about 40 years old by Hillman-Smith *et al.*, (1986), according to cementum line counts from a tooth section.

vi) Responses to Stimuli

Details of the response of the rhinos to the presence of the tracker was included to provide background information for possible further studies. It was found that rhinos are very sensitive to disturbance and always react to human scent. Normally, rhinos do not seem alert to sounds, possibly because they are masked by the noise of their own movements. However, when alerted and listening attentively, their hearing abilities are clearly sensitive. If already disturbed and they then heard another sound, they would probably run. These observations agree with those of Owen-Smith (1973), who noted that rhinos in the Umfolozi Game Reserve had an acute sense of smell, good hearing and poor eyesight. He estimated that they were alerted to potential danger at distances of 800m, when a steady breeze was blowing towards them.

vii) Characteristics of Resting Areas

Through the middle of the day, rhinos always rested in the shade of a tree or bush and it was noticed that they sometimes moved around the tree as the shade rotated. No favoured sites were identified and only a weak preference for north facing slopes was noticed. The rhinos in Kaross did not appear to have a significant preference for denser trees for shade, although Owen-Smith (1973) noted that they prefer deep shade for their midday rest.

viii) Drinking Frequency, Mud Wallowing and Dust Bathing

Drinking frequency during the dry season was every two days on average. Owen-Smith (1988) described drinking frequency in the Umfolozi as every two to three days (or sometimes four day intervals) and Pienaar (1994a) recorded two to four day intervals in the Kruger. Both this study and Umfolozi research (Owen-Smith 1988) noticed that during the rainy season, when water was readily available, rhinos drank daily or even twice daily. Permanent water availability is an essential habitat characteristic, which supports the observations of Owen-Smith (1973) and Pienaar (1994a). It appears that the more arid conditions of Namibia have increased white rhinos dependence on water availability during the dry season. The rhinos did not exhibit a preference for individual water holes, despite water availability being unreliable at several locations during the study period.

During the dry season dust baths were regularly visited. Rolling in dust probably has a cooling effect on the rhinos, and it may also help with ectoparasite control and cleaning the skin. Mud wallows were mainly utilised during the rainy season, although the mud hole at KarossHoek was occasionally utilised during visits to this water hole. Wallowing was similar to behaviour described by Owen-Smith (1988).

ix) Home Ranges and Distances Moved

Under the conditions in Kaross the two bulls divided the available area between them. Because these areas were limited by the boundary fence it was not possible to identify a natural home range. In other areas, home ranges of white rhinos have been discussed by Owen-Smith (1975), Pienaar *et al.* (1993b), Pienaar (1994b), Condy (1973), van Gysegham (1984) and Conway & Goodman (1989).

x) Rhino Responses to Climate

Due to the high daytime temperatures, the rhinos rested through most of the daylight hours. In the Umfolozi, Owen-Smith (1973) also found that white rhinos were mainly active in the early morning and late afternoon and had long rests through the middle of the day. The length of this period of inactivity appeared to be affected by temperature and cloudiness. During the rainy season, the rhinos continued grazing into higher temperatures than during the rest of the year.

Rainfall in Kaross was approximately 365mm over the last few decades. This is much lower than the annual rainfall in the Umfolozi, which was generally between 700 and 985mm (Owen-Smith 1973), and in Kruger where it ranges between 430 and 700mm (Pienaar *et al.* 1993a&b). This difference in rainfall results in the Kaross habitat having a reduced biomass and different component species in the herbaceous layer.

A comparison of daytime temperatures between Etosha (Beyers & Katsiambirtas 1987) and the Umfolozi (Owen-Smith 1988), shows little difference in the maximum values in July which were both approximately 25.0°C. However the minimum July value in Etosha was 6.0°C compared with 13.2°C in the Umfolozi.

5.4.2 Lack of Recruitment

Over the period of three years since these white rhinos were released, no calves are known to have been born despite an apparently favourable sex ratio. Owen-Smith (1988) stated that it is unusual for a cow not to produce a calf over a four year period, and if this is the case, it can be presumed that she is either infertile or had lost the calf shortly after birth. He also stated that megaherbivores can have very flexible birth intervals in response to ecological circumstances and if conditions are unfavourable, conception may be delayed or the foetus aborted early in pregnancy. Consequently, if breeding success in terms of successful recruitment is taken to indicate habitat suitability, it might be inferred that Kaross is not an appropriate environment for rhinos.

However, a number of other factors complicate this issue. From the history of these rhinos it was known that before they were moved to Kaross, they were on a nearby farm where they had also been unproductive. This farm had a similar habitat to Kaross, although it was periodically overgrazed and reputed to be poorly managed. The animals were known to be in an 'older' age category although visual assessment indicated that the condition of all the rhinos was good to excellent for most of the year. Mating had apparently occurred between one of the cows and the original dominant bull. After his removal there were no indications that the subordinate bull was mating with the females, although he often accompanied female 4. If recruitment in the Kaross population continues to be absent, MET propose to either introduce a young bull to promote successful reproduction or to relocate all individuals to Etosha National Park.

Possible factors which might have influenced the reproductive success of these individuals therefore include:

- The males may have been infertile, possibly due to age.
- The females may have stopped cycling due to stress from conditions in Ohorongo.
- The females may have stopped cycling because they had not been motivated due to a lack of competition from the males (Louis Geldenhys, MET, Windhoek, *pers. comm.*).
- The animals were too old and past the breeding period, although wild animals usually continue breeding until they die (Louis Geldenhys, *pers. comm.*).
- Small populations are sensitive to unusual chance events because they are made up of a small number of individuals. It is therefore possible that the males or females have some reproductive abnormality.
- Calves might have been aborted or born and died prematurely, although this did not occur during the study period.
- The habitat could be inherently unsuitable due to nutritional deficiency or unknown factors.

5.4.3 Critique of Methods

i) Tracker Skills

Skilled tracking is learned through age and experience. Bushmen are native to the Etosha area and until several decades ago, lived in the bush, using tracking as a skill to survive. Three Bushmen trackers were employed between 26th March and 19th April 1996, however various problems associated with old age and lack of motivation were encountered. Eventually field work began intensively following the recruitment of Mr Solomon Haikuti (of Damara - Owambo origin), who was recommended by the

Ministry of Environment and Tourism as an ex-Save The Rhino employee. Mr. Haikuti was employed from 2nd May 1996 until the 28th February 1997.

The primary language of all trackers is their regional dialect, with a second language of Afrikaans and if they spoke any English, it was at best poor. Communication could therefore be difficult. Mr Haikuti fortunately spoke reasonable English, which greatly assisted field work. Because the trackers had no scientific understanding they found it difficult to understand my interest in where the rhino had been grazing and the activity as indicated by the spoor. Frequent explanations of the purpose of the study were therefore necessary. To ensure that the tracker was giving an accurate indication of activity, it was also necessary to personally learn basic tracking skills.

Tracking and the interpretation of spoor was determined by Stander *et al.* (1997) to be a scientifically sound technique when studying wild animals in their natural habitat. Conversely, Liebenberg (1990) assessed tracking as subject to a large degree of bias depending upon the techniques used. Tracking is completely non-intrusive (Bothma *et al.* 1993) and scientifically legitimate (Stander *et al.* 1997).

For this study, tracking spoor on foot with the aid of an African tracker was found to be the only reliable technique for locating the rhinos on a daily basis, following their nocturnal activity patterns and minimising disturbance to their daily routine and activity patterns. By studying the animal's spoor and freshly grazed areas in detail, regular observations could conveniently be collected by simple and repeatable techniques. Direct observations of grazing were often only possible at too great a distance for the grass species ingested to be identified.

It had been planned that direct observations would be compared with tracker data to allow the accuracy of the tracker to be assessed, and hence determine the confidence which can be placed on indirect records. This would have been carried out by observing the rhinos activity in the absence of the tracker, and later asking him to reconstruct the movement and activity of the rhino. However, the activity classes used to describe rhino behaviour and the movements of the rhinos were thought to be sufficiently broad for this to be unnecessary. In addition, after direct observations were obtained, if possible the location was revisited the following day to identify activity with respect to herbaceous layer. This also confirmed indirect observation accuracy.

Chapter 6

Rhino Utilisation of Kaross

6 Rhino Utilisation Of Kaross

6.1 Introduction

6.1.1 Background

The objective of this section is to correlate information collected during the Kaross habitat survey (Chapter 4) and the Kaross rhino study (Chapter 5), to identify and examine patterns of habitat utilisation. Spatial analysis of information with GIS should enable habitat utilisation to be compared with habitat availability. Significant differences will be identified by statistical analysis techniques. The discussion in this chapter incorporates some items discussed in the previous two chapters, relevant details will be summarised in the overall discussion.

6.1.2 Previous Studies

In South Africa, Pienaar described the landscape preference of white rhinos in the Kruger National Park (Pienaar *et al.* 1992, 1993a; Pienaar 1994a). Owen-Smith (1973) studied the ethology of rhinos in the Umfolozi Game Reserve and also discussed their habitat utilisation. Other investigations included Borthwick (1986), who studied habitat use of the white rhinoceros in relation to other grazing ungulates in Pilanesberg Game Reserve, Bophuthatswana.

Ferrier and Smith (1990) discussed the use of GIS for biological surveys, highlighting its capacity for data analysis and spatial extrapolation. GIS has been used to examine characteristics of black-tailed prairie dog (*Cynomys ludovicianus*) colonies in Montana, with parameters including slope, aspect, land tenure and distance from roads (Reading & Matchett 1997). Smith *et al.*, (1997) applied GIS as a tool to establish regional biodiversity by investigating Lemur distribution and abundance in western Madagascar.

6.1.3 Aims

This chapter aims to establish and analyse the habitat utilisation and grazing preferences of the white rhinos in Kaross as follows:

- To correlate the locations of recorded rhino activities with spatial maps of environmental parameters by using GIS techniques, and to identify preferences for individual parameters and homogenous areas.

- To establish grazing preferences by analysing observations of the focal area of rhino in relation to activity and season.

- To identify patterns of habitat utilisation by comparing results of the Kaross habitat survey with white rhino observations associated with activity and season.

6.2 Method

Patterns of utilisation in Kaross were determined by using GIS techniques to overlay maps of observed rhino activity locations on to maps of environmental parameters. Herbaceous layer data and habitat utilisation information were then statistically analysed to identify preferences and seasonal trends. Finally the effectiveness of using GIS analysis techniques for this study was assessed.

6.2.1 Geographical Information System Analysis

6.2.1.1 Data Collected

i) Environmental Maps

The habitat survey of Kaross, detailed in Chapter 4, established and mapped the distribution of habitat, herbaceous layer and tree species. This habitat survey produced detailed descriptions of the following environmental parameters:

Herbaceous Layer

a) Grassland type analysis, which was separated into three, four and eight categories. These were analysed as basic maps and as detailed maps with the rivers and water holes as additional grassland categories.
b) Occurrence of species including; *Schmidtia kalahariensis*, *Stipagrostis uniplumis*, *Eragrostis nindensis*, *Eragrostis porosa*, *Aristida adscensionis*, grouped *Aristida* species and grouped *Eragrostis* species.
c) Grass biomass.
d) Grass density.
e) Forage factor.

Habitat

a) Habitat type according to the basic and detailed maps.
b) Vegetation class.
c) Distance from rivers.
d) Distance from water holes.
e) Two maps of rockiness.
f) Three maps of soil type based on the original 11-class map of Beugler-Bell (1996), the redefined map with 5 categories and the 5-class map analysed with the assign proximity function. The results of the analysis with the assign proximity map will provide an indication of the accuracy of this GIS function.

Trees

a) Tree classification according to basic and detailed maps.
b) Tree cover.
c) Tree species including; *Mopane*, *Acacia* species, *Combretum* species and *Terminalia* species.

ii) Rhino Activity

White rhino activity observations of pure grazing and walking were extracted from the study of the Kaross rhinos in Chapter 5. These two activity classes were considered fundamental to this analysis since they represent the extremes of activities and were considered most likely to be a product of their surrounding habitat parameters.

6.2.1.2 Analysis

Using the GIS programme Arc View v3, maps of the environmental parameters were created in grid form with component pixels of 50m by 50m. It was possible to count the number of pixels of each environmental parameter category and the number of grazing or walking observations within each category. The following graphs were then constructed to illustrate the quantity of data in each habitat or herbaceous layer class, its influence on activity and the error associated with analysis:

a) The number of pixels, converted into hectares.
b) The number of grazing observations.
c) The number of walking observations.
d) The number of grazing observations per hectare for each activity class. This was calculated as the number of observations in the selected class/number of hectares in that area.
e) The number of walking observations per hectare for each activity class.
f) To enable comparison between the different observations, a graph of the index of utilisation of each grass class for grazing and for walking was produced. This used the following formula:

$$\text{Utilisation Index} = \frac{\text{Number of activity observations in that class / Total of activity observations}}{\text{Number of hectares in that class / Total number of hectares.}}$$

When the utilisation index value exceeds one, there is apparent selection for the activity observed. When it is less than one avoidance is apparently occurring and when equal to one selection is apparently random.

Error bars were calculated and superimposed on the utilisation index graph to indicate the 95% confidence limits. These identified results in which a small area or few activity observations may be introducing a relatively large degree of error. The standard error (S.E.) was calculated from:

$$\text{S.E.} = \sqrt{\frac{p(1-p)}{(n-1)}}$$

where:
p is the proportion of the nominated activity observations or hectares, and
n is the number of all activity observations or hectares.

The results become unreliable when p is greater than 0.9 or less than 0.1. This situation justifies the grouping of data to minimise the influence of extreme or rarely encountered classes.

The standard error provides the 68% confidence interval for the mean results. This is increased to 95% confidence interval by multiplying the standard error by 1.96. It is then possible to be 95% confident that the population mean will be found between the limits of the sample mean plus and minus 1.96 S.E.

With a confidence interval (Conf. Int.) of 95%, the maximum and minimum values of utilisation index were determined as follows:

$$\text{Maximum value} = \frac{\text{p activity} + \text{activity Conf. Int.}}{\text{p area} - \text{area Conf. Int.}} = \frac{\text{Maximum activity}}{\text{Minimum area}}$$

$$\text{Minimum value} = \frac{\text{p activity} - \text{activity Conf. Int.}}{\text{p area} + \text{area Conf. Int.}} = \frac{\text{Minimum activity}}{\text{Maximum area}}$$

6.2.2 Analysis of Seasonal and Activity Trends in Rhino Observations

6.2.2.1 Data Collection

Information on utilisation of the Kaross habitat by the white rhinos was obtained by compiling tracker guided and direct observations (see Section 5.2.1) as follows:

- Tracker guided or indirect observations; every 10 minutes an appraisal of rhino activity and a grass assessment (described in (i) below) of the focal area was recorded; every 30 minutes a complete habitat assessment (described in (ii) below), grass assessment and details of rhino activity were noted.

- During direct observations; every 30 minutes the rhino activity, grass and habitat assessments were recorded.

These observations were then compared with the habitat survey (Chapter 4), in which various environmental parameters were measured, including details of the habitat and herbaceous layer.

i) Grass Assessment

Whenever rhino activity observations were recorded, the herbaceous layer was described in terms of the semi-circle (of one metre diameter) in front of the rhino. Termed the **focal area** of the rhino, this area of approximately $0.4m^2$ is similar to that used by Owen-Smith (1973) to investigate the diet composition of feeding white rhinos. Since rhinos have poor eyesight and a keen sense of smell, it is assumed that the focal area will exert a significant affect on the rhinos activity. This technique also assumes that the rhino is selecting areas for grazing based upon what it perceives or senses to be in the area in front of it. During direct observations, if freshly grazed areas could be visited without disturbing the rhinos, these grasses were identified. Records of the focal area included the grass species, the phenology (greenness) and the biomass as follows:

> a) **Grass species.** The dominant grass species were recorded as percentages of the area's total biomass. Personal calibration to enable this to be visually estimated was undertaken before the study on a series of test sites. The technique involved estimating the relative percentages of each grass present within the focal area. All the grass species were then clipped to ground level and each species separated and weighed. The relative percentages were calculated and rounded into the nearest 10% class. Calibration of these estimates of percentage were continued until personal estimates achieved 90% accuracy.
>
> b) **Phenology** of each grass species. This was classified according to the classes of Du Plessis (1997), Table 6.1, and was assessed to provide an indication of the moisture content, which relates to the nutritional quality of the grass.

Table 6.1 Classification of Grass Phenology (Du Plessis 1997).

Description	Classification
Dry	1
More dry than green	2
50% dry and 50% green	3
More green than dry	4
Green	5

c) **Total Grass Biomass** within the focal area was estimated according to techniques derived using the Disc Pasture Meter system as described in Chapter 4.2.1(iii). Biomass ratings were assigned to classes as in Chapter 4, Table 4.16.

ii) Habitat Assessment

To compare the habitat utilised by the rhinos with that available, details of the habitat in the vicinity (up to 50metres) of the rhino were recorded at regular intervals. Records included information on the following parameters using the techniques described in section 4.2.2:

- Vegetation classification.
- Tree cover.
- Rockiness.
- Slope of the landscape. A note was also made if the rhino was walking along a fence, road, hill crest, riverbed, erosion gully or any other landscape feature.
- Substratum detail in terms of the type of rocks in the area.

iii) Rhino Activity Observations

Activity classes of 'grazing', 'grazing/walking', 'walking/grazing', 'walking' and 'other' were analysed. For the purpose of analysis, 'other' referred to observations of lying down, drinking, running, standing, wallowing and dust bathing. The 'other' category formed a separate group which was not expected to contribute to the main data, but provided additional information. If no activity was recorded and only a GPS location was taken, this was recorded as an unknown activity.

6.2.2.2 Analysis of Activity with Respect to Season

The influence of season on activity was detailed in Chapter 5.3.1 and was investigated by counting the number of observations in each month and providing this information in proportional bar charts with 95% confidence intervals. The standard error (S.E.) was calculated from the following equation and this was used to establish the 95% confidence intervals as detailed in section 6.2.1.2 :

$$S.E. = s / \sqrt{n}$$

Where s = sample standard deviation
n = number of observations

Chi-square statistical analysis was used to confirm the significance of any trends (Fowler & Cohen 1990). If there were no seasonal trends in the rhinos activity pattern, then there would have been no significant difference between the number of times an activity was observed, compared to that expected.

$$\text{Chi-square } (\chi^2) = \sum \frac{(O-E)^2}{E} \qquad \text{d.f.} = (n-1)$$

where: O is Observed frequency
E is Expected frequency
d.f. is Degrees of freedom.
n is Number of categories

6.2.2.3 Analysis of Activity with Respect to Herbaceous Layer

Observations of the focal area with respect to different activities provides an indication of grazing preferences. Data analysis of grass biomass ratings used the same techniques as that for habitat parameters, which were discussed in section 4.2.3.

To investigate whether the mass of any particular grass species in the focal area influenced rhino activity, it was necessary to consider the total biomass rating of the focal area as well as the relative percentage of each grass species. Recorded biomass ratings were converted into approximate average weights of grass, derived from the calibration of the Disc Pasture Meter for use in Etosha National Park (Kannenberg 1992; Du Plessis 1997), when each biomass rating was correlated to a range of values for dry mass in kg/ha. The mean value in this range was taken and converted into g/m^2. The focal area of the rhino formed a semi-circle of radius 0.5m or an area of 0.39m^2 (Owen-Smith 1973). The average biomass in grams within the focal area was therefore calculated for each rating category. This series of calculations can be followed in Table 6.2.

Table 6.2 Derivation of Biomass of Grass in the Rhino Focal Area, from the Biomass Rating

Biomass Rating	Dry mass (kg/ha) (Du Plessis 1997)	Average kg/ha	Average g/m^2	Total biomass in focal area of rhino (g)
(Bare Ground)	0	0	0	0.00
Extra Low	≤ 100	50	5	2.00
Very Low	101 - 500	300	30	11.78
Low	501 - 1200	850	85	33.38
Medium	1200 - 2000	1600	160	62.83
High	2001 - 3300	2650	265	104.07
Very High	>3300	3950	395	155.12

The fraction of each grass species in the focal area was multiplied by the total biomass as indicated by the biomass rating. This provided an indication of the biomass of each grass species in the focal area of the rhino. The absence of a grass species was recorded as zero biomass. Therefore, if in a particular case the biomass in the focal area was low, with *Schmidtia kalahariensis* comprising 80% of the total and *Stipagrostis uniplumis* 20%, the approximate biomass of all the grass would have been 33.38g, of which *Schmidtia kalahariensis* comprised 26.70g and *Stipagrostis uniplumis* 6.68g.

i) All Species Analysis

For each activity, the average of all observations of focal area biomass was calculated. These data were converted into percentages of the total observed biomass for each grass species and then compared with herbaceous layer data from the Kaross habitat survey. It was necessary to use a different technique for the habitat survey, ie. the wheel-point apparatus, therefore results were not directly comparable with biomass observations of rhino focal area. Nevertheless, comparisons of the percentage occurrence of each species could provide an indication of how grass encountered during different rhino activities compared with that recorded in the habitat survey.

To compare these results, pie charts were used to illustrate the percentage of each herbaceous species in the habitat survey and in the focal area of the rhino during grazing and walking activities. All species which were under two percent of the total were classed as 'other' and details of the nominal classes were provided in a table that detailed the results.

ii) Individual Species Analysis

Graphs showing the average biomass of each individual grass species in the focal area of the rhino, for each activity class and for each season were plotted. The standard error (S.E.) was calculated (section 6.2.2.2) to provide error bars indicating 95% confidence intervals.

ANOVA (ANalysis Of VAriance) statistical analysis was carried out using the SPSS statistical package to analyse variations in rhino activity and season for each grass species. ANOVA was applied to these results since it allows comparisons to be made between any number of sample means and is a reasonably flexible technique (Zar 1996). For statistical analysis, each grass species was analysed separately because the density of grasses is very low in Kaross, hence the presence of one species did not affect the presence of another. ANOVA demonstrates two-way significant differences which identify whether activity, season or other parameters represent a cause of statistical significance in the data. Altogether fifteen groups, representing five activities and three seasons were examined.

Initially an F-Test was carried out to indicate whether activity or season (or both) were significantly associated with the grass species.

Classes were allocated to each combination of activity and season to complete a one-way ANOVA. Following this analysis *post-hoc* tests, which indicate specifically where significant differences lie, were conducted. For the purpose of this study, two *post-hoc* tests were consistently applied. Firstly, the Tukey Honestly Significant Difference test was performed, which is widely regarded to be the best *post-hoc* test. Secondly, the Scheffé test which is designed to cope with an uneven number of observations.

iii) Grazing Observations

Freshly grazed grass was identified by examination of the grazed stems. In addition to regular grazing observations, notes were also made of other significant feeding observations.

iv) Direct Observations

Description of grass species grazed which were clearly identified by direct observations were recorded. It was necessary to avoid disturbing the rhinos whilst collecting direct observations, therefore observations were only recorded when identification of grass species could be made from a distance or by visiting a precise location after the rhino had moved away.

v) Phenology of Grasses

Observations were made of how the phenology of grasses changed through the seasons and whether this was found to influence rhino activity.

vi) Grass biomass

Grass biomass ratings in the focal area and in the vicinity of the rhino were analysed according to rhino activity and season. It was not possible to compare these data to the Kaross habitat survey since the habitat survey was carried out at a fixed time of year whereas grass biomass varied throughout the year as observations continued.

Proportional bar charts were created to compare biomass ratings for different rhino activities and for three seasons. Error bars with 95% confidence limits were applied to provide a visual indication of the size of the samples.

Chi-square analysis (see section 6.2.2.2) was then used to compare all activity observations (grazing, grazing/walking, walking/grazing and walking), to determine whether any selection of grass biomass ratings within these activities was significant. Observations were also compared between seasons, to establish whether this influenced grass biomass selection.

Errors in focal area biomass ratings could be caused by grazing activity reducing grass biomass in the focal area, which may lead to overall results indicating grazing in lower biomass areas. Consequently, grass biomass was recorded in the vicinity of the rhino as well as in the focal area. Biomass ratings were then analysed to investigate whether grazing reduced the biomass in the focal area. The biomass in the focal area was compared with the biomass in the vicinity in terms of an increase, decrease or no change.

vii) Mean Height of Grass Before and After Grazing

Where freshly grazed grass was evident, the height of the grass before, as indicated by nearby (within 1 to 2 metres) identical species, and after grazing, was recorded. Initially grass height was measured and later it was estimated.

6.2.2.4 Analysis of Activity with Respect to Habitat

Rhino observations in each class of habitat were extracted and compared with the habitat survey. These parameters were suitable for comparison as identical techniques had been used for data collection in both circumstances.

i) Habitat classes

During data collection, each habitat parameter was recorded as one of a broad range of potential classes to provide flexibility during the survey. However, it was found that in practice data collected were only distributed across a few categories. Consequently, these were reclassified to remove non-existent classes and classes with very few observations. Reclassification provided a reasonably even number of values in each class which facilitated statistical and graphical analysis, since observations in extreme classes did not subsequently exert a skewing effect during data analysis.

Habitat classes for vegetation type, tree cover, grass biomass in vicinity and slope were reclassified identically to MVSP analysis (see Chapter 4.2.3). It was necessary to reclassify results for rockiness to identify medium and high rockiness as separate values. High rockiness ratings were infrequently encountered in the habitat survey, but not recorded during rhino activity observations. Separating these classes enabled the effect of a broader range of rockiness gradients to be analysed. Rockiness ratings were therefore grouped as indicated in Table 6.3..

Table 6.3 **Reclassification of Rockiness Ratings for Analysis.**

Rockiness Class	Description of Rockiness
1	None
2	Extra Low, Very Low & Low
3	Medium
4	High

Substratum parameters were briefly described in terms of dusty, sandy, gravely, pebbles and small rocks, rocks and boulders, kopjes and sheet rock. These parameters were not mapped in Chapter 4 since more appropriate spatial maps were available.

ii) Graphs

As in section 6.2.2.3 (vii), proportional bar charts with 95% confidence limits were used to illustrate variations in habitat classes with rhino activity and season.

iii) Statistics

The observations of rhino selection were recorded as frequencies amongst classes, which enabled Chi-square statistical analyses to be carried out as in section 6.2.2.2. This identified significant differences between parameters as follows:

a) Grazing and walking activities observed were compared with what was expected from the habitat survey results, i.e. the availability of habitats in Kaross.
b) All activity observations (Grazing, grazing/walking, walking/grazing and walking) were compared with what was expected if no selection was occurring, to establish whether certain activities preferred particular habitats.
c) Observations during each season were compared with what was expected from the habitat survey results.
d) Observations between seasons were compared with what was expected if no selection was occurring between seasons, to establish whether different seasons influenced habitat selection.

If the rhinos demonstrated no selection then there would be no significant difference between the number of times a habitat class was observed, compared to that expected.

6.2.3 Assessment of Analysis Techniques

The results from each analysis technique were compared by summarising significant trends identified by each analysis. Having established the efficiency of the extrapolation of environmental variables, the benefits and limitations of using GIS were then assessed.

6.3 Results

All graphs in this section include error bars which indicate 95% confidence limits.

6.3.1 Geographical Information System Analysis

Patterns of utilisation were analysed by GIS techniques, using spatial maps of environmental variables derived from Chapter 4, overlaid with locations of grazing and walking activity observations from Chapter 5. A GIS map of each environmental parameter showing classes was produced, together with a graph showing utilisation index, to indicate whether any preferences were apparently associated with that parameter. Confidence limits were also shown, in particular to indicate where a class is highly variable or may cover an area which is too small to provide an accurate indication of preference. Other graphs analysing the results are provided, where indicated, in Appendix VII.

6.3.1.1 Herbaceous Layer

i) Herbaceous Layer Classification

Homogenous areas of herbaceous layer were represented by three classification systems, relating to different interpretations of the multivariate analysis results. These results divided Kaross into eight, four and three-class systems, which are detailed in Chapter 4.3.3.1. Two maps for each classification system were analysed, one basic map and a second detailed map incorporating rivers and water holes as separate classes, as follows:

a) The MVSP **eight-class** grass classification;
Basic map – (Fig. 6.1a, Fig. 6.1b and App. VII, Fig 1). This indicated that class two (high levels of *Eragrostis nindensis* and *Aristida adscensionis*) was less utilised than other classes. Several unique classes which represented a very small area of Kaross were identified. Because of their small size, these areas rarely correlated with rhino activity locations and the error associated with these results was too great to derive any conclusions.
Detailed map – (Fig. 6.2a, Fig. 6.2b and App. VII, Fig 2). The utilisation of river areas for grazing appeared high. Utilisation of water holes and class five (high levels of *Eragrostis rotifer* and *Eragrostis annulata*) was also high, especially for walking activity. Utilisation of class two remained low.

b) The TWINSPAN **four-class** system;
Basic map – (Fig. 6.3a, Fig. 6.3b and App. VII, Fig 3). This classification system divided homogenous herbaceous species into regions of approximately equal areas. Areas characteristic of grass class one (higher than average proportions of *Enneapogon cenchroides*, bare ground, *Melinus repens*, *Triaphis ramosissima*, *Stipagrostis hochstetterana* and *Anthephora pubescens*) were less well utilised than those of class four (high proportions of *Stipagrostis uniplumis* and bare ground).
Detailed map – (Fig. 6.4a, Fig. 6.4b and App. VII, Fig 4). This indicated high utilisation of riverine areas for grazing and of water hole areas for walking. This map did not indicate any increased walking activity in grass class four.

c) The MVSP **three-class** system;
Basic map – (Fig. 6.5a, Fig. 6.5b and App. VII, Fig 5). This identified two major herbaceous layer classes in Kaross. Class one (higher than average levels of *Eragrostis nindensis*, *Anthephora schinzii*, *Aristida adscensionis* and less *Eragrostis rotifer*, slightly less *Stipagrostis uniplumis*) was less utilised than class two (higher than average levels of *Schmidtia kalahariensis*, *Eragrostis rotifer*, *Cenchrus ciliaris*, *Eragrostis annulata* and *Eragrostis echinochloidea*). Class three (higher than average levels of *Stipagrostis hochstetterana* and

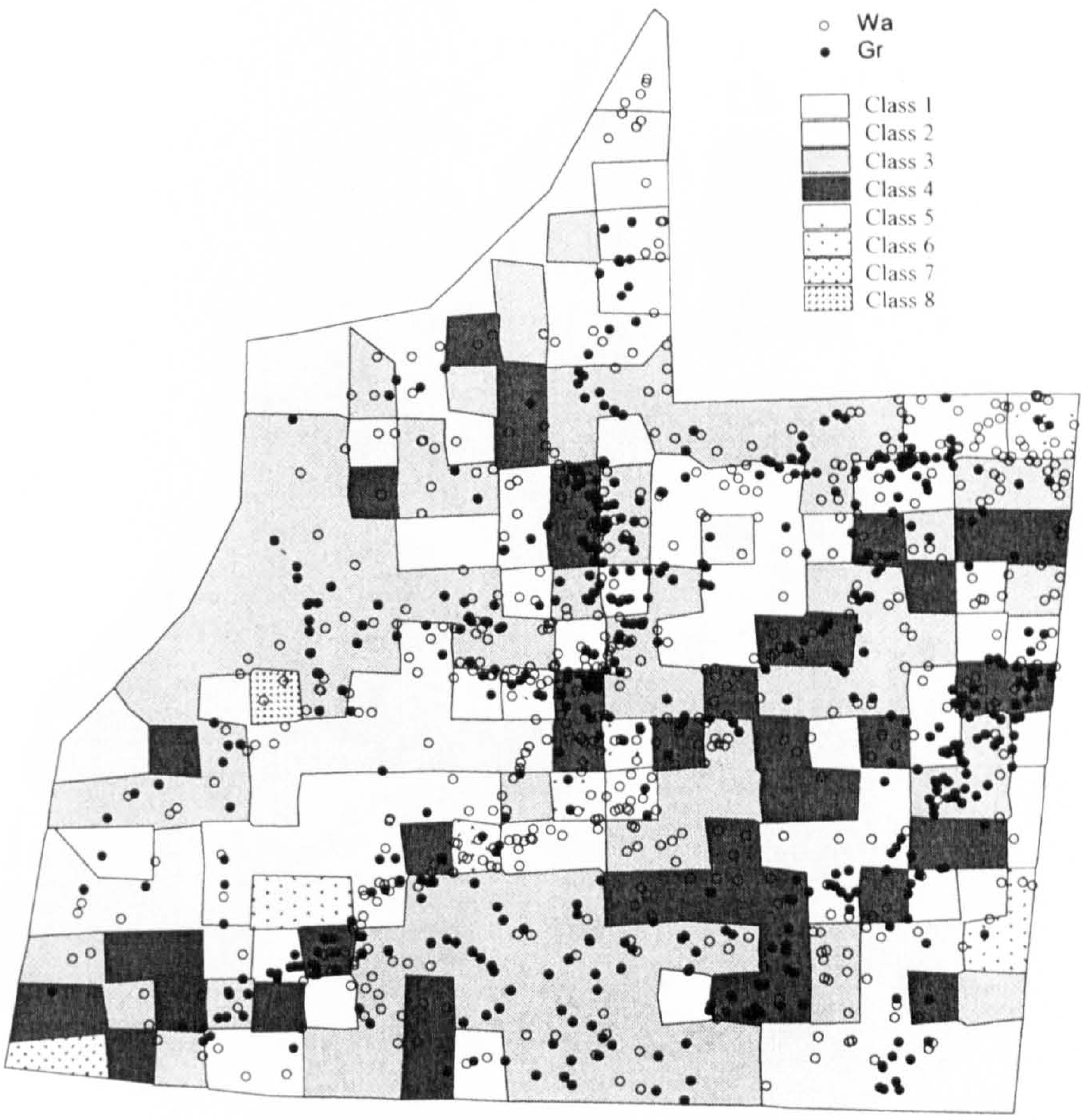


Fig. 6.1a Eight-Class Herbaceous Layer Classification, with Rhino Grazing and Walking Locations

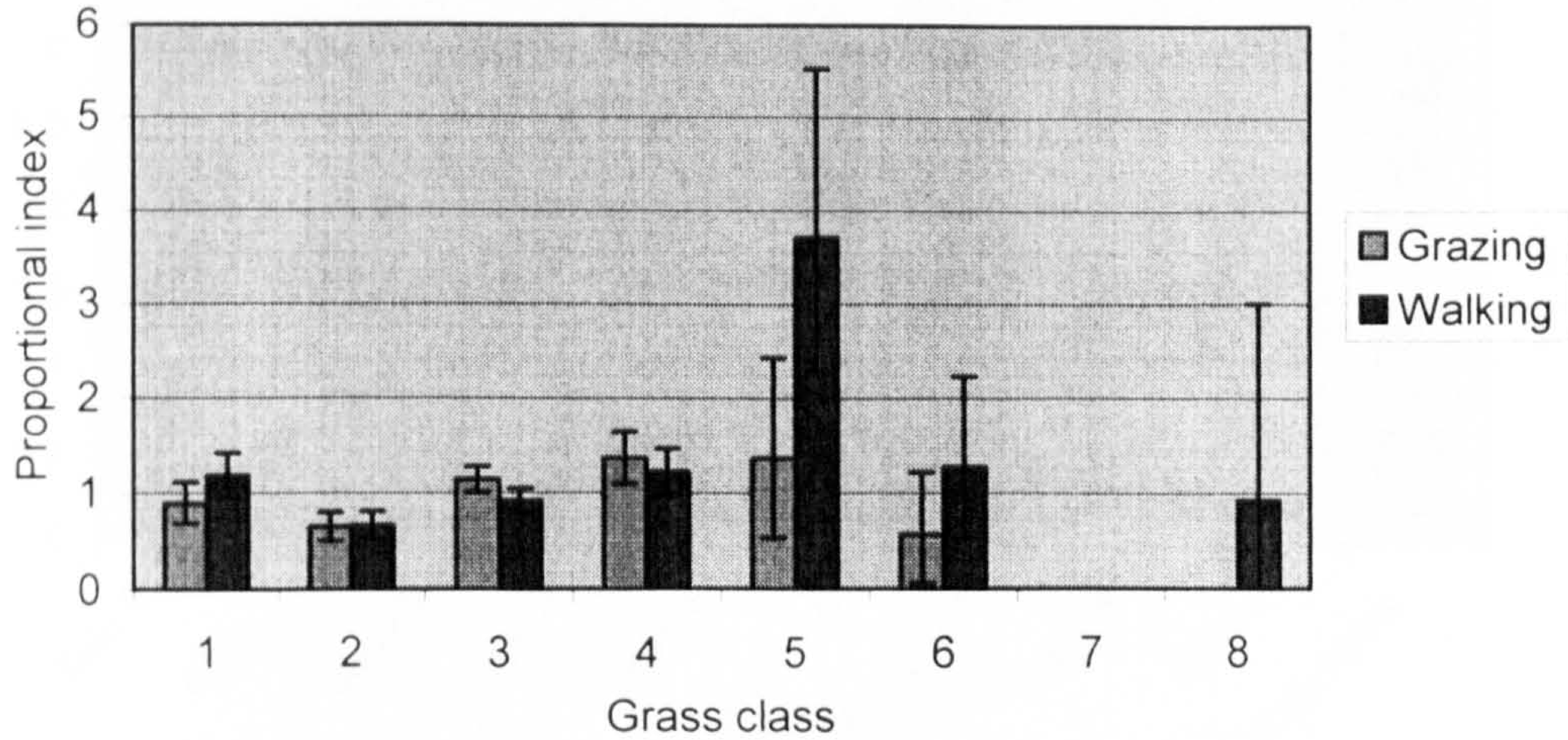


Fig. 6.1b Utilisation Index of MVSP Eight-Class Herbaceous Layer Classification

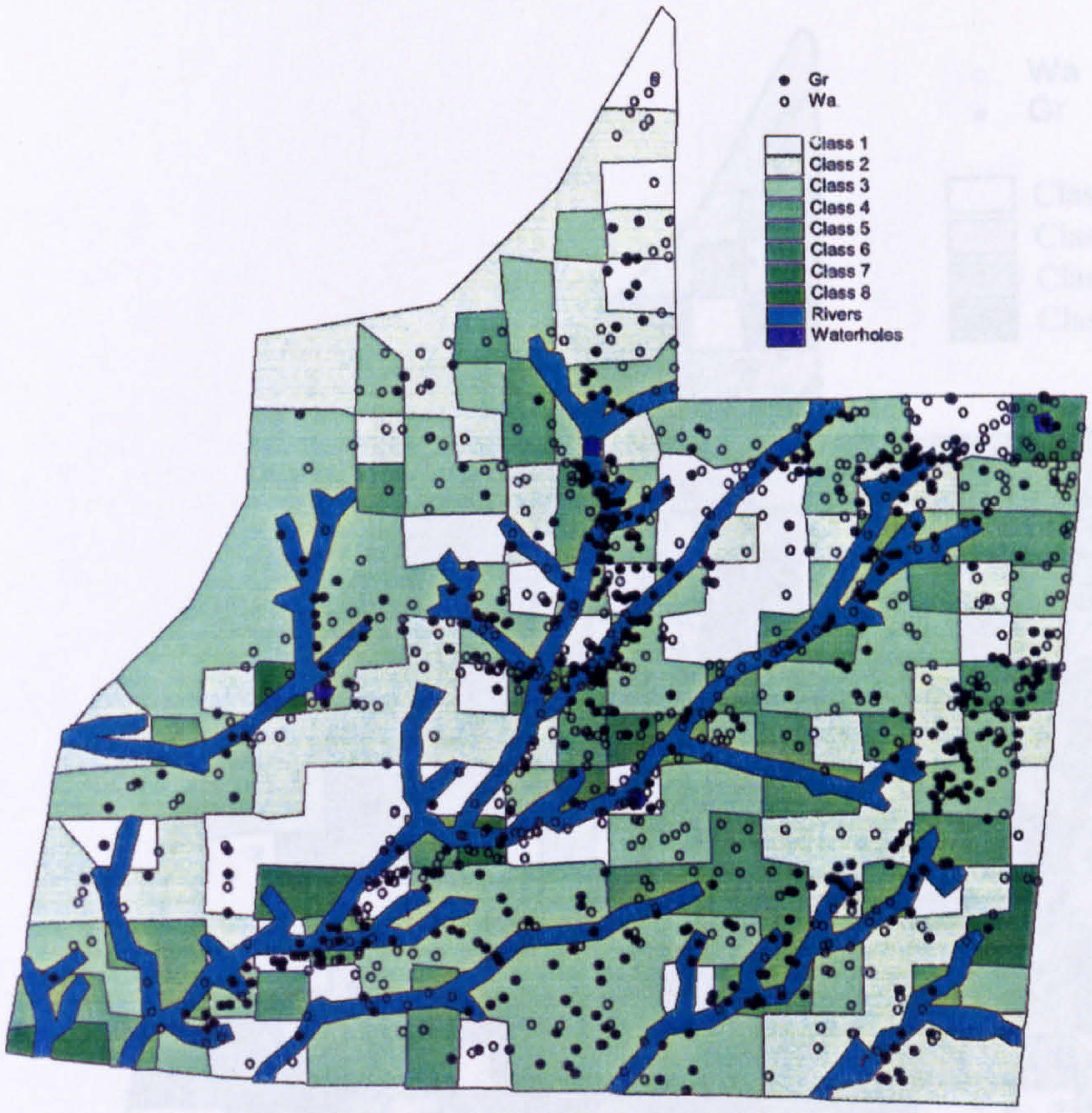


Fig. 6.2a Detailed Eight-Class Grass Classification with Rhino Grazing and Walking Locations

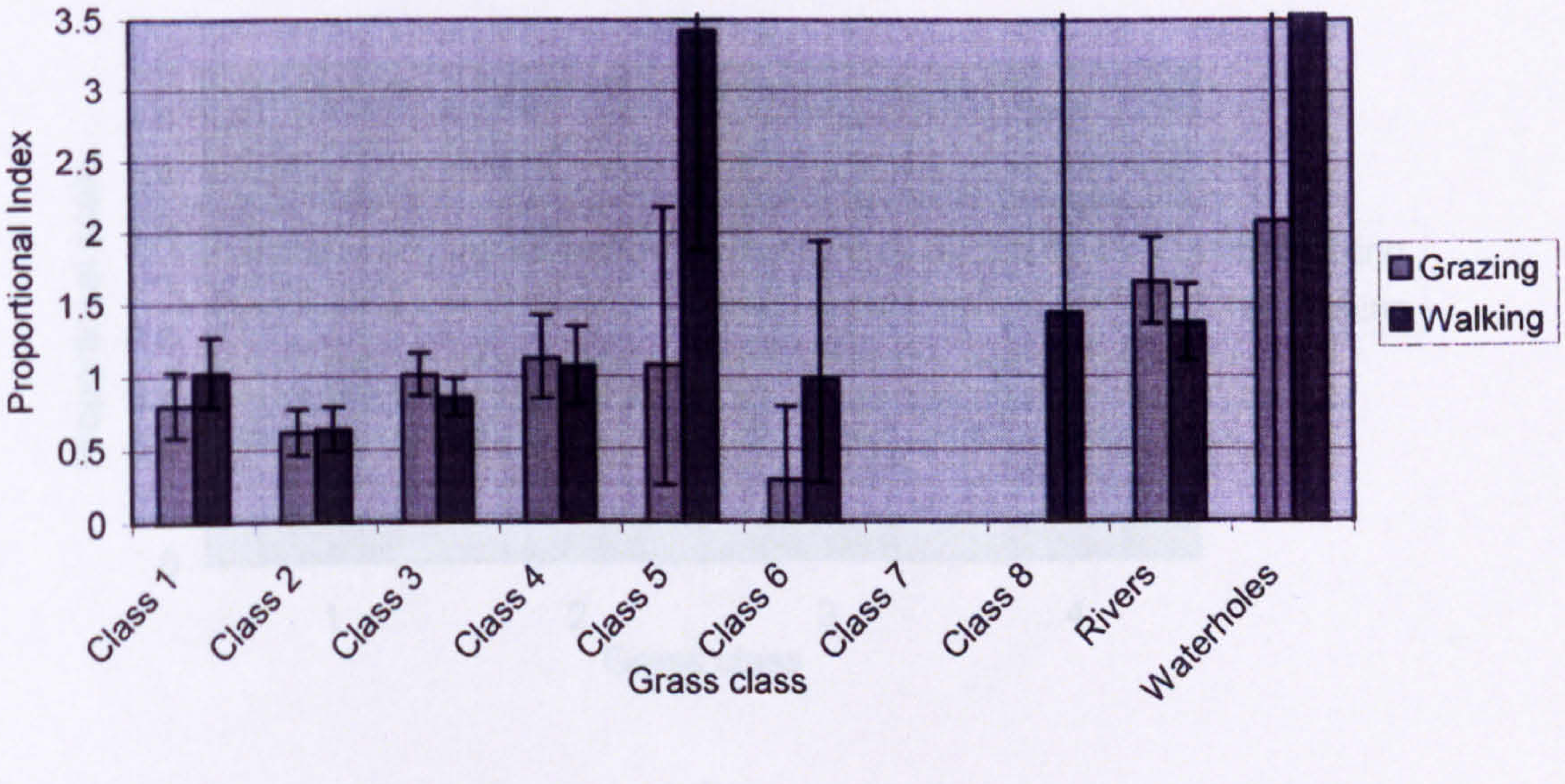


Fig. 6.2b Utilisation Index of Detailed Eight-Class Grass Classification

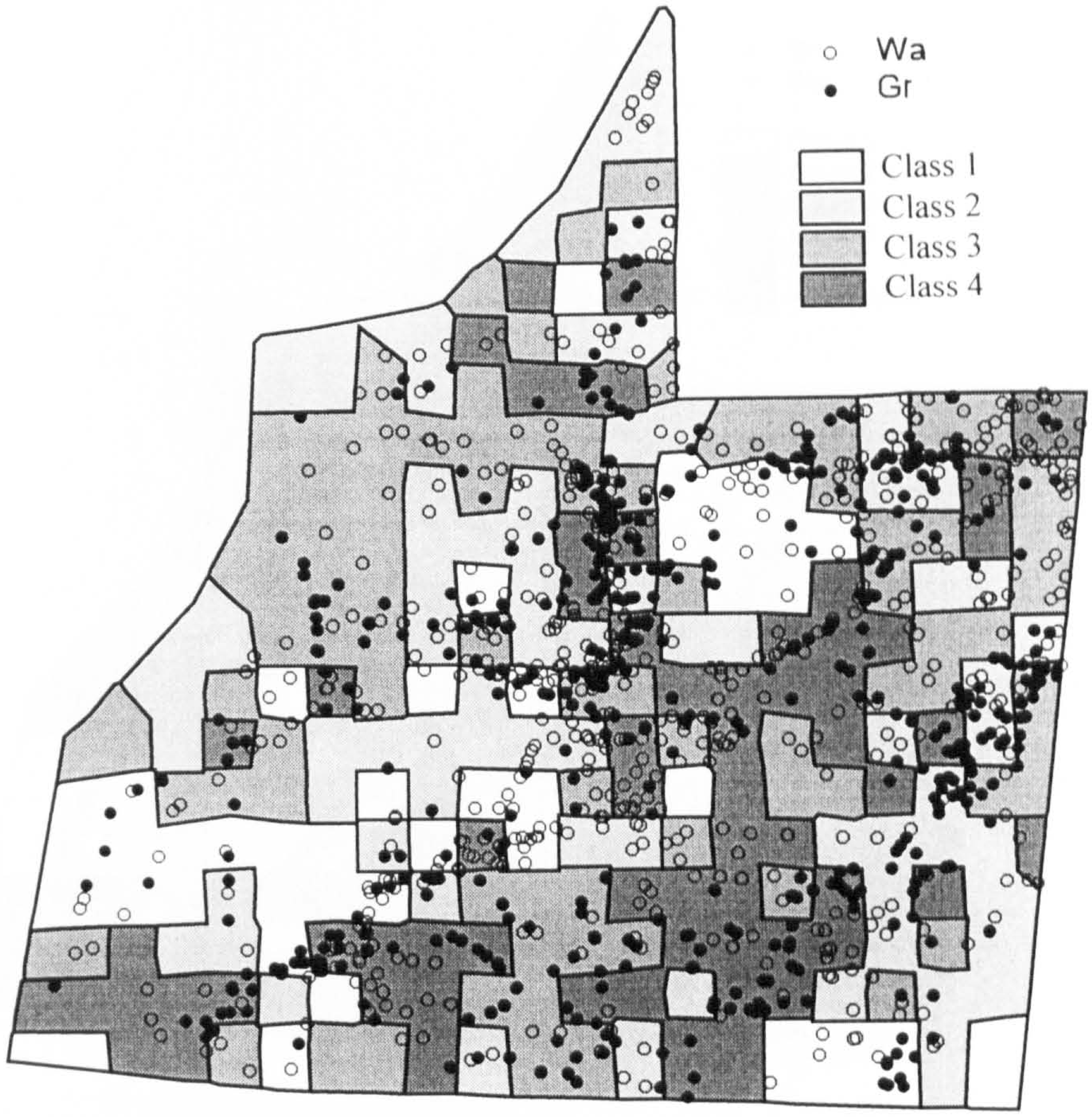


Fig. 6.3a Four-Class Herbaceous Layer Classification, with Rhino Grazing and Walking Locations

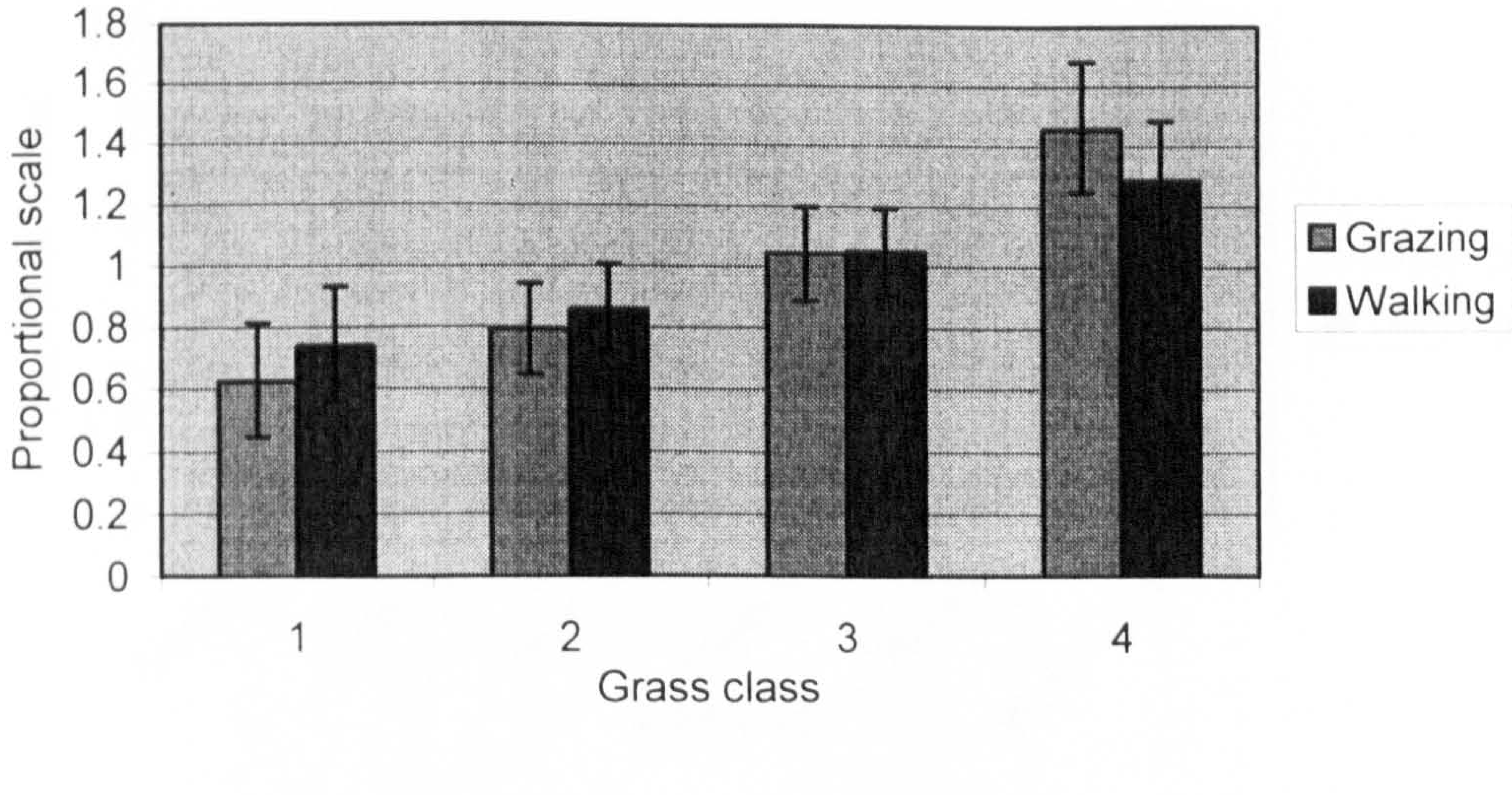


Fig. 6.3b Utilisation Index of TWINSPAN Four-Class Herbaceous Layer Classification

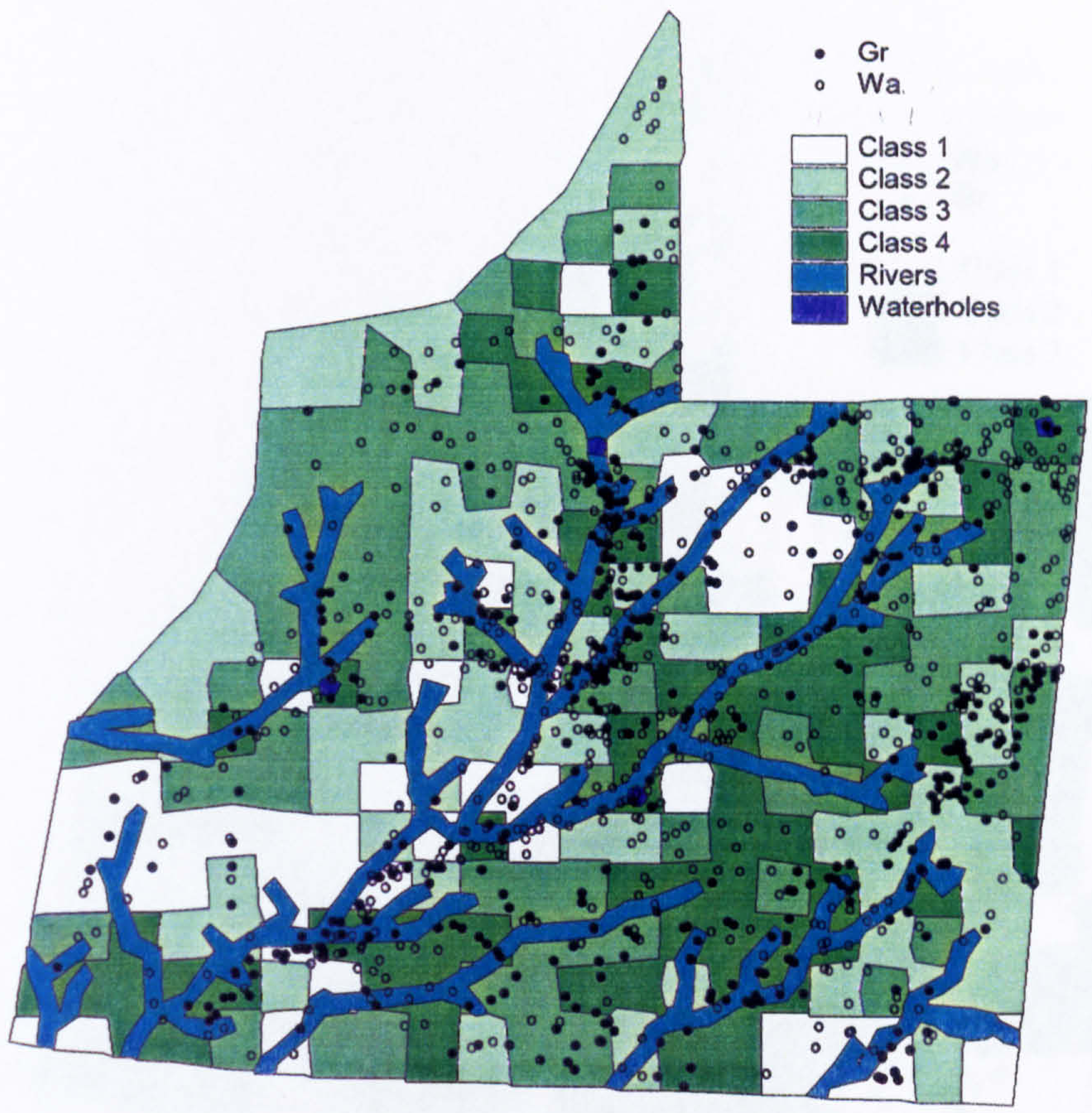


Fig. 6.4a Detailed Four-Class Grass Classification, with Rhino Grazing and Walking Locations

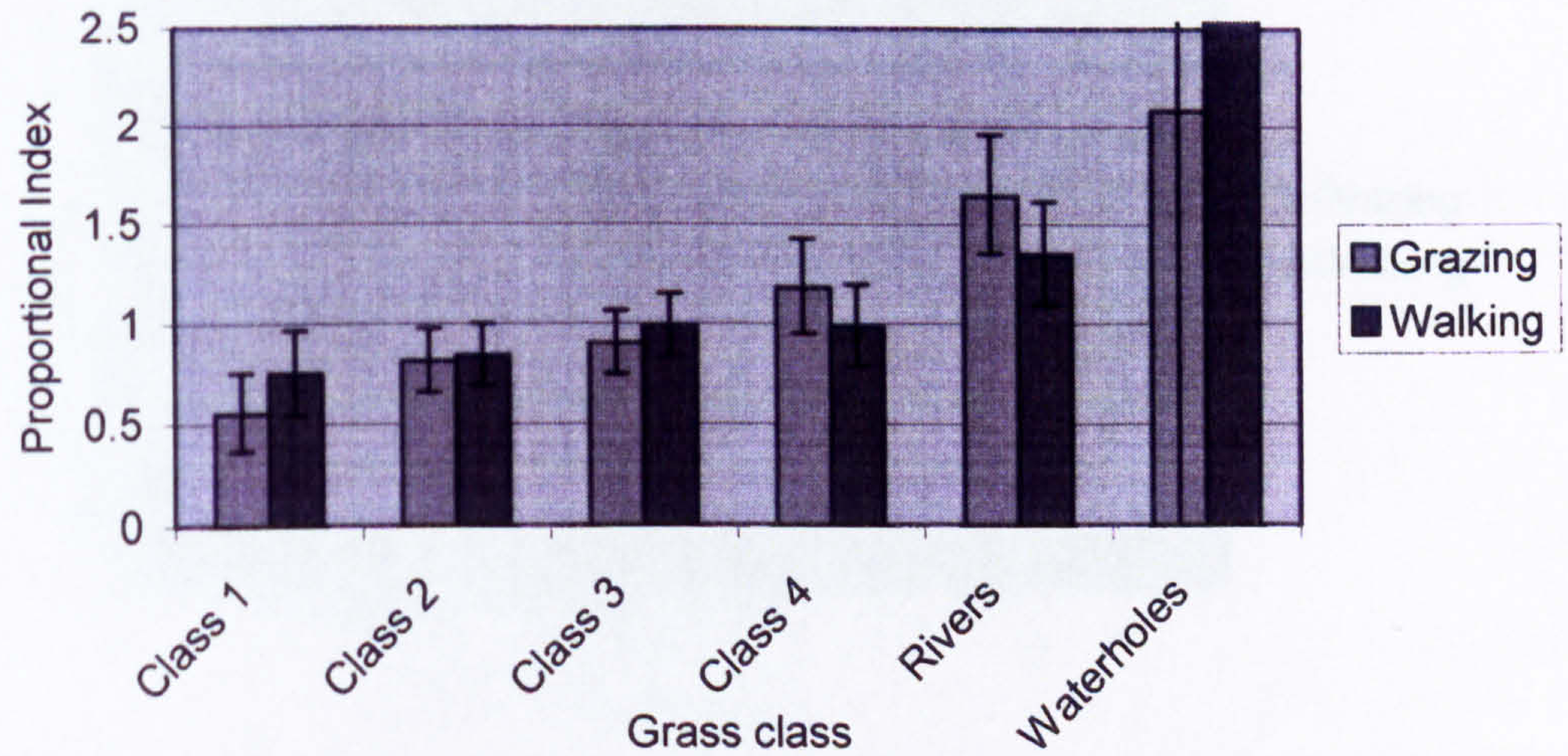


Fig. 6.4b Utilisation Index of Detailed Four-Class Grass Classification

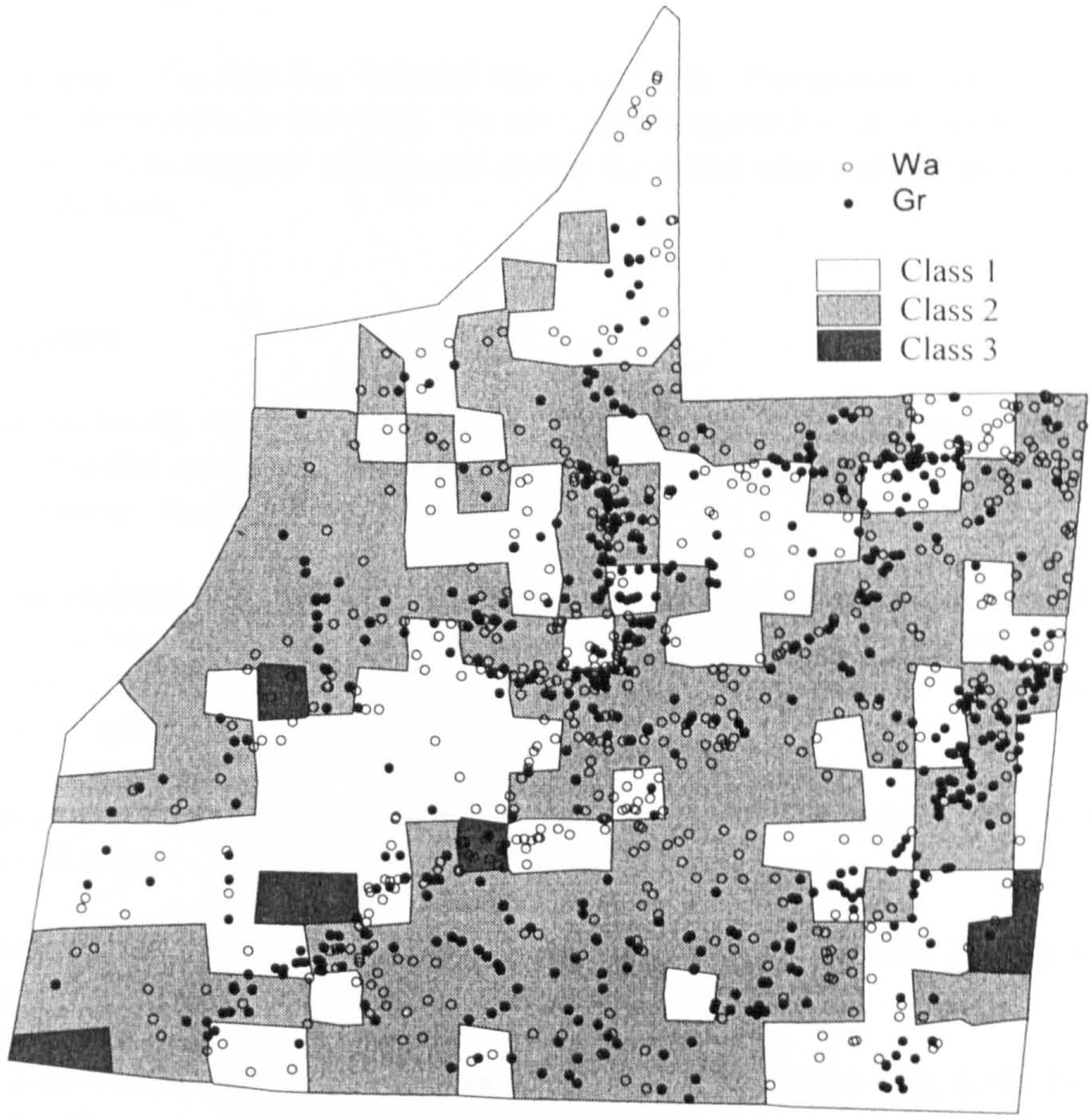


Fig. 6.5a Three-Class Herbaceous Layer Classification, with Rhino Grazing and Walking Locations

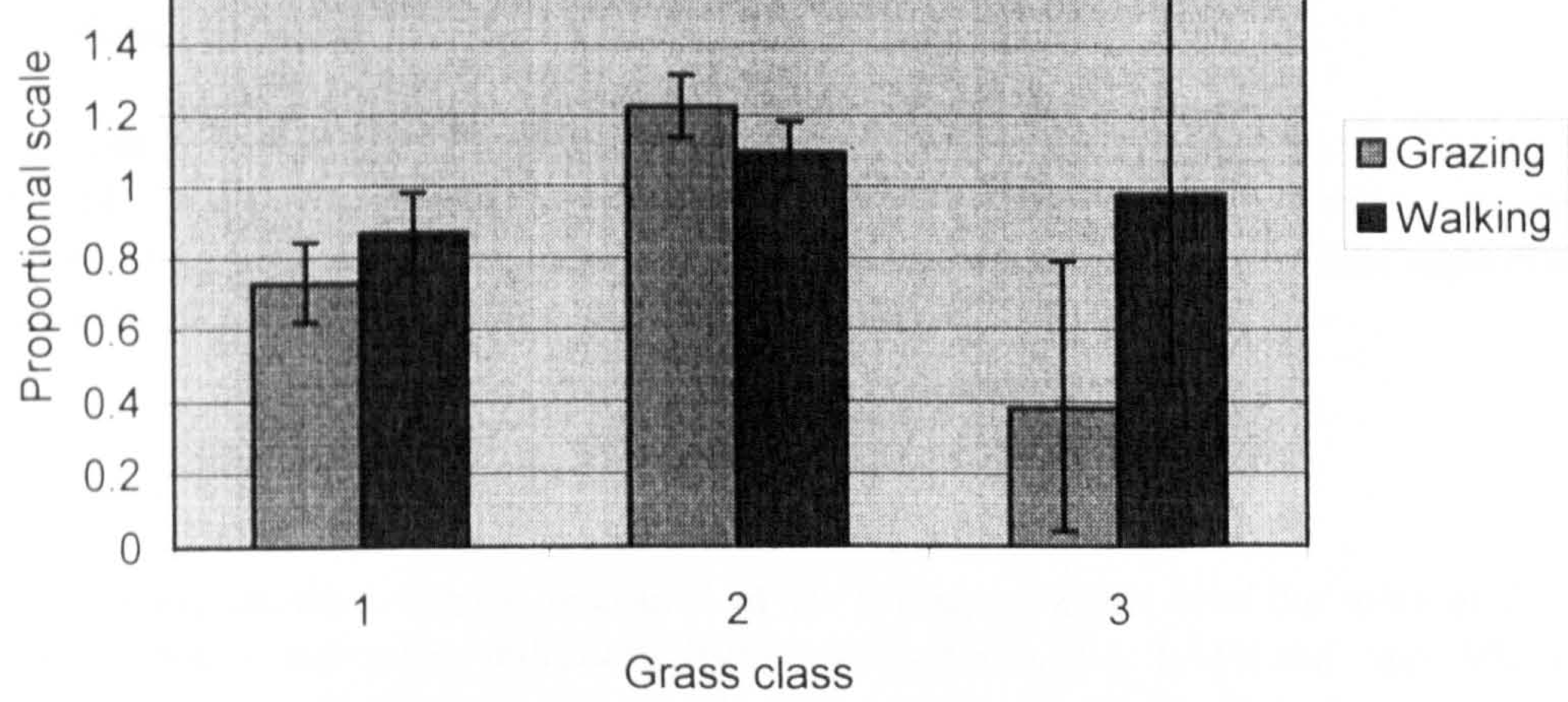


Fig. 6.5b Utilisation Index of MVSP Three-Class Herbaceous Layer Classification

Triaphis ramosissima and low levels of *Schmidtia kalahariensis*, and *Eragrostis nindensis*) was avoided for grazing.

Detailed map – (Fig. 6.6a, Fig. 6.6b and App. VII, Fig 6). Trends associated with class one and class three continued to be indicated. No preferences appeared to be associated with utilisation of class two, while increased grazing was evident in riverine areas and increased walking activity around water holes.

ii) Grass Species

In the Kaross habitat survey, each class of grass species abundance represented the number of times the grass species was recorded as closest to the spike of the wheel-point apparatus at the 100 survey points in each of the 257 transects. Results were as follows:

a) As ***Schmidtia kalahariensis*** abundance increases there is a slight increase in rhino utilisation until the point where it forms up to 60% of the total biomass (Fig. 6.7a, Fig. 6.7b and App. VII, Fig 7). At higher densities of the species the level of error increases to the point where it is difficult to detect any influence on activity.

b) ***Stipagrostis uniplumis*** abundance appears to have no affect on rhino activity (Fig. 6.8a, Fig. 6.8b and App. VII, Fig 8).

c) As the abundance of ***Eragrostis nindensis*** increases, utilisation for both grazing and walking activities apparently decrease (Fig. 6.9a, Fig. 6.9b and App. VII, Fig 9).

d) ***Eragrostis porosa*** abundance appears to have no affect on rhino activity (Fig. 6.10a, Fig. 6.10b and App. VII, Fig 10).

e) ***Aristida adscensionis*** abundance does not appear to influence rhino activity (Fig. 6.11a, Fig. 6.11b and App. VII, Fig 11).

f) The abundance of a grouped class representing the average percentage occurrence of all ***Aristida* species** appeared to have little or no affect on rhino selection (Fig. 6.12a, Fig. 6.12b and App. VII, Fig 12).

g) The abundance of grouped ***Eragrostis* species** appears to have no affect on rhino activity (Fig. 6.13a, Fig. 6.13b and App. VII, Fig 13).

iii) Grass Biomass

In areas with a medium biomass, rhino utilisation increased for grazing (Fig. 6.14a, Fig. 6.14b and App. VII, Fig 14). Most of the Kaross area was classified as low biomass and this had no apparent effect on utilisation. Only a few areas were classified as having an extra low biomass. These areas often coincided with water holes and were associated with walking activity.

iv) Grass Density

As grass density becomes sparser, measured as the average distance from the spike of the wheel-point apparatus to the closest grass, utilisation declines (Fig. 6.15a, Fig. 6.15b and App. VII, Fig 15). At densities of greater that 300mm, the error levels increase due to the limited area representing these classes.

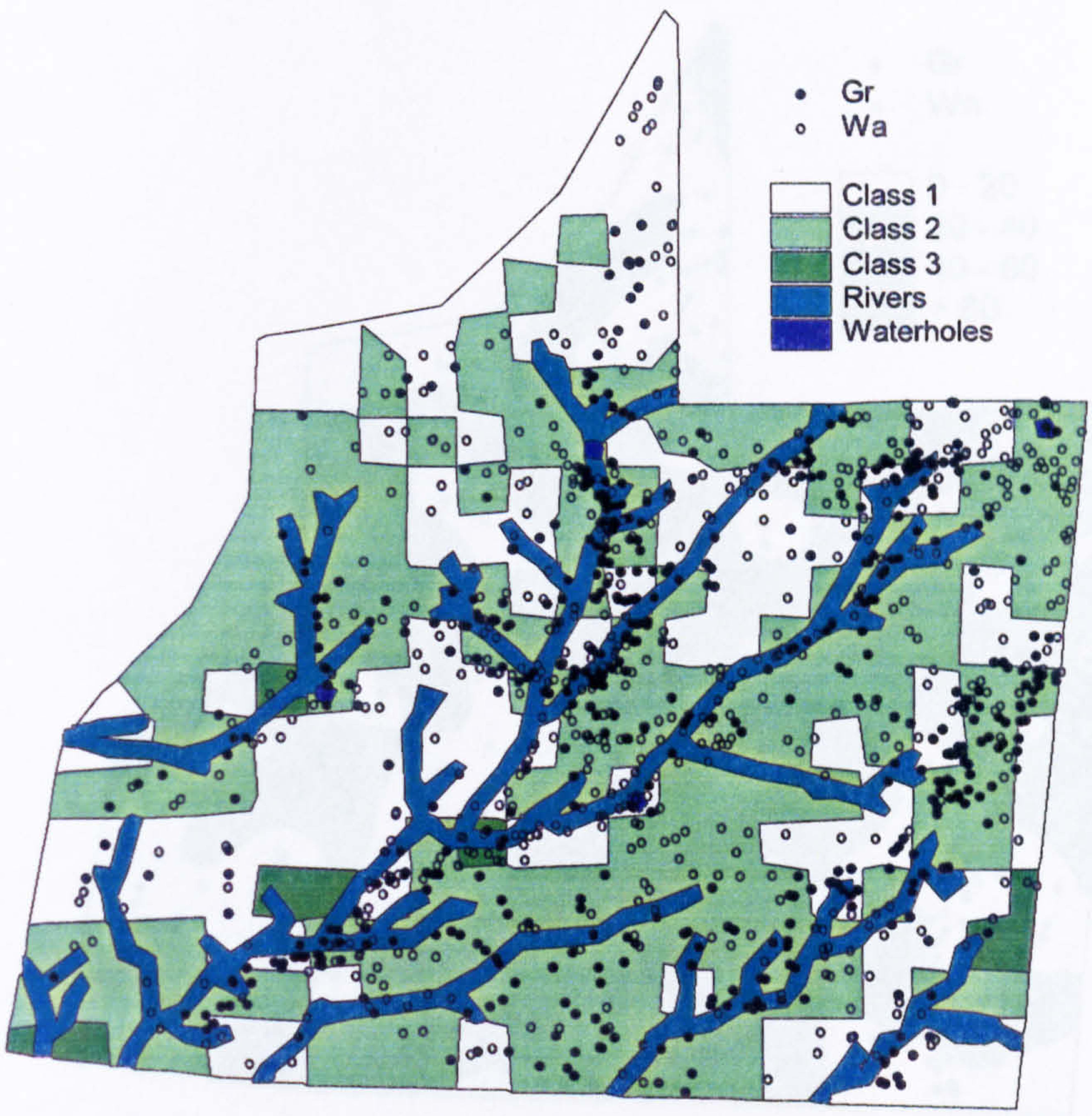


Fig. 6.6a Detailed Three-Class Grass Classification, with Rhino Grazing and Walking Locations

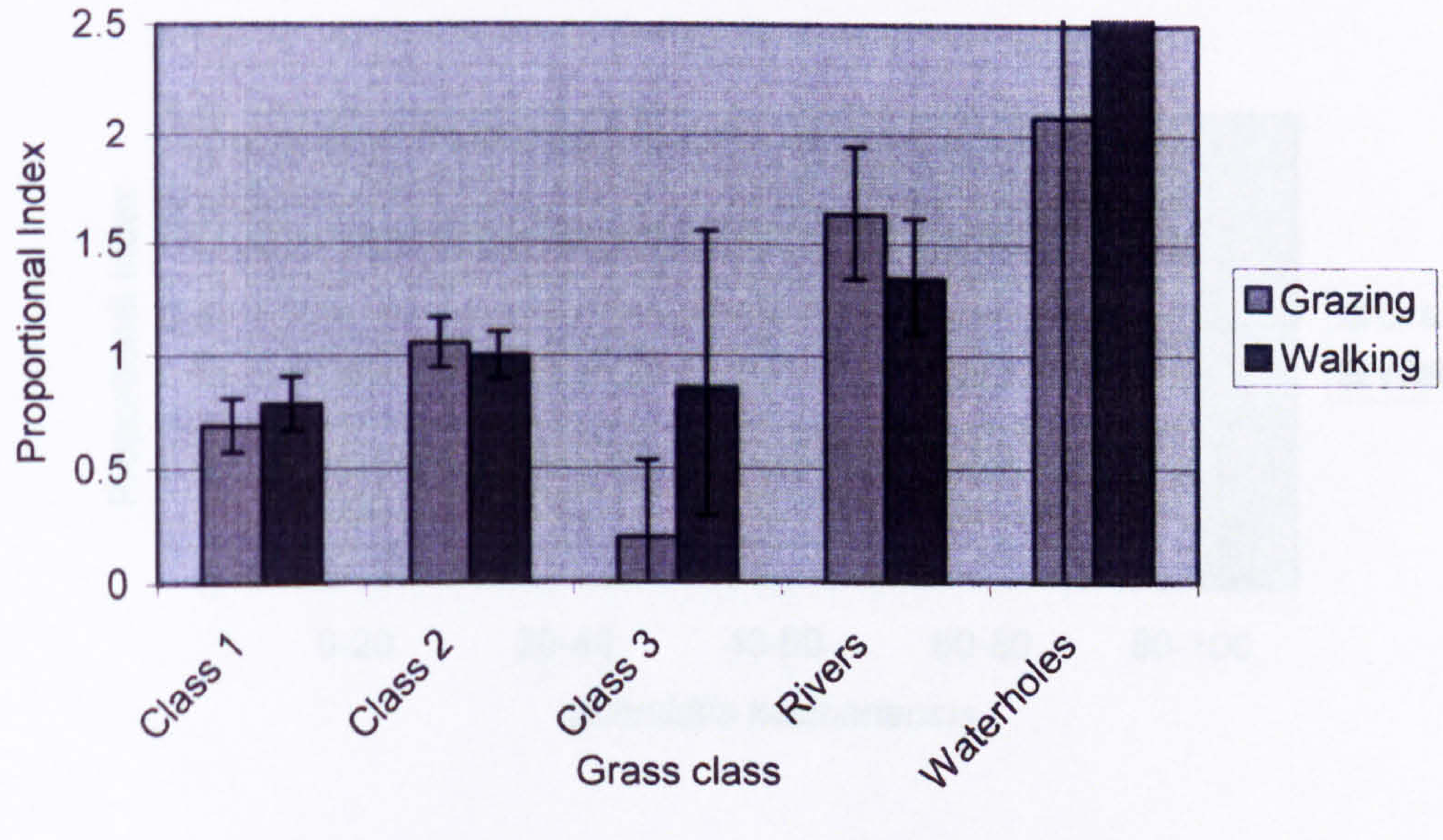


Fig. 6.6b Utilisation Index of Detailed Three-Class Grass Classification

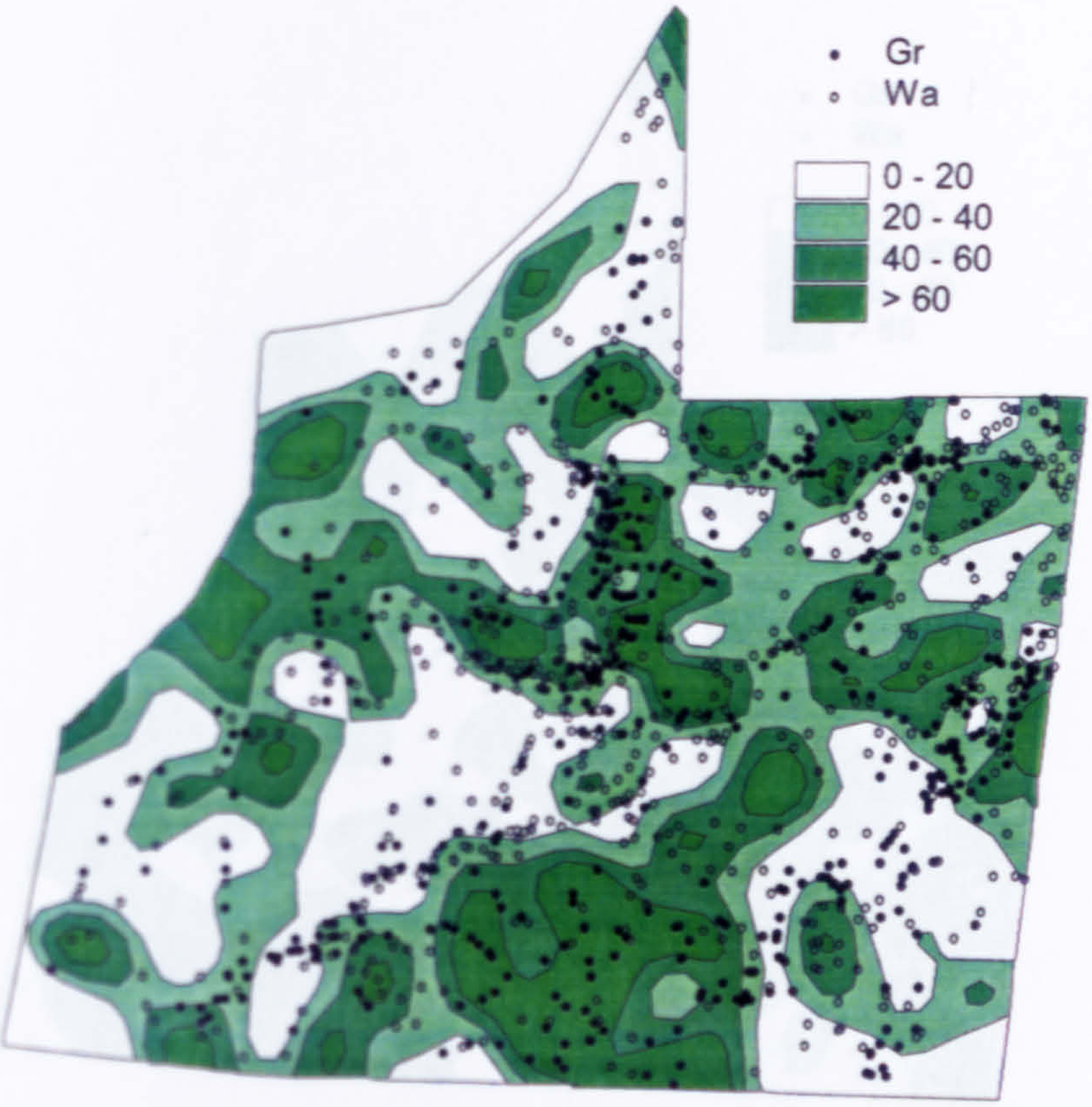


Fig. 6.7a *Schmidtia kalahariensis* Distribution, with Rhino Grazing and Walking Locations

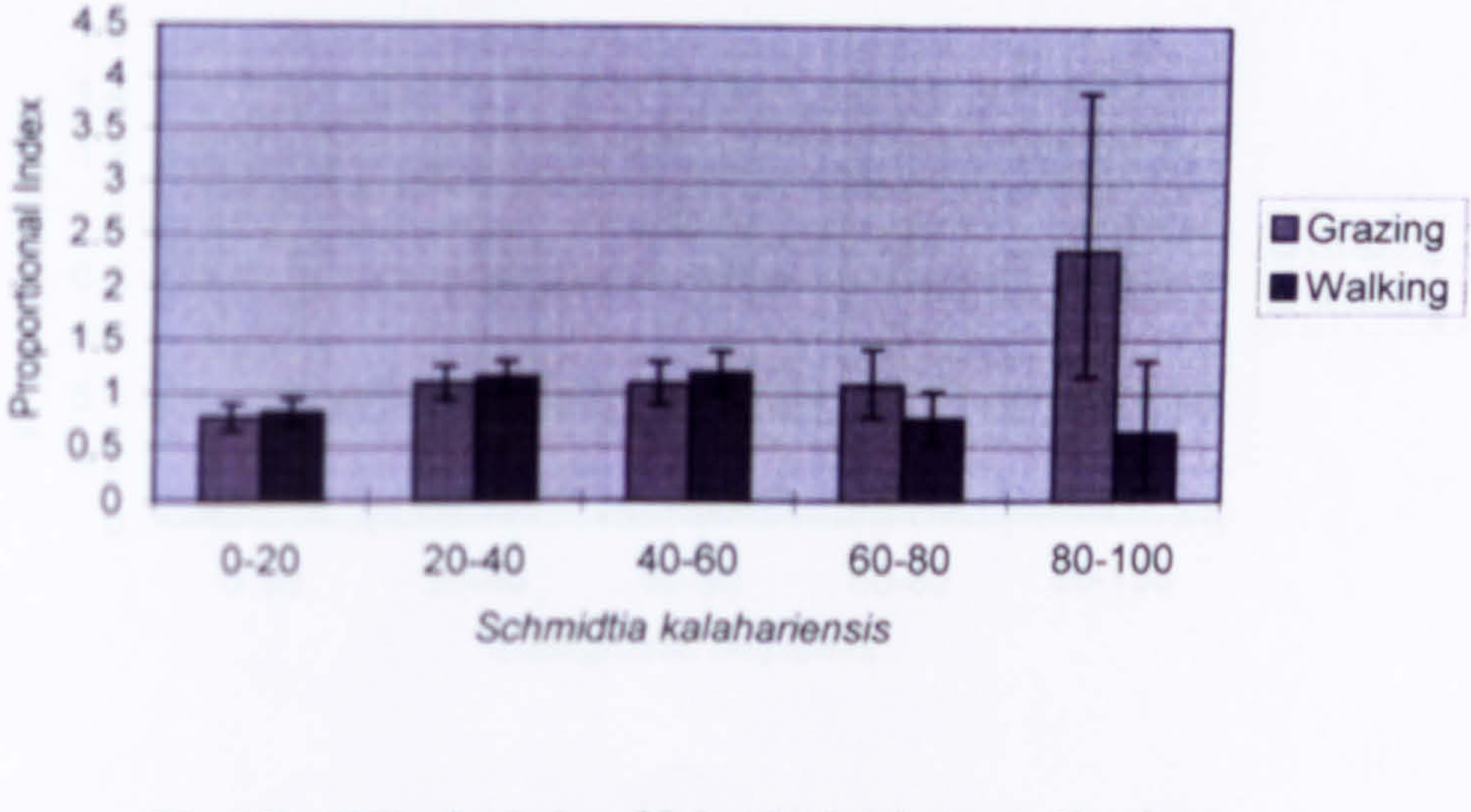


Fig. 6.7b Utilisation Index of *Schmidtia kalaheriensis* Abundance

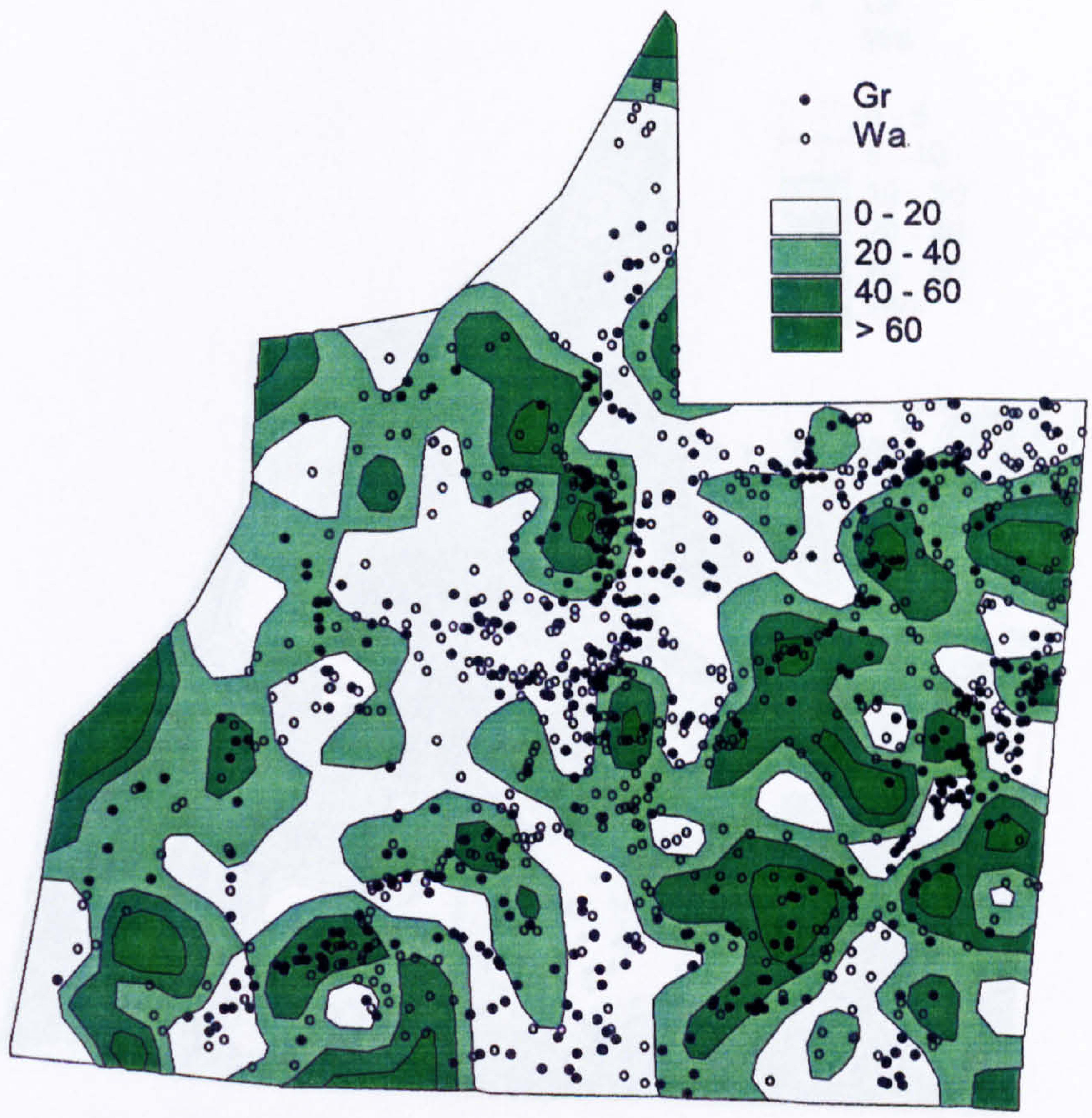


Fig. 6.8a *Stipagrostis uniplumis* Distribution, with Rhino Grazing and Walking Locations

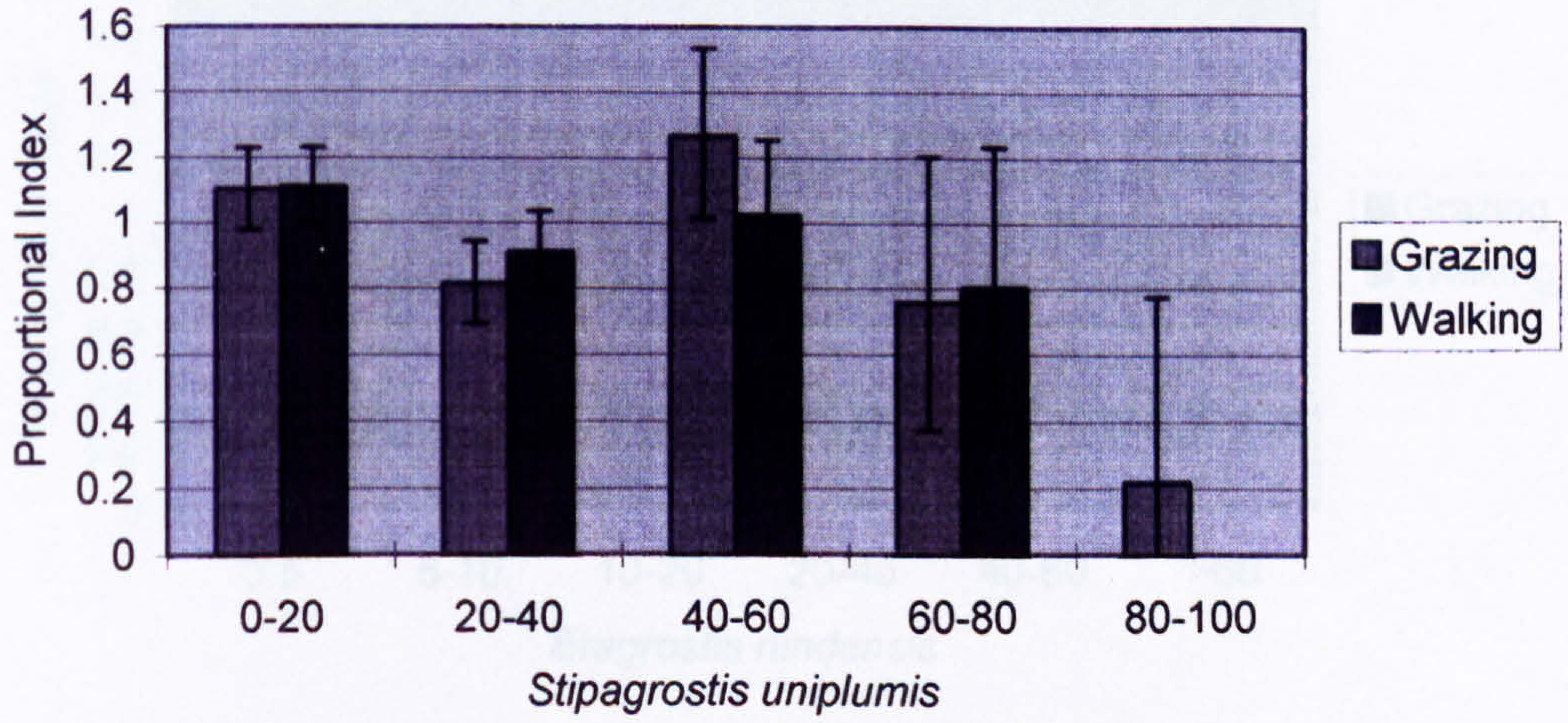


Fig. 6.8b Utilisation Index of *Stipagrostis uniplumis* Abundance

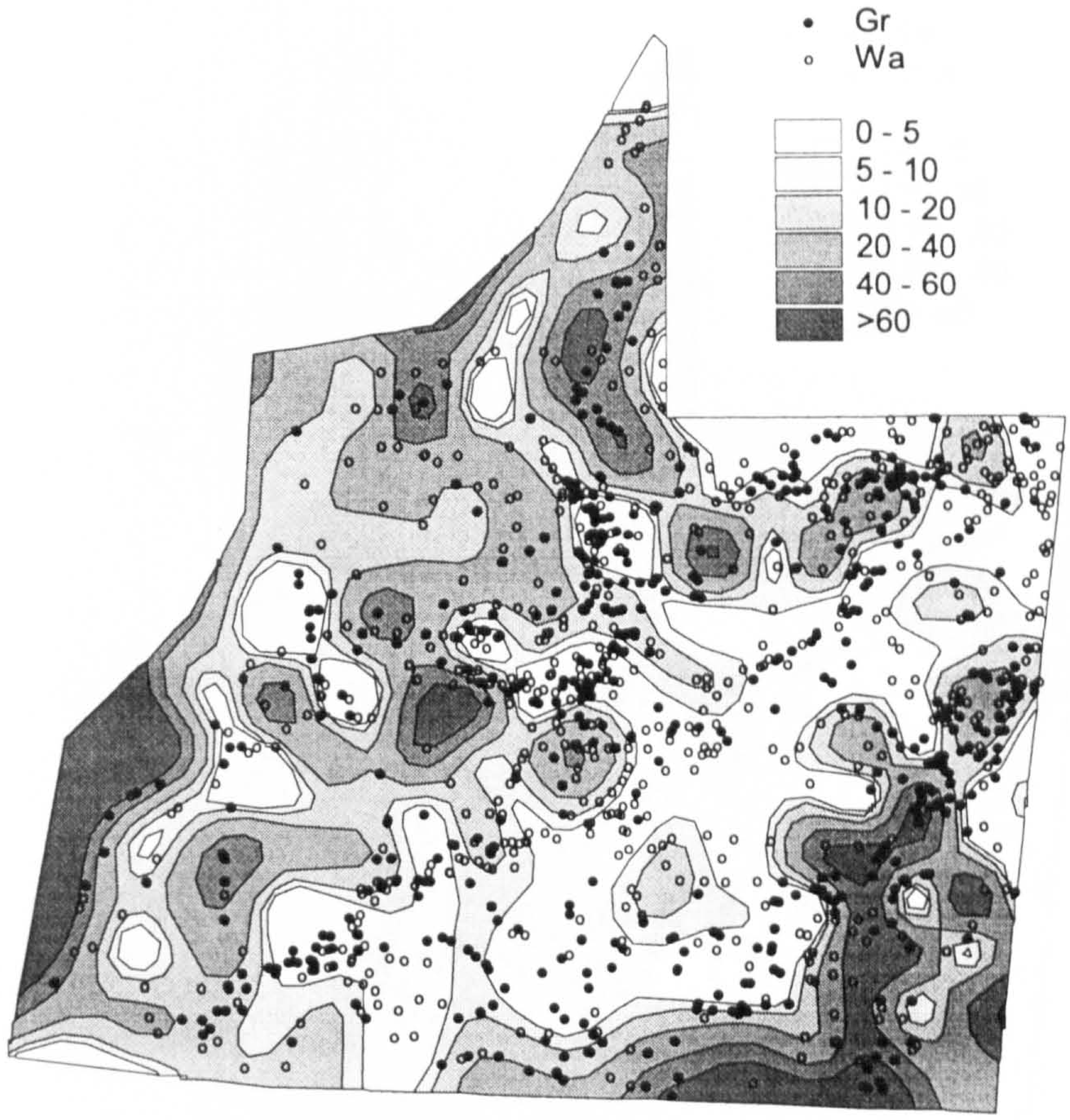


Fig. 6.9a *Eragrostis nindensis* Distribution, with Rhino Grazing and Walking Locations

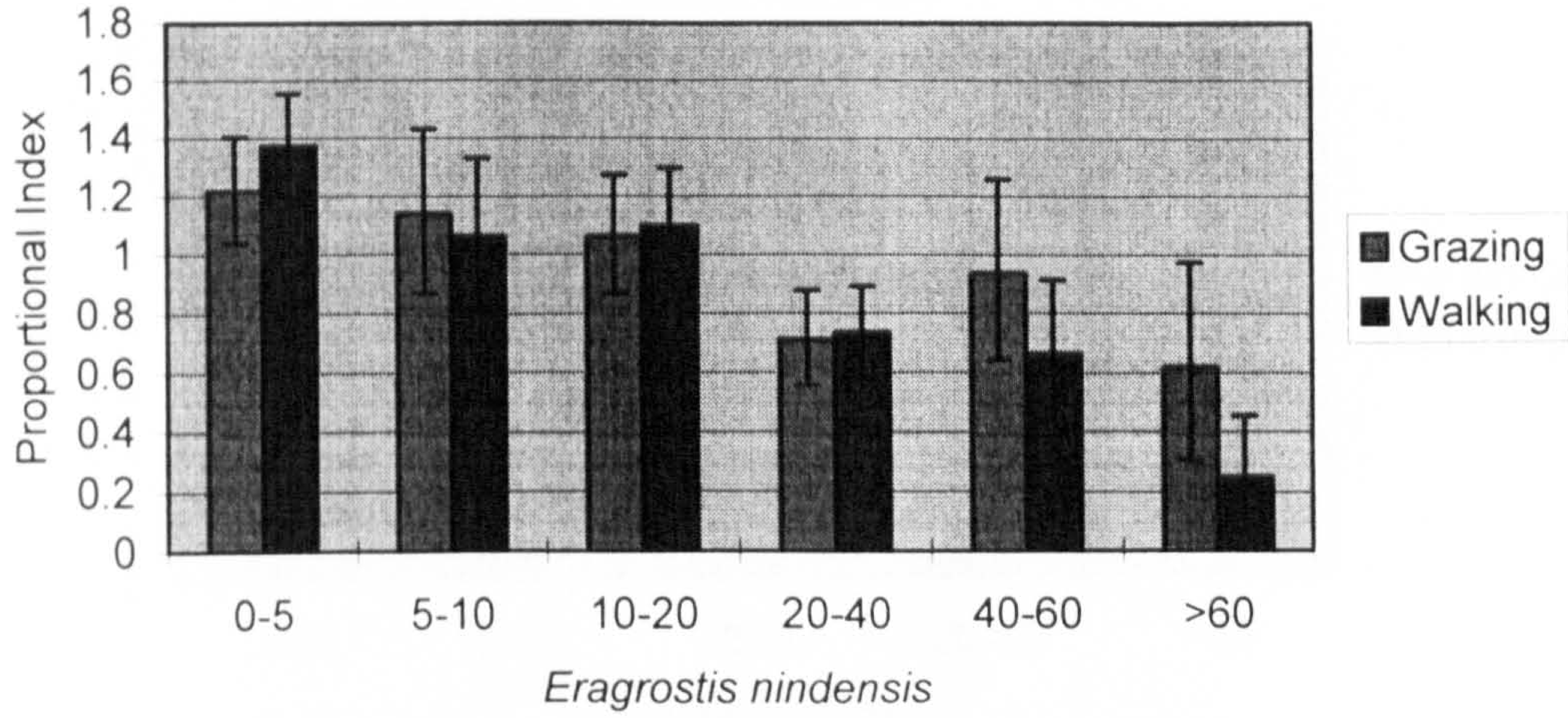


Fig. 6.9b Utilisation Index of *Eragrostis nindensis* Abundance

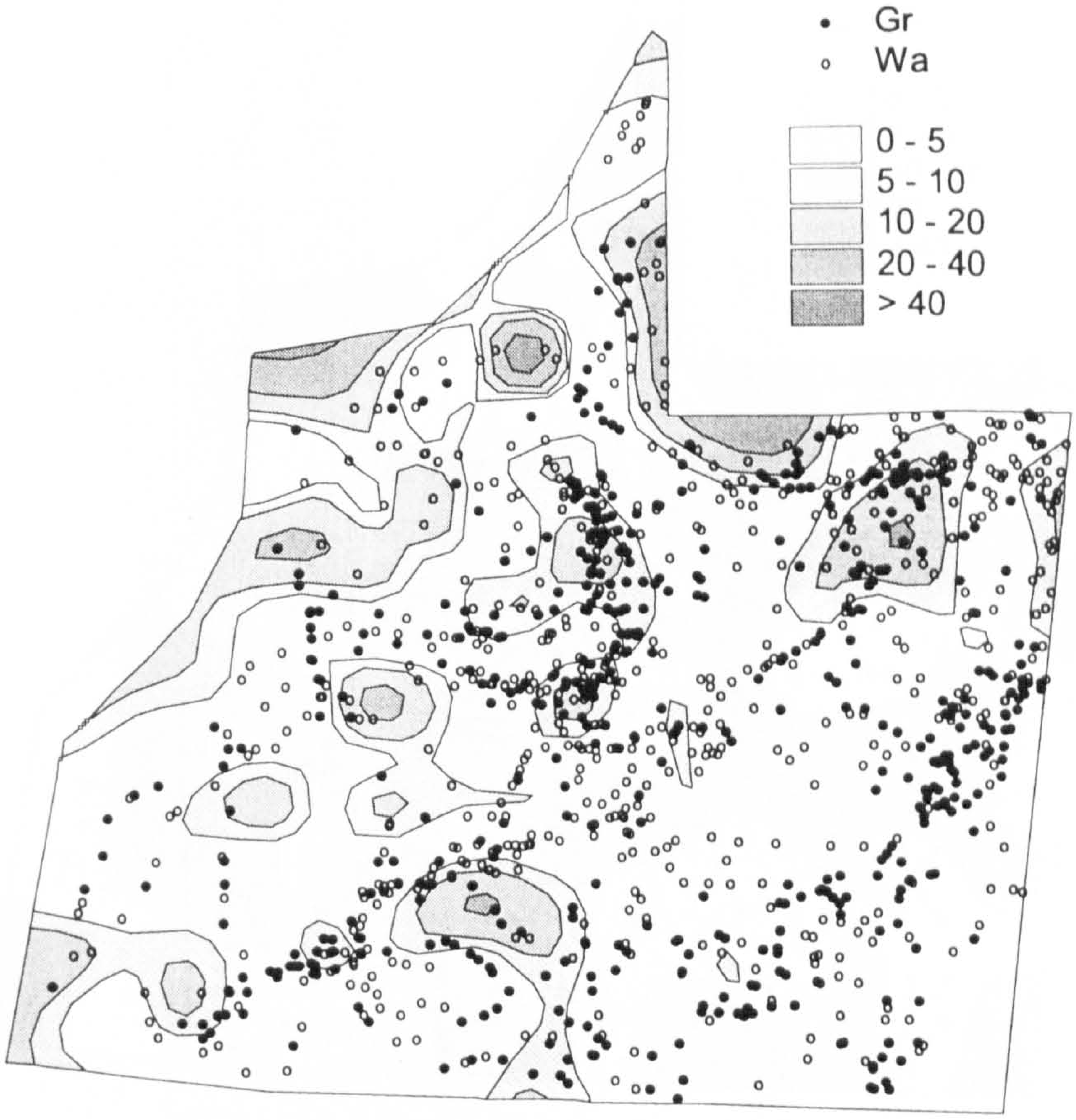


Fig. 6.10a Utilisation of *Eragrostis porosa*, with Rhino Grazing and Walking Locations

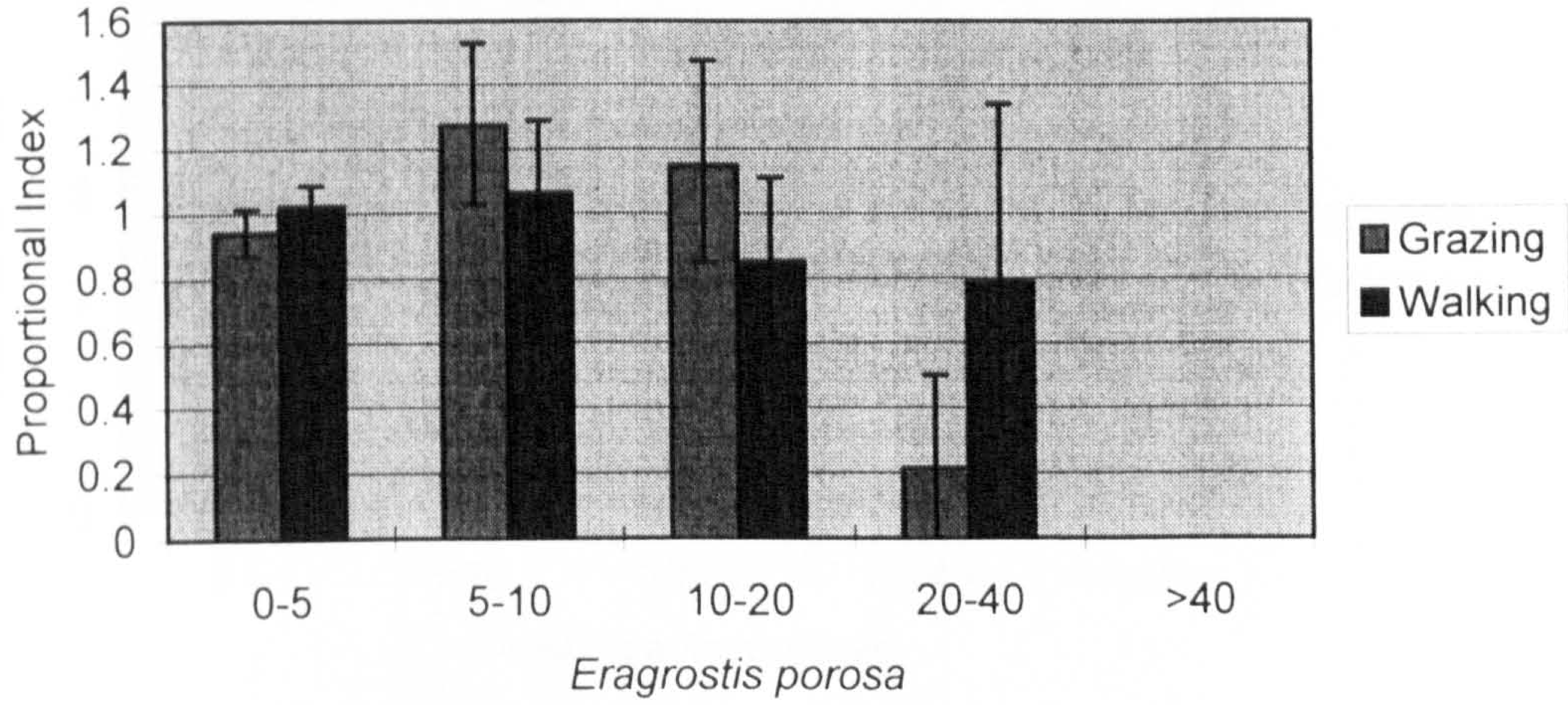


Fig. 6.10b Utilisation Index of *Eragrostis porosa* Abundance

Fig. 6.11a Utilisation of *Aristida adscensionis*, with Rhino Grazing and Walking Locations

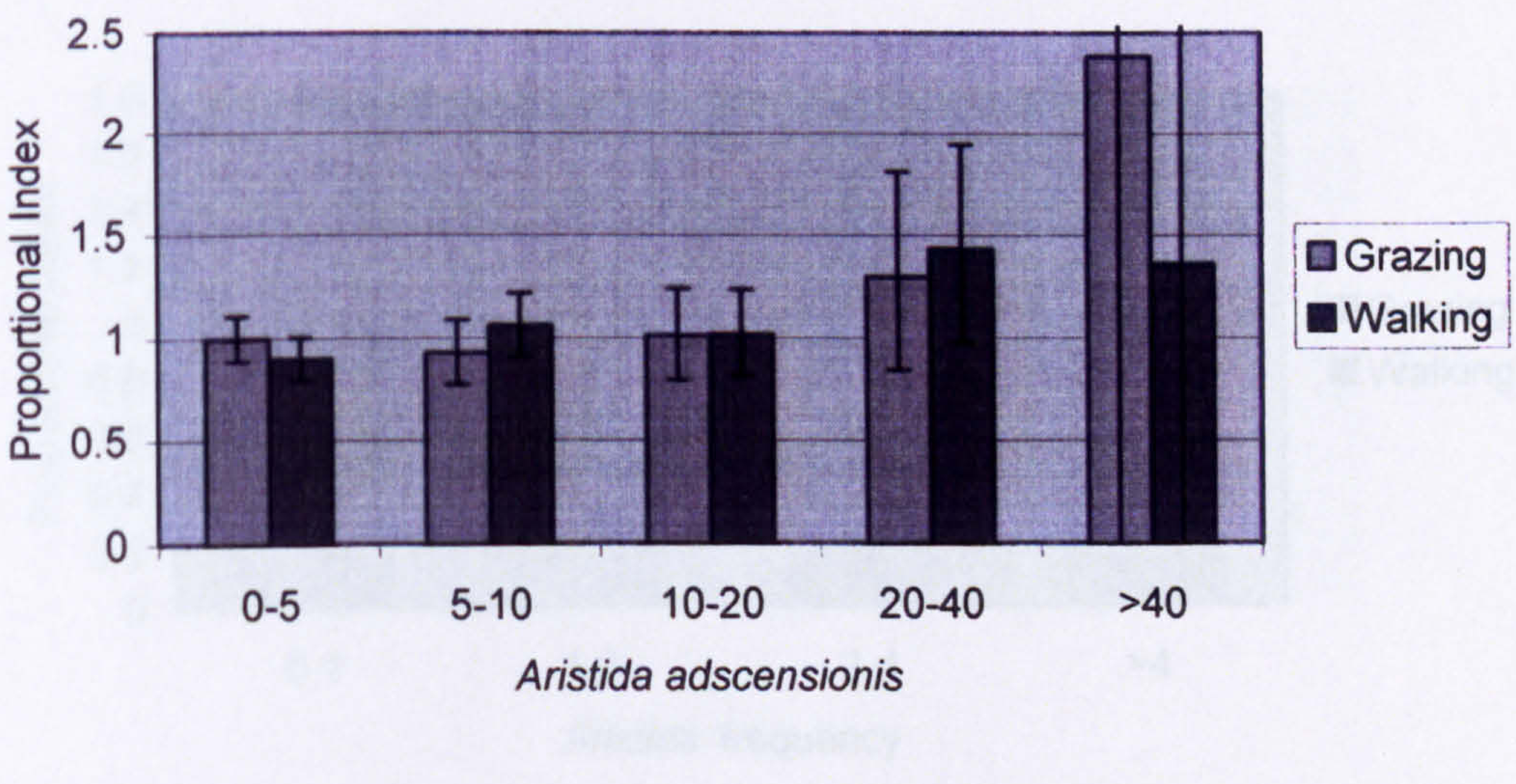


Fig. 6.11b Utilisation Index of *Aristida adscensionis* Abundance

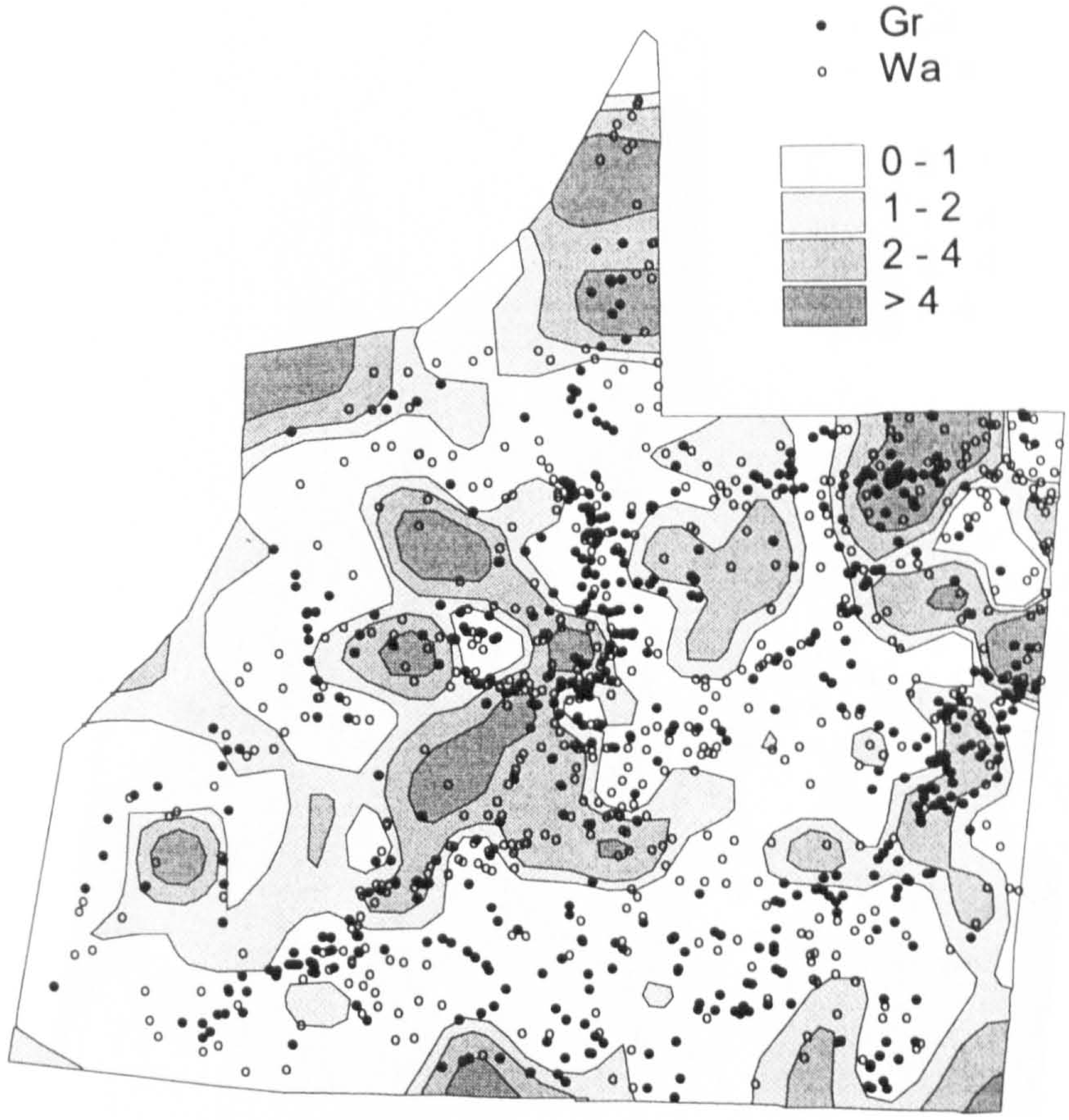


Fig. 6.12a Utilisation of *Aristida* species, with Rhino Grazing and Walking Locations

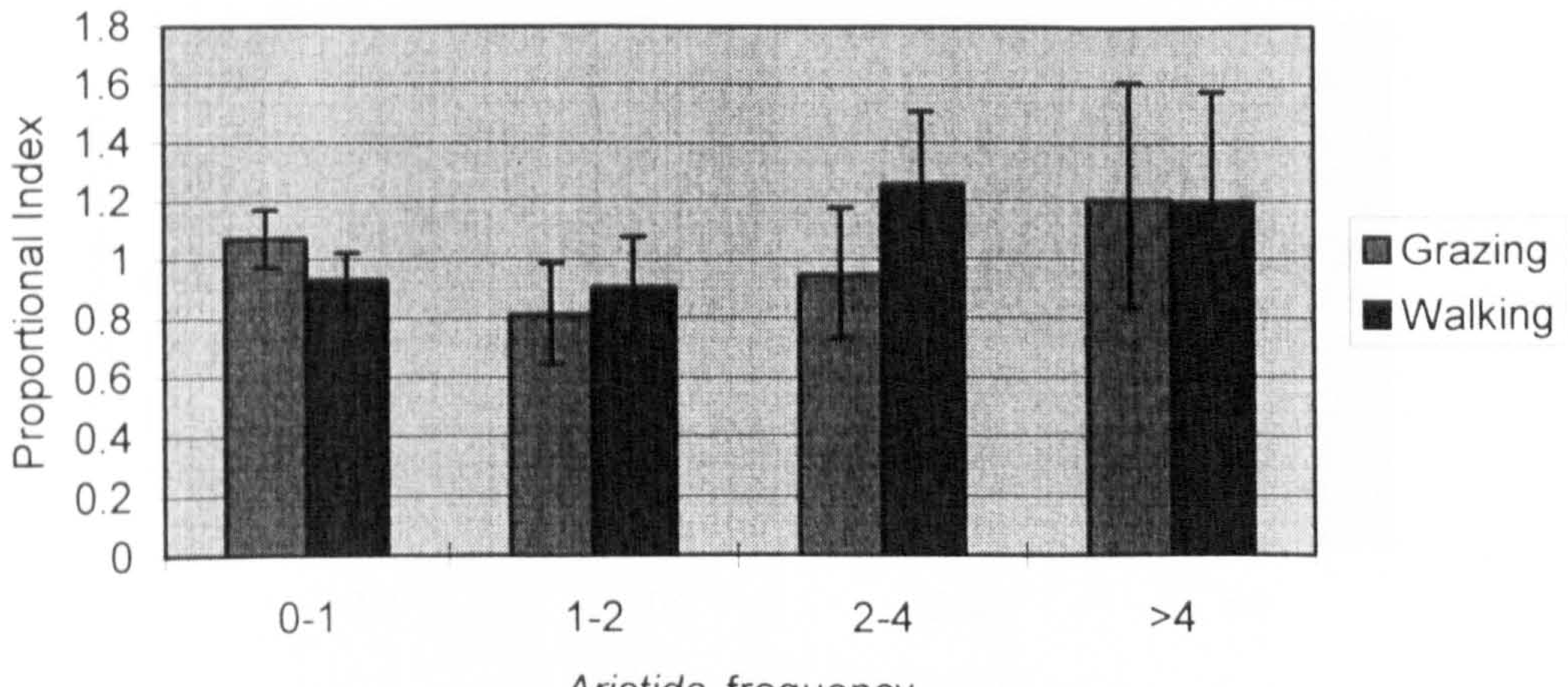


Fig. 6.12b Utilisation Index of *Aristida* species

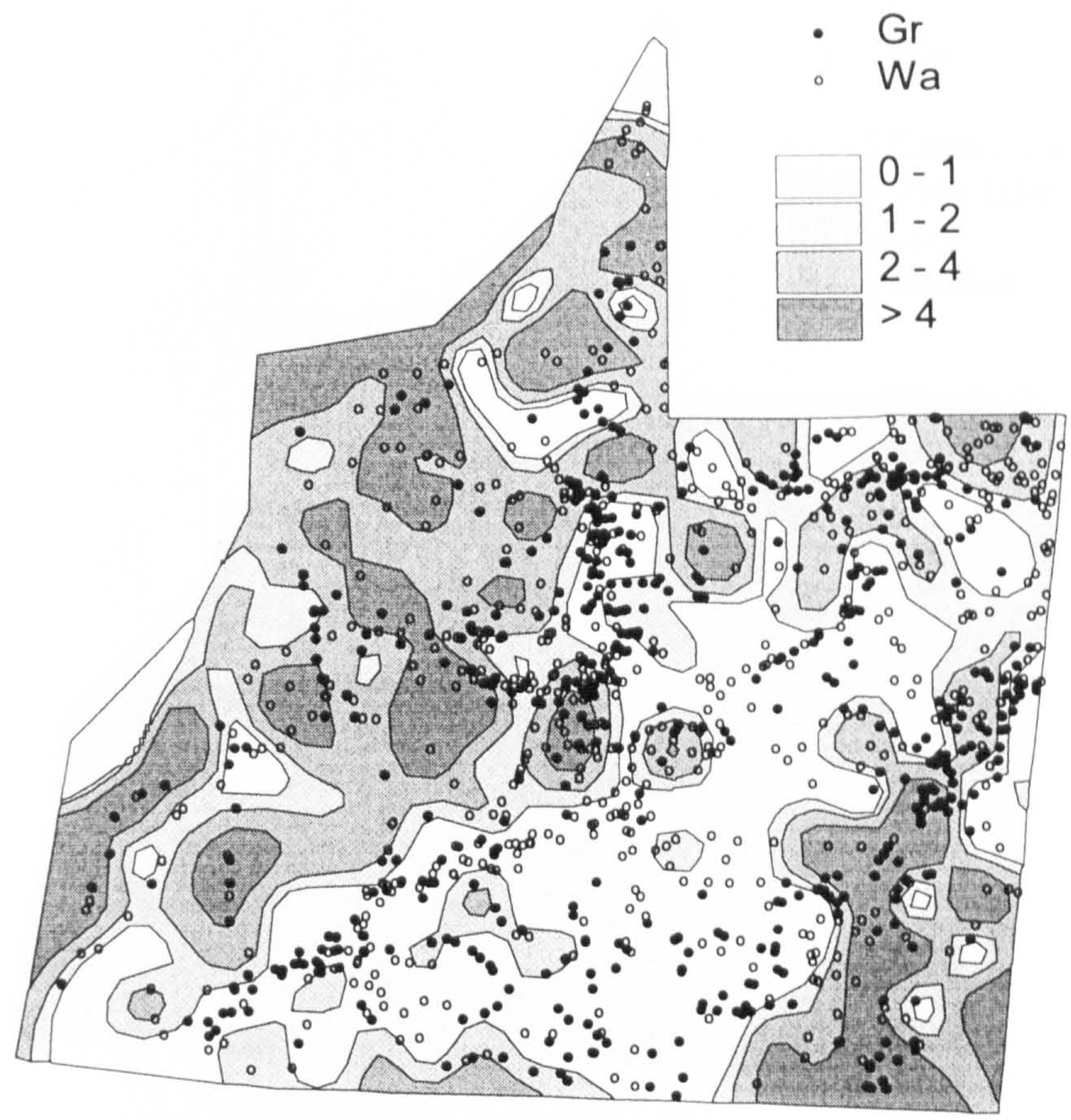


Fig. 6.13a Utilisation of *Eragrostis* species, with Rhino Grazing and Walking Locations

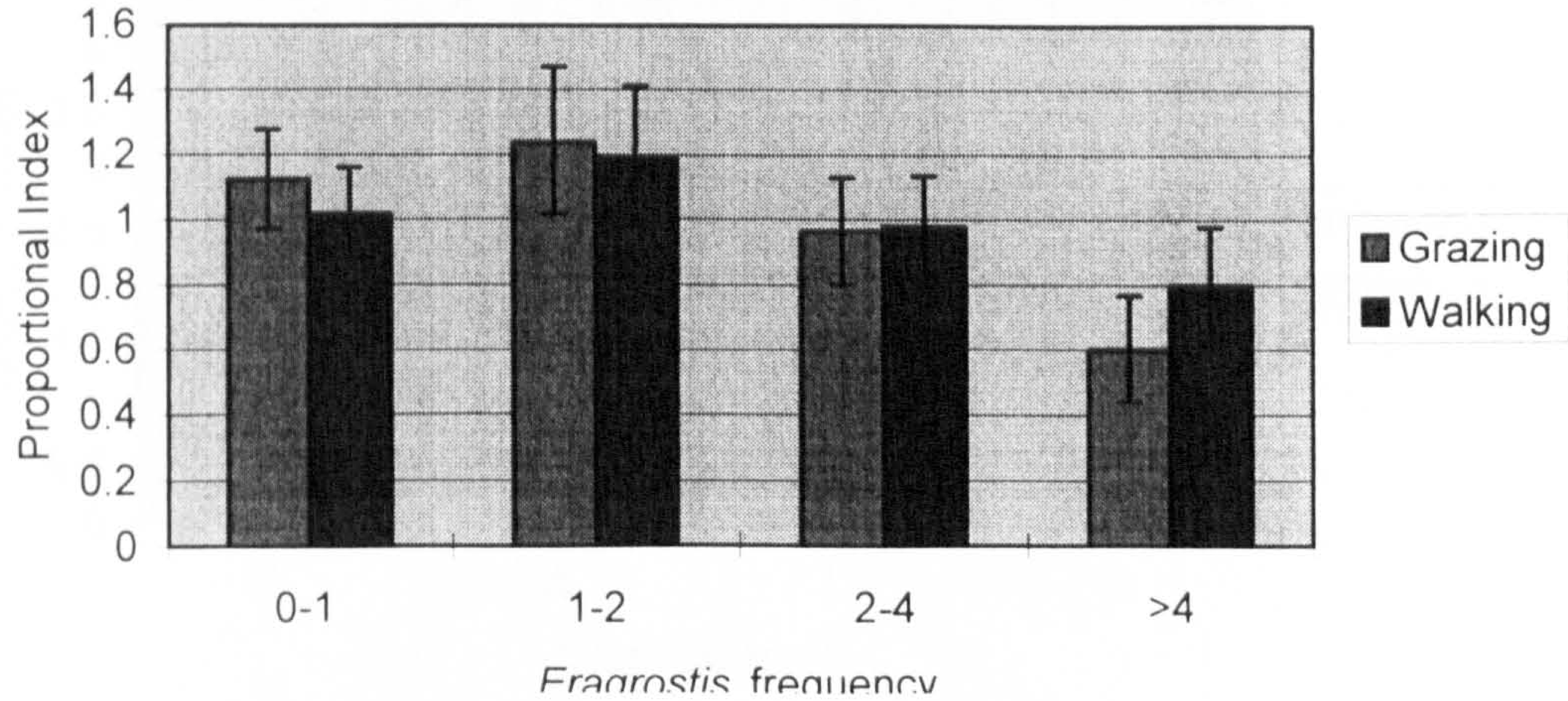


Fig. 6.13b Utilisation Index of *Eragrostis* species

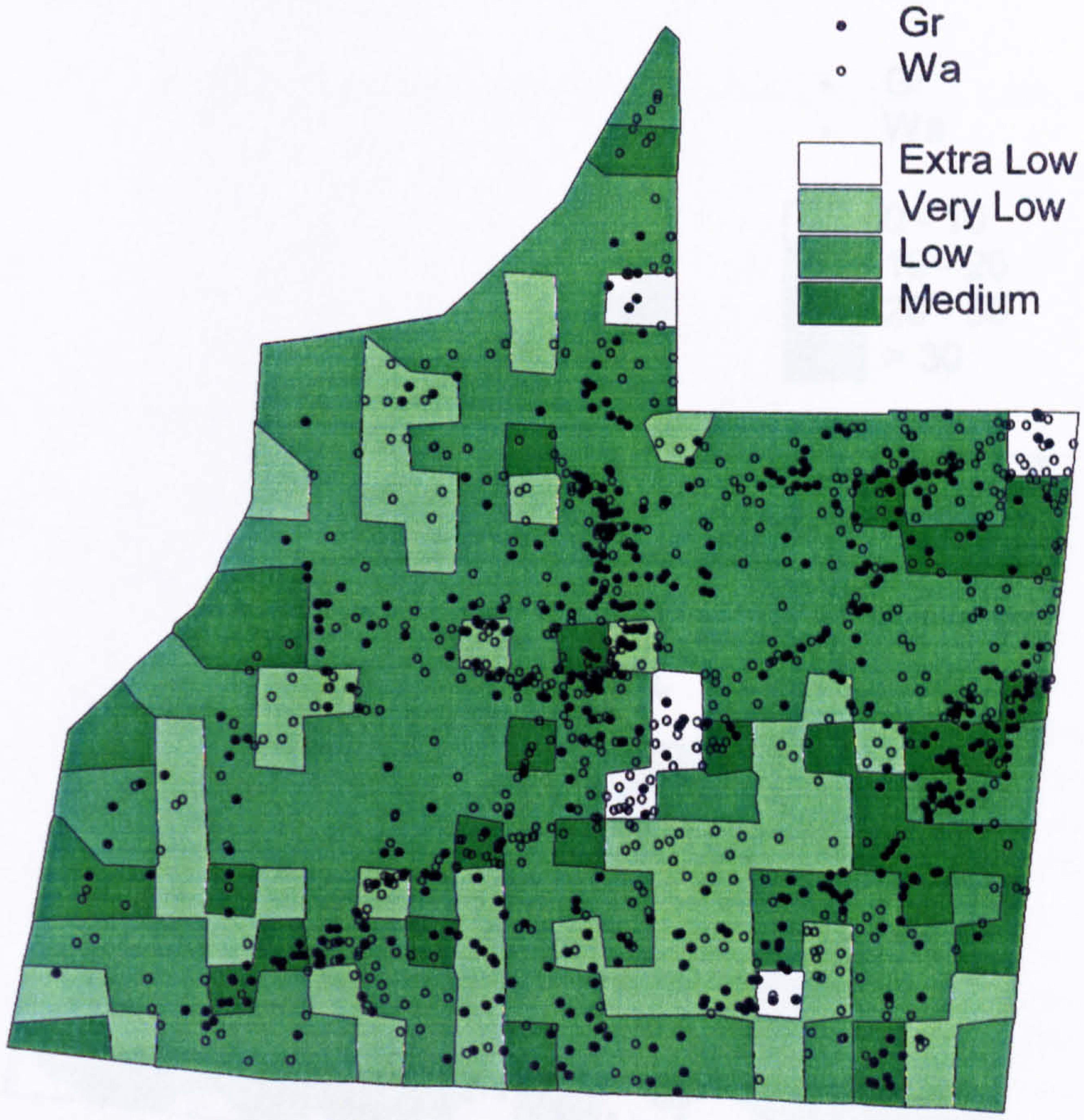


Fig. 6.14a Utilisation of Grass Biomass Ratings, with Rhino Grazing and Walking Locations

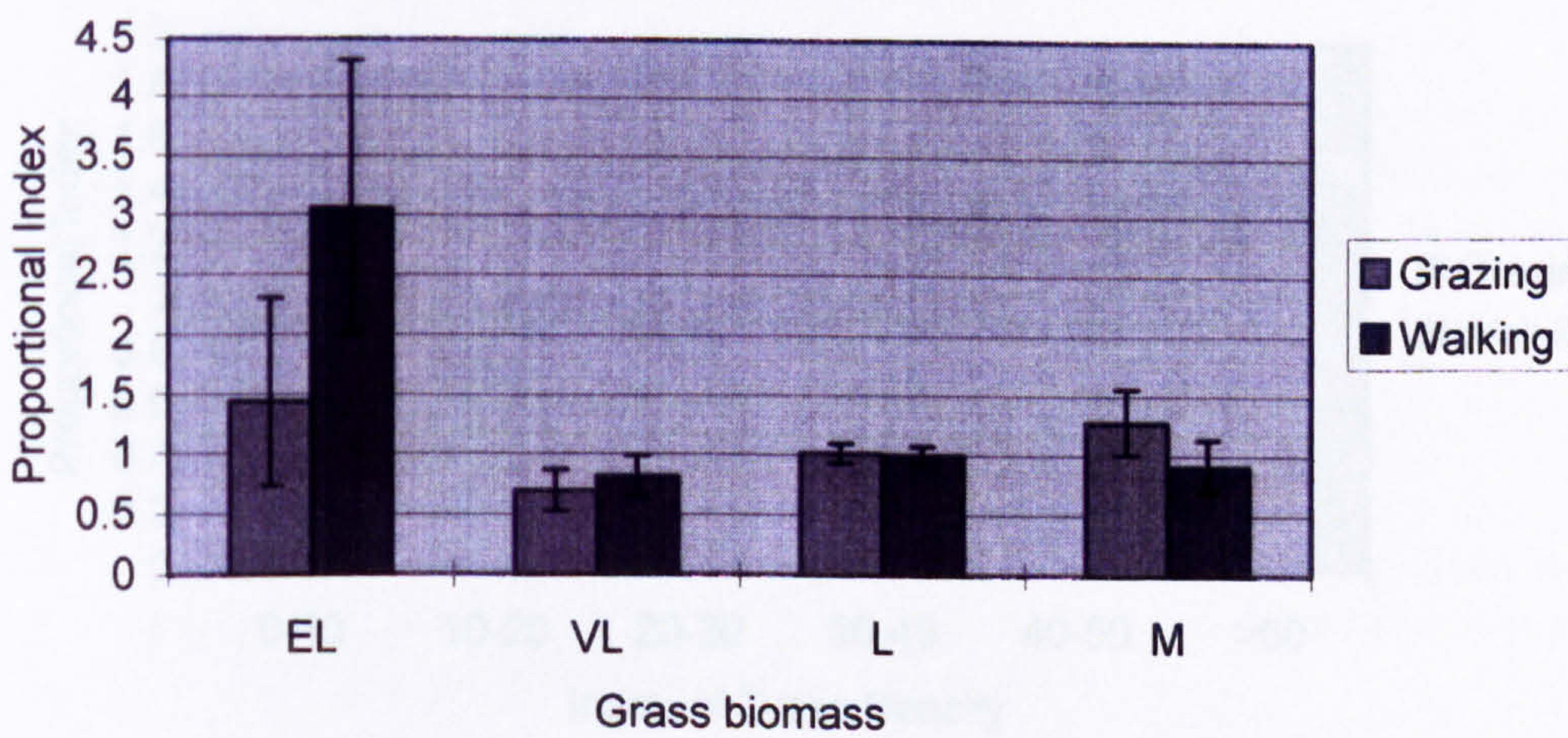


Fig. 6.14b Utilisation Index of Grass Biomass Ratings

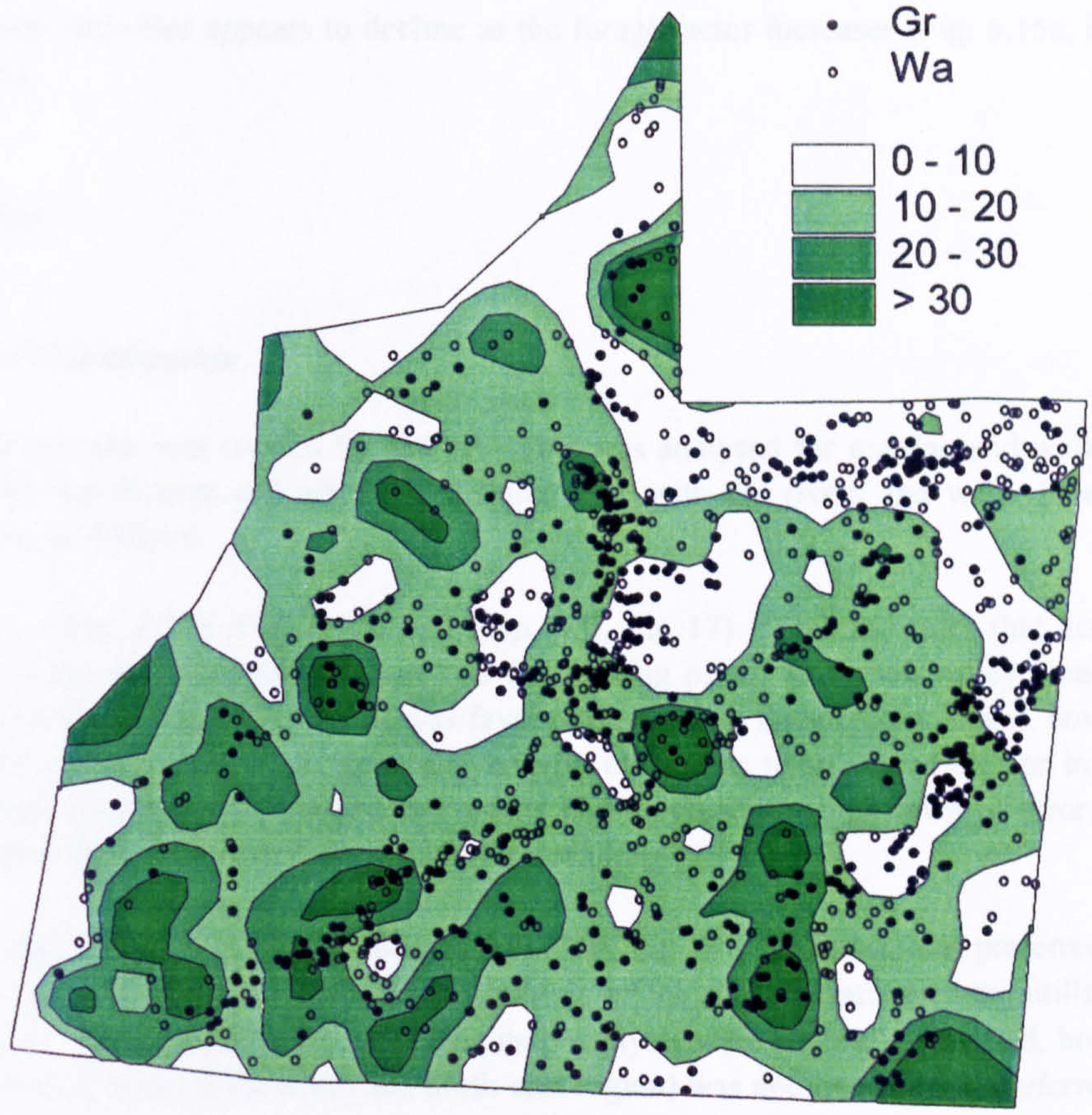


Fig. 6.15a Utilisation of Grass Density Classes, with Rhino Grazing and Walking Locations

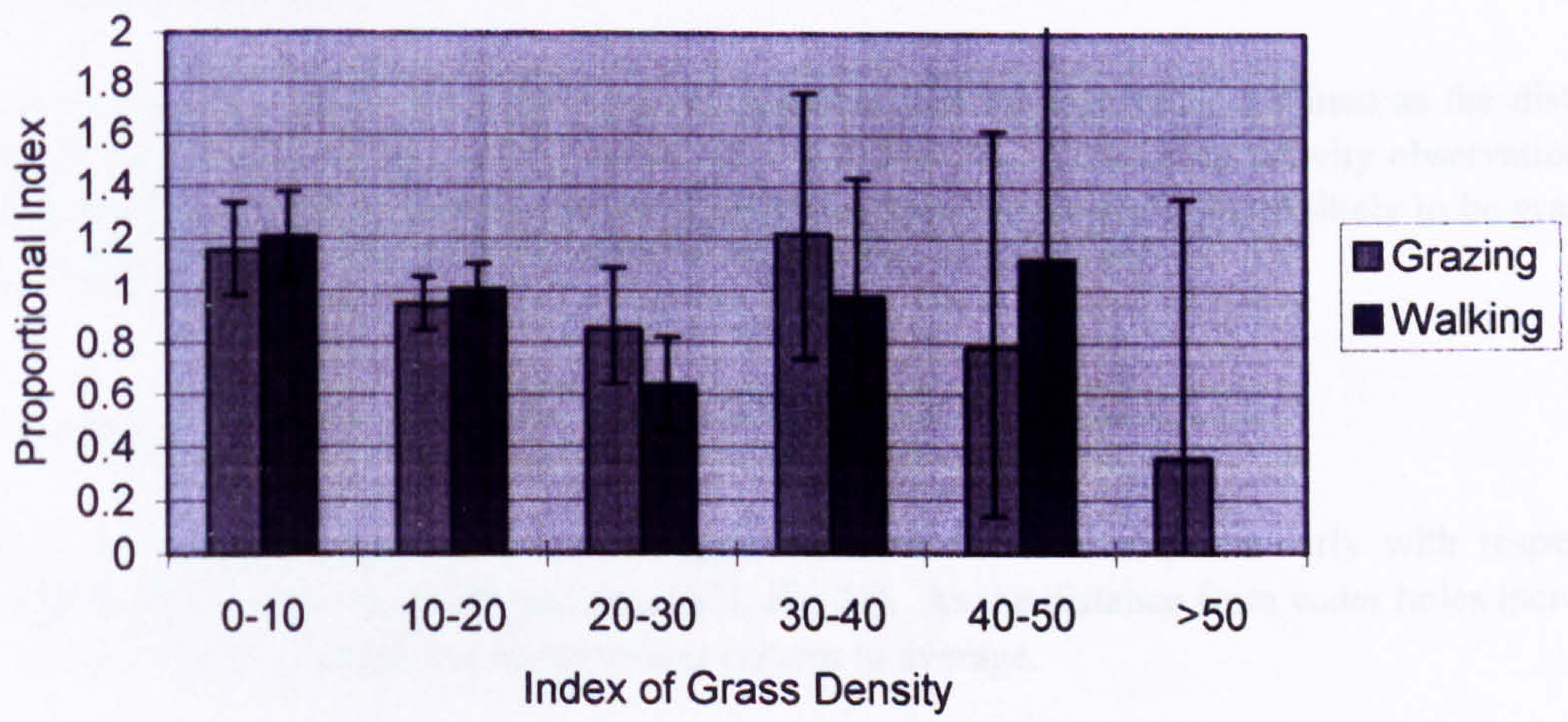


Fig. 6.15b Utilisation Index of Grass Density Classes

v) **Forage Factor**

Utilisation for both activities appears to decline as the forage factor increases (Fig. 6.16a, Fig. 6.16b and App. VII, Fig 16).

6.3.1.2 Habitat

i) **Habitat Classification**

A four-class habitat map was created by MVSP. This was analysed for grazing and walking, first as a basic map for the whole area and also as a detailed map with the rivers and water holes included as additional classes, as follows:

a) **Basic map** – (Fig. 6.17a, Fig. 6.17b and App. VII, Fig 17). This indicates that activity was not influenced in the dominant habitat type two (undulating plains and open valley areas). Class one (north and north east areas of plateau) was favoured over class three (rocky areas), however this was only a minor effect. Class four (generally heavily utilised as near water holes or in sheet erosion areas) covered a very small area and the results had a potentially high level of error, however this class was often found to be associated with rhino walking.

b) **Detailed map** – (Fig. 6.18a, Fig. 6.18b and App. VII, Fig 18). This indicates preferred utilisation of rivers while grazing and water holes while walking, which slightly decreased the utilisation ratios of other classes. Trends indicated in the basic map analysis were generally repeated, however, habitat class one (plateau areas in the north and north-east region) was not identified as preferred for grazing.

ii) **Vegetation Type**

Neither grazing nor walking was influenced by low tree savanna, which is the dominant vegetation type of the area (Fig. 6.19a, Fig. 6.19b and App. VII, Fig 19). Open areas characteristic of grassland savanna would appear to be a preferred vegetation type for both activities, especially for walking. High tree savanna was often associated with walking activity, however too few observations were recorded to enable any conclusions to be reached.

iii) **Distance from Rivers**

The rhinos were found to prefer areas close to rivers and utilisation apparently declined as the distance from a river increased (Fig. 6.20a, Fig. 6.20b and App. VII, Fig 20). Comparing activity observations, it was apparent that if a rhino is at distance of less than 100m from the river it is more likely to be grazing. As the distance from the river increases, walking is observed more frequently.

iv) **Distance from Water Holes**

Utilisation of the area around water holes is higher than of other areas, particularly with respect to walking activity (Fig. 6.21a, Fig. 6.21b and App. VII, Fig 21). As the distance from water holes increases above 500m, the frequency of grazing observations returns to average.

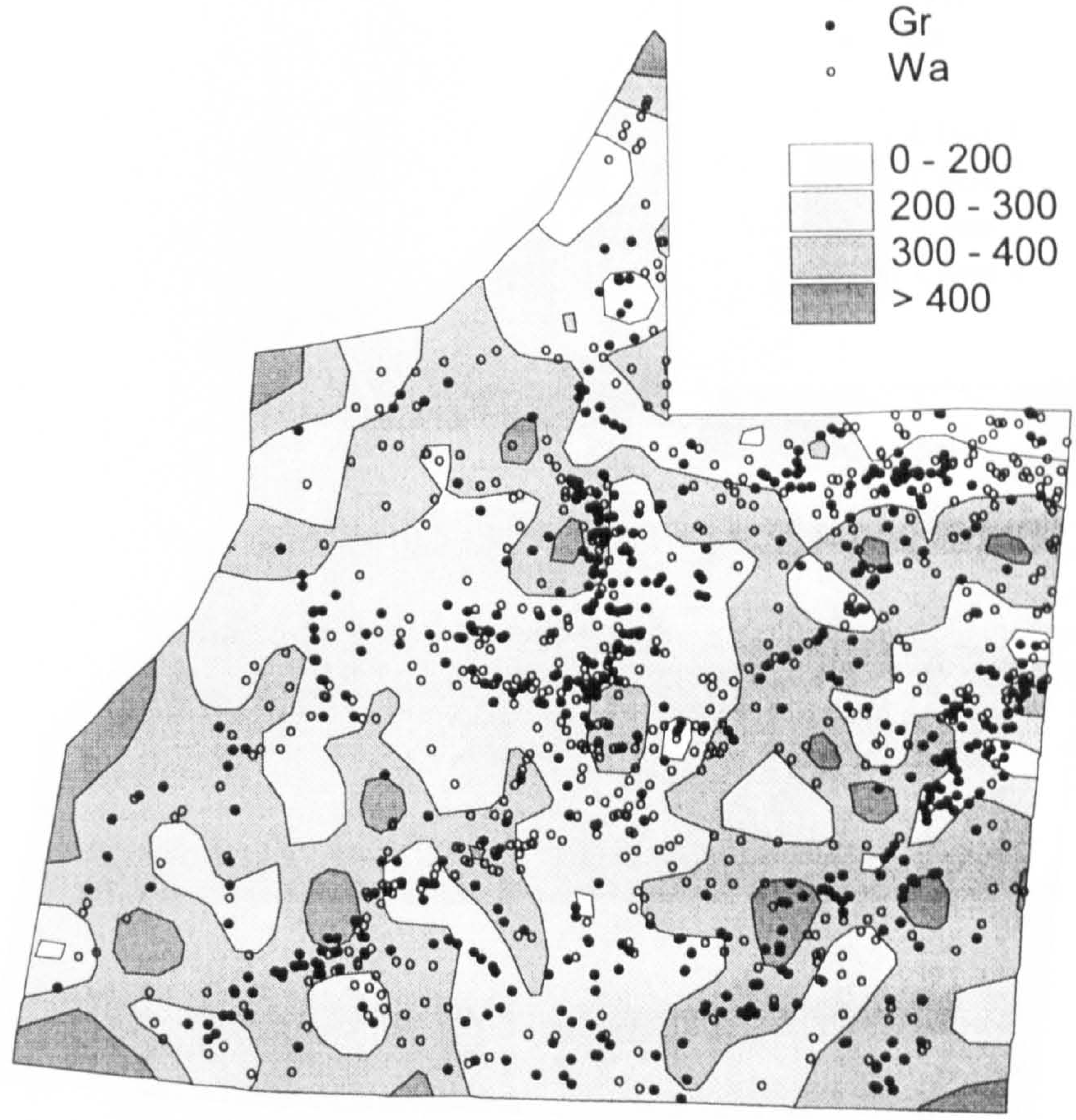


Fig. 6.16a Utilisation of Forage Factor Classes, with Rhino Grazing and Walking Locations

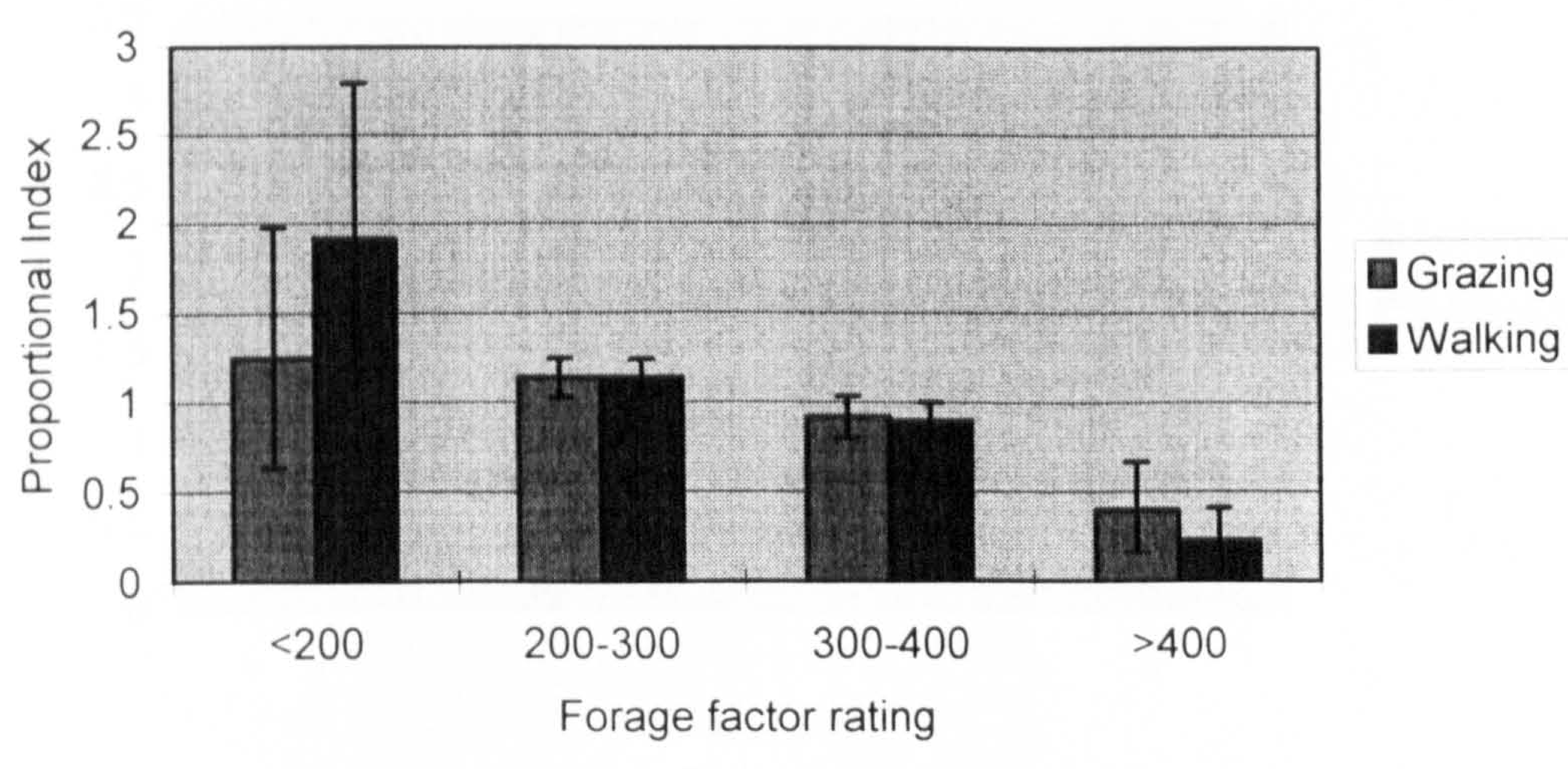


Fig. 6.16b Utilisation Index of Forage Factor Classes

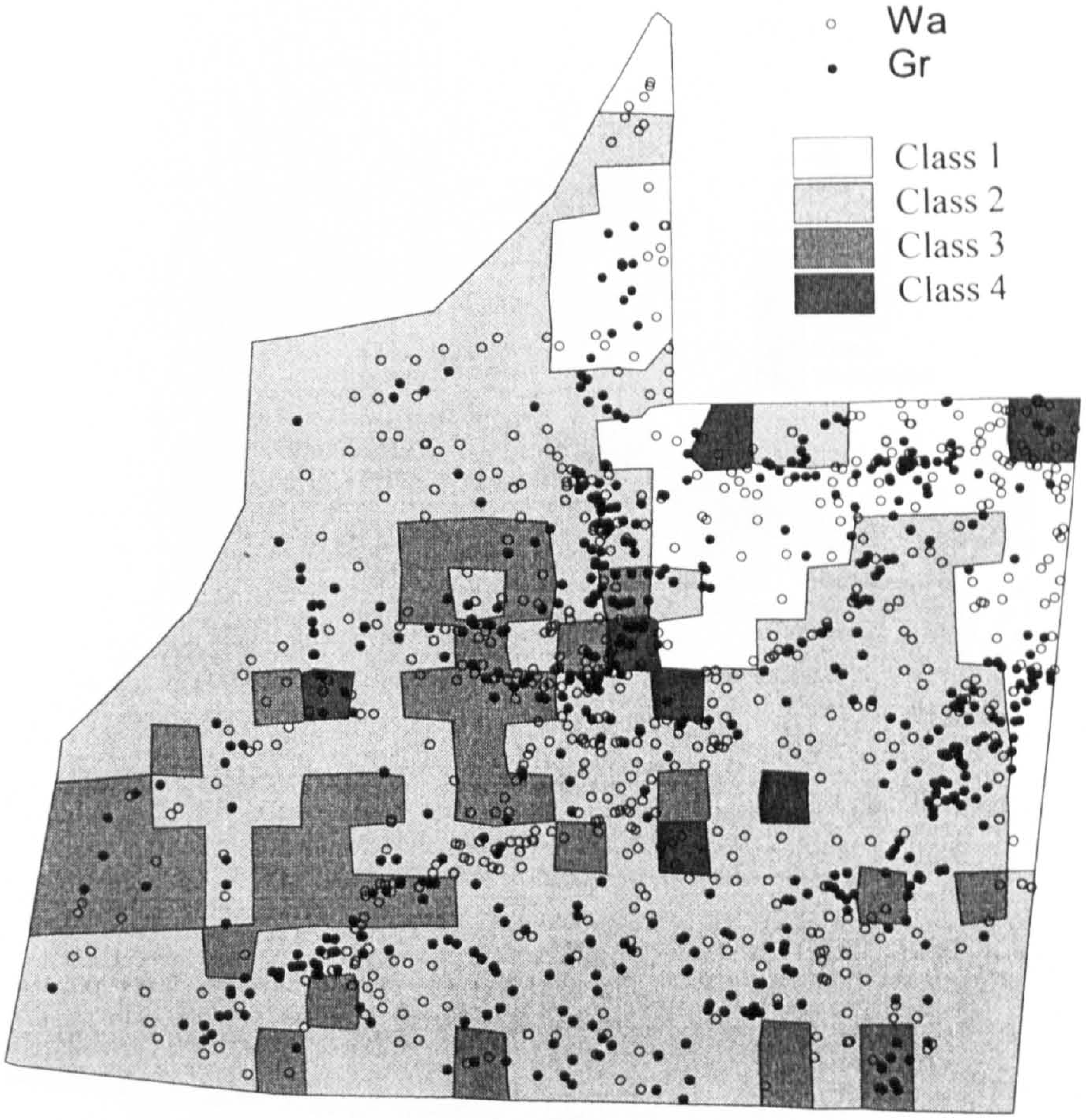


Fig. 6.17a Four-Class Habitat Classification, with Rhino Grazing and Walking Locations

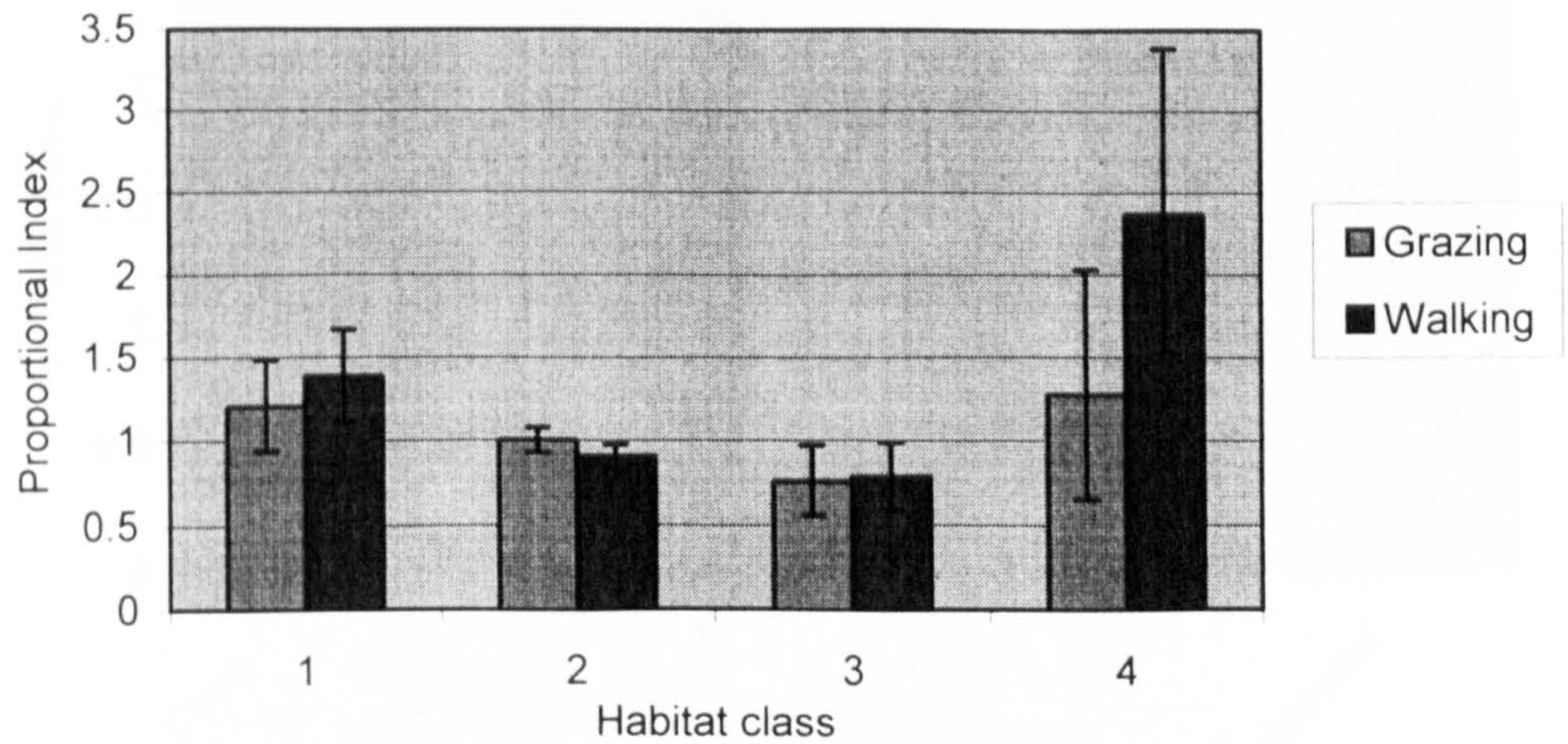


Fig. 6.17b Utilisation Index of Four-Class Habitat Classification

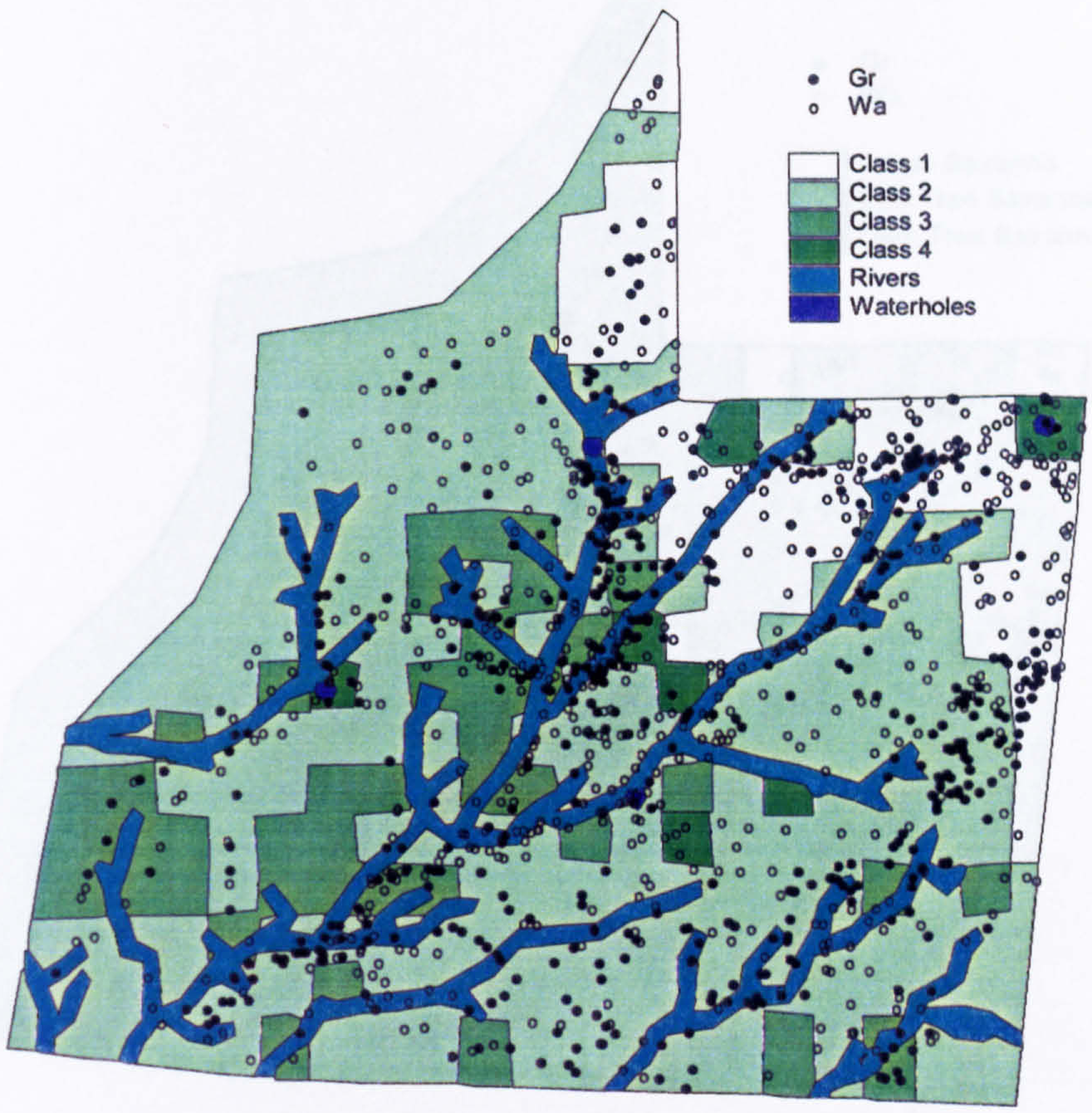


Fig. 6.18a Detailed Four-Class Habitat Classification, with Rhino Grazing and Walking Locations

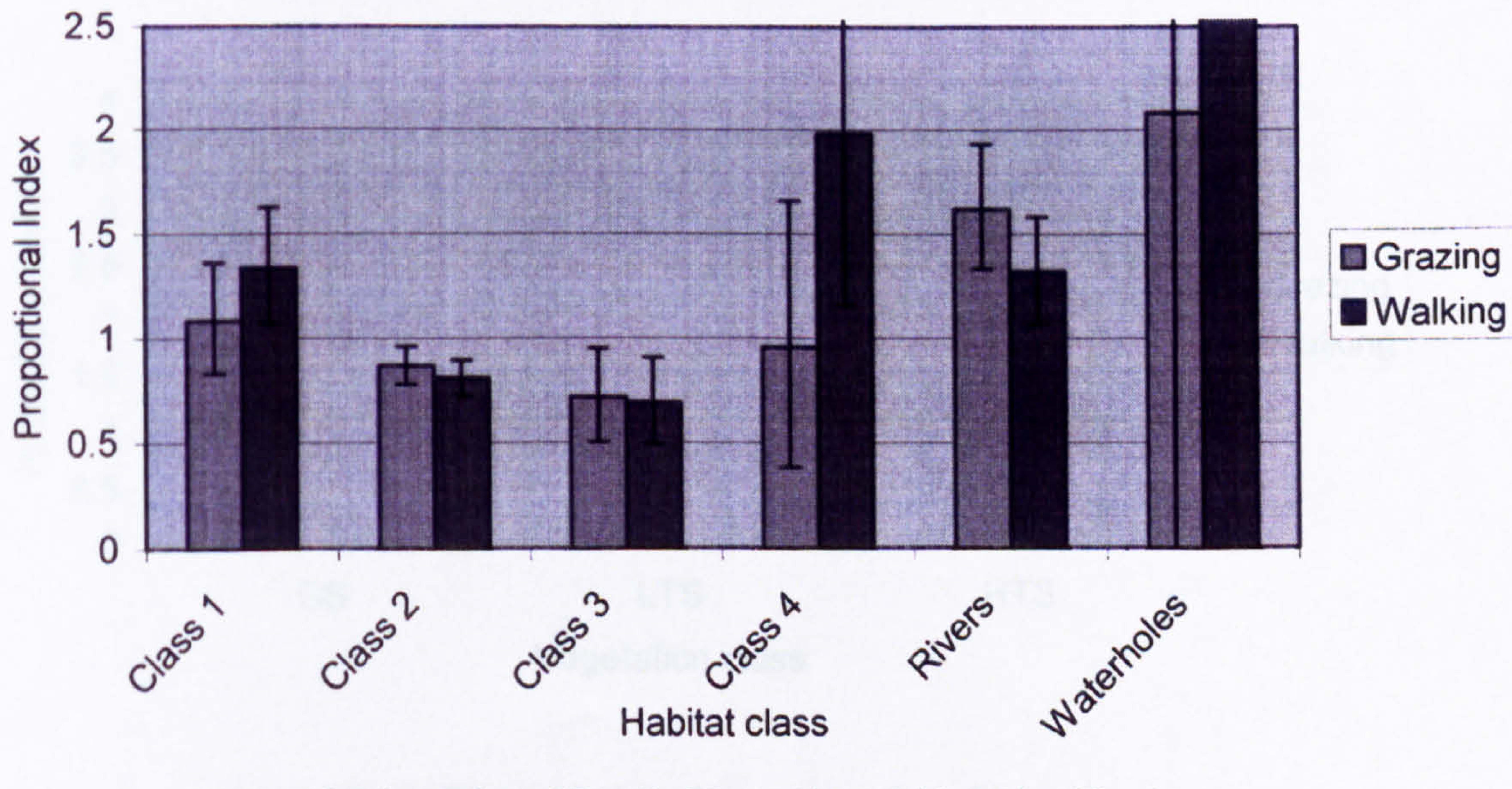


Fig. 6.18b Utilisation Index of Detailed Four-Class Habitat Classification

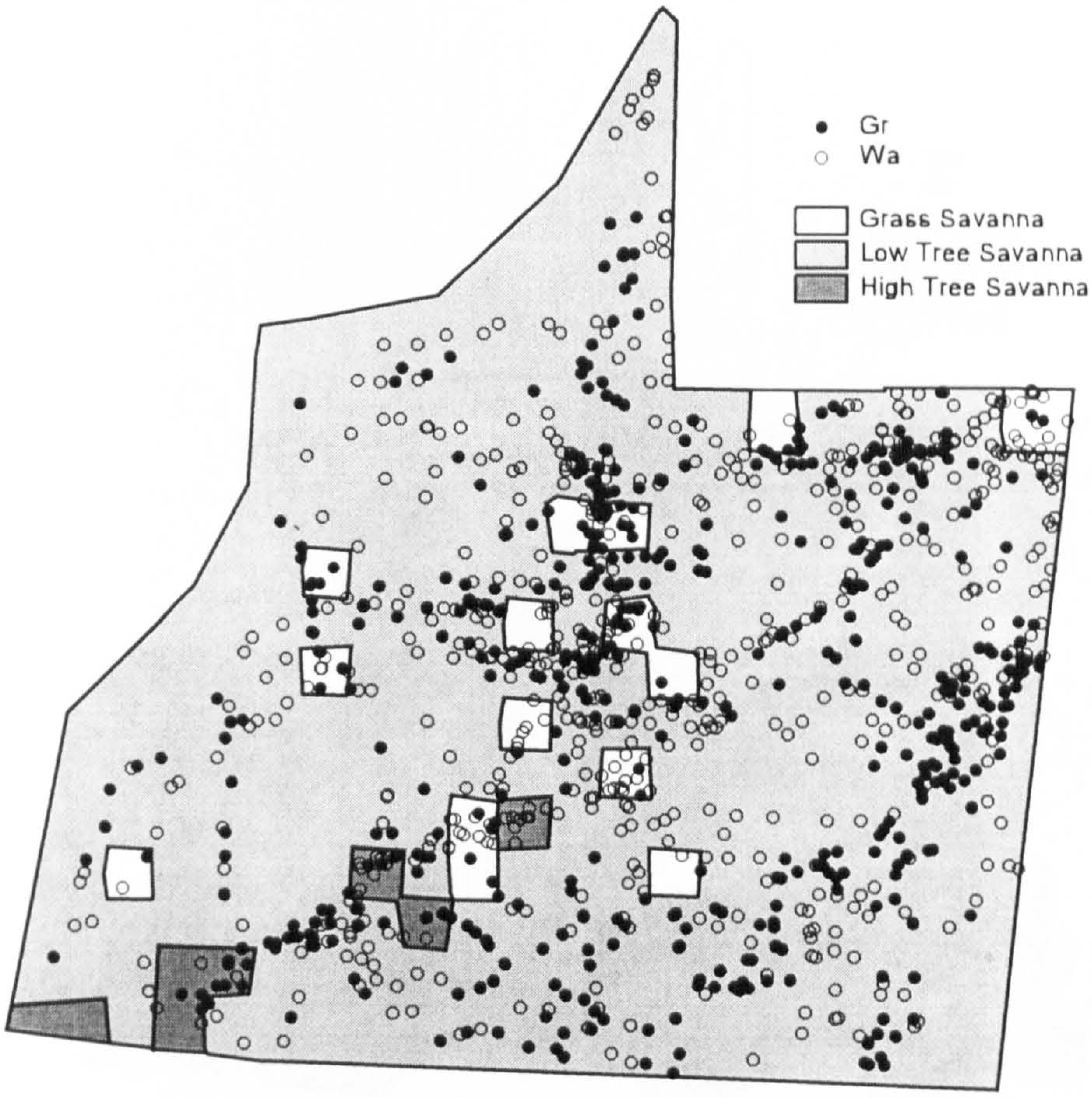


Fig. 6.19a Utilisation of Vegetation Type Classes, with Rhino Grazing and Walking Locations

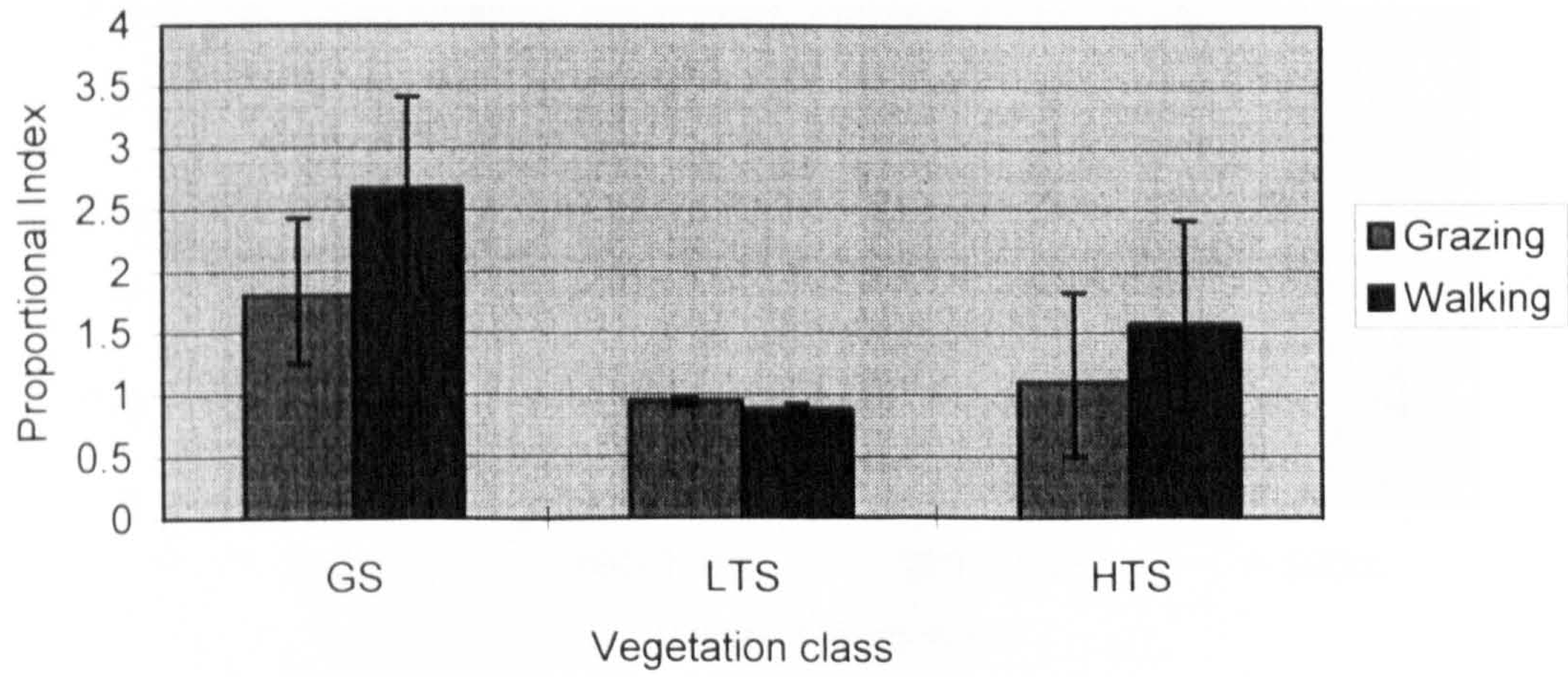


Fig. 6.19b Utilisation Index of Vegetation Type Classes

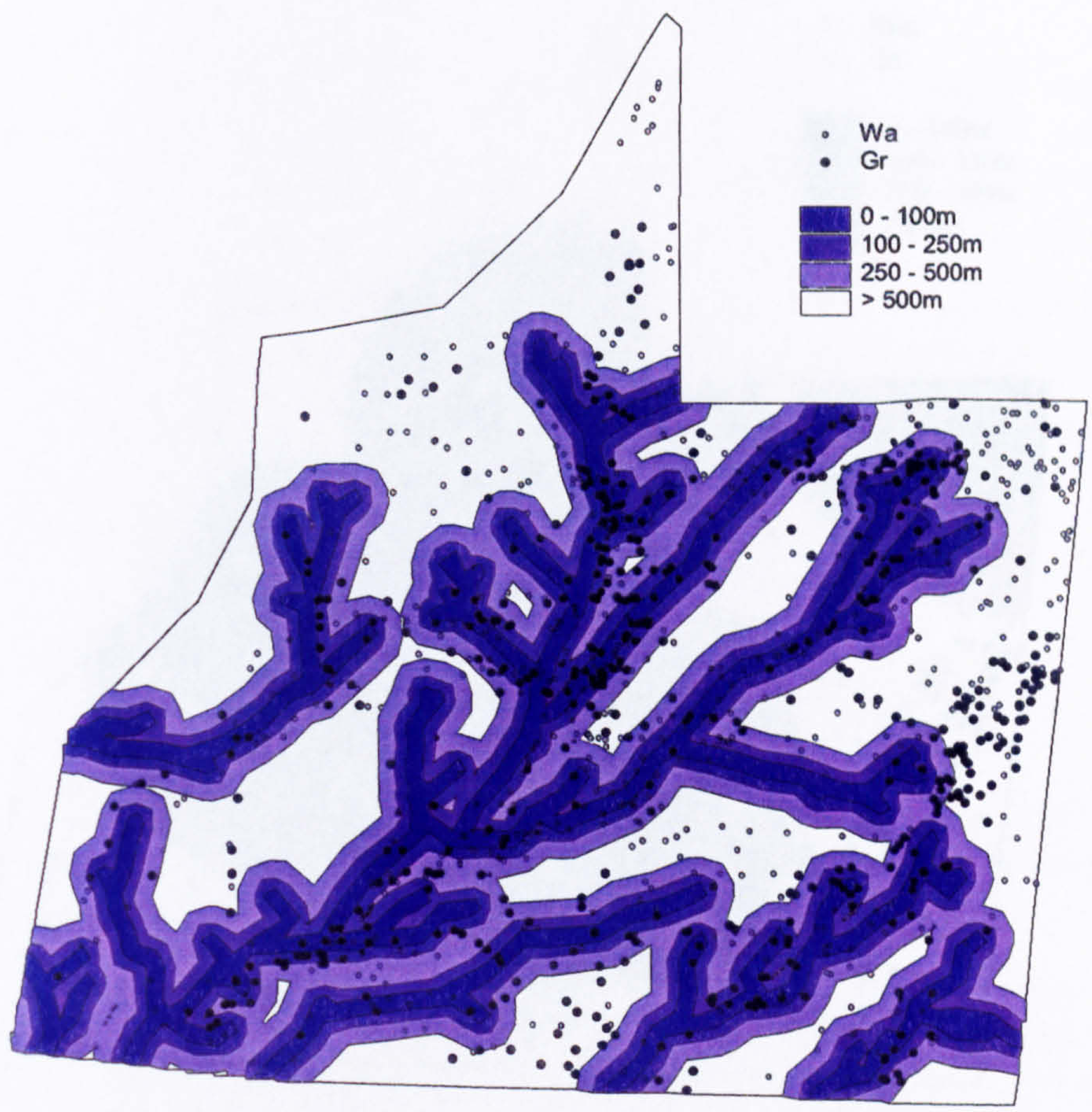


Fig. 6.20a Utilisation of Distances from Rivers, with Rhino Grazing and Walking Locations

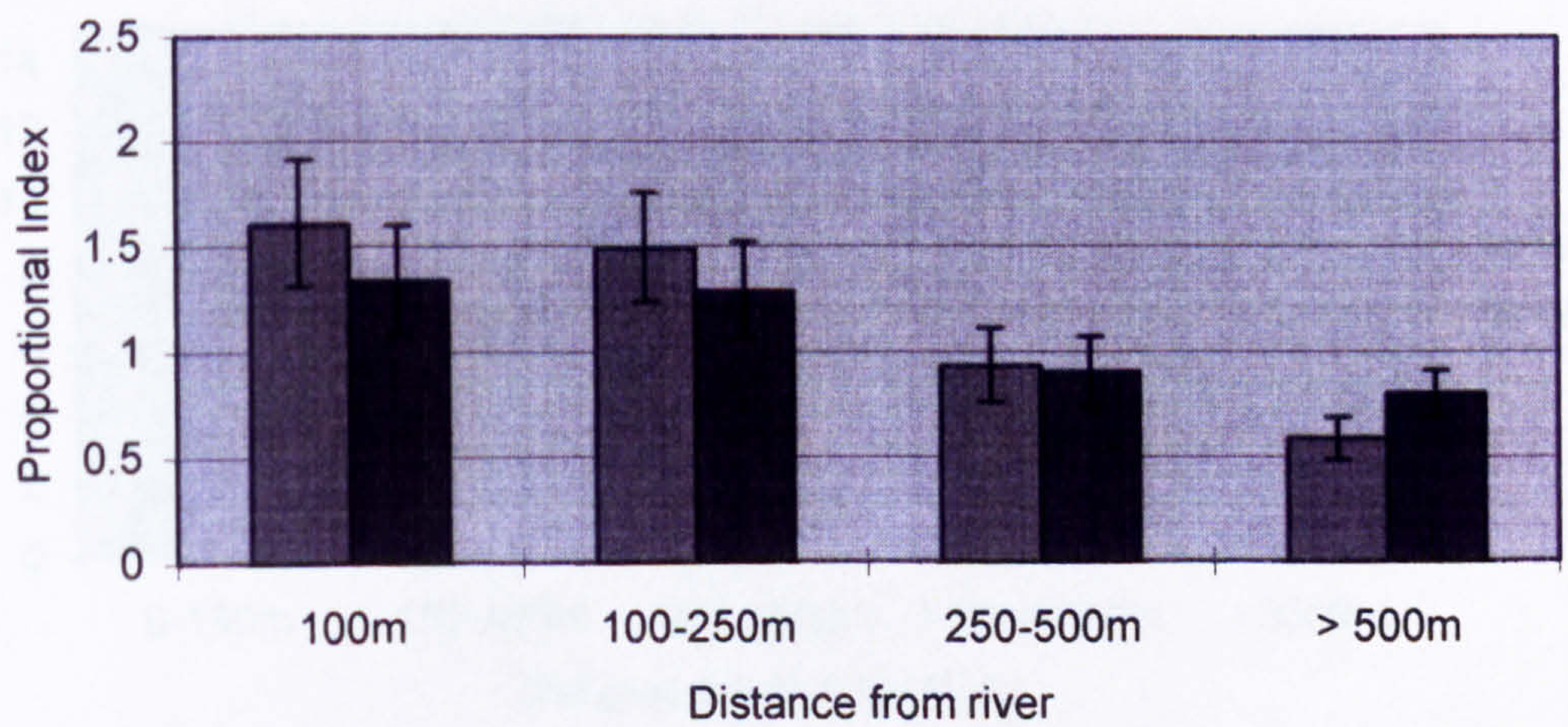


Fig. 6.20b Utilisation Index of Distances from Rivers

Fig. 6.21a Utilisation of Distances from Water Holes, with Rhino Grazing and Walking Locations

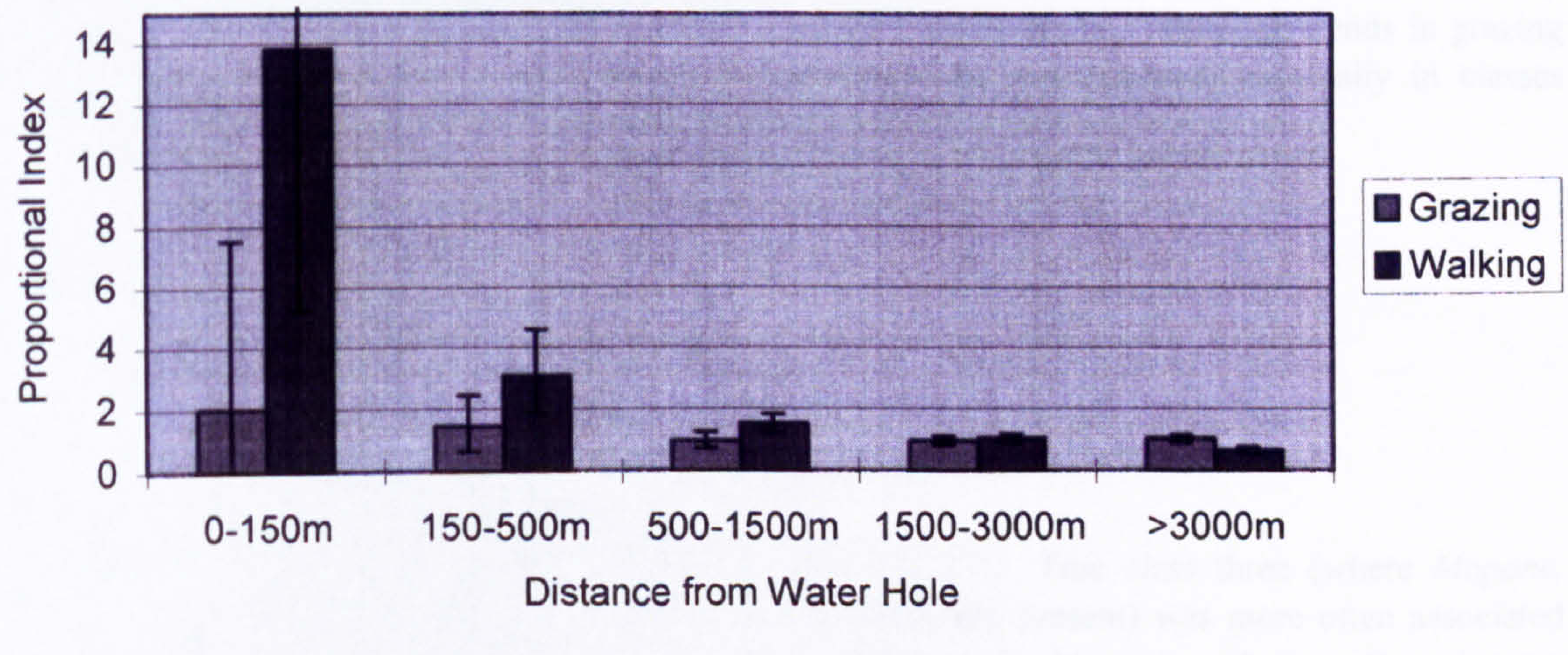


Fig. 6.21b Utilisation Index of Distances from Water Holes

v) **Rockiness**

Mapping the presence or absence of areas with over 60% rock was considered to provide more accurate resolution for comparison with rhino activity. However, although the map of rockiness ratings has a coarse resolution, it did enable gradients of rockiness to be investigated. Both results are discussed below.

a) Rocky areas were mapped in Fig. 6.22a. Areas classified as rocky cover 28% of the area in Kaross (App. VII, Fig 22). Rocky areas were generally avoided and when in these areas, rhinos were generally walking (Fig. 6.22b).
b) Rockiness ratings were mapped in Fig. 6.23a. Rhinos preferred grazing in areas where there were no rocks, in comparison with areas with higher rockiness ratings (Fig. 6.23b). In low rockiness areas the number of walking observations was slightly higher than average, which was reflected in fewer grazing records. When rockiness ratings become high, utilisation for both activities declined. See also App. VII, Fig 23d&e.

vi) **Soil**

Soil classes were represented by alphabetic labels (Beugler-Bell 1996) which represent individual types of soil. Analysis incorporated the detailed eleven-class map, five-class map and the five-class map with GIS assign proximity function, as follows:

a) **Eleven-class -** This incorporates all soil class subdivisions in the area. Soil classes which were rare or infrequent (Fig. 6.24a) were found to introduce large margins of error, making the results of many of the soil categories unusable (A2a, D1 and D2) (Fig. 6.24b). Of the C1 and C2 soils (from the Kaross granite zone), C2 rocky areas were infrequently visited and grazing observations were particularly low, but C2 areas without rock appeared to be preferred to the C1 regions. Regions with soil class D4 (soils from fluvial sediments), which are associated with riverine areas, were preferred by rhinos for grazing and for walking. See App. VII, Fig 24d&e.

b) **Five-class -** (Fig. 6.25a, Fig. 6.25b and App. VII, Fig 25). By grouping the soils into five classes, less error is introduced from rare or infrequent classes. The results showed a slight preference for soils type A (soils of the Highveld and Otavi mountains, occurring in the plateau areas in the north-eastern corners) and type D (from fluvial sediments and generally occurring in riverine areas).

c) The **five-class assign proximity** map was analysed (Fig. 6.26a, Fig. 6.26b and App. VII, Fig 26) to determine the influence of poor resolution of the sampling grid by comparing results from this map with those of the more accurate five-class map described in (b) above. Although trends in grazing and walking were similar, the influence of poor resolution was apparent, especially in classes covering a small area.

6.3.1.3 Trees

i) **Tree classification**

Tree species were divided into three classes and analysed as follows:

a) **Basic map -** (Fig. 6.27a, Fig. 6.27b and App. VII, Fig 27). Tree class three (where *Mopane, Terminalia, Combretum, Acacia* and *Boscia* were all generally present) was more often associated with utilisation. Tree species associated with class one (generally *Mopane*, with some *Catophractes* and *Boscia*) were generally found in less utilised areas.

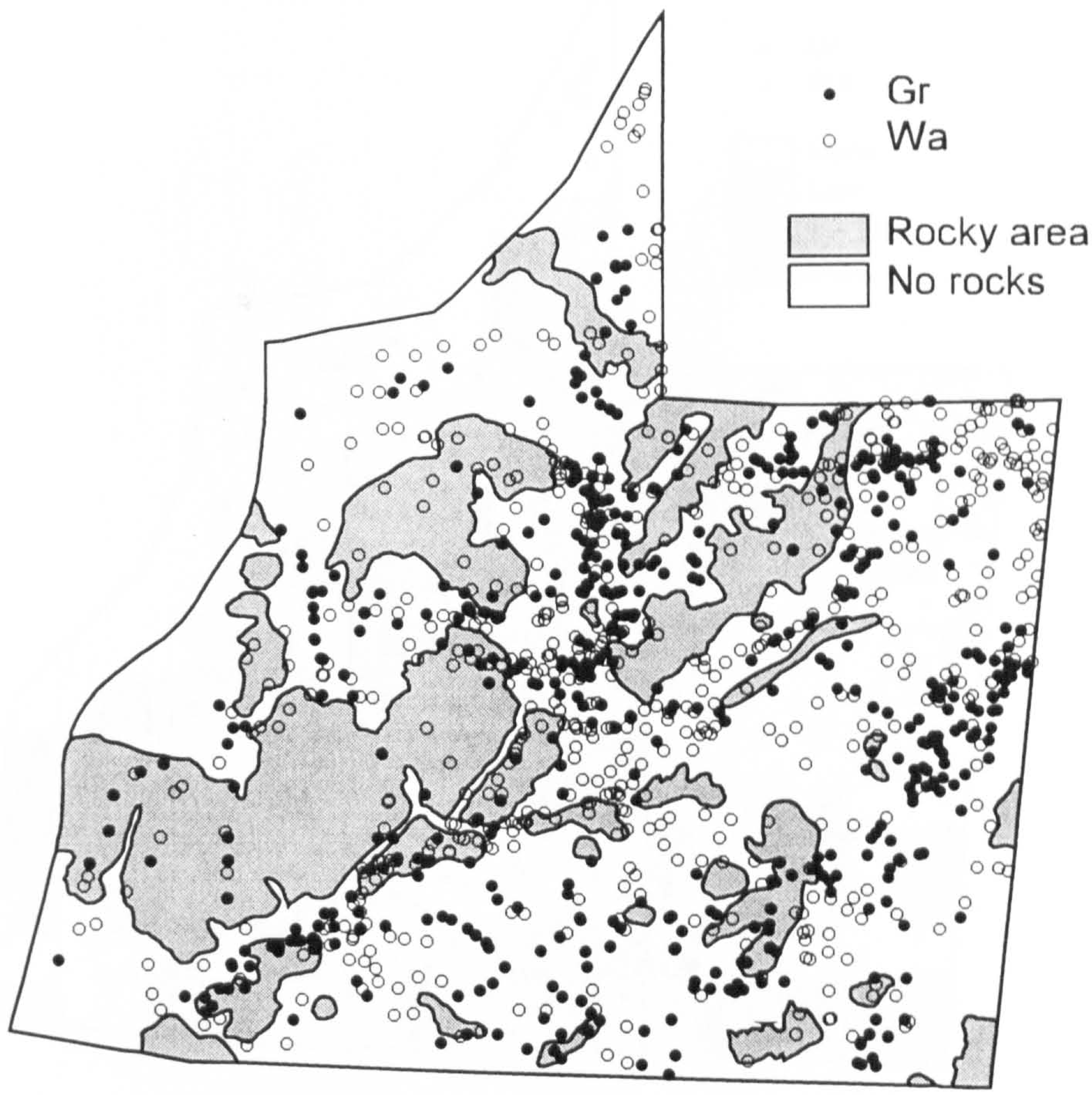


Fig. 6.22a Utilisation of Rocky Areas, with Rhino Grazing and Walking Locations

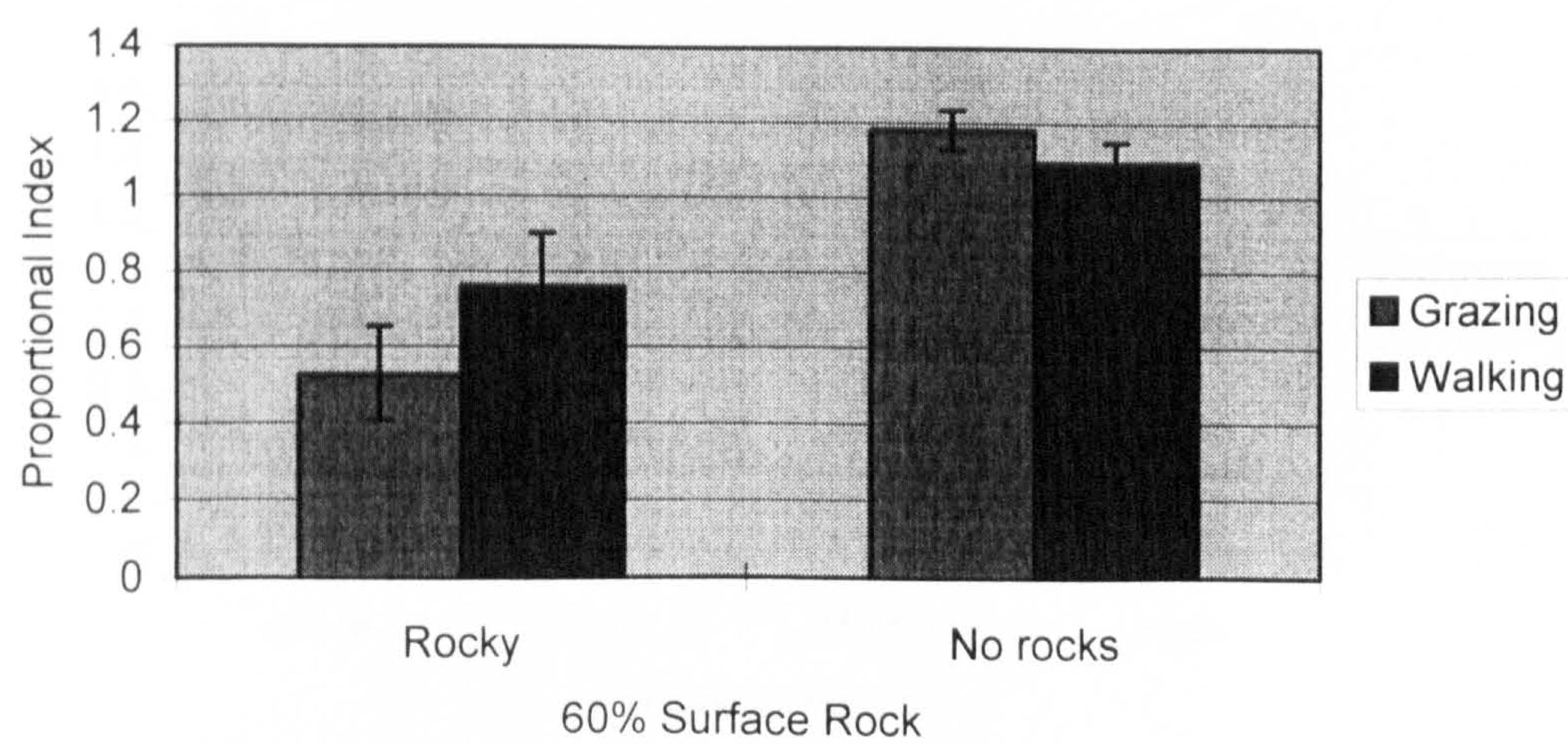


Fig. 6.22b Utilisation Index of Rocky Areas

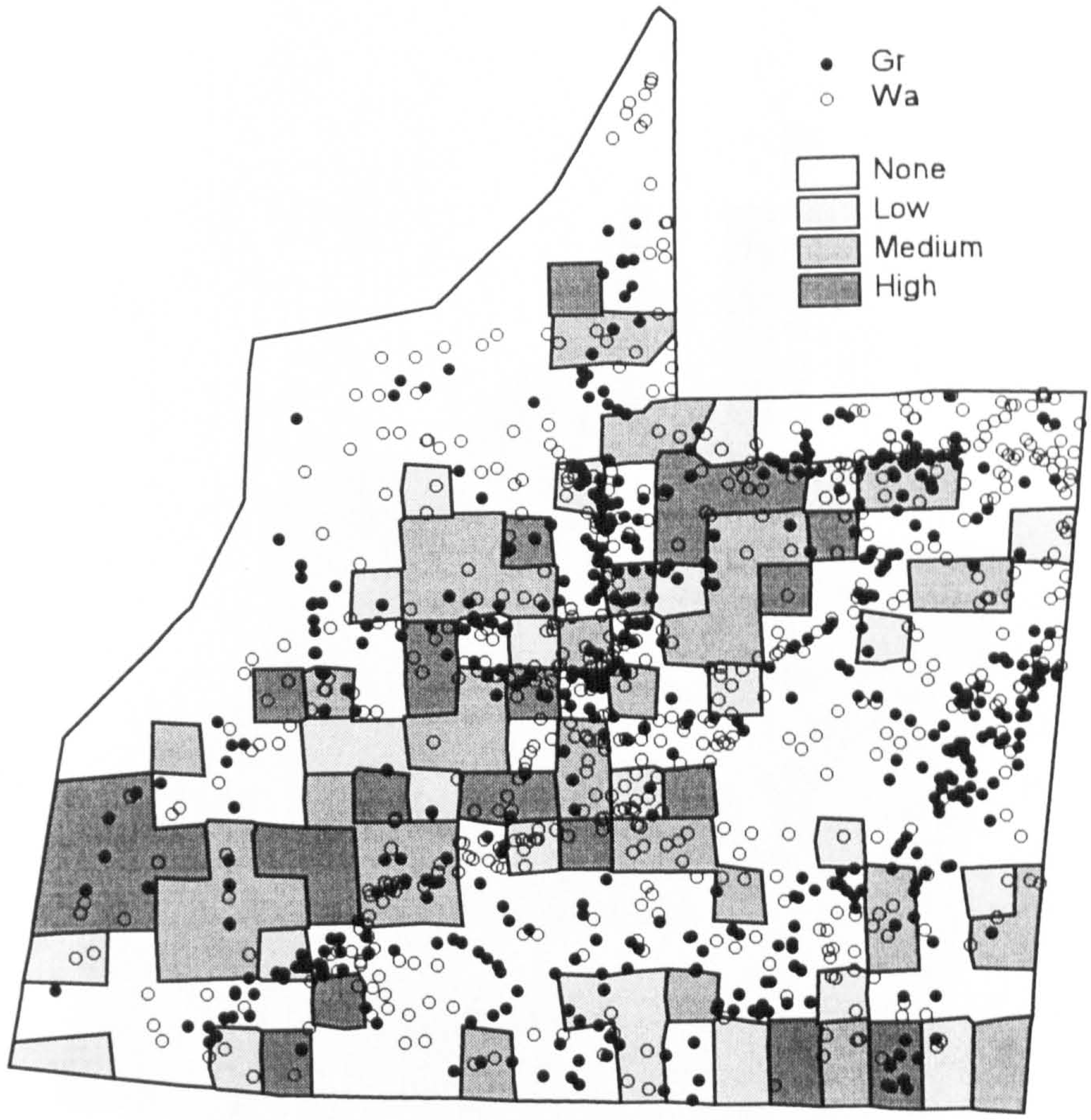


Fig. 6.23a Utilisation of Rockiness Ratings, with Rhino Grazing and Walking Locations

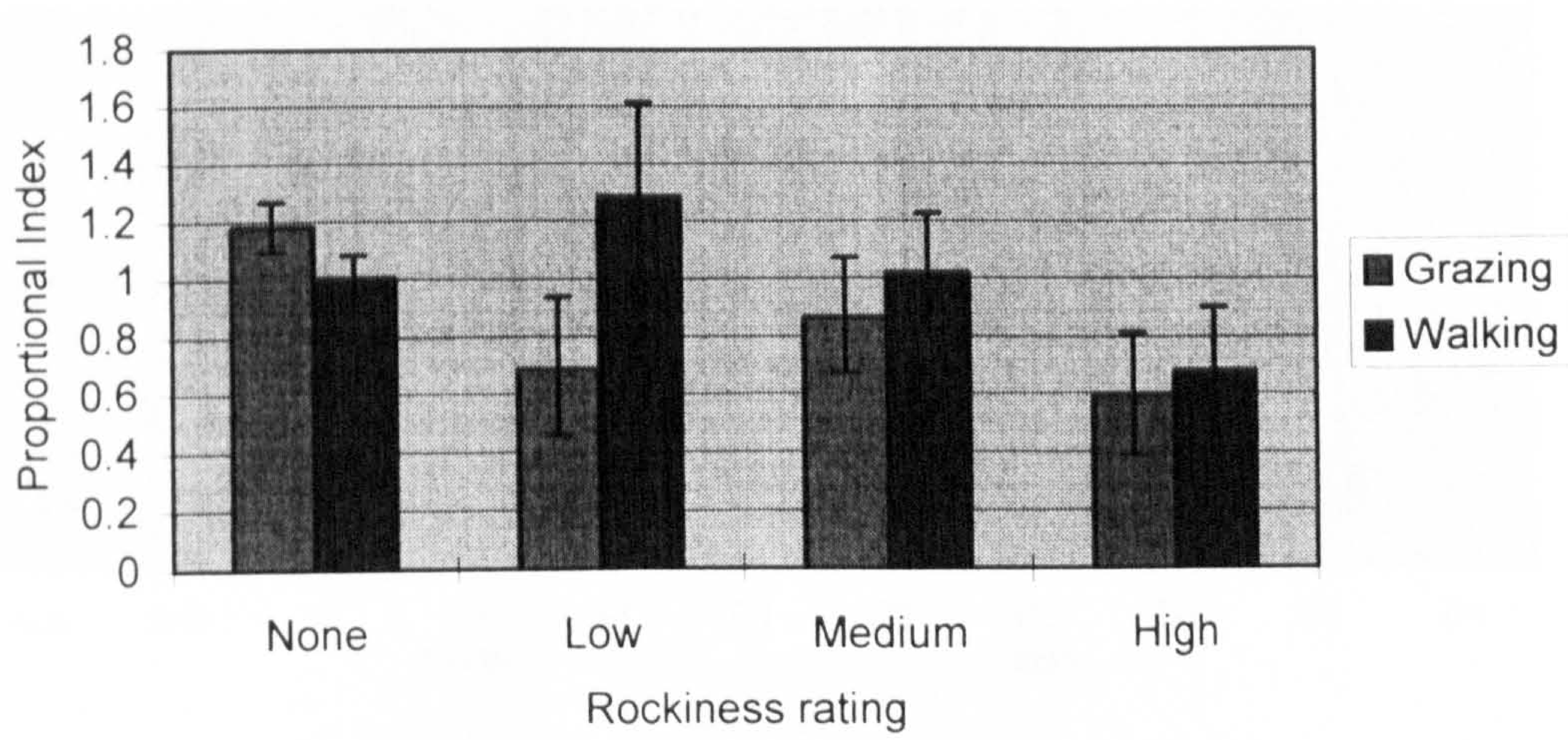


Fig. 6.23b Utilisation Index of Rockiness Ratings

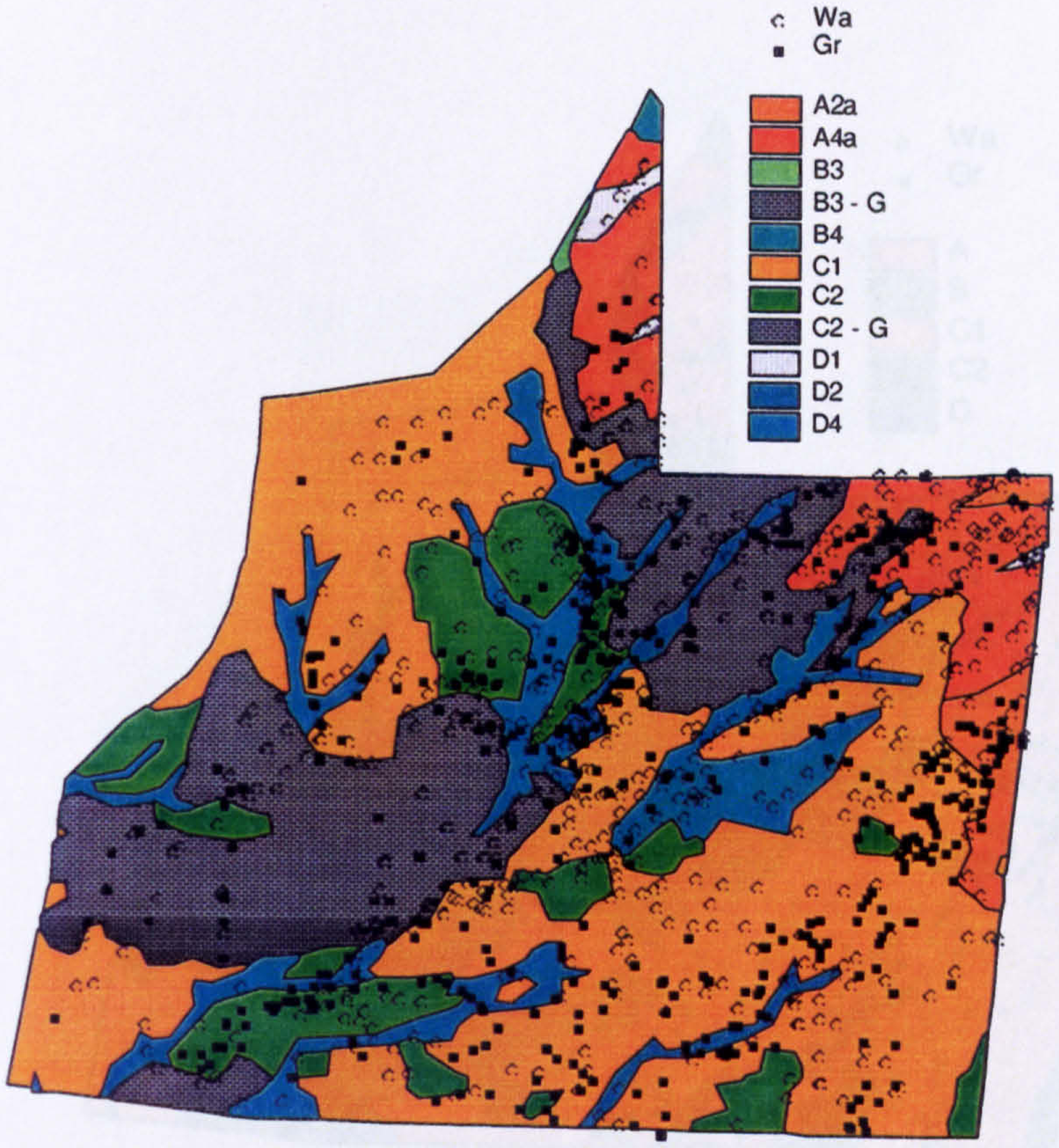


Fig. 6.24a Utilisation of Eleven-Class Soil Types, with Rhino Grazing and Walking Locations

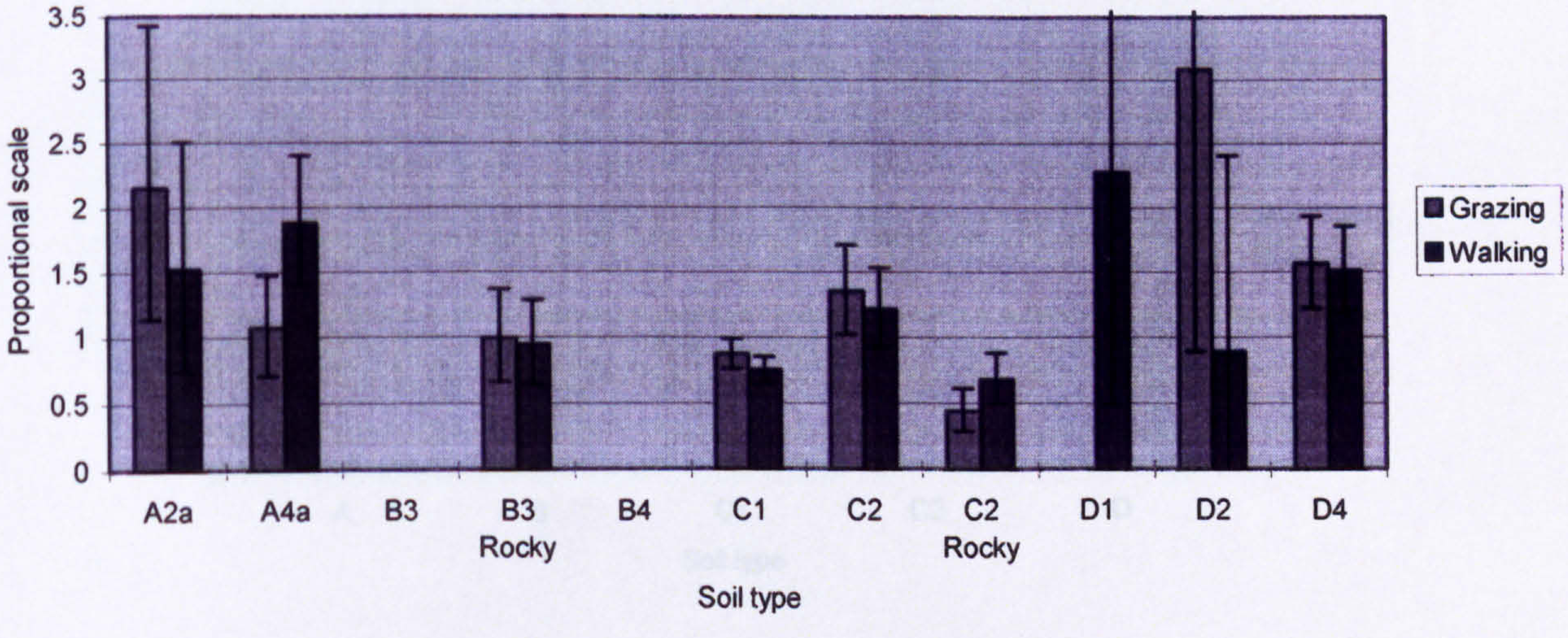


Fig. 6.24b Utilisation Index of Eleven-Class Soil Types

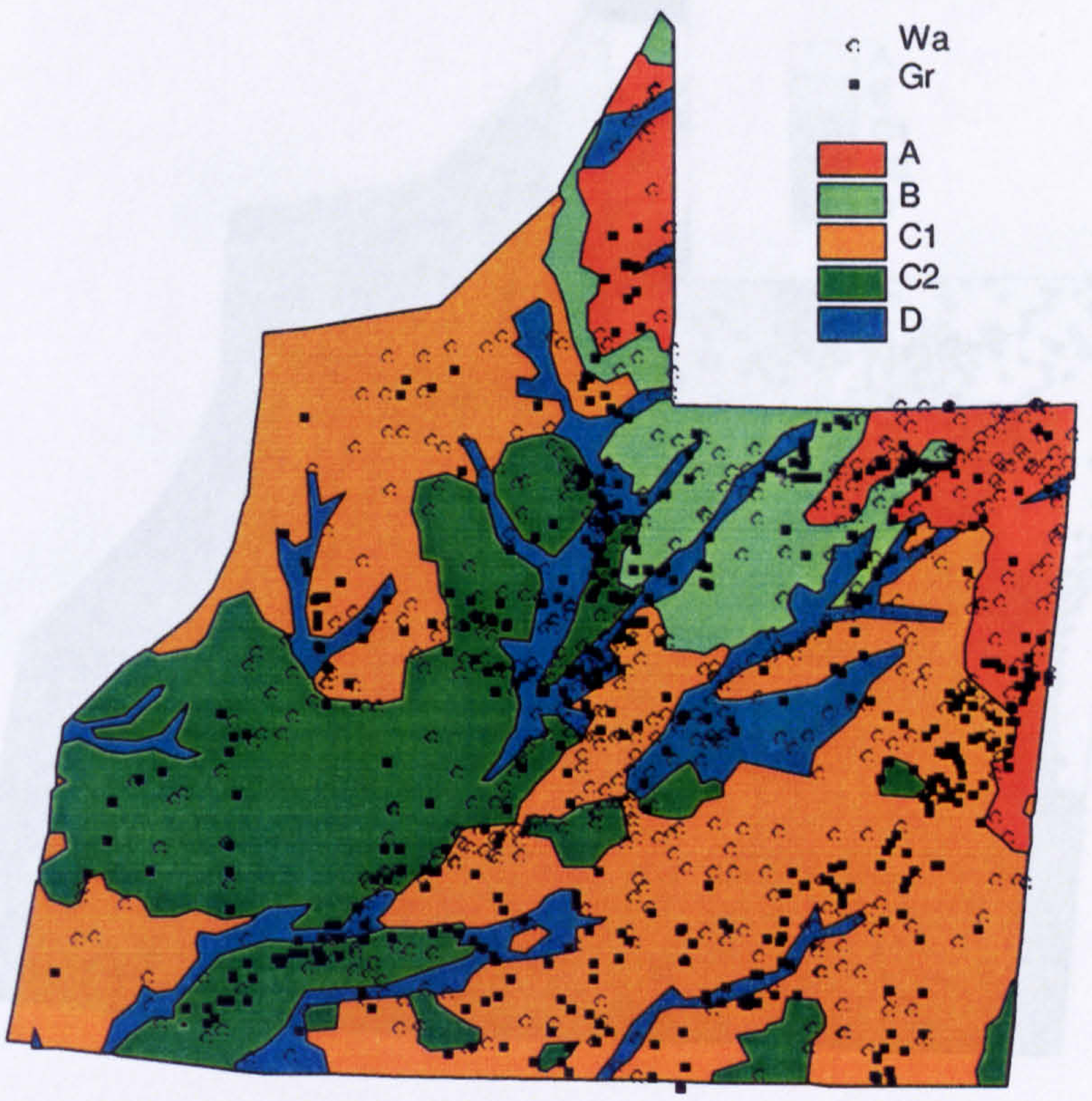


Fig. 6.25a Utilisation of Five-Class Soil Types, with Rhino Grazing and Walking Locations

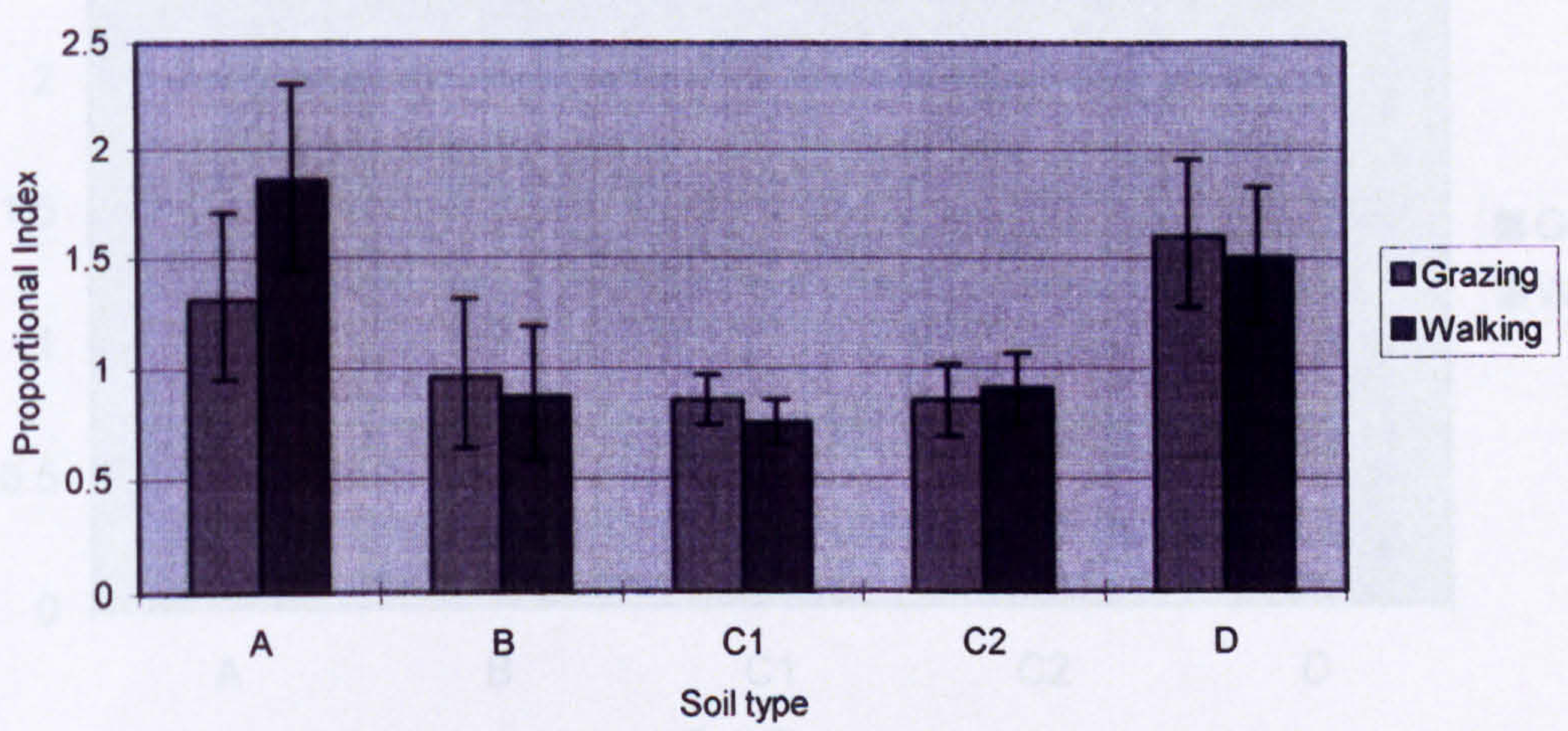


Fig. 6.25b Utilisation Index of Five-Class Soil Types

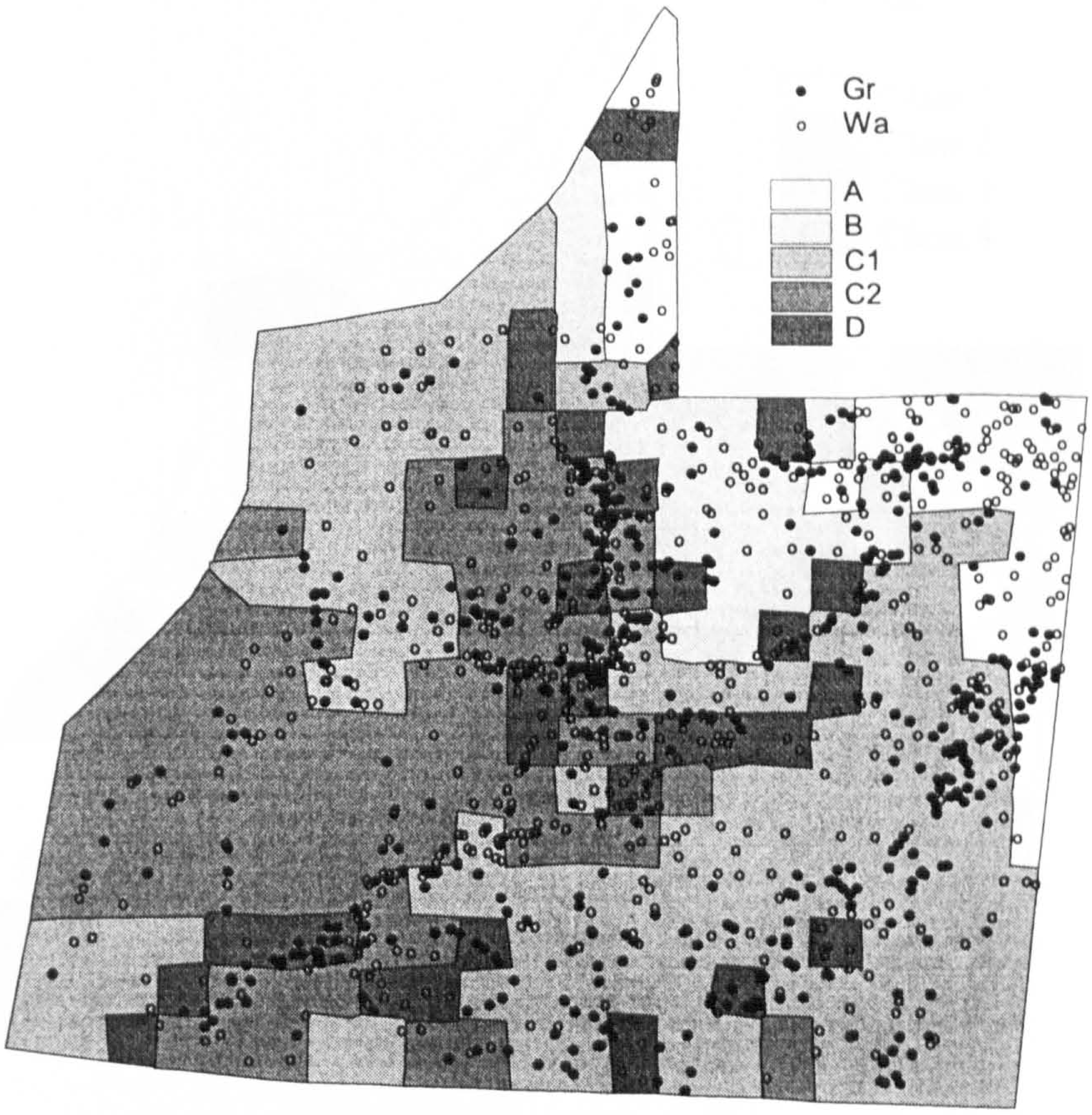


Fig. 6.26a Utilisation of Five-Class Assign Proximity Soil Types, with Rhino Grazing and Walking Locations

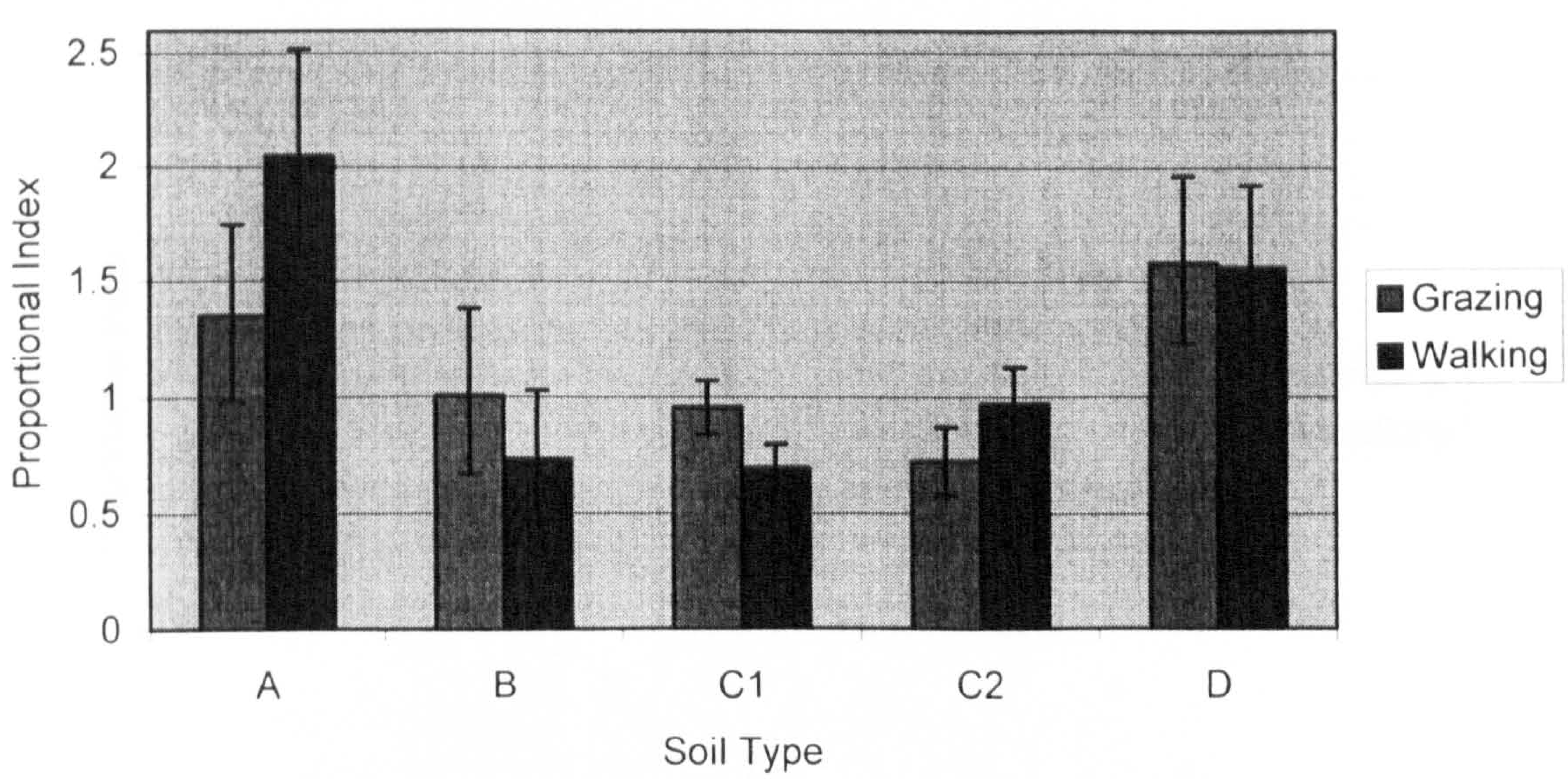


Fig. 6.26b Utilisation Index of Five-Class Assign Proximity Soil Types

Fig. 6.27a Utilisation of Four-Class Tree Classification, with Rhino Grazing and Walking Locations

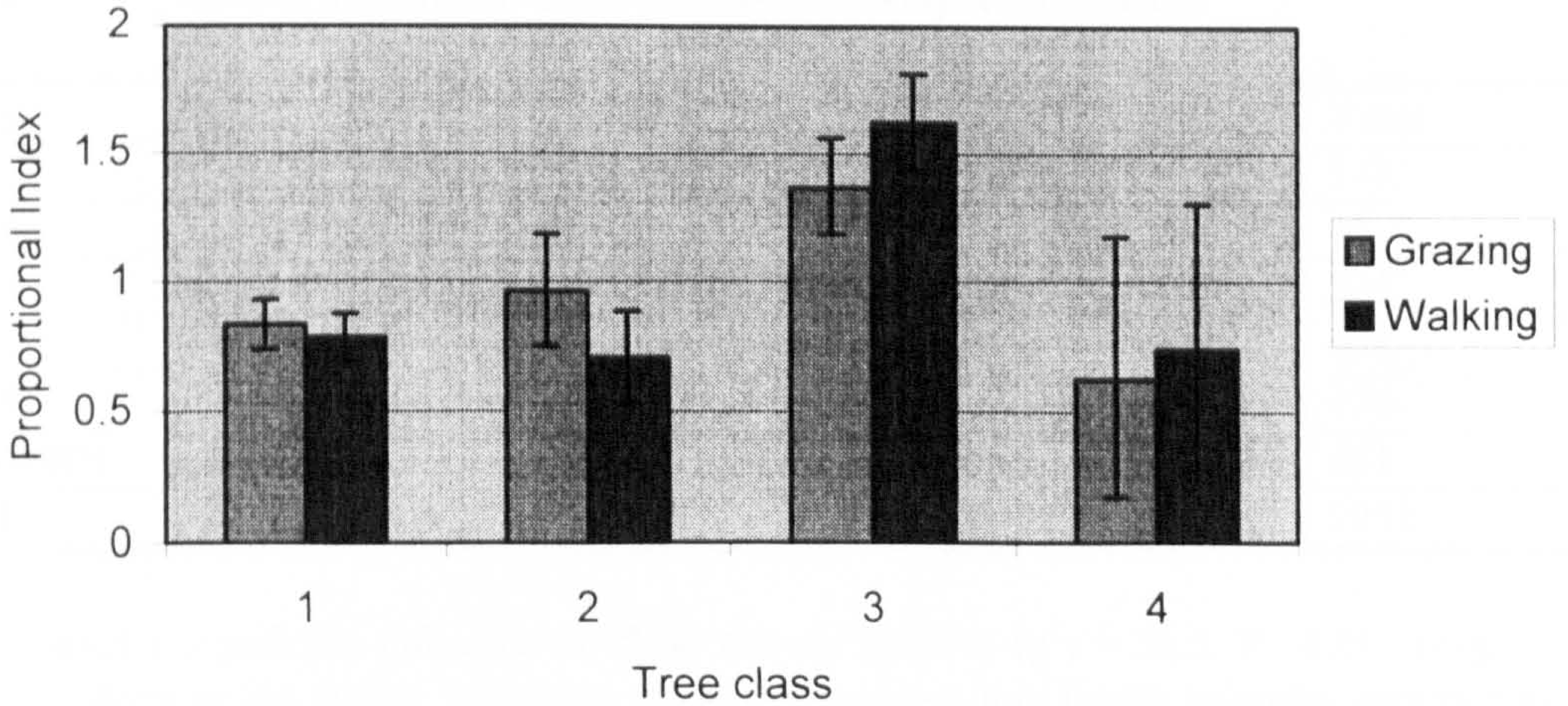


Fig. 6.27b Utilisation Index of Four-Class Tree Classification System

b). **Detailed map** - (Fig. 6.28a, Fig. 6.28b and App. VII, Fig 28). This indicated increased grazing utilisation in riverine areas and many walking observations around water holes were apparent, however there were no significant variations in utilisation of different tree classes.

ii) Tree cover

Low and medium tree cover classes appeared not to influence rhino utilisation (Fig. 6.29a, Fig. 6.29b and App. VII, Fig 29). Therefore, tree cover in Kaross never became sufficiently dense to the point where rhinos avoided an area. Utilisation of very low tree cover was high. Extra low tree cover was represented by too few observations to enable any conclusions to be drawn.

iii) Tree species

Rhino utilisation analysis indicated the following associations with tree species:

a) Rhino movements were generally more common in areas where ***Mopane*** **trees** and **shrubs** were absent (Fig. 6.30a, Fig. 6.30b and App. VII, Fig 30).

b) The presence of ***Acacia*** **species** was apparently characteristic of areas preferred by rhinos, although these areas were not necessarily utilised for grazing (Fig. 6.31a, Fig. 6.31b and App. VII, Fig 31).

c) The presence or absence of ***Combretum*** **species** was not associated with any parameter relating to rhino utilisation (Fig. 6.32a, Fig. 6.32b and App. VII, Fig 32).

d) ***Terminalia*** **species** were possibly marginally associated with habitats which rhinos preferred to use (Fig. 6.33a, Fig. 6.33b and App. VII, Fig 33).

6.3.2 Analysis of Activity with Respect to Season

The total number of observations for each activity with respect to the seasons specified are described in Table 6.4. These results are the sum of direct observations and tracker guided data and were calculated from all observations where the GPS positions fell within the boundaries of Kaross. It is not possible to allocate times to specific activities since tracking speed varied and was totally unrelated to the speed of rhino movements.

Table 6.4 Number of Activity Observations with Respect to Season.

Activity	Jan - April	May - Aug	Sept – Dec	Total
GR	227	243	46	516
GR/WA	30	13	5	48
WA/GR	82	101	38	221
WA	138	382	81	601
OTHER	49	90	37	176
UNKNOWN	136	299	56	491
TOTAL	662	1128	263	2053

Seasons exerted a significant influence on rhino activity patterns (χ^2_3 = 56.5, P< 0.01). (Fig. 6.34 and Table 6.5). Because the survey technique remained constant, this figure indicates approximately the variations in time spent by the rhinos, undertaking each activity in each season. During the January to April season more of the rhinos' time was spent grazing, and less was spent walking than at other times of

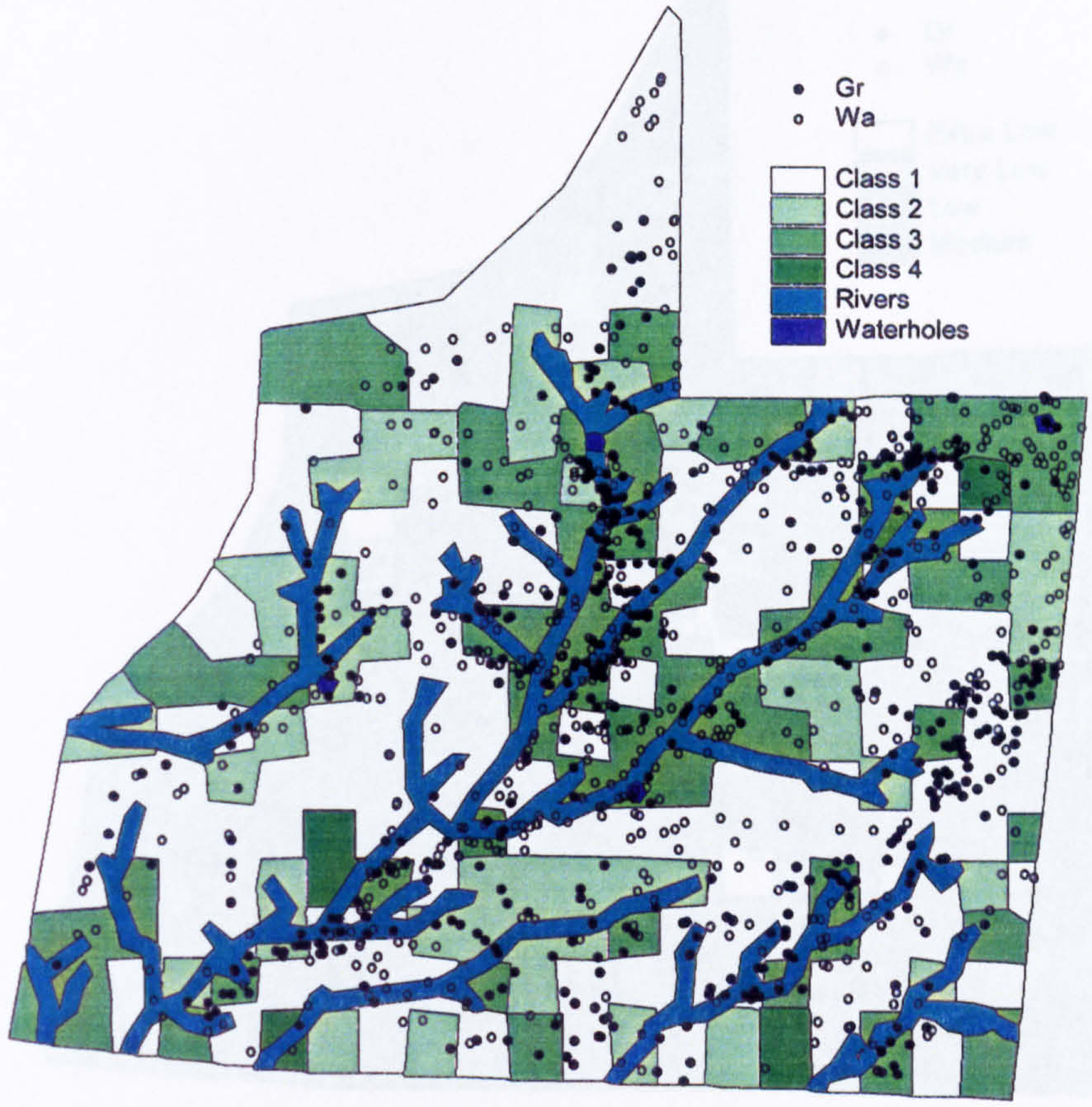


Fig. 6.28a Utilisation of Detailed Four-Class Tree Classification, with Rhino Grazing and Walking Locations

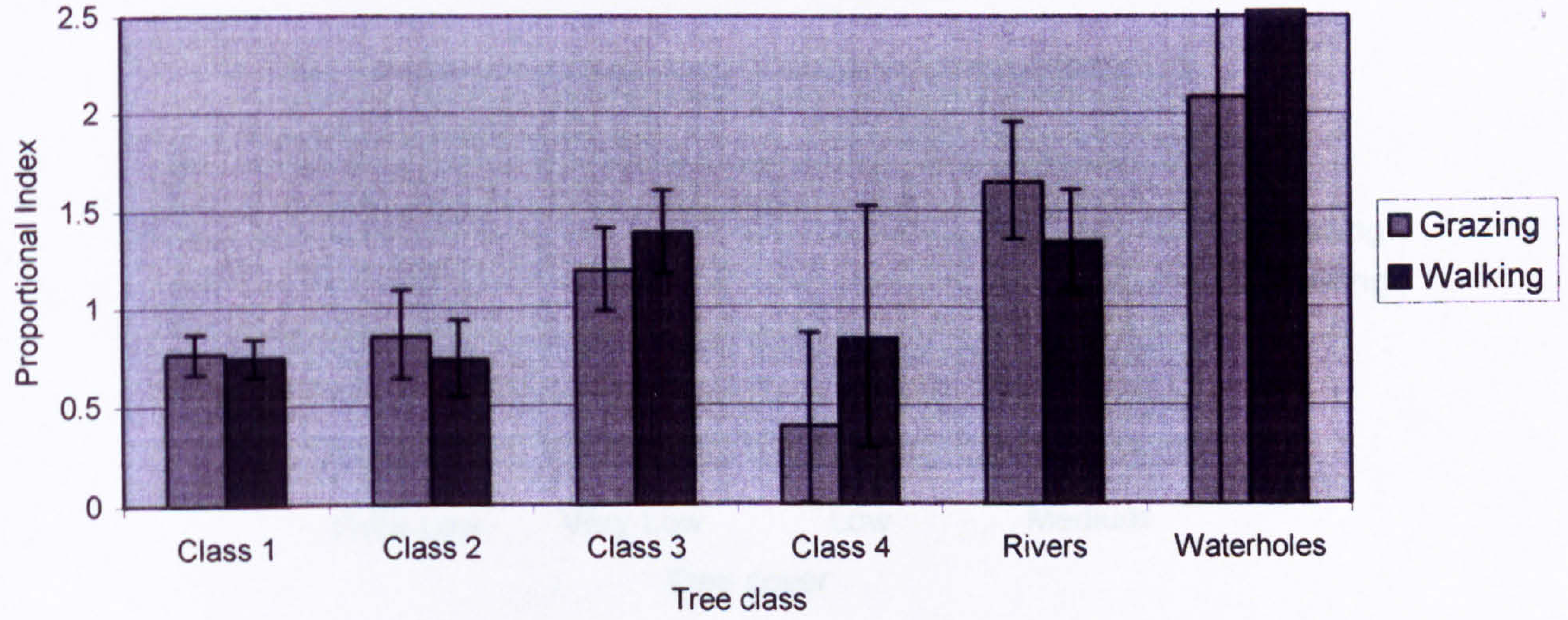


Fig. 6.28b Utilisation Index of Detailed Four-Class Tree Classification

Fig. 6.29a Utilisation of Tree Cover Classes, with Rhino Grazing and Walking Locations

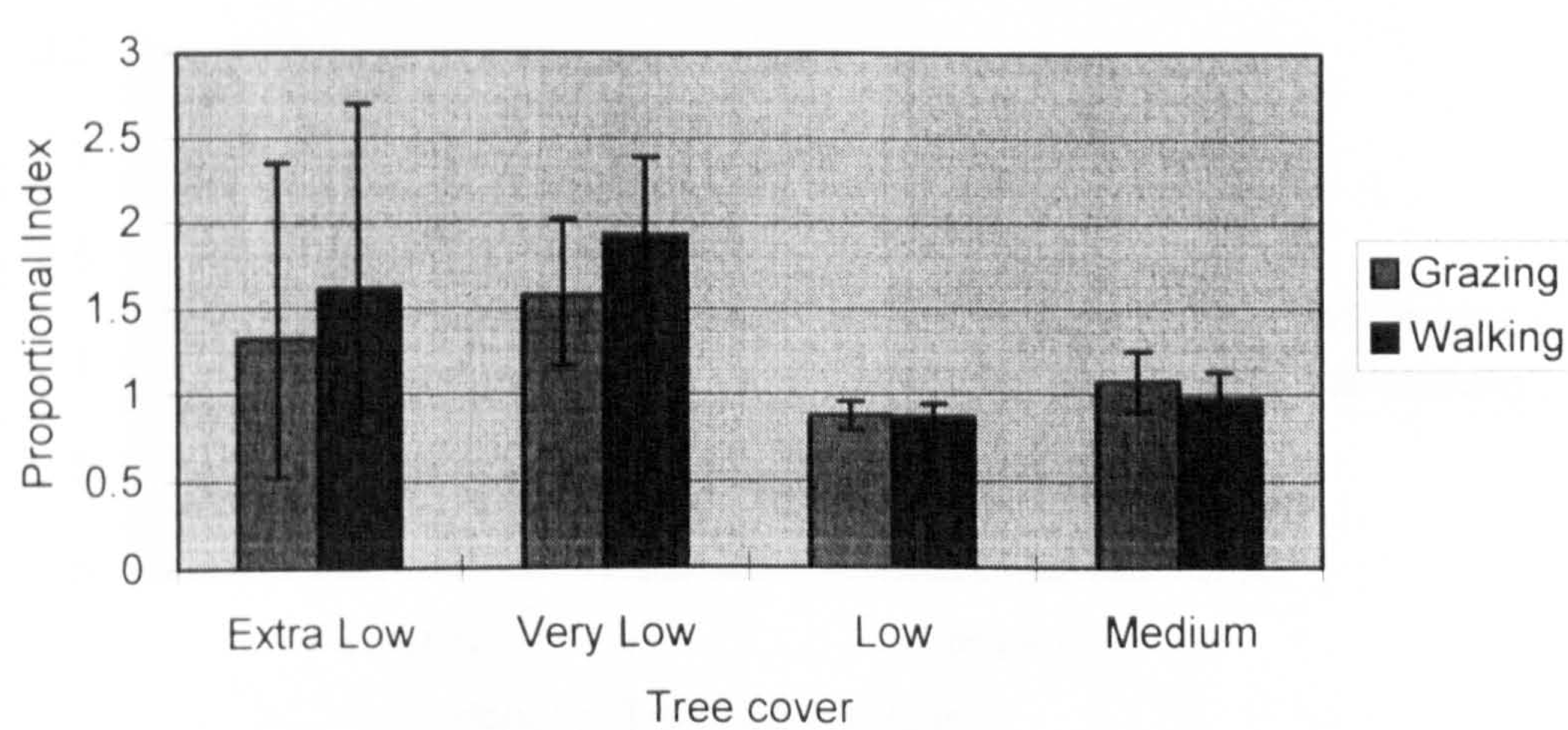


Fig. 6.29b Utilisation Index of Tree Cover Classes

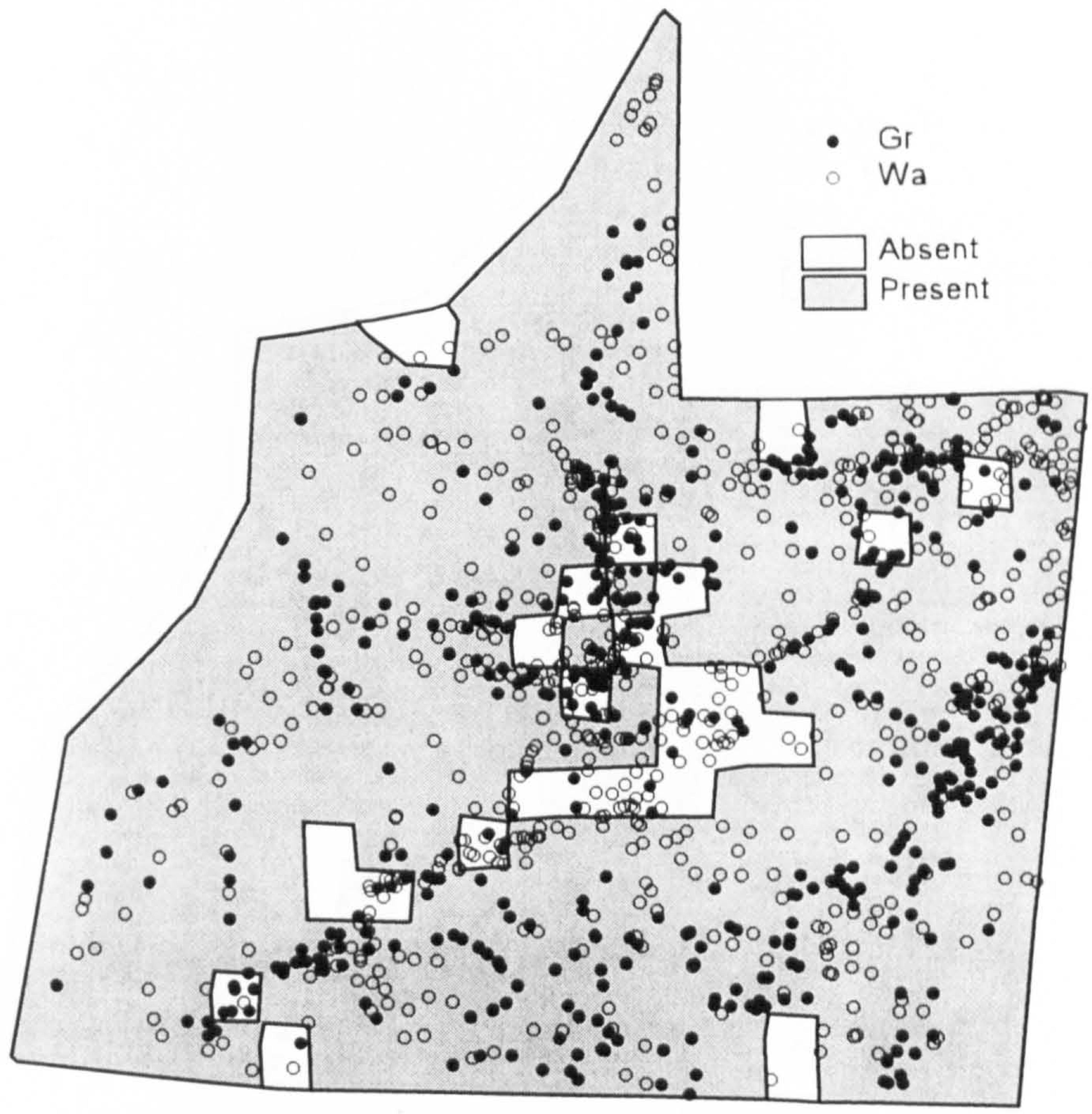


Fig. 6.30a Utilisation of *Mopane* Trees and Shrubs, with Rhino Grazing and Walking Locations

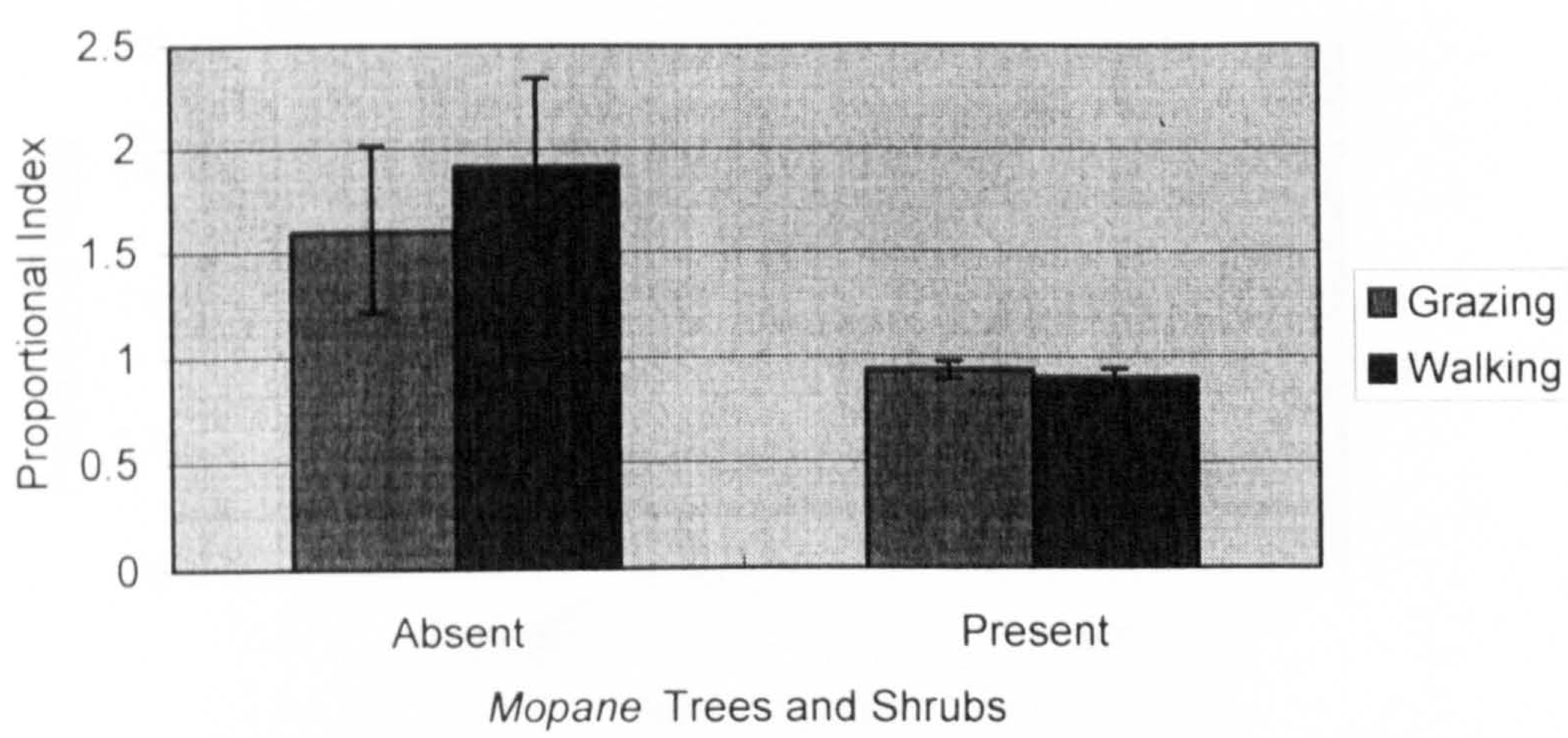


Fig. 6.30b Utilisation Index of Areas with *Mopane* Trees and Shrubs

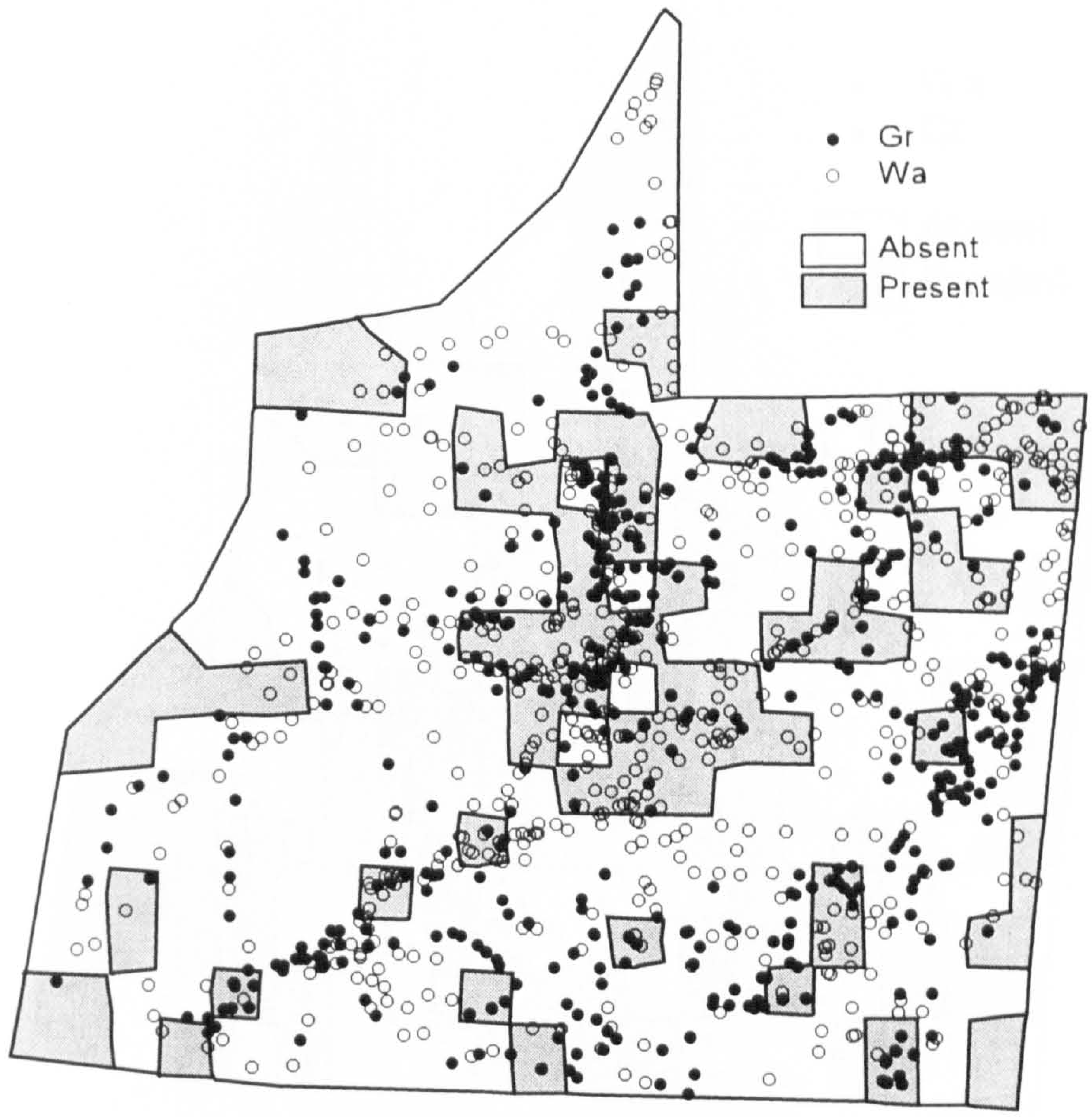


Fig. 6.31a Utilisation of *Acacia* Species, with Rhino Grazing and Walking Locations

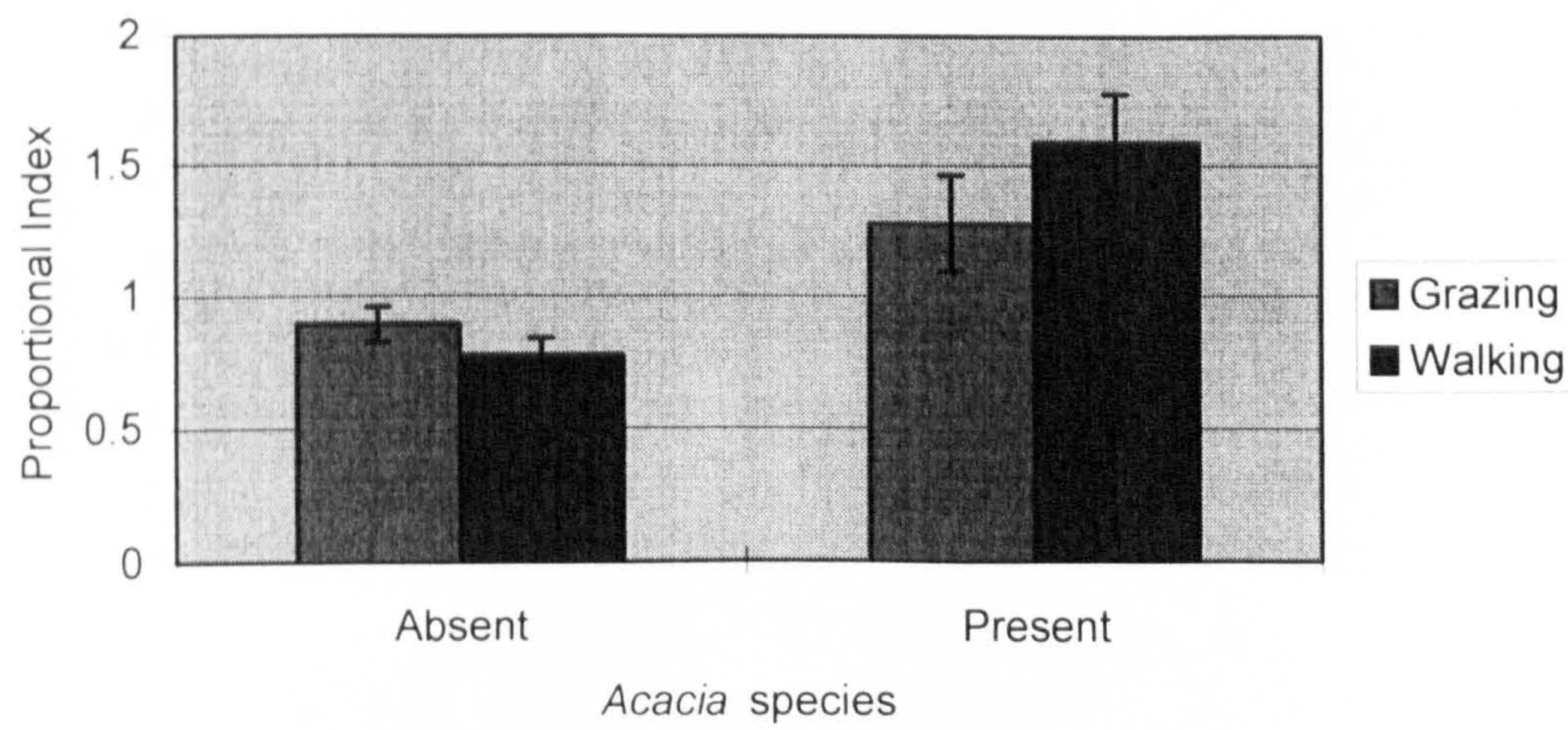


Fig. 6.31b Utilisation Index of Areas with *Acacia* Species

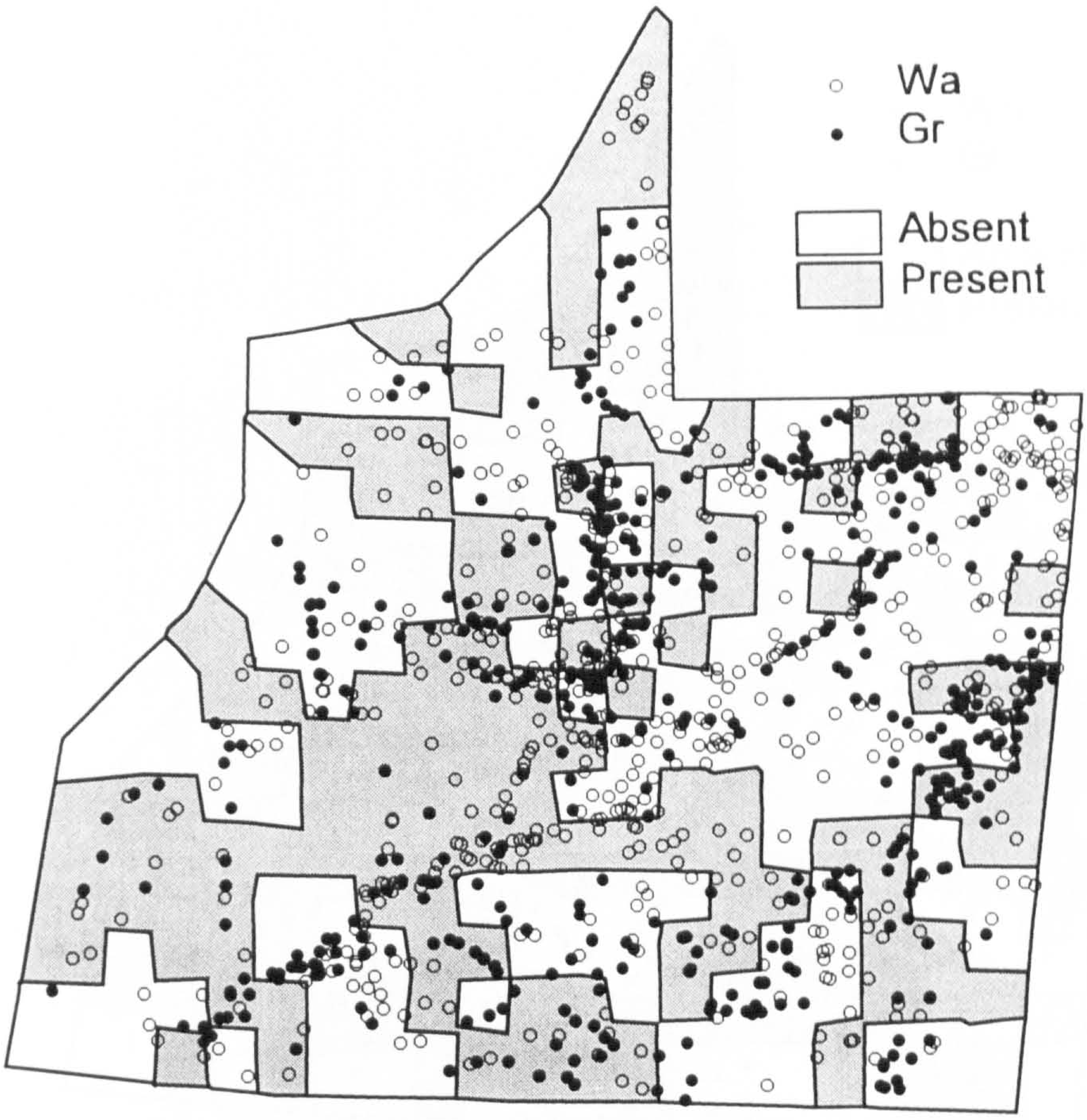


Fig. 6.32a Utilisation of *Combretum* Species, with Rhino Grazing and Walking Locations

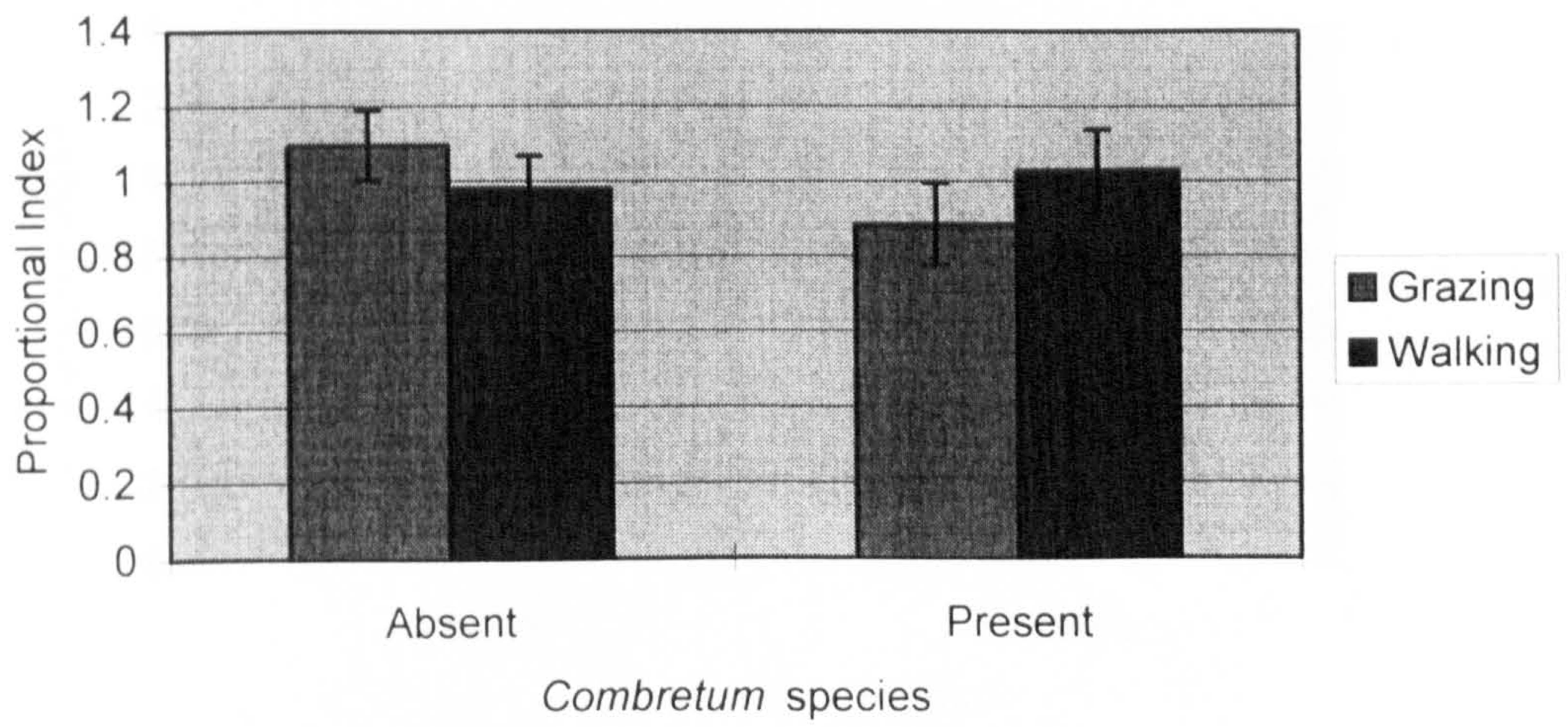


Fig. 6.32b Utilisation Index of Areas with *Combretum* Species

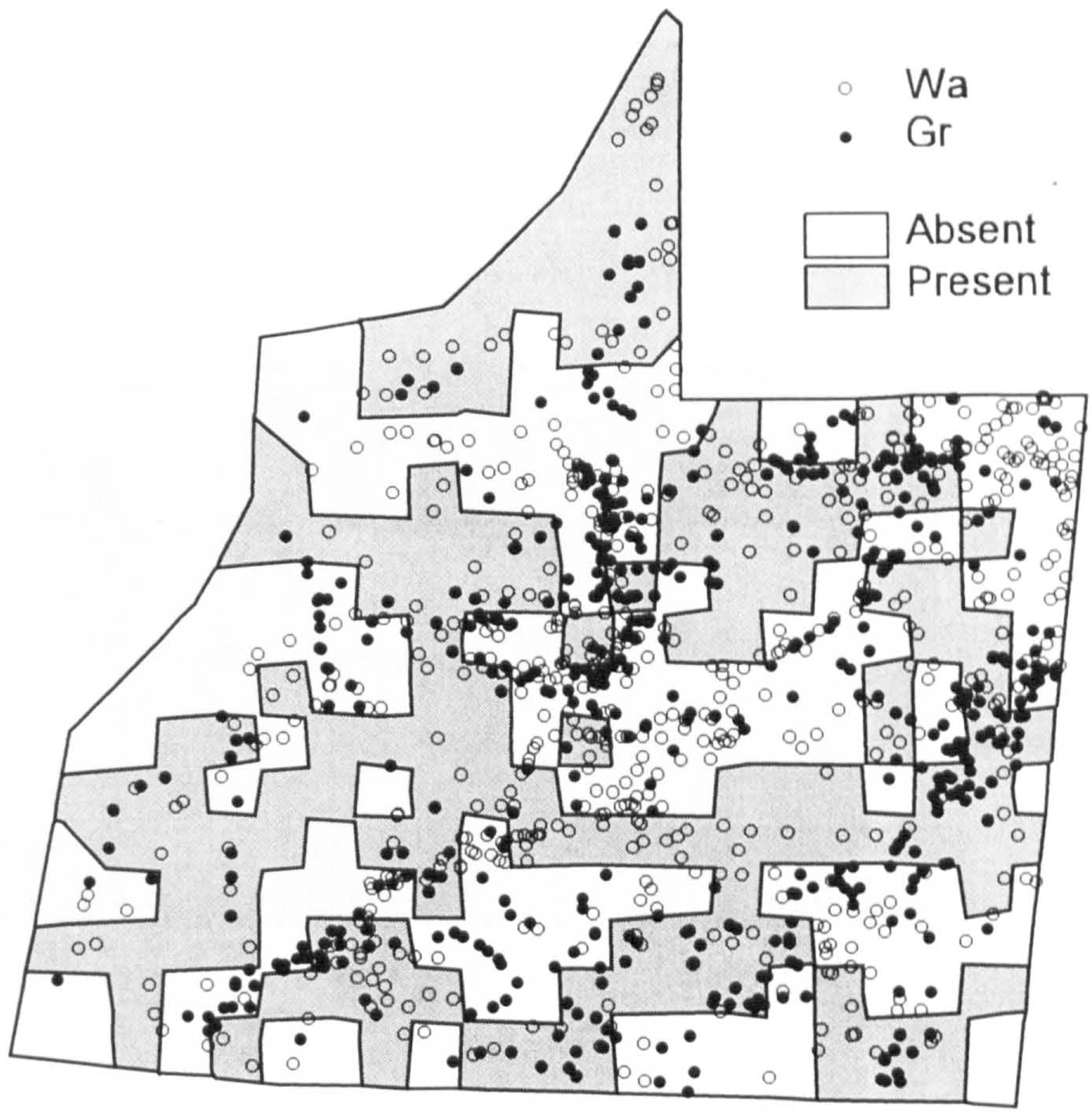


Fig. 6.33a Utilisation of *Terminalia* Species, with Rhino Grazing and Walking Locations

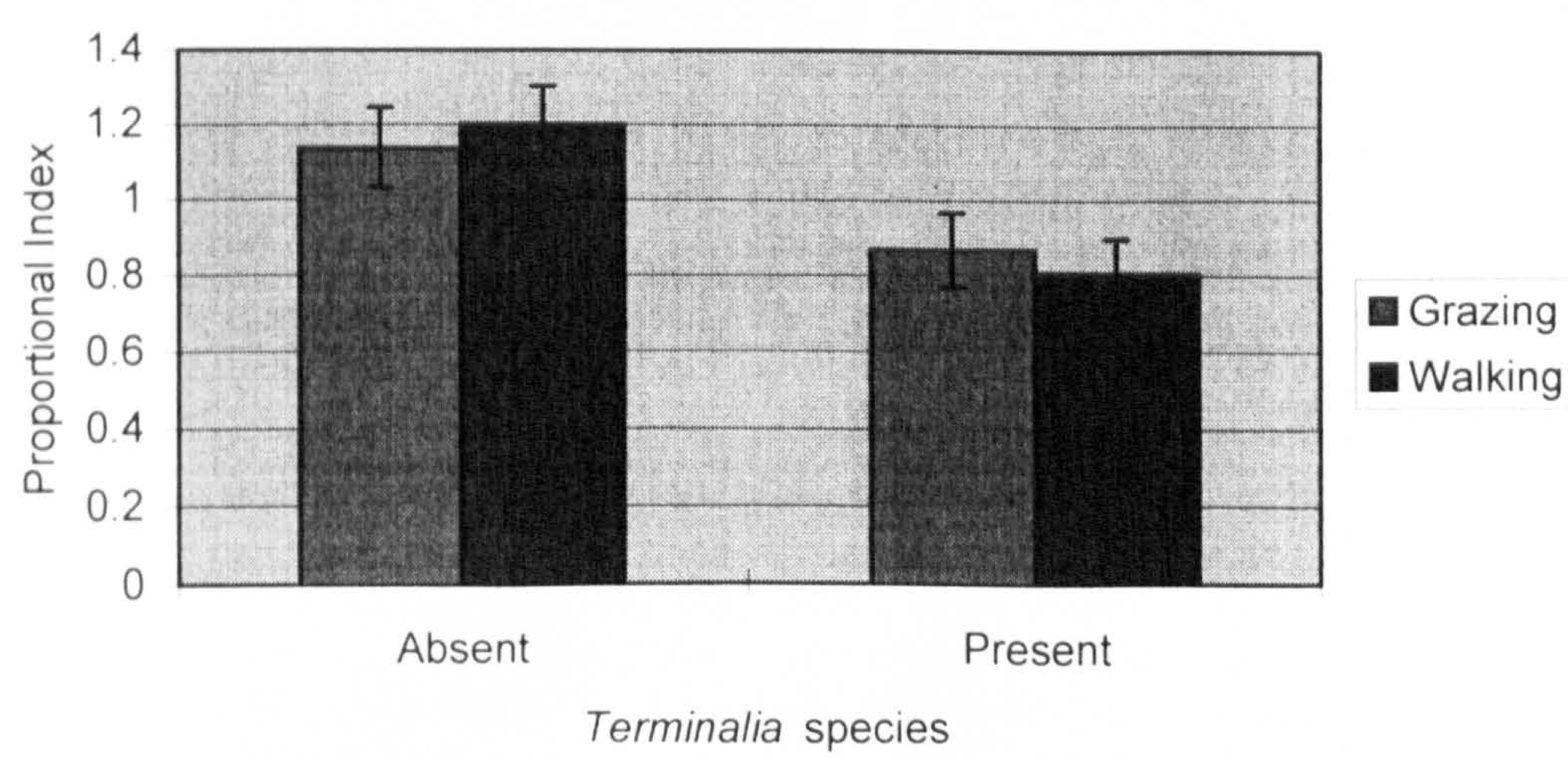


Fig. 6.33b Utilisation Index of Areas with *Terminalia* Species

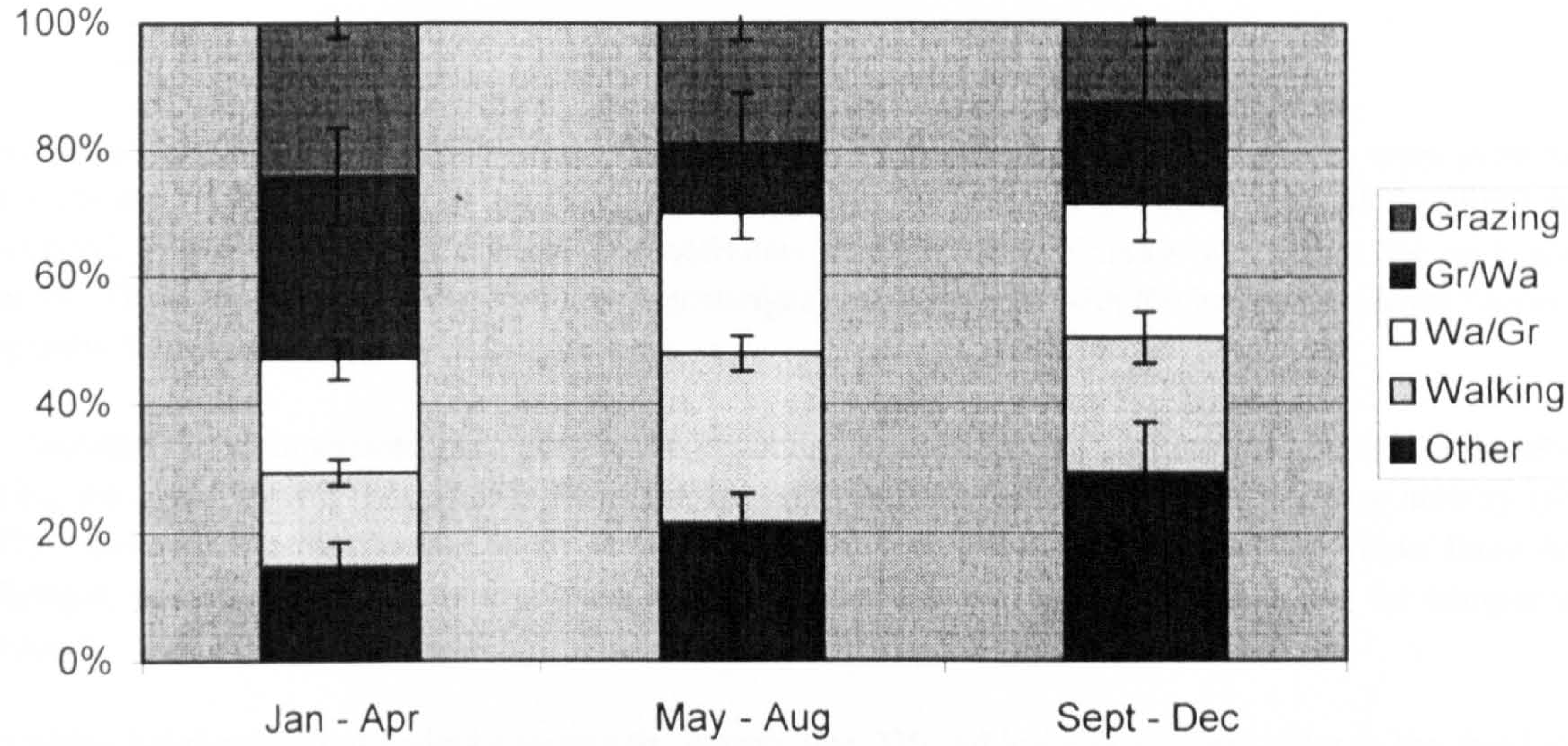


Fig. 6.34 Influence of Season on Rhino Activity

Table 6.5 Influence of Activity on Season Identified by Chi Square Analysis

Influence of Activity on Season	d.f.	Test Result	Significance
	3	56.50	**

the year. This may be because from May to December, rhinos regularly visited the water holes and they often had to walk considerable distances to reach them. Also the technique used to locate fresh spoor varied because fresh spoor could not be located at water holes. There appeared to be a decrease in grazing and an increase in 'other' activities during the September to December period, however fewer observations during this time increased the level of error.

6.3.3 Analysis of Activity with Respect to Herbaceous Layer

i) All Species

Observations of rhino activity with respect to grass species and biomass in the focal area were extracted. For each record, the quantity or biomass of each species of grass in the focal area of the rhino was calculated. Results were then divided into activities and the mean biomass was found for each grass species. These values were converted into percentages and compared with the herbaceous layer survey in Appendix VII, Table1.

To illustrate this comparison, pie charts were produced to indicate the herbaceous species composition during the grass survey (Fig. 6.35), rhino grazing activity (Fig. 6.36) and rhino walking activity (Fig. 6.37). Because the herbaceous layer survey technique was different to that of the rhino focal area technique, no statistical tests were applied to the data and these graphs were only used for comparison purposes.

Schmidtia kalahariensis abundance during the survey was 31% which was similar to that in the focal area during walking observations (28%). However its abundance in the focal area of the rhino during grazing was higher at 42%. Grazing therefore appeared to be favouring areas with high *Schmidtia kalahariensis* abundance. *Stipagrostis uniplumis* formed approximately 27% of the herbaceous species in Kaross. Its abundance was lower (17%) during rhino grazing observations and higher (36%) during walking records. Therefore rhinos appear to avoid these areas for grazing but their overall utilisation patterns result in this species being regularly encountered. *Eragrostis nindensis* was recorded more frequently during the habitat survey than during either activity observations, indicating that areas with this grass species are apparently avoided. *Eragrostis porosa* was slightly less abundant during the survey than during either activity observations. There was a difference between the survey and walking observations, possibly indicating that areas with this grass species were typical of areas preferred for utilisation although this species itself was not selected for grazing. The abundance of *Aristida adscensionis* was greater during the habitat survey than either activity observation, indicating that areas with this species were generally avoided.

ii) Individual Species

Analysis was completed on the six most common species; *Schmidtia kalahariensis*, *Stipagrostis uniplumis*, *Eragrostis porosa*, *Eragrostis nindensis*, Annuals and *Cenchrus ciliaris*. In addition, *Aristida adscensionis* was analysed to discover whether this spiky, unpleasant grass was specifically avoided by grazing rhinos.

Graphs of the mean biomass of each species in the focal area with respect to activity and season provide indications of trends. 95% confidence limits have been applied to all these graphs, which are influenced by the number of observations in each category and the standard deviation of the values. Often the confidence intervals are wide which reflects the quantity of data collected in each activity or season category (see Table 6.4 in Section 6.3.2). For example, results for December have a large margin of error due to the low sampling frequency over this period.

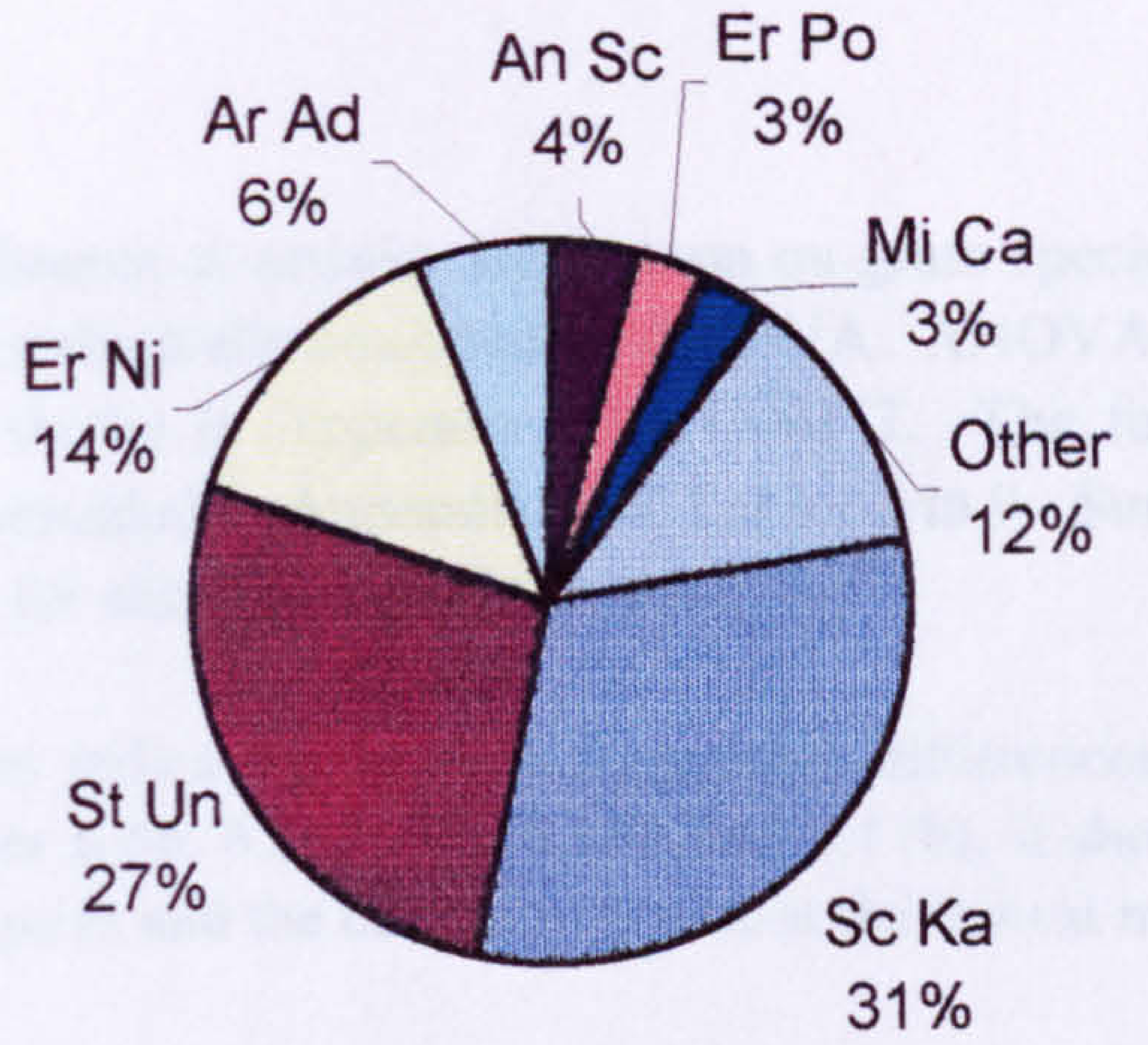


Fig. 6.35 Herbaceous Species Occurrence in Kaross Indicated by Habitat Survey
(According to percentage occurrence)

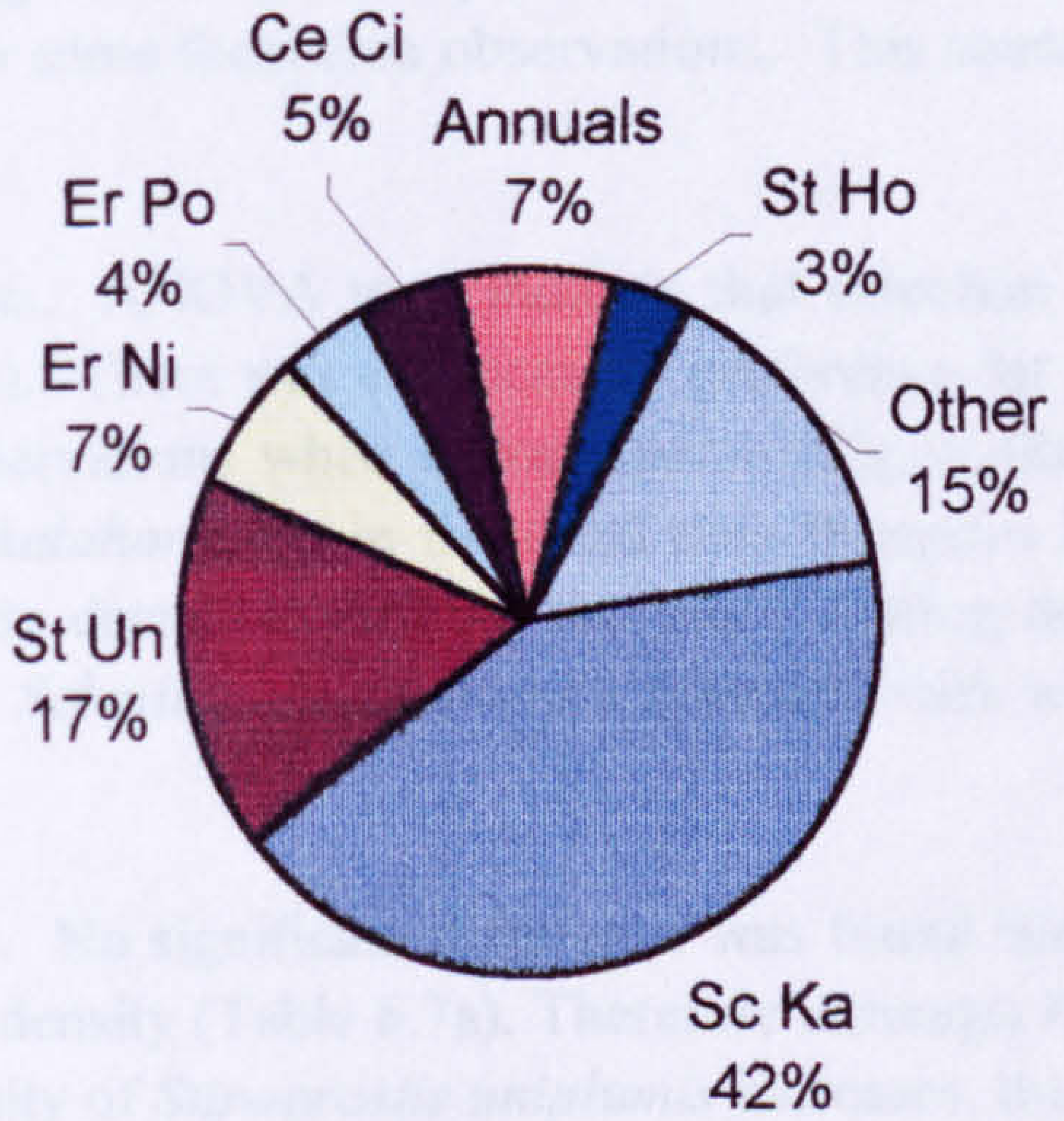


Fig. 6.36 Herbaceous Species in Focal Area During Grazing Observations
(According to average biomass)

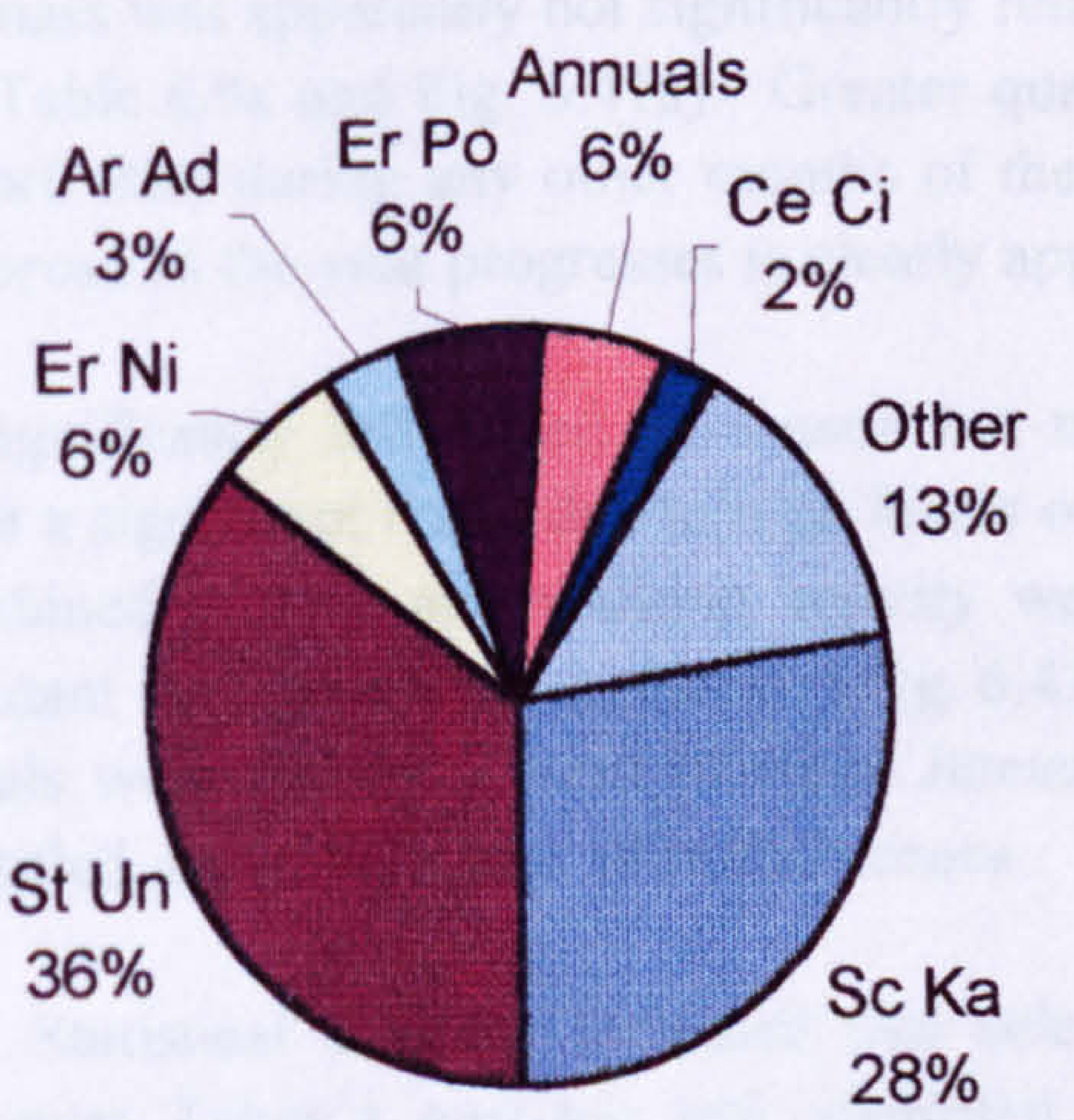


Fig. 6.37 Herbaceous Species in Focal Area During Walking Observations
(According to average biomass)

To indicate when the influence of activity and season on grass species composition in the focal area was significant, records were statistically analysed by ANOVA. ANOVA classes or numbers assigned to each activity and season are shown in Appendix VII, Table 2. The full ANOVA analysis for each grass species from SPSS, are provided in Appendix VII, Tables 3 to 9. Summaries of these results are included as tables after the graphs for each individual species.

With respect to the tables indicating detailed significant differences identified by ANOVA analysis for each grass species (Tables 6.6b, 6.8b, 6.9b, 6.10b and 6.11b), it should be noted that rows represent the highest mean biomass figures and the columns represent the lowest mean biomass figures.

Results from all analyses indicated that the variances of the samples were not homogeneous, which was tested by Levene's test. Log transformations of the data were carried out, however Levene's test continued to indicate that homogeneity had not been achieved. On the basis that ANOVA is to a certain extent tolerant to departures from homogeneity of variance and non-normality (Dr. J. Thompson, Dept. of Mathematics, University of Hull, *pers. comm.*), ANOVA continued to be used, since the outcome of the *post-hoc* tests were essential for this analysis. In addition, the data were known not to be homogenous since the biomass ratings had created steps in the data and there was an abundance of zeros due to the absence of species from some focal area observations. This source of error was recognised and remained consistent throughout.

Schmidtia kalahariensis. ANOVA tests indicate that selection of this species was affected by activity and season (Table 6.6a). There was a noticeable preference for grazing when this species was plentiful and fewer walking observations when it was sparse (Fig. 6.38a). Fig. 6.38b illustrates that the mean biomass of *Schmidtia kalahariensis* in the focal area increases in January and February after the rainy season, but subsequently decreases through the year. During the first two seasons of the year, grazing was related to a higher *Schmidtia kalahariensis* biomass, with walking relating to lower biomass groups (Table 6.6b).

Stipagrostis uniplumis. No significant difference was found between activities and season with varying *Stipagrostis uniplumis* density (Table 6.7a). Therefore although Fig. 6.39a indicates slightly greater levels of walking as the quantity of *Stipagrostis uniplumis* increases, this trend was not statistically significant.

Eragrostis nindensis. This species was influenced by different seasons, while activity had no influence (Table 6.8a and Fig. 6.40a). ANOVA indicates that between September to December and also January to April, grazing activities were characterised by higher biomass of *Eragrostis nindensis* than other activities from September to December (Tables 6.8b). However Fig. 6.40b does not apparently confirm this trend.

Eragrostis porosa. Biomass was apparently not significantly related to activity, whereas season did exert a significant influence (Table 6.9a and Fig. 6.41a). Greater quantities of *Eragrostis porosa* were found between January and April than during any other months of the year (Table 6.9b). The decrease in the quantity of *Eragrostis porosa* as the year progresses is clearly apparent in Fig. 6.41b.

Annual species were significantly influenced by season but not apparently related to activity (Table 6.10a&b). Although not a significant result due to high levels of potential error, Fig. 6.42a indicates that no observations of combined grazing and walking activity were recorded. During January to April, annuals were more abundant than during other seasons (Fig. 6.42b and Table 6.10b). These results could be expected since annuals were mainly present between January and April as they were grass species which could not be identified due to their lack of inflorescence.

Aristida adscensionis. Statistical analysis indicated that selection was not significantly affected by activity or season, however Tukey's *post-hoc* test identified some differences (Table 6.11a&b). It appeared that between January and April combined grazing and walking was the main activity while both grazing and walking were less frequently recorded at that time of the year (Table 6.11b). However, it was difficult to identify any consistent trends in either activity or season (Fig. 6.43a&b) because this species was infrequently encountered.

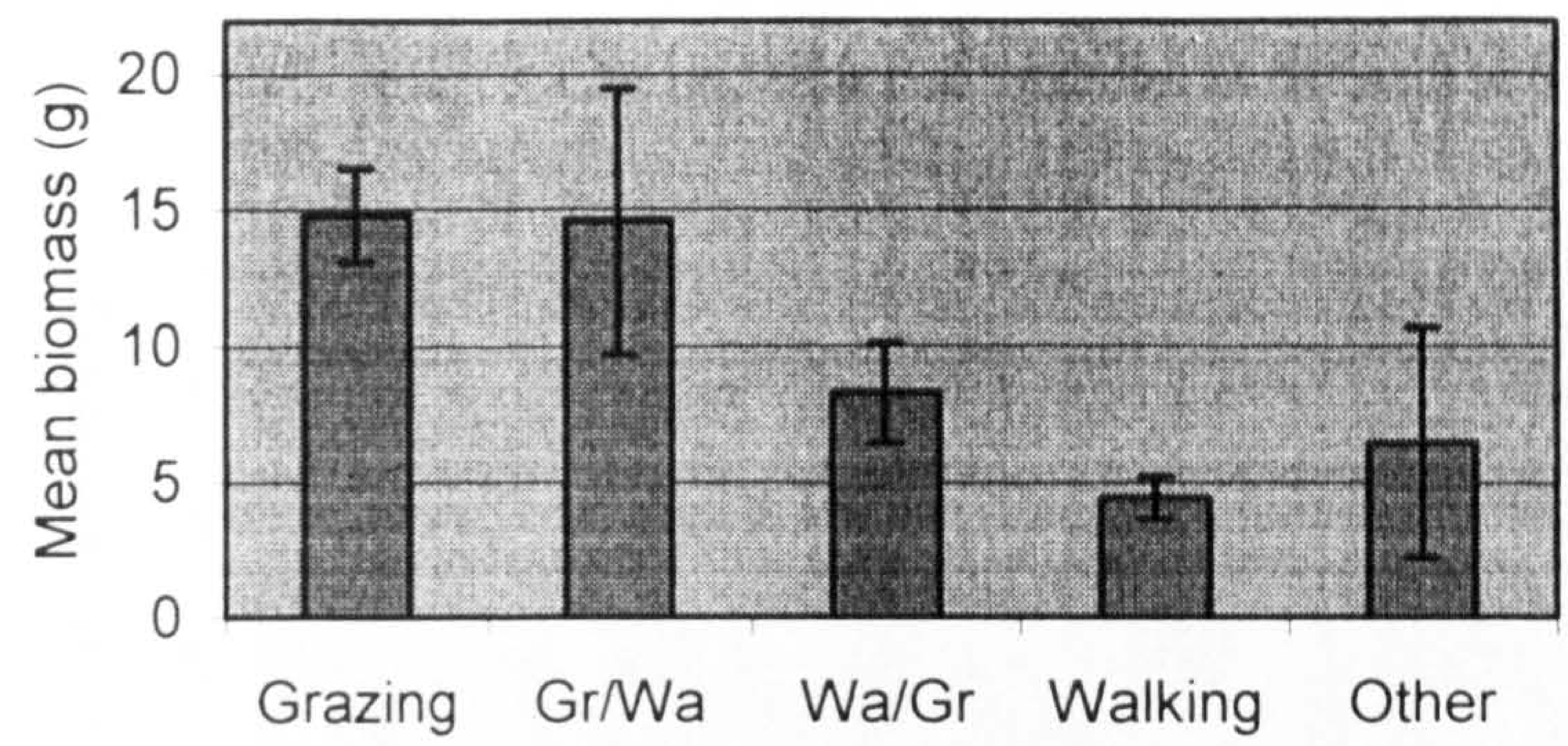


Fig. 6.38a Influence of *Schmidtia kalahariensis* Biomass in the Focal Area of the Rhino on Activity

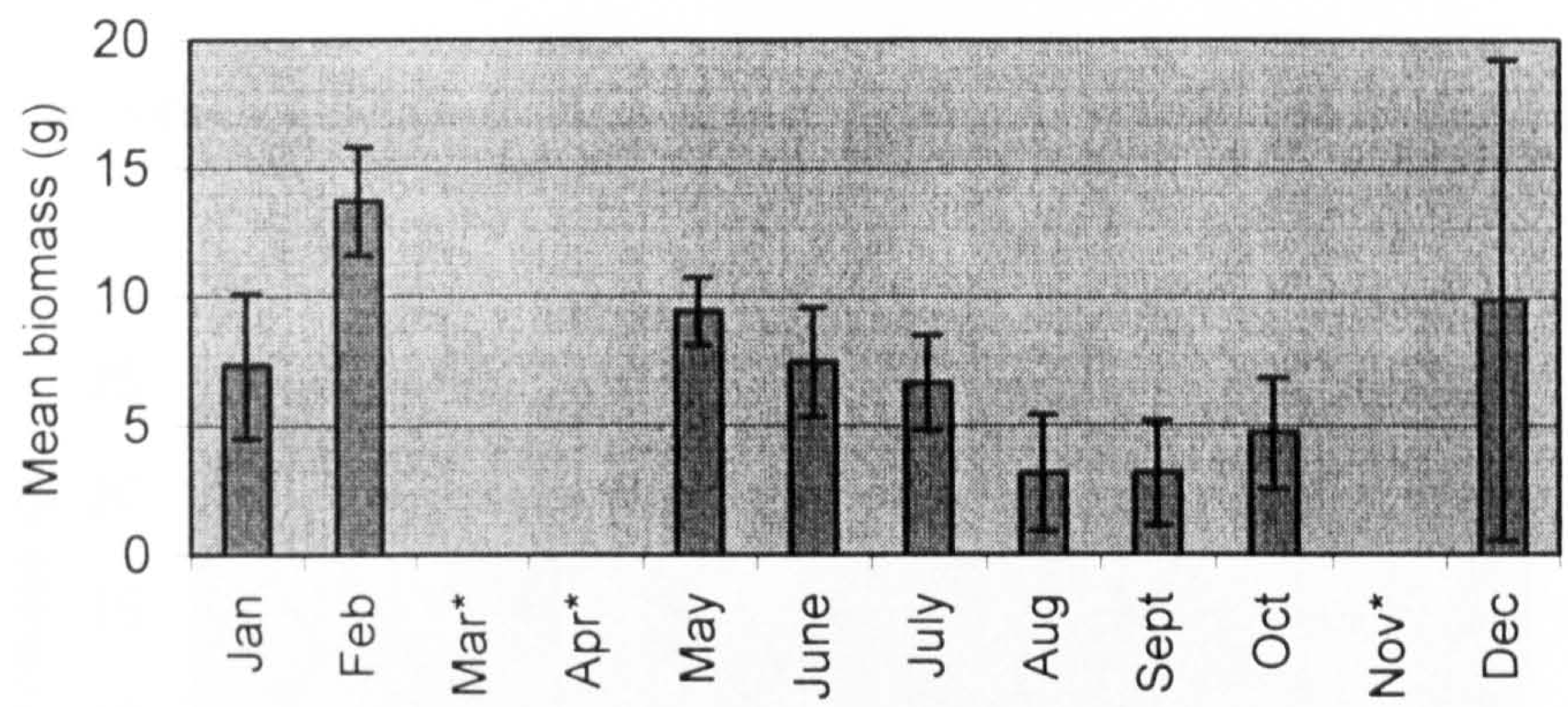


Fig. 6.38b Influence of Season on *Schmidtia kalahariensis* Biomass in the Focal Area of the Rhino

* No data for these months.

Table 6.6a Factors Significantly Associated with *Schmidtia kalahariensis*

F-Test Analysis	Significance of Result
Activity	**
Season	**

NS Not significant.
* P<0.05, significant.
** P<0.01, highly significant.

Table 6.6b Summary of ANOVA Analysis of *Schmidtia kalahariensis* with Rhino Activity and Season

Activity Season	Other Sept-Dec	Wa Sept-Dec	Wa May-Aug	Other May-Aug	Wa Jan-Apr	Wa/Gr May-Aug
Wa/Gr Jan-Apr			a			
Gr May-Aug		b	b		b	a
Gr Jan-Apr		b	b		b	a
Gr/Wa Jan-Apr	a	b	b	a	a	a

a Significant differences as indicated by Tukey.
b Significant differences as indicated by Tukey and Scheffé *post-hoc* tests.

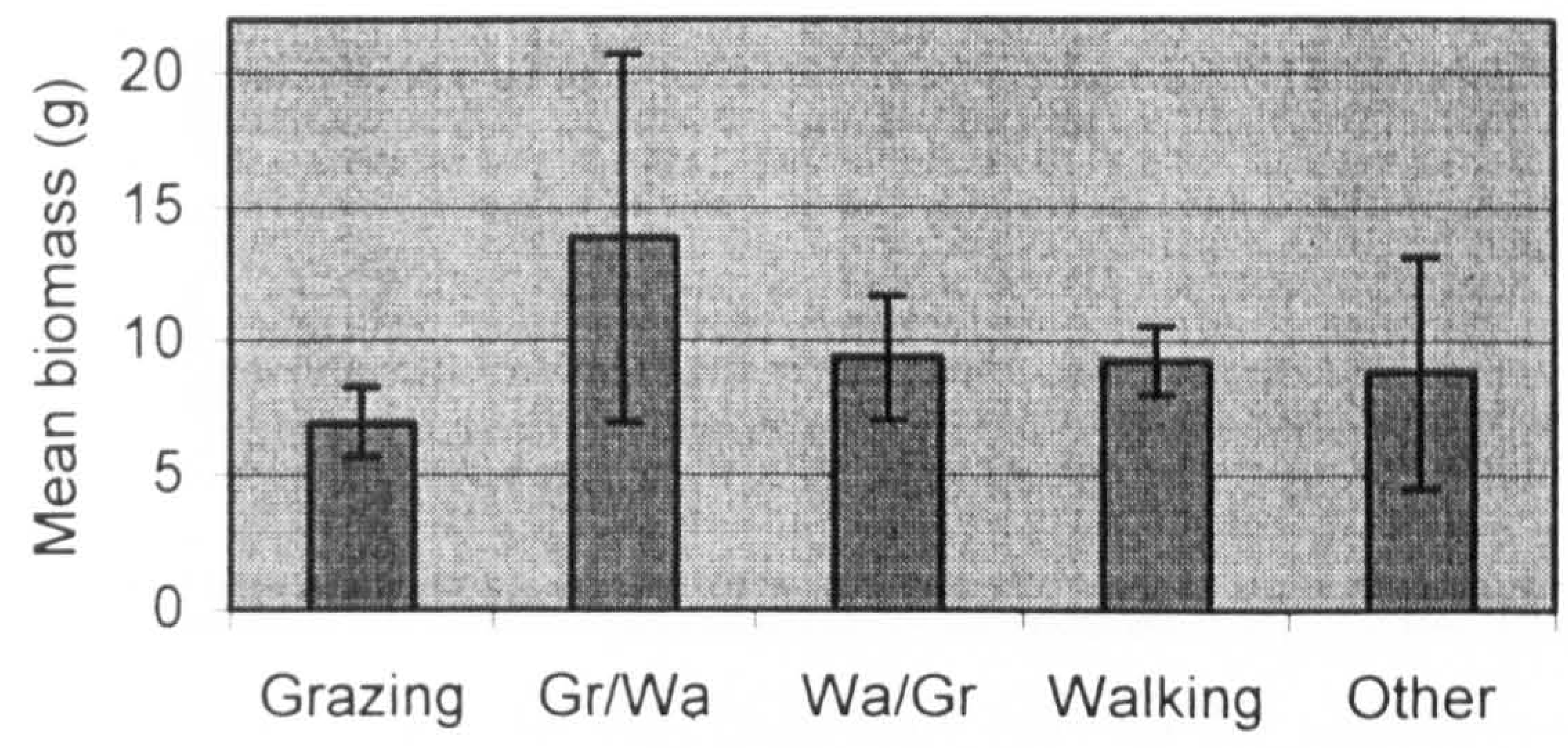


Fig. 6.39a Influence of *Stipagrostis uniplumis* Biomass in the Focal Area of the Rhino on Activity

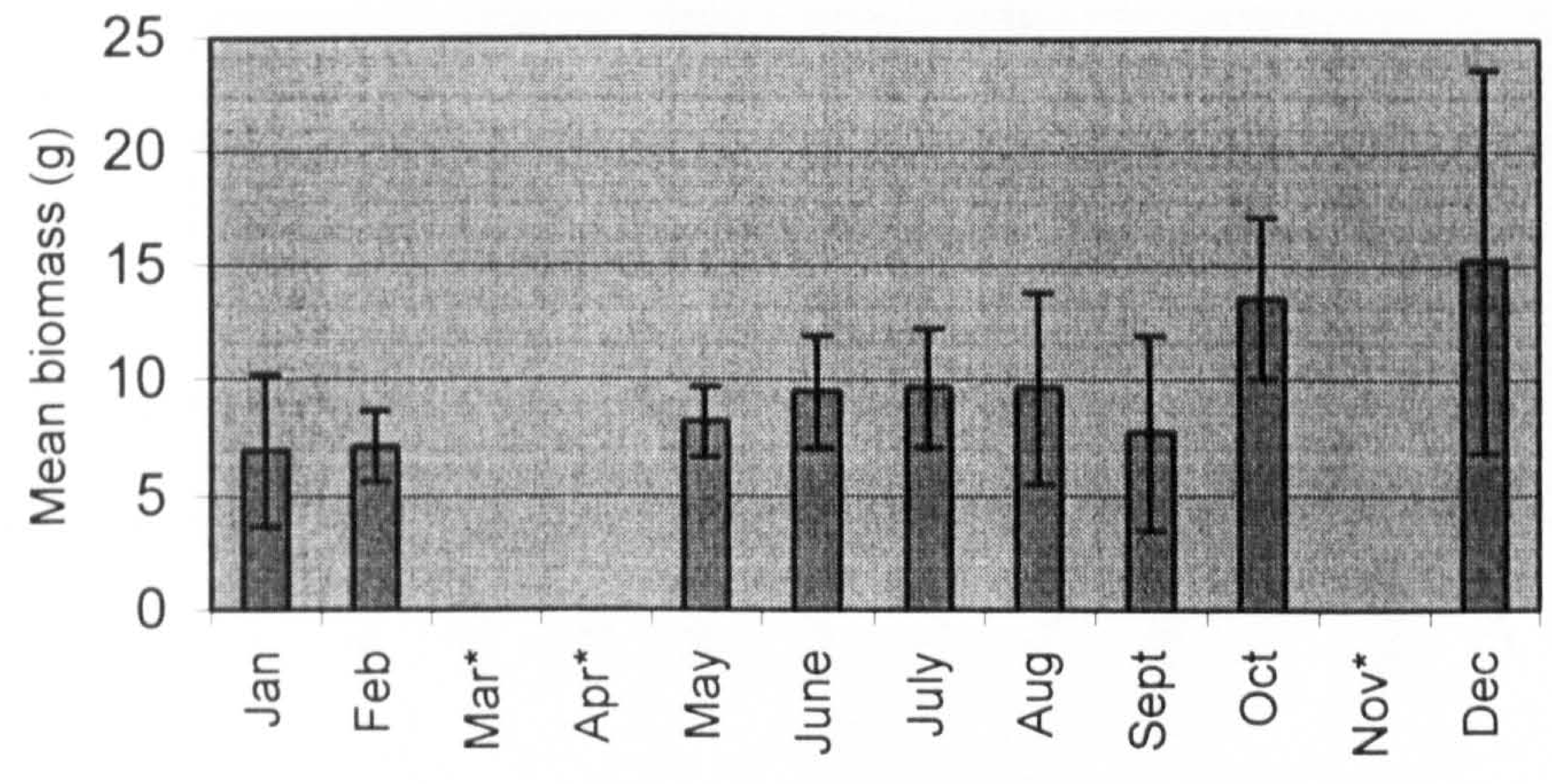


Fig. 6.39b Influence of Season on *Stipagrostis uniplumis* Biomass in the Focal Area of the Rhino

* No data for these months.

Table 6.7a Factors Significantly Associated with *Stipagrostis uniplumis*

F-Test Analysis	Significance of Result
Activity	NS
Season	NS

NS Not significant.

* P<0.05, significant.

** P<0.01, highly significant.

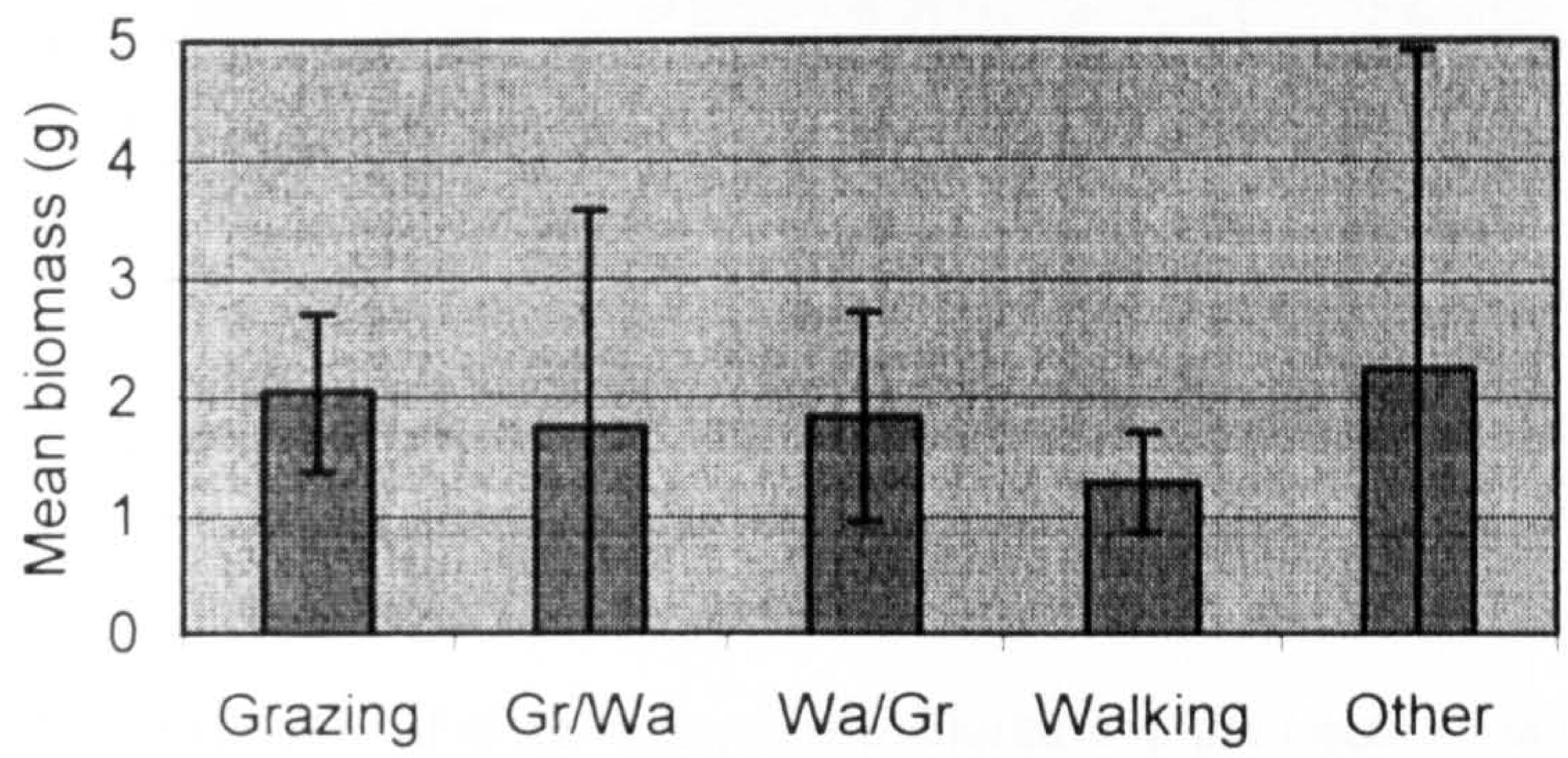


Fig. 6.40a Influence of *Eragrostis nindensis* Biomass in the Focal Area of the Rhino on Activity

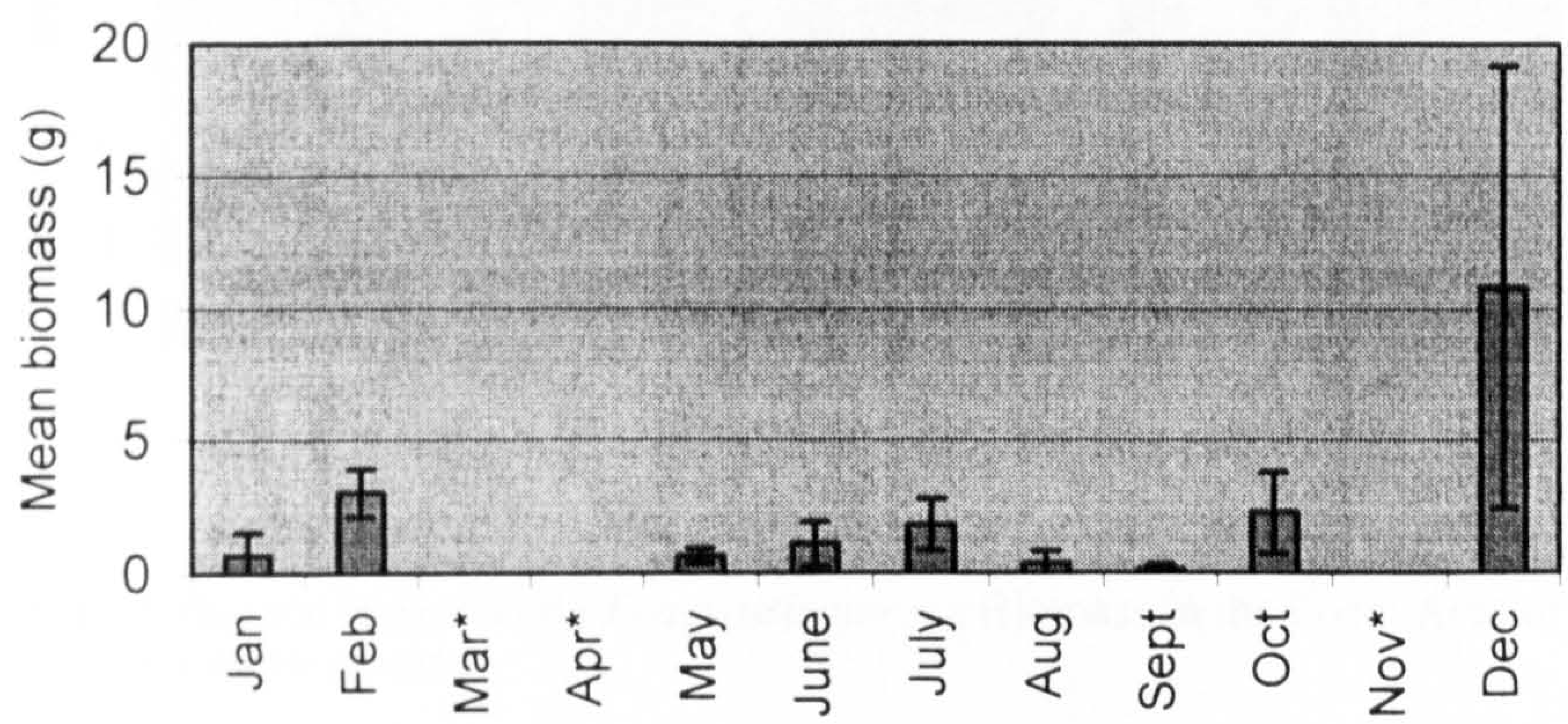


Fig. 6.40b Influence of Season on *Eragrostis nindensis* Biomass in the Focal Area of the Rhino

* No data for these months.

Table 6.8a Factors Significantly Associated with *Eragrostis nindensis*

F-Test Analysis	Significance of Result
Activity	NS
Season	*

NS Not significant.
* P<0.05, significant.
** P<0.01, highly significant.

Table 6.8b Summary of ANOVA Analysis of *Eragrostis nindensis* with Rhino Activity and Season

Activity and Season	Other Sept-Dec
Gr Jan-Apr	a
Gr Sept-Dec	a

a Significant differences as indicated by Tukey.
b Significant differences as indicated by Tukey and Scheffé *post-hoc* tests.

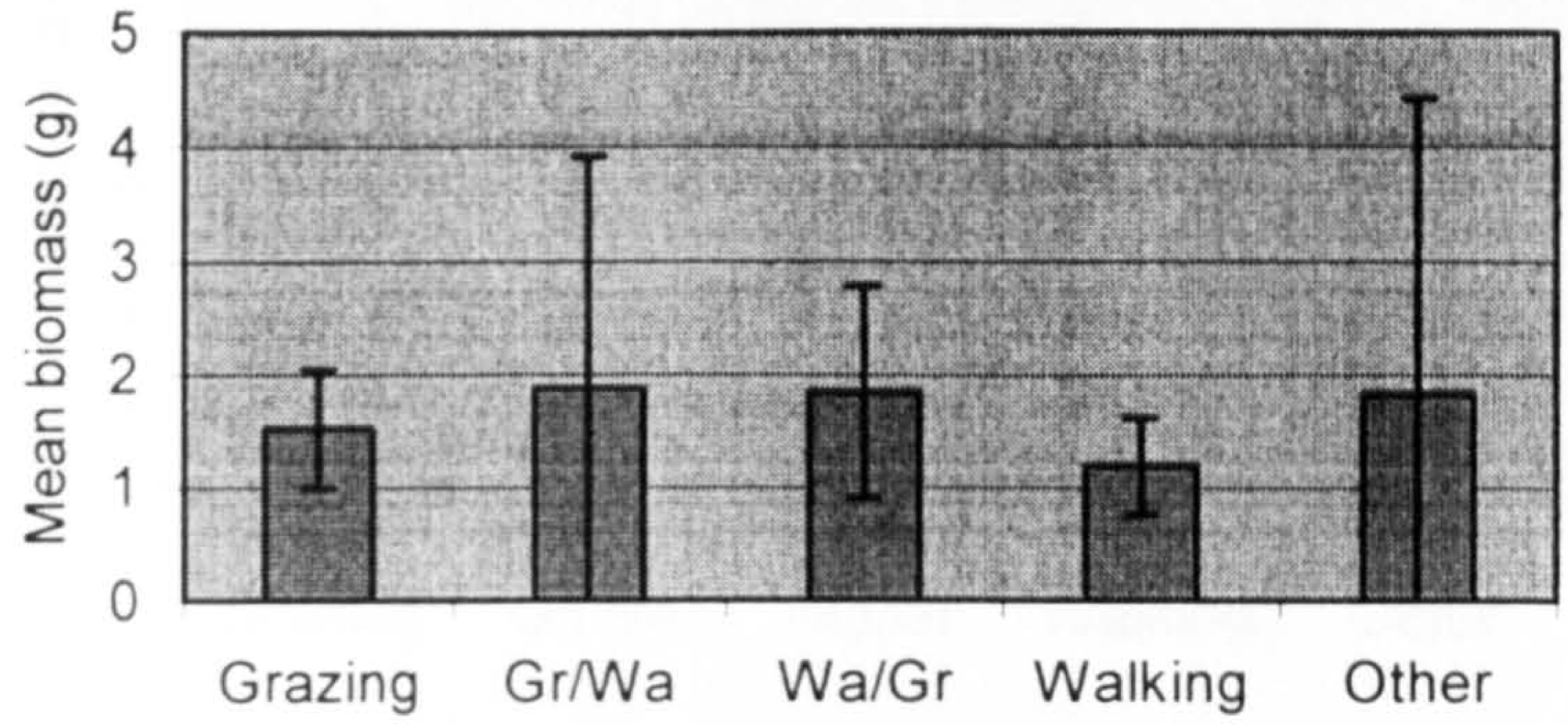


Fig. 6.41a Influence of *Eragrostis porosa* Biomass in the Focal Area of the Rhino on Activity

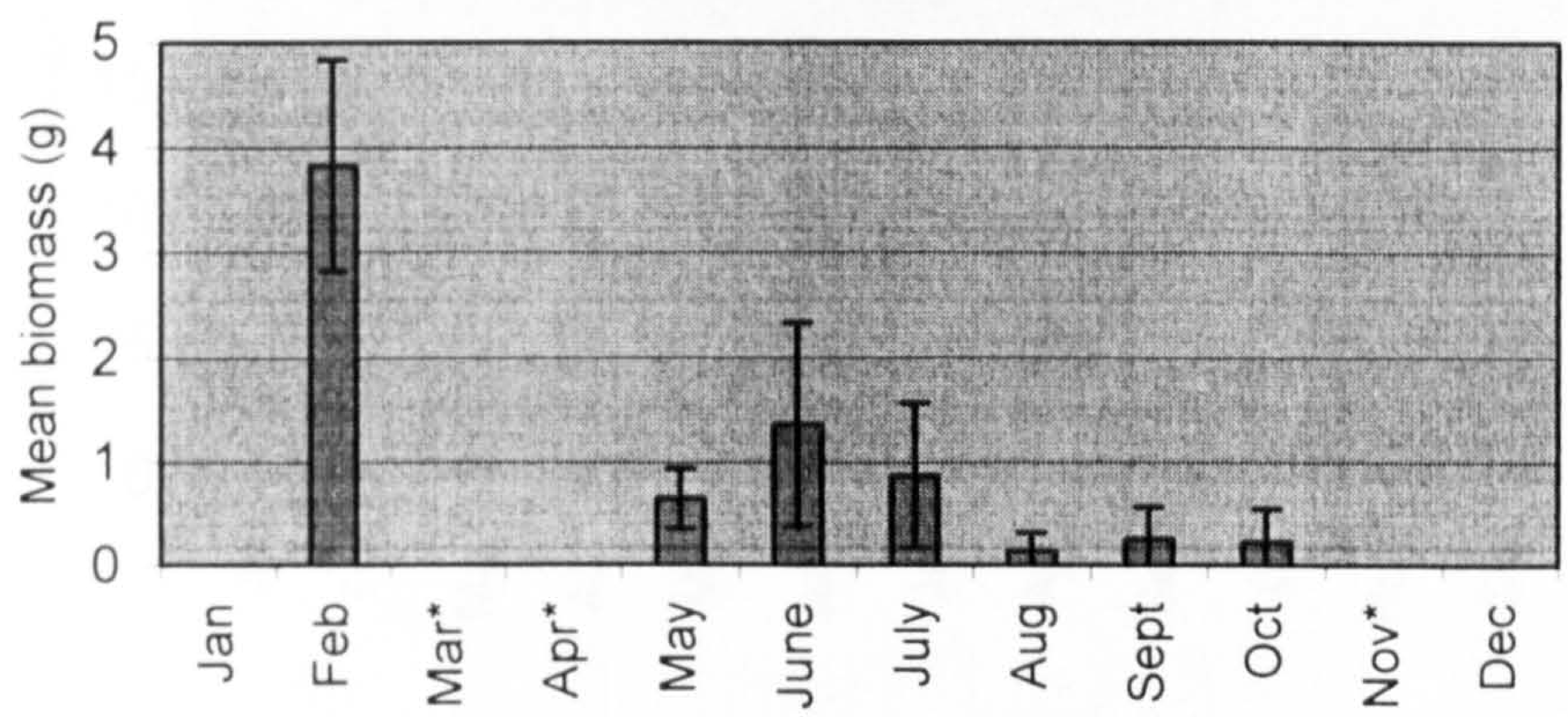


Fig. 6.41b Influence of Season on *Eragrostis porosa* Biomass in the Focal Area of the Rhino

* No data for these months.

Table 6.9a Factors Significantly Associated with *Eragrostis porosa*

F-Test Analysis	Significance of Result
Activity	NS
Season	**

NS Not significant.
* P<0.05, significant.
** P<0.01, highly significant.

Table 6.9b Summary of ANOVA Analysis of *Eragrostis porosa* with Rhino Activity and Season

Activity and Season	Wa/Gr Sept-Dec	Wa Sept-Dec	Gr May-Aug
Gr Jan-Apr		a	
Wa Jan – Apr	a	b	a
Wa/Gr Jan-Apr	a	a	

a Significant differences as indicated by Tukey.
b Significant differences as indicated by Tukey and Scheffé *post-hoc* tests.

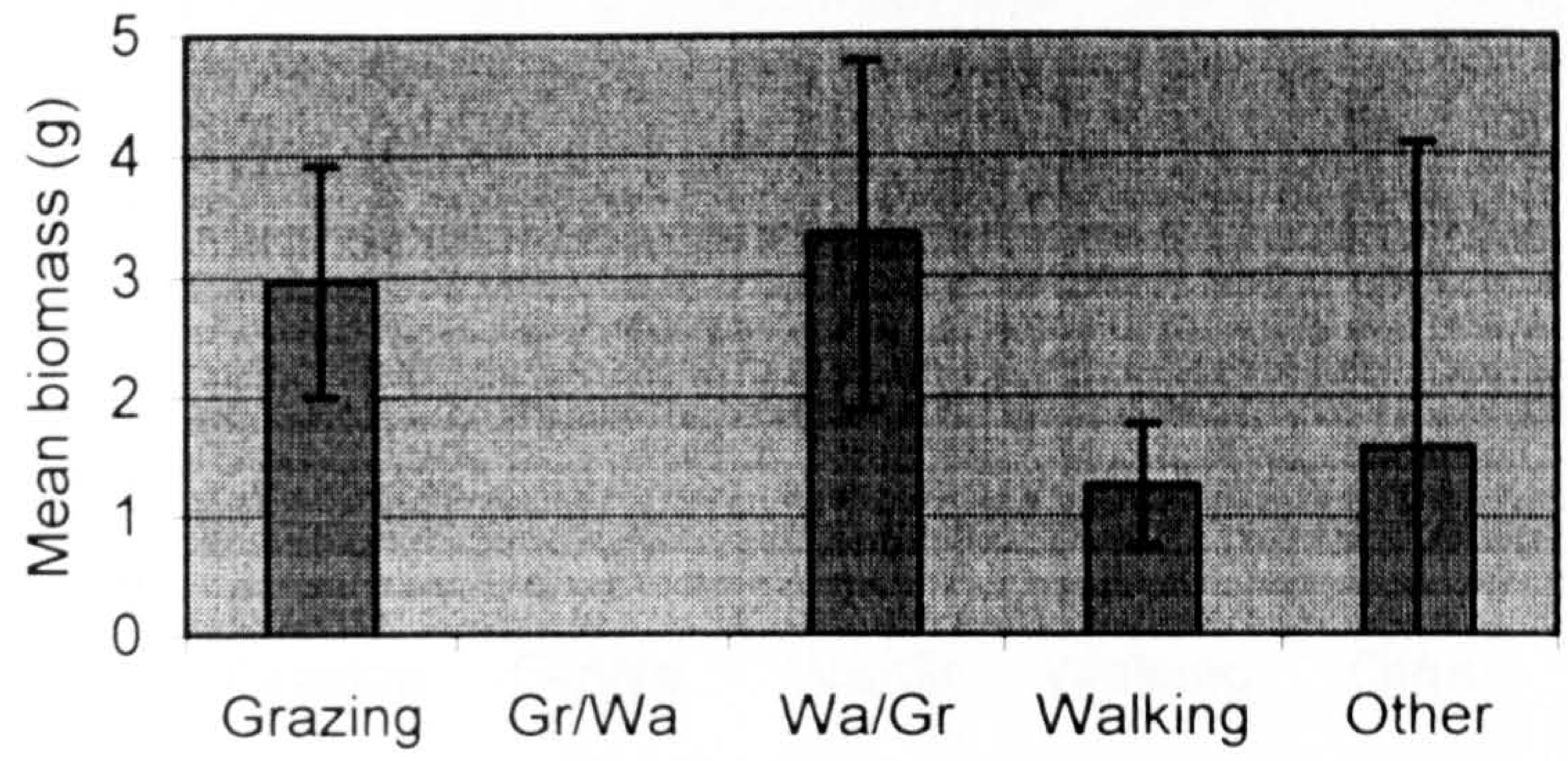


Fig. 6.42a Influence of the Biomass of Annuals in the Focal Area of the Rhino on Activity

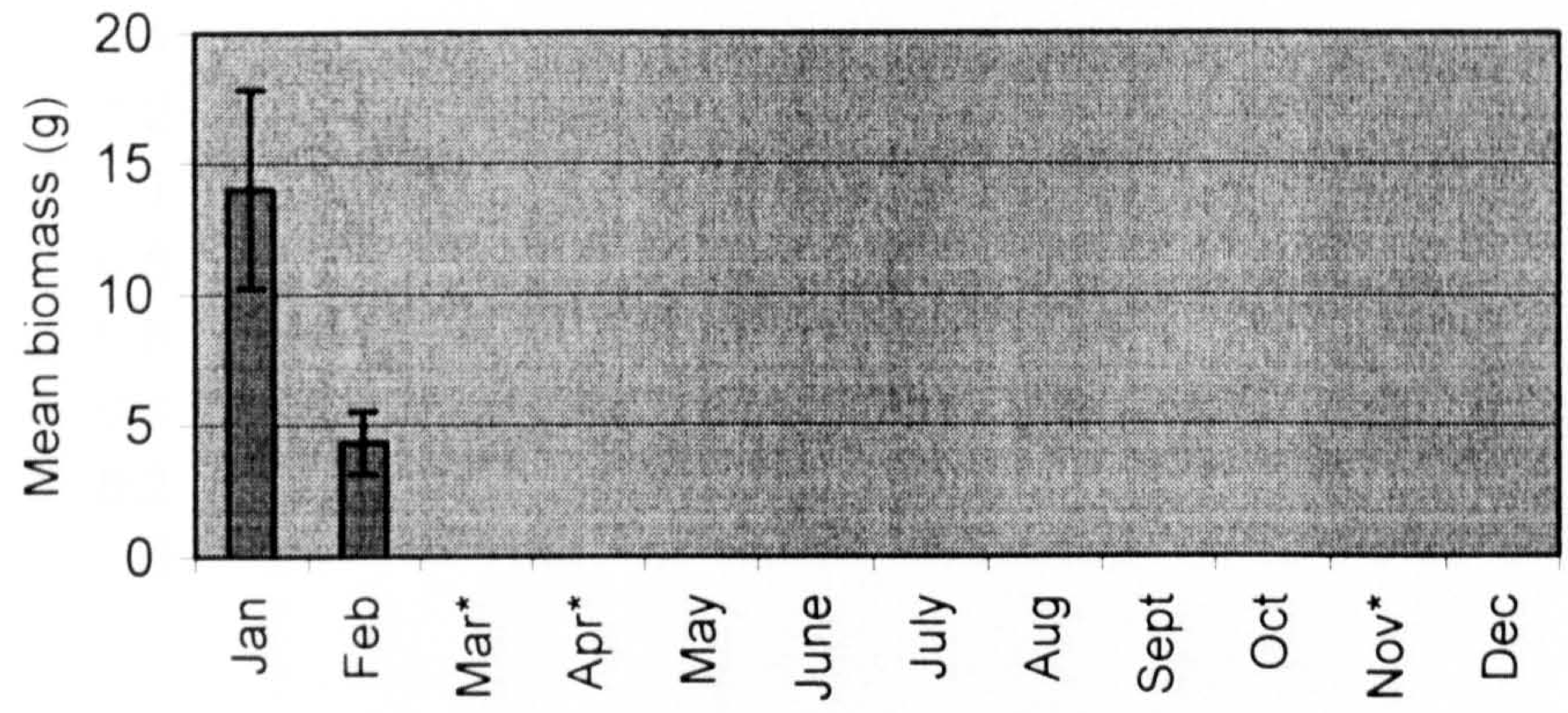


Fig. 6.42b Influence of Season on the Biomass of Annuals in the Focal Area of the Rhino

* No data for these months.

Table 6.10a Factors Significantly Associated with Annual Grasses

F-Test Analysis	Significance of Result
Activity	NS
Season	**

NS Not significant.
* P<0.05, significant.
** P<0.01, highly significant.

Table 6.10b Summary of ANOVA Analysis of Annual Grasses with Rhino Activity and Season

Activity Season	Gr/Wa Jan-Apr	Gr May-Aug	Gr/Wa May-Aug	Wa/Gr May-Aug	Wa May - Aug	Other May-Aug	Gr Sept-Dec	Gr/Wa Sept-Dec	Wa/Gr Sept-Dec	Wa Jan-Apr
Wa Jan-Apr		b		b	b			a	a	
Gr Jan-Apr	a	b		b	b	a	a	a	b	
Wa/Gr Jan-Apr	a	b	a	b	b	b	b	b	b	a

a Significant differences as indicated by Tukey.
b Significant differences as indicated by Tukey and Scheffé *post-hoc* tests.

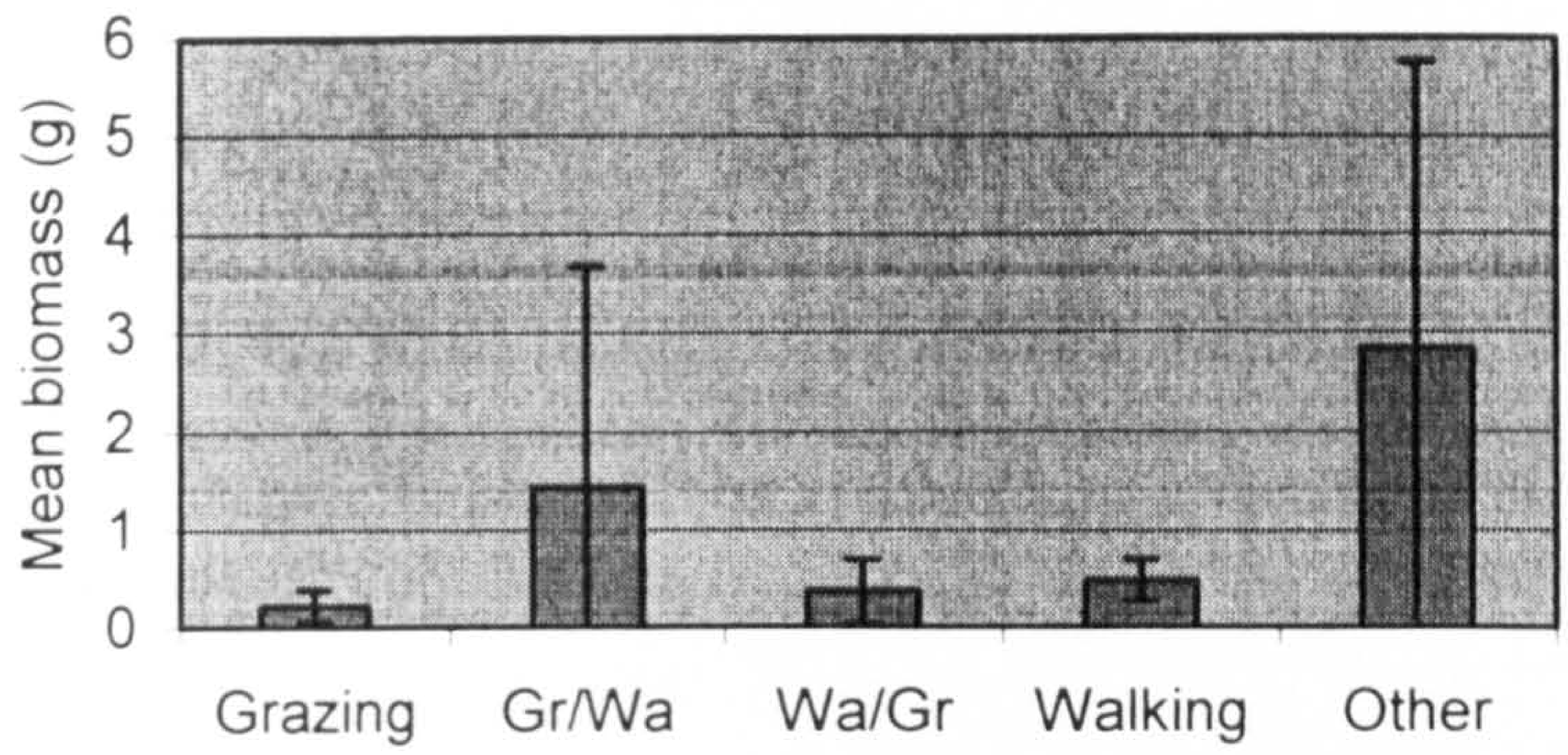


Fig. 6.43a Influence of *Aristida adscensionis* Biomass in the Focal Area of the Rhino on Activity

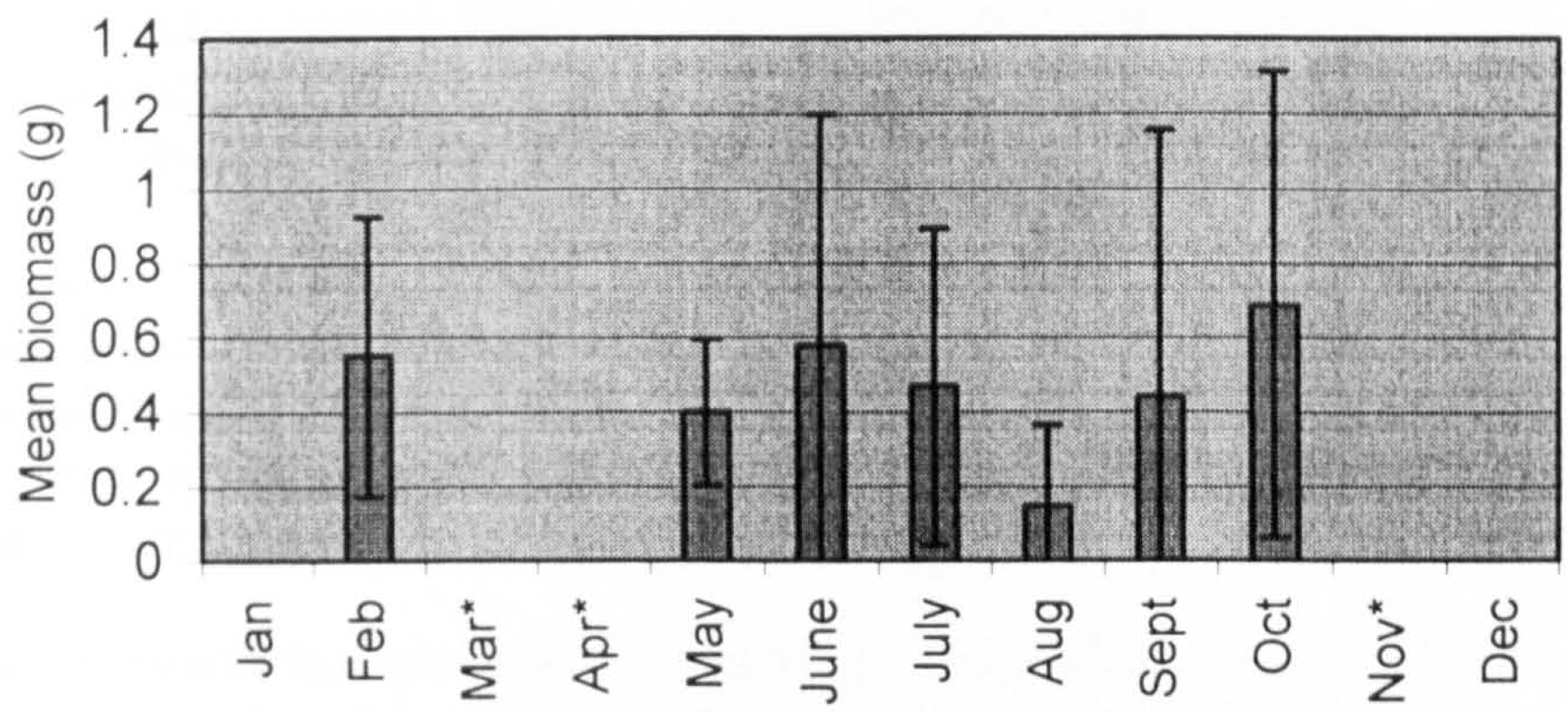


Fig. 6.43b Influence of Season on *Aristida adscensionis* Biomass in the Focal Area of the Rhino
* No data for these months.

Table 6.11a Factors Significantly Associated with *Aristida adscensionis*

F-Test Analysis	Significance of Result
Activity	NS
Season	NS

NS Not significant.
* P<0.05, significant.
** P<0.01, highly significant.

Table 6.11b Summary of ANOVA Analysis of *Aristida adscensionis* with Rhino Activity and Season

	Gr Sept-Dec	Wa/Gr May-Aug	Gr Jan-Apr	Gr May-Aug	Wa Jan-Apr	Wa May-Aug
Other May-Aug		*	*			
Gr/Wa Jan-Apr	*	*	*	*	*	*

* Significant differences as indicated by Tukey.
** Significant differences as indicated by Tukey and Scheffé *post-hoc* tests.

Cenchrus ciliaris showed no significant effect with either activity or season (Table 6.12a). Although not statistically significant, Fig. 6.44a tends to indicate a preference for grazing when the biomass of *Cenchrus ciliaris* was high. Also this species was most frequently encountered between May and October (Fig. 6.44b). Confidence limits were wide because this species was infrequently encountered.

Whenever unidentifiable annual grasses were encountered during the rainy season they were recorded as annuals, which reduced the number of observations of specific annual species observed at this time. This did not affect observations of *Stipagrostis uniplumis, Eragrostis nindensis* or *Cenchrus ciliaris* which are perennial species, because early growth was clearly identifiable from the old stems of the grass.

iii) Grazing Observations

Freshly grazed grass was identified by looking at the gradual drying out of blades and stems after they had been broken. Between April and June it was possible to break a sample of the grass to look at the colour of the inner stem and compare it with the colour of a freshly grazed end. As the freshly cut stem aged, the colour became lighter and eventually it dried out completely. As the dry season continued it was not possible to identify which grass had been eaten, since all the grasses were completely brown and dry. The results were found to be consistent with both tracker guided and direct observations.

Throughout the year, an imitation of the grazing action of a rhino was simulated on various grass species to investigate the visible changes associated with this activity. This was carried out by pulling the grasses by hand in a similar manner to how rhinos had been observed to graze. Certain grasses normally broke at their base at ground level or were pulled out from the centre of a folded leaf group, while others cut cleanly. This breaking point was found to vary throughout the year, depending upon greenness.

Grazing observations were taken at regular pre-determined intervals, but additional feeding observations were occasionally taken between these times, when clear observations were made. These included the observation while tracking, that on several occasions rhinos were eating *Cenchrus ciliaris, Cynodon dactylon* and the sedge *Cyprus* while walking along the rivers.

Wherever forbs were present, they were recorded independently of standard observations. Generally rhinos seemed to avoid forbs, especially the yellow thorn flowers (*Tribulus zeyheri*) which were plentiful after the rainy season.

iv) Direct Observations

Only a limited number of direct grazing observations could be made without disturbing the rhinos by approaching too closely. Results from direct observations when grasses grazed could clearly be identified have been summarised in Table 6.13. These observations were collected wherever possible and broadly support tracker guided observations in the focal area, with the exception of *Stipagrostis uniplumis*, which was recorded as grazed on several occasions between January and August.

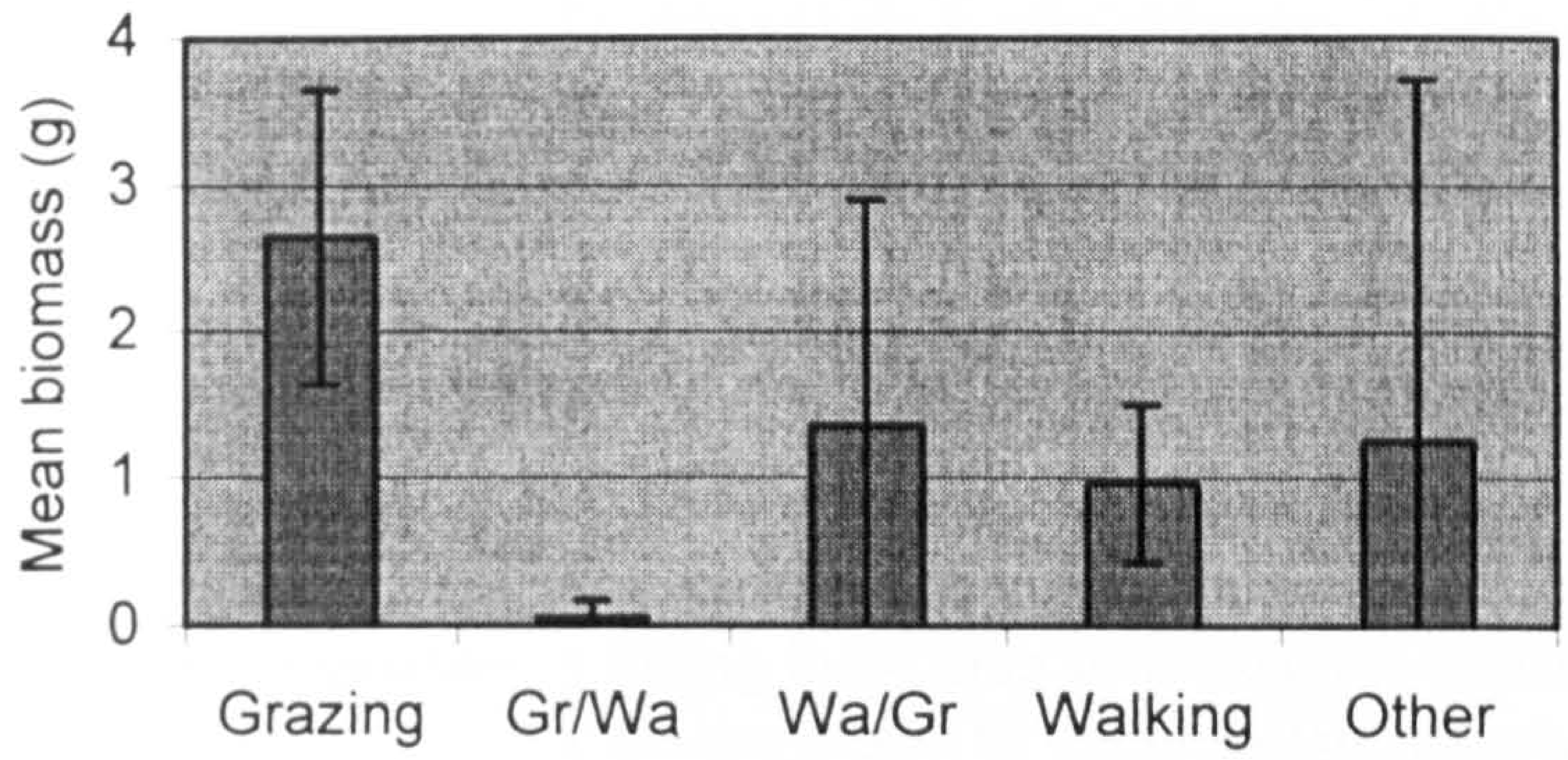


Fig. 6.44a Influence of *Cenchrus ciliaris* Biomass in the Focal Area of the Rhino on Activity

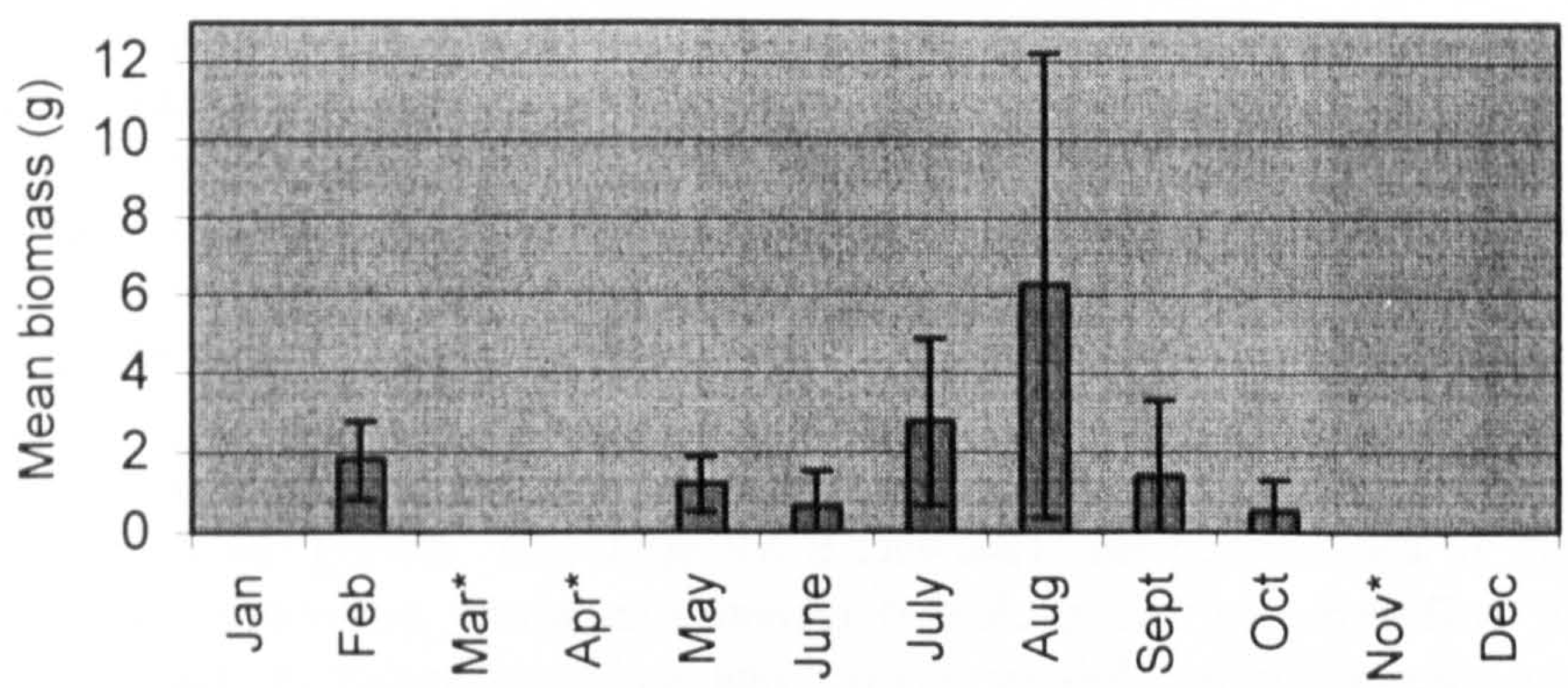


Fig. 6.44b Influence of Season on *Cenchrus ciliaris* Biomass in the Focal Area of the Rhino

* No data for these months.

Table 6.12a Factors Significantly Associated with *Cenchrus ciliaris*

F-Test Analysis	Significance of Result
Activity	NS
Season	NS

NS Not significant.
* P<0.05, significant.
** P<0.01, highly significant.

Table 6.13 Feeding Details Recorded During Direct Observations.

Season	Feeding Observations
January - April	In January, rhinos were eating a variety of the new green grass which could not yet be identified (2). Definitely eating *Schmidtia kalahariensis*, *Cenchrus ciliaris* and new shoots of *Stipagrostis uniplumis* (1).
May – August	Grazing sparse grasses including *Eragrostis nindensis* (3) and *Microchloa caffra* (2), especially in places where they were growing abundantly. Intensively eating *Stipagrostis uniplumis* (3), *Schmidtia kalahariensis* (2) and *Antephora schinzii* (2). Grazing *Lucern* which had been cleaned out of a boma where Roan antelope (*Hippotragus equinus*) were being held in captivity (2).
September - December	Eating loose litter of broken-off blades of grass (2) especially *Schmidtia kalahariensis* (1). Ignoring *Stipagrostis uniplumis* (3).

( ) Indicates number of observations.

v) Rainy Season Observations

While tracking, it was noticed that the area south of KarossHoek produced new green grass earlier than other areas and the initial biomass of grass was significantly higher in this region. During this period, the rhinos concentrated their activity in a small area since water was available from holes in rocks and mud wallows. Rhino and other game species apparently concentrated their utilisation in these regions. The second area to produce a green flush was the area north of KarossDrink. Many animals also moved to this area, however the rhinos remained south of KarossHoek. As the rainy season progressed the whole of the study area became green and the rhinos began moving across the whole area. Sightings of other game species then became less frequent.

Early in the rainy season, it was not possible to identify annual grass species since there was only a few centimetres of leaf growth. Consequently, if they could not be identified by the leaf or base area, they were recorded as annuals. During this time no *Aristida* species were identified. This may be because this species produces its inflorescence later and it is also possible that this species is more palatable to rhinos while in this young stage.

vi) Phenology Of Grasses

All grass species passed through phenology changes at similar times, i.e. from green to brown as the dry season progressed, although some species retained their greenness for slightly longer. These were generally the more woody or stemmy species, for example *Stipagrostis uniplumis*. In the riverbeds and in shady areas *Cynodon dactylon* remained green for longer. The sedge *Cyprus* remained green for a very long time. Table 6.14 indicates the average phenology of grasses during each season and the number of observations of phenology which provided these measurements. Phenology ratings were from 5 (green) to 1 (brown and dry). Data for March and April were missing and these were the most important months for drying of grasses, therefore it was not feasible to analyse the influence of phenology.

Table 6.14 Change in Grass Phenology throughout the Seasons.

Season	Average Phenology	Number of observations
January - April	4.9	392
May – August	1.3	692
Sept – December	1.6	146

vii) Grass Biomass

a) Grass Biomass in Focal Area (1241 observations)

Rhino activity was significantly influenced by the biomass of grass in the focal area (Table 6.15). Grazing activity was generally on areas with a low biomass, but apparently favoured areas with a medium or high biomass when available (Fig. 6.45a). Rhinos were generally recorded as walking where the biomass in the focal area was between none and very low. Thus where the biomass in the focal area is between none and very low, walking is preferred as feeding would be less productive.

There is a statistically significant difference in biomass ratings in the focal area of the rhino over different seasons (Table 6.15). Utilisation of areas with higher than average biomass increases in the wet season between January and April, and decreases between September and December (Fig. 6.45b).

b) Grass Biomass in Vicinity (512 observations)

There is a statistically significant difference between biomass ratings and the rhinos activity (Table 6.16). Fig. 6.46a indicates that rhino activity varied with the total grass biomass in the area and most of these trends were reflected in the focal area observations.

There is also a statistically significant difference in biomass ratings in the vicinity of the rhino over different seasons (Table 6.16). Grass biomass ratings increase in the wet season between January and April and decrease between September and December (Fig. 6.46b). In January to April, grass was growing across the region and in all areas a minimum of a low biomass was recorded.

c) Possible Reduction in Biomass Ratings due to Grazing

The possibility of error being introduced by grazing activity decreasing the grass biomass in the focal area was investigated by comparing grass biomass in the focal area with grass biomass in the vicinity of the rhino, with respect to rhino activity. Table 6.17 indicates the change in biomass as a result of grazing in terms of percentages of observations.

Table 6.17 Influence of Grazing on Biomass of Grass in Focal Area of Rhino, Compared with Biomass in the Vicinity.

Change in Biomass Rating Between Focal Area and Vicinity	Pure Grazing Observations	All Other Activity Observations
Percentage of observations increased	11/127 x100= 8.6%	33/263x100= 12.5%
Percentage of observations unchanged	82/127x100= 64.5%	153/263x100= 58.2%
Percentage of observations decreased	34/127x100=26.8% (1)	77/263x100= 29.3% (2)

If grazing did reduce grass biomass ratings in the focal area, then (1) would be greater than (2). However these results indicate that there was no detectable decrease in grass biomass as a result of grazing, in fact there appeared to be a slight increase. Consequently, although rhino grazing obviously would reduce focal area biomass, the reduction was insufficient to be detected on the ratings scale. It may be possible that areas selected for grazing might have a higher biomass than the surrounding areas before grazing, and feeding pressure is not heavy enough to reduce this to the same or less than the surrounding area. The probable explanation is that the biomass rating scale is too crude to indicate these small changes. This

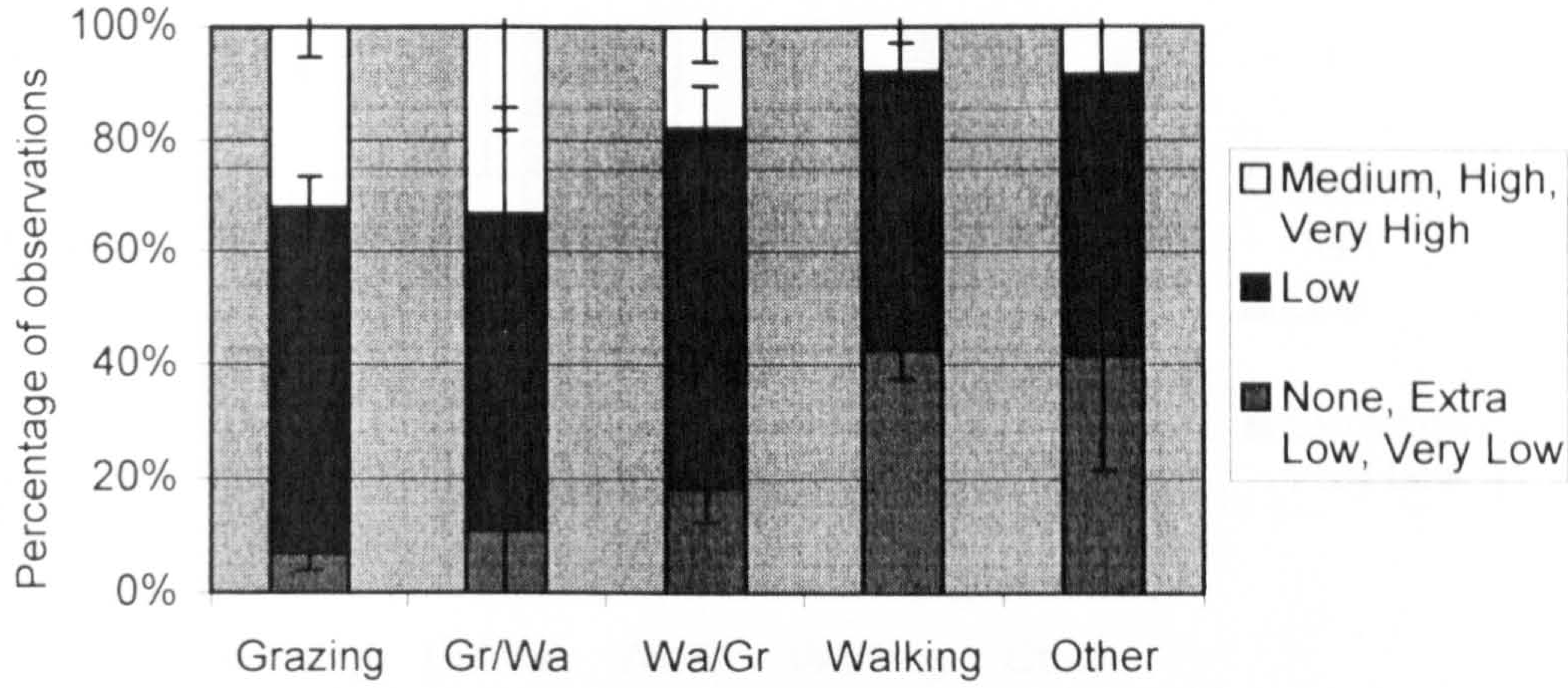


Fig. 6.45a Influence of Biomass in the Focal Area of the Rhino on Activity

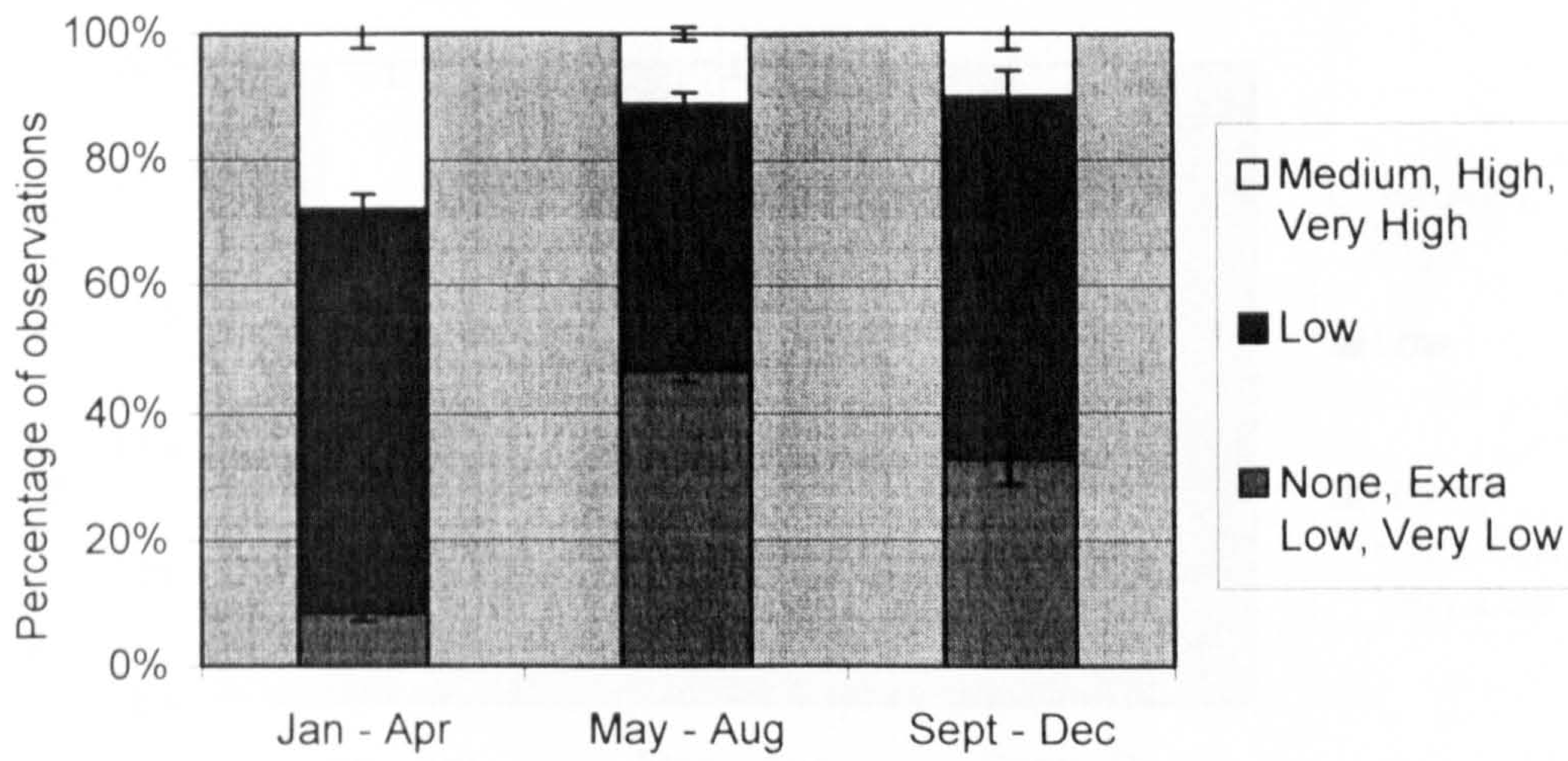


Fig. 6.45b Influence of Season on the Average Biomass in the Focal Area of the Rhino

Table 6.15 Significant Differences for Grass Biomass in the Focal Area of the Rhino with Respect to Activity and Season Identified by Chi Square Analysis

Grass Biomass in Focal Area of Rhino	Activity			Season		
	df	Test Result	Sig	df	Test Result	Sig
	8	154.69	**	4	185.85	**

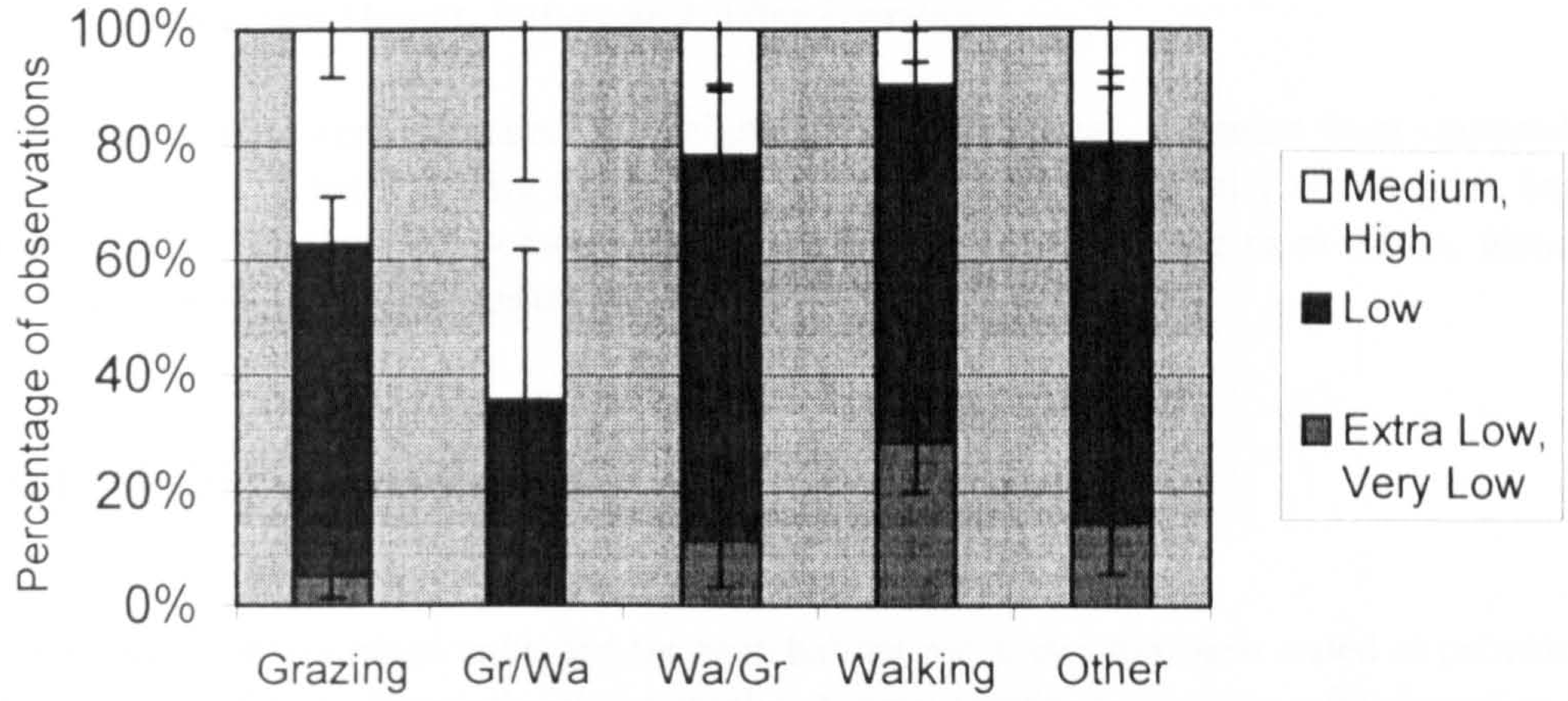


Fig. 6.46a Influence of Grass Biomass in the Vicinity of the Rhino on Activity

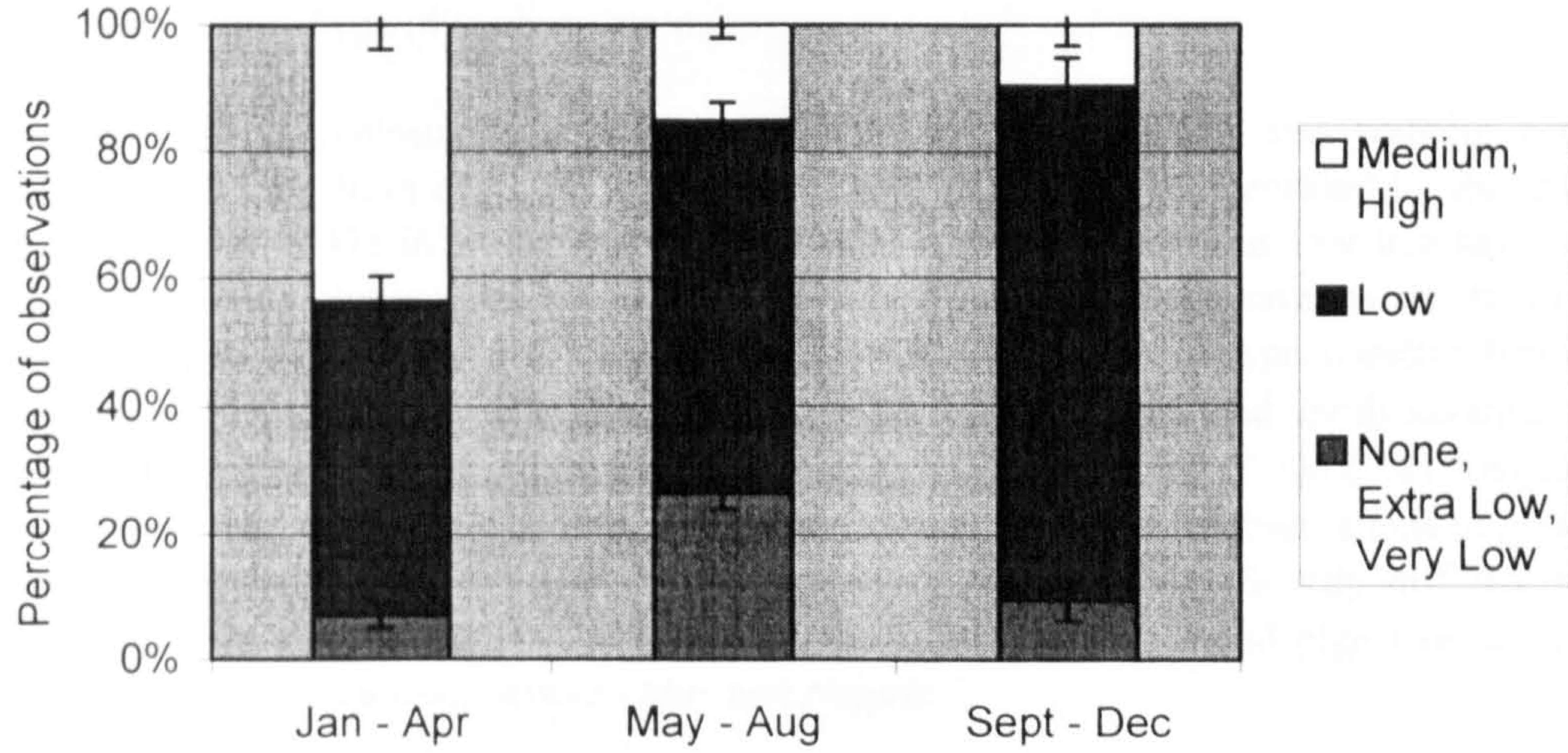


Fig. 6.46b Influence of Season on the Biomass in the Vicinity of the Rhino

Table 6.16 Significant Differences for Grass Biomass in Vicinity of Rhino with Respect to Activity and Season Identified by Chi-Square Analysis

Grass Biomass in Vicinity of Rhino	Activity			Season		
	df	Test Result	Sig	df	Test Result	Sig
	8	55.12	**	4	81.18	**

confirms that it is possible to use the biomass ratings for all activities without concern that the biomass of grasses preferred for grazing will be reduced by the activity.

viii) Mean Grass Height, Before and After Grazing

When grass heights were estimated, the height before grazing was estimated from surrounding strands of the same species. This was only feasible when it was possible to identify which grass had been freshly grazed. During the late dry season, assessment was not possible due to problems identifying exactly which grass shoots had been freshly grazed.

6.3.4 Habitat Utilisation

The number of observations collected for each habitat parameter has been stated to provide an indication of the quantity of data. Proportional bar graphs of rhino activity and season with respect to habitat classes were constructed with 95% confidence limits. Chi-square analysis was then applied to identify whether habitat selection was occurring for different activities and seasons. It was not possible to analyse these data using ANOVA due to the low number of observations associated with each activity and month.

i) Vegetation Type (496 observations)

Chi-square analysis indicated that habitat selection for both grazing and walking activities was significantly different from available vegetation classes in the area as identified by the habitat survey (Table 6.18). Fig. 6.47a indicated that the dominant vegetation class was low tree savanna, however grazing and walking observations preferentially selected grass and shrub savanna and to a lesser extent high tree savanna. There was also a significant difference in vegetation type selection between activity classes (χ^2_6 = 24.54, P<0.01), since rhinos preferentially utilise grass and shrub savanna for grazing. Seasonal selection also significantly affected vegetation class utilisation (Table 6.18) compared with the habitat survey. Fig. 6.47b indicated that there were a greater number of observations in grass and shrub savanna during all seasons. Vegetation type utilisation was also significantly different between the seasons (χ^2_4 = 26.10, P<0.01). It was very apparent that rhinos selected high tree savanna (usually associated with riverine areas), between May and August.

ii) Tree cover (509 observations)

Walking observations in different classes of tree cover were statistically similar to those available in the area according to the habitat survey (χ^2_2 = 5.60). However, grazing observations exhibited a statistically significant difference, preferring very low tree density classes (Fig. 6.48a and Table 6.19). Tree cover classes also varied significantly between activities (Table 6.19), supporting the observation that as the density of tree cover increased, utilisation for grazing activities tended to decrease (Fig. 6.48a). Chi-square analysis indicated that selection of varying densities of tree cover was significantly different to available classes identified in the habitat survey, during all seasons (Table 6.19). Fig. 6.48b indicates greater utilisation of very low tree cover ratings in all seasons. There was also a statistically significant difference between classes of tree cover during all seasons (χ^2_4 = 14.98, P<0.01). Fig. 6.48b also indicates greater utilisation of very low tree cover ratings and low utilisation of medium and high tree cover ratings between January and April. Utilisation of different ratings between May and December are reasonably similar. Overall, it appears that tree cover classes only exert a slight influence on rhino activity observations (Fig. 6.48a).

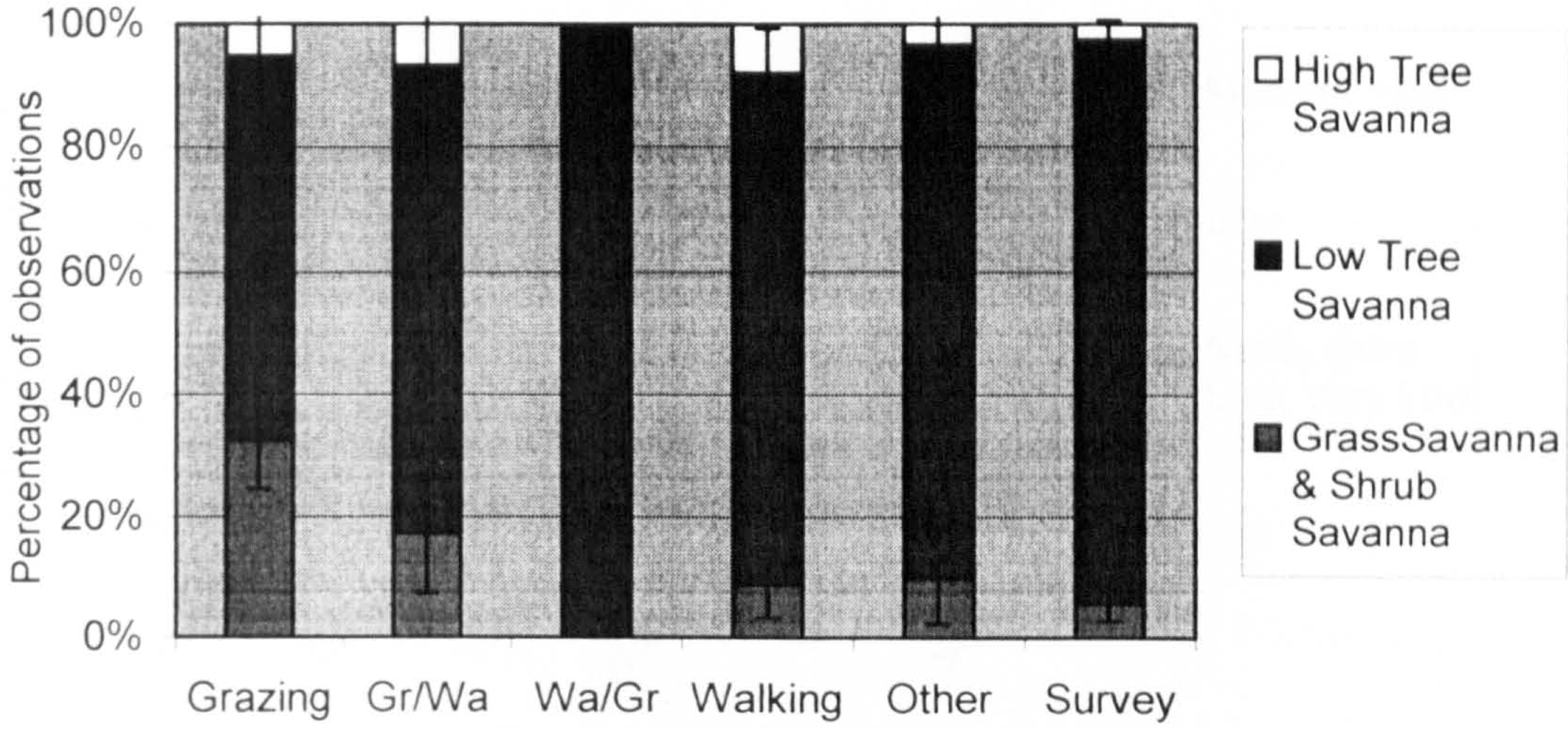


Fig. 6.47a Influence of Vegetation Type on Rhino Activity

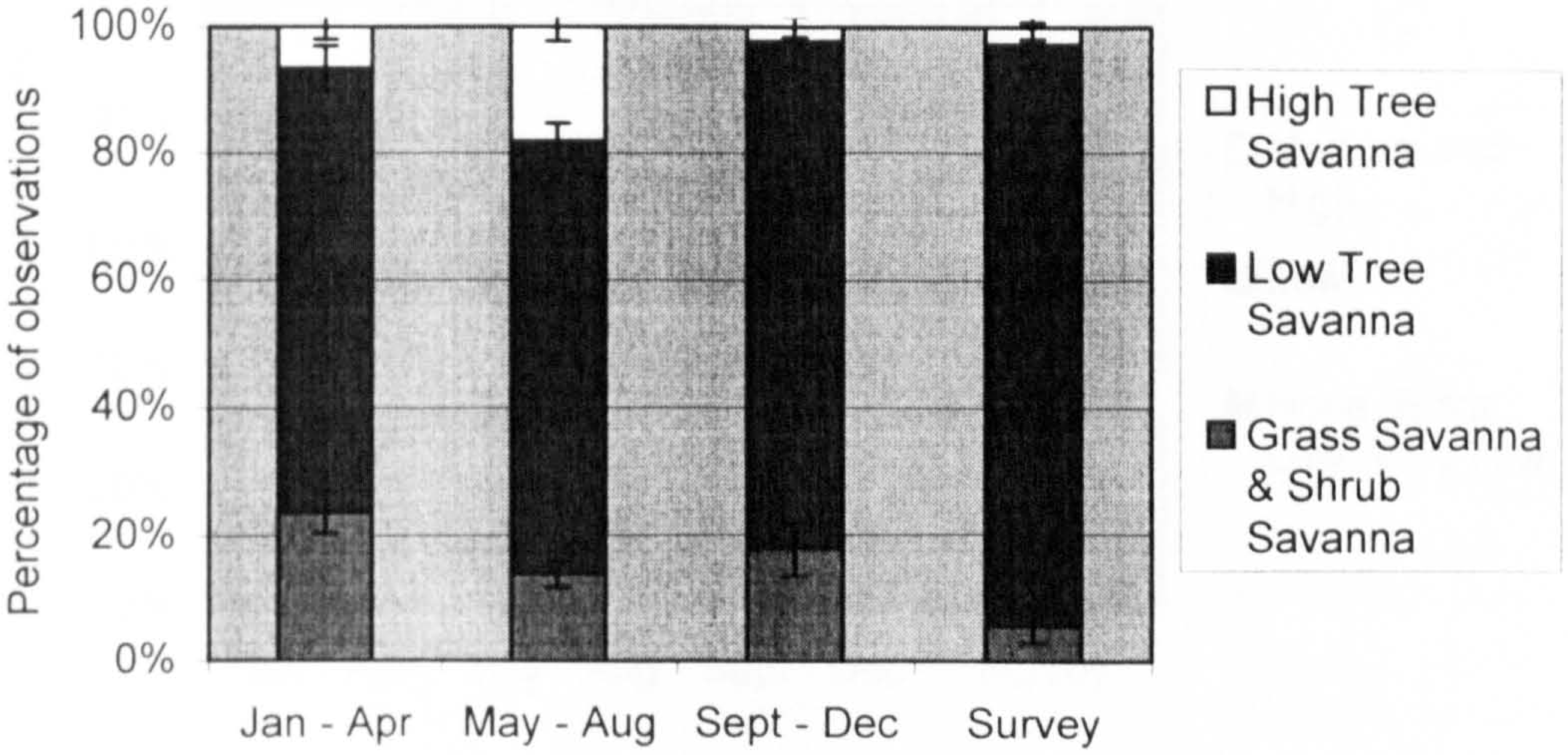


Fig. 6.47b Influence of Season on Vegetation Type Selected by the Rhino

Table 6.18 Significant Differences for Activity and Season with Respect to Vegetation Type Identified by Chi Square Analysis

Vegetation Type	df	Test Result	Significance
Observed grazing observations, compared with expected survey observations	2	177.33	**
Observed walking observations, compared with expected survey observations	2	13.03	**
Comparison between main activities	6	24.54	**
Observed selection between January to April, compared to habitat survey	2	110.72	**
Observed selection between May to August, compared with habitat survey	2	282.19	**
Observed selection between September to December, compared with habitat survey	2	22.08	**
Comparison between three seasons	4	26.10	**

NS Not Significant
* $p<0.05$
** $p<0.01$

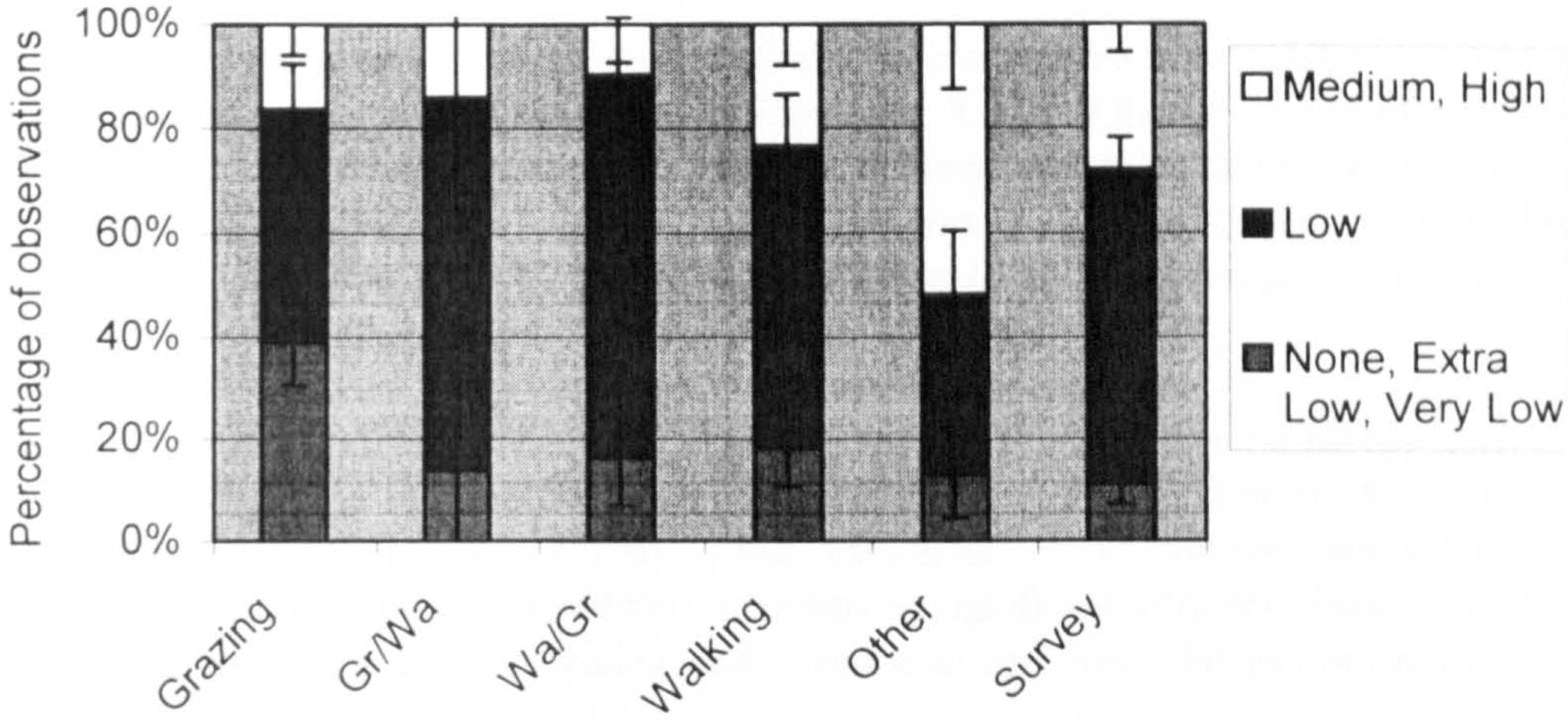


Fig. 6.48a Influence of Tree Cover Ratings on Rhino Activity

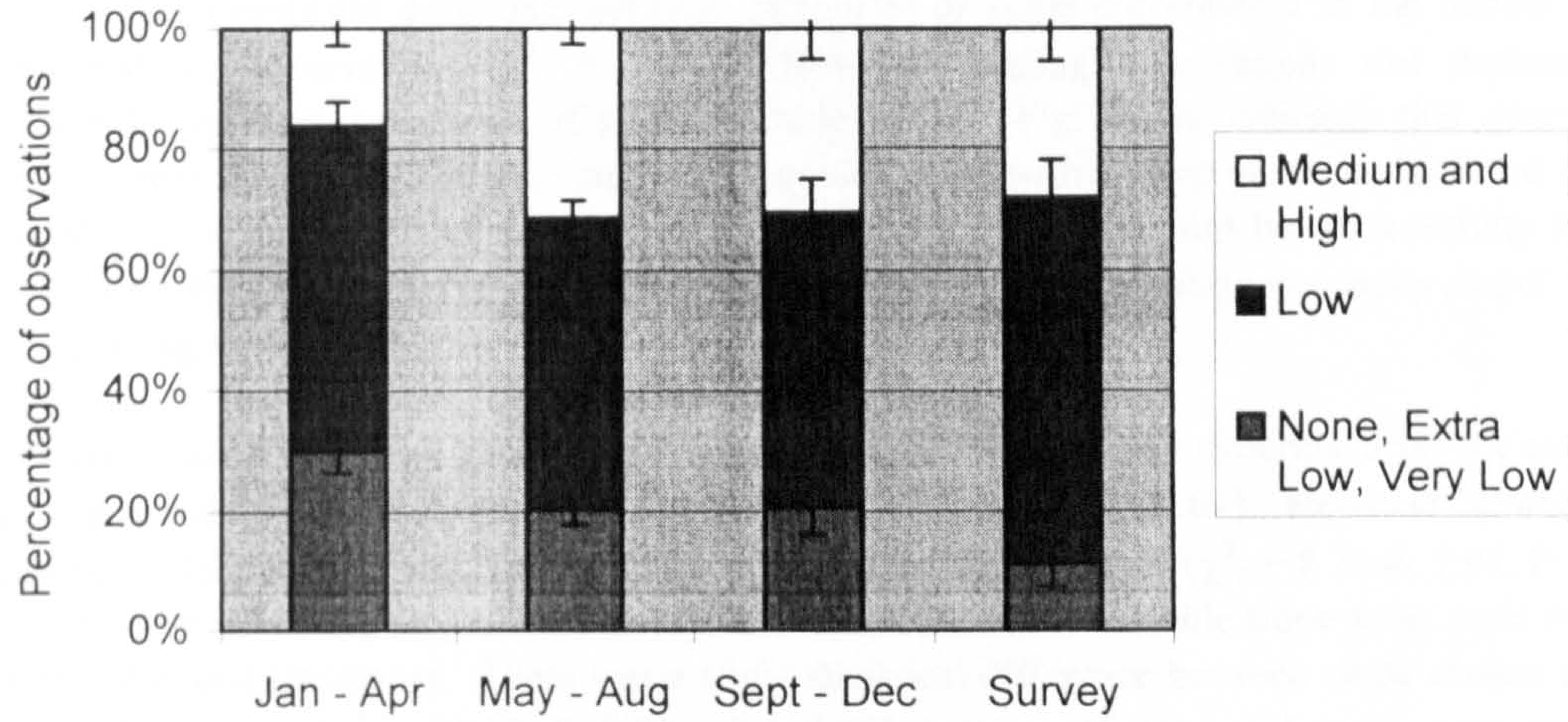


Fig. 6.48b Influence of Season on Tree Cover Ratings Selected by the Rhino

Table 6.19 Significant Differences for Activity and Season with Respect to Tree Cover Ratings Identified by Chi Square Analysis

Tree Cover	df	Test Result	Significance
Observed grazing observations, compared with expected survey observations	2	104.82	**
Observed walking observations, compared with expected survey observations	2	5.60	NS
Comparison between main activities	6	24.48	**
Observed selection between January to April, compared to habitat survey	2	61.15	**
Observed selection between May to August, compared with habitat survey	2	29.64	**
Observed selection between September to December, compared with habitat survey	2	8.58	*
Comparison between three seasons	4	14.98	**

NS Not Significant
* $p<0.05$
** $P<0.01$

iii) Rockiness (469 observations)

Results indicate that rockiness ratings are statistically different between the habitat survey and both rhino grazing and walking activities (Table 6.20). In Fig. 6.49a, it is clear that low levels of rockiness appear to have no significant influence on activity, whereas medium and high ratings are strongly avoided in relation to their occurrence in the habitat survey. There was no significant difference in rockiness ratings between rhino activity classes ($\chi^2_6 = 3.81$), indicating that the trends observed with grazing and walking observations extend to all activities.

Rhino selection of rockiness ratings was statistically different to the habitat survey during all seasons (Table 6.20). Again, it is clear that areas with medium and high rockiness classes are consistently avoided throughout the year (Fig. 6.49b). Areas with extra low to low rockiness are more frequently utilised in relationship to their availability. There was no significant difference between rockiness ratings during all seasons ($\chi^2_4 = 2.72$) indicating that selection of rockiness classes does not vary through the year.

iv) Slope (504 observations)

There was no significant difference between categories of slope encountered in the habitat survey and during walking observations ($\chi^2_2 = 5.24$). However grazing observations did statistically select significantly different categories of slope (Table 6.21). Fig. 6.50a indicates that grazing activity preferred areas with a slight slope, completely avoided areas with a steep slope, and utilised areas with a reasonable slope for less than their availability. Utilisation of slope ratings between activity observations were statistically different ($\chi^2_6 = 22.83$, $P<0.01$) supporting the observation that steep slopes are avoided during grazing-related activities.

Rhino utilisation of different categories of slope were statistically very different from the availability of slope classes in the area, between January and April ($\chi^2_2 = 21.95$, $P<0.01$). However between May and December, selection was only slightly different from the habitat survey ($\chi^2_2 = 8.35$ & 7.91, $P<0.05$). Fig. 6.50b indicates that steep slopes were always avoided, however reasonable slope areas were utilised more between May and December. There was a slight statistical difference between slope classes encountered between the seasons ($\chi^2_4 = 10.58$, $P<0.05$). Fig. 6.50b indicates that the main difference was low rhino utilisation of reasonable slope areas between January and April.

v) Substratum (527 observations)

Substratum types observed during rhino grazing and walking activity were significantly different from those observed during the habitat survey (Table 6.22). Fig. 6.51a indicates that these activities occurred more frequently in sandy substrata, which are typical of river beds. There was no statistical difference between the activity observations ($\chi^2_{18} = 18.26$) and different substratum types. Utilisation during all seasons was statistically significantly different from available substrata indicated in the habitat survey (Table 6.22). Fig. 6.51b indicated low utilisation of dusty areas and higher utilisation of areas with pebbles and small rocks. Utilisation of different substratum types was also statistically different between seasons ($\chi^2_{12} = 82.29$, $P<0.01$). Fig. 6.51b indicates higher utilisation of areas with pebbles and small rocks as the year progressed.

6.3.5 Summary Of Results

A summary of the results of the analyses were compiled for herbaceous layer utilisation in Table 6.23, for habitat utilisation in Table 6.24 and for tree species utilisation in Table 6.25. Comparison of these results enabled trends in the utilisation of herbaceous species and habitat in Kaross to be identified.

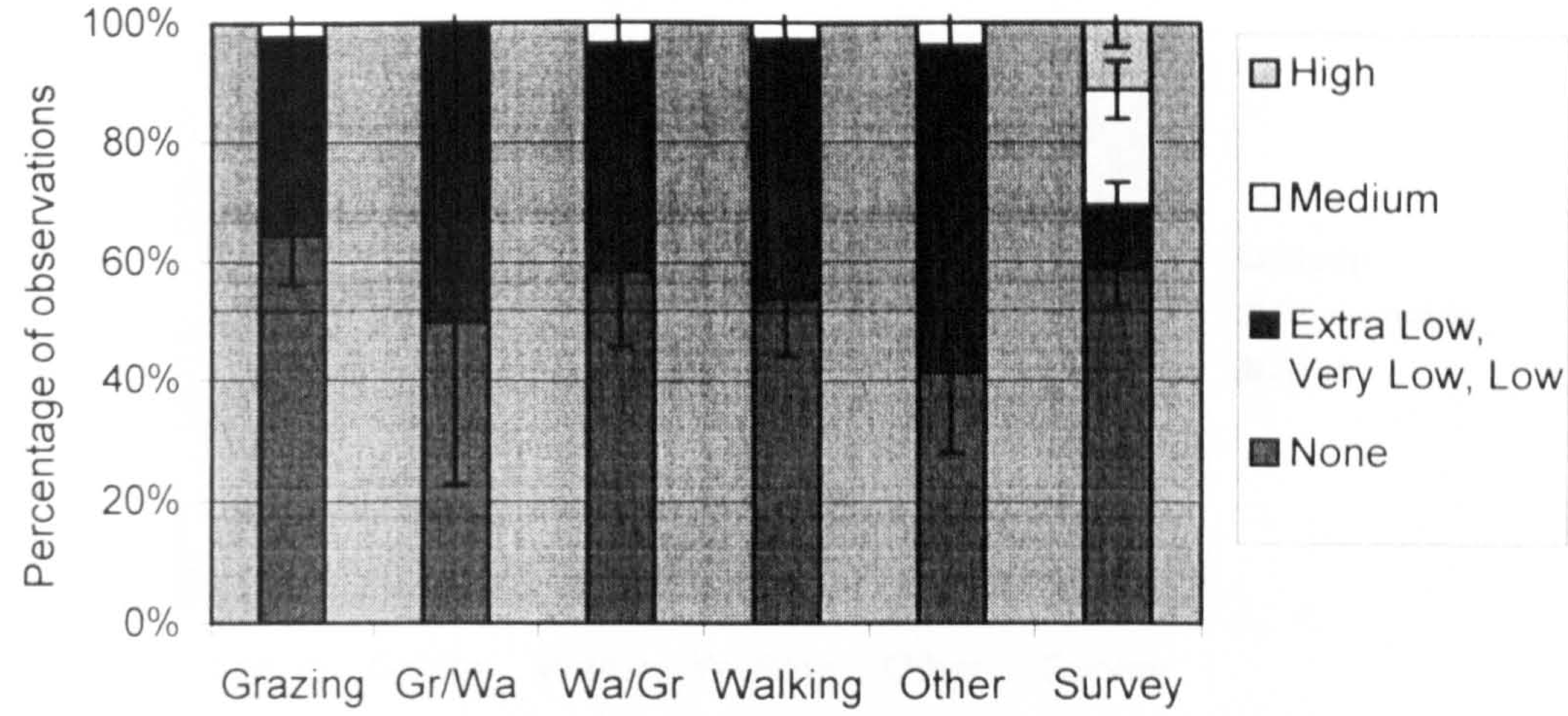


Fig. 6.49a Influence of Rockiness Ratings on Rhino Activity

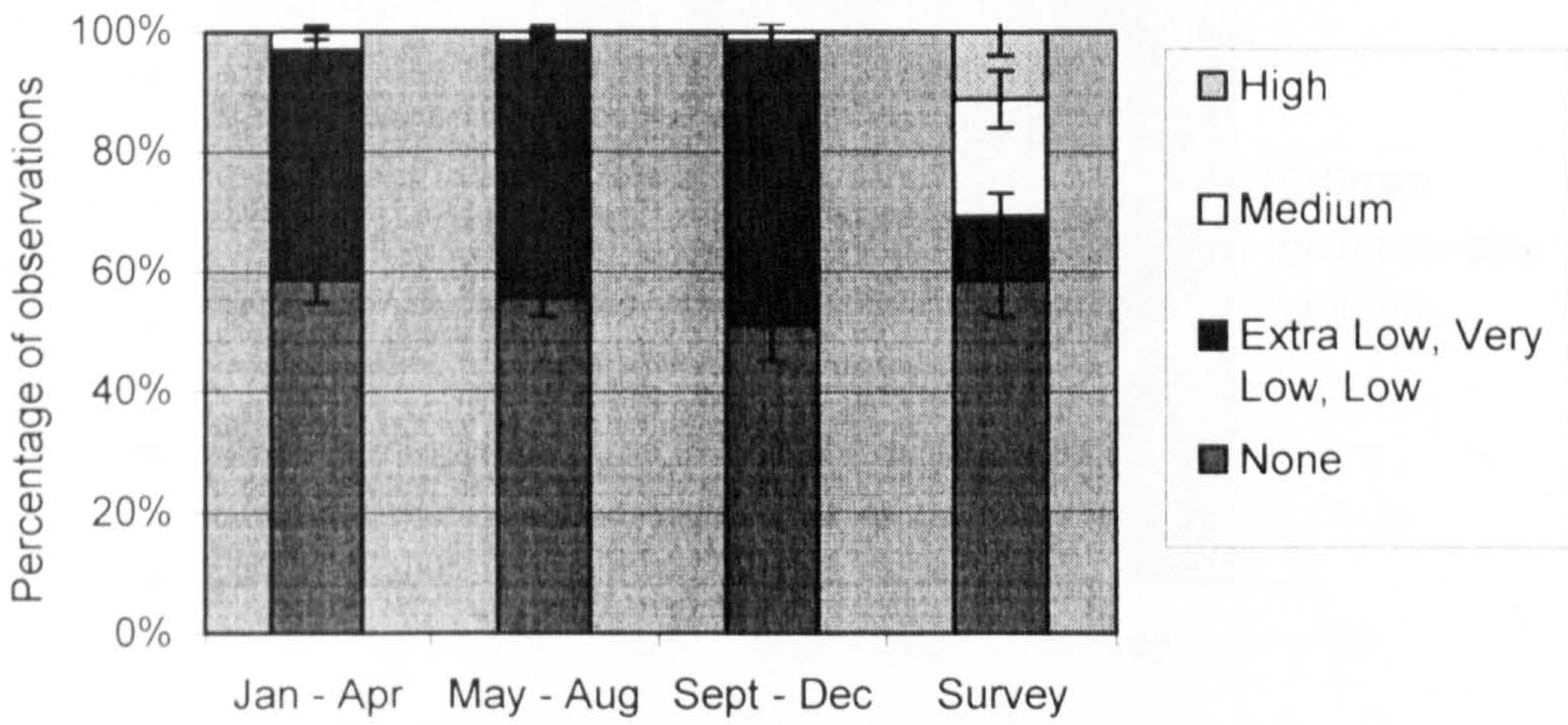


Fig. 6.49b Influence of Season on Rockiness Ratings Selected by the Rhino

Table 6.20 Significant Differences for Activity and Season with Respect to Rockiness Ratings Identified by Chi Square Analysis

Rockiness Rating	df	Test Result	Significance
Observed grazing observations, compared with expected survey observations	3	98.68	**
Observed walking observations, compared with expected survey observations	3	129.59	**
Comparison between main activities	6	3.81	NS
Observed selection between January to April, compared to habitat survey	3	161.79	**
Observed selection between May to August, compared with habitat survey	3	322.03	**
Observed selection between September to December, compared with habitat survey	3	109.66	**
Comparison between three seasons	4	2.72	NS

NS Not Significant
* $p<0.05$
** $p<0.01$

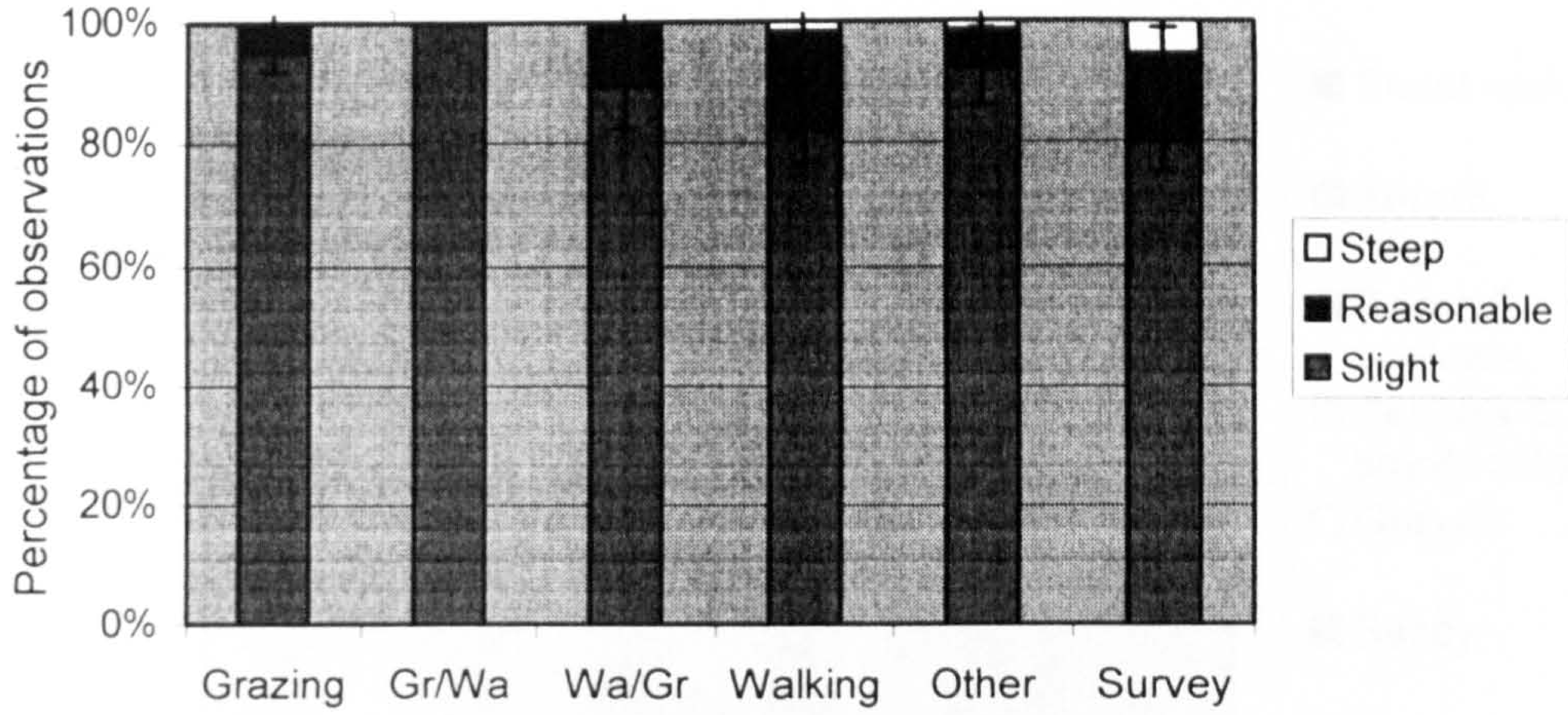


Fig. 6.50a Influence of Slope Ratings on Rhino Activity

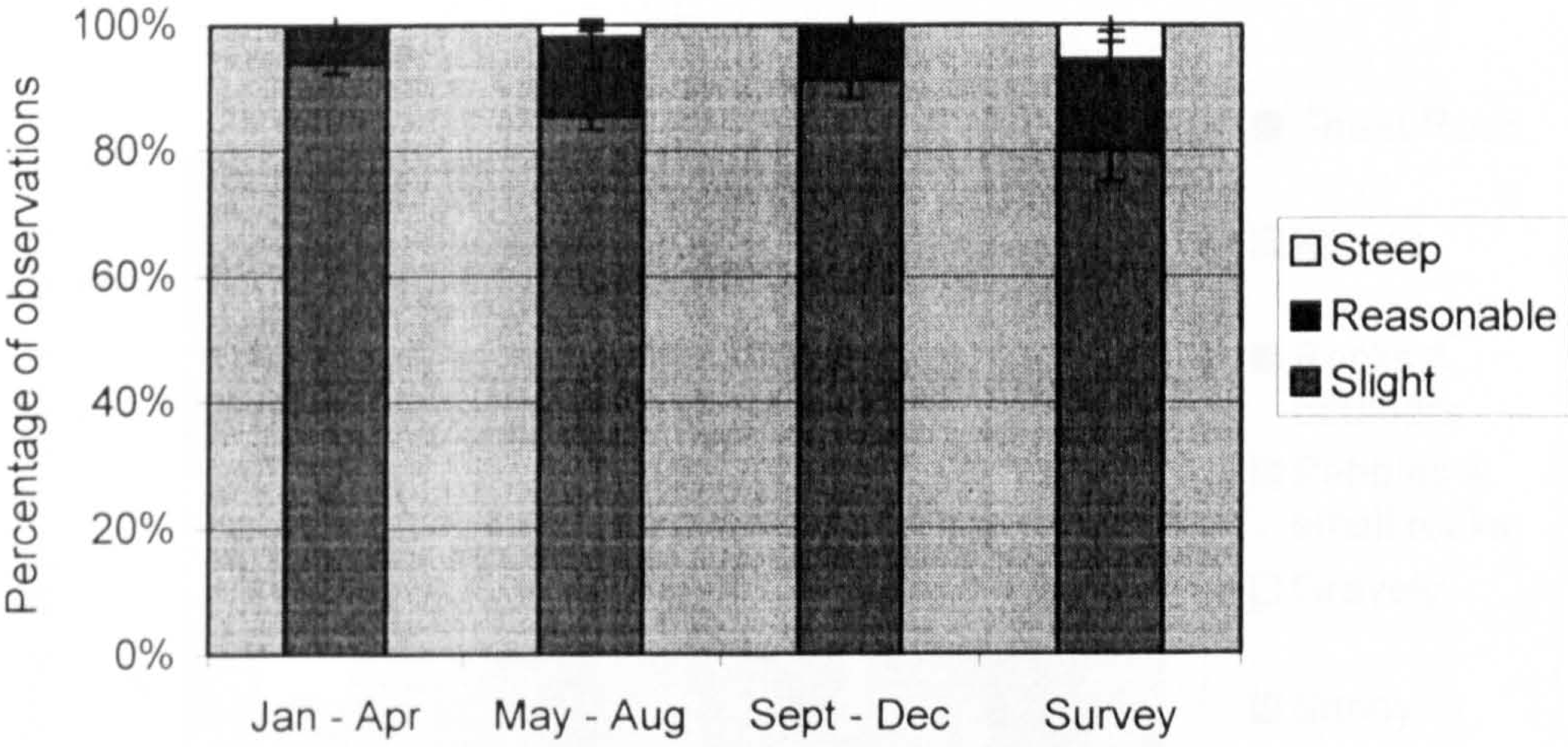


Fig. 6.50b Influence of Season on Slope Ratings Selected by the Rhino

Table 6.21 Significant Differences for Activity and Season with Respect to Slope Ratings Identified by Chi Square Analysis

Slope	df	Test Result	Significance
Observed grazing observations, compared with expected survey observations	2	23.84	**
Observed walking observations, compared with expected survey observations	2	5.24	NS
Comparison between main activities	6	22.83	**
Observed selection between January to April, compared to habitat survey	2	21.95	**
Observed selection between May to August, compared with habitat survey	2	8.35	*
Observed selection between September to December, compared with habitat survey	2	7.91	*
Comparison between three seasons	4	10.58	*

NS Not significant
* $p<0.05$
** $p<0.01$

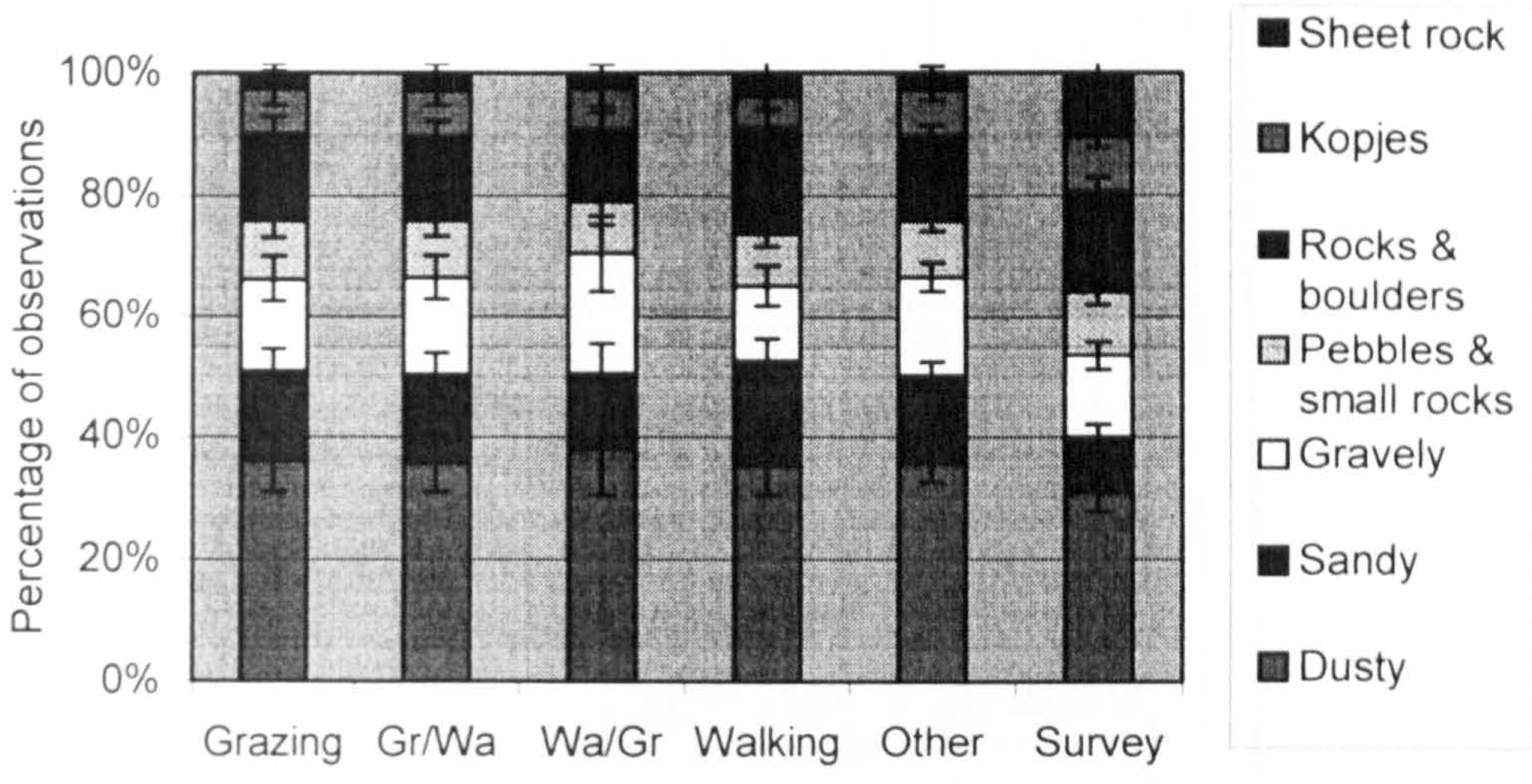


Fig. 6.51a Influence of Substratum Type on Rhino Activity

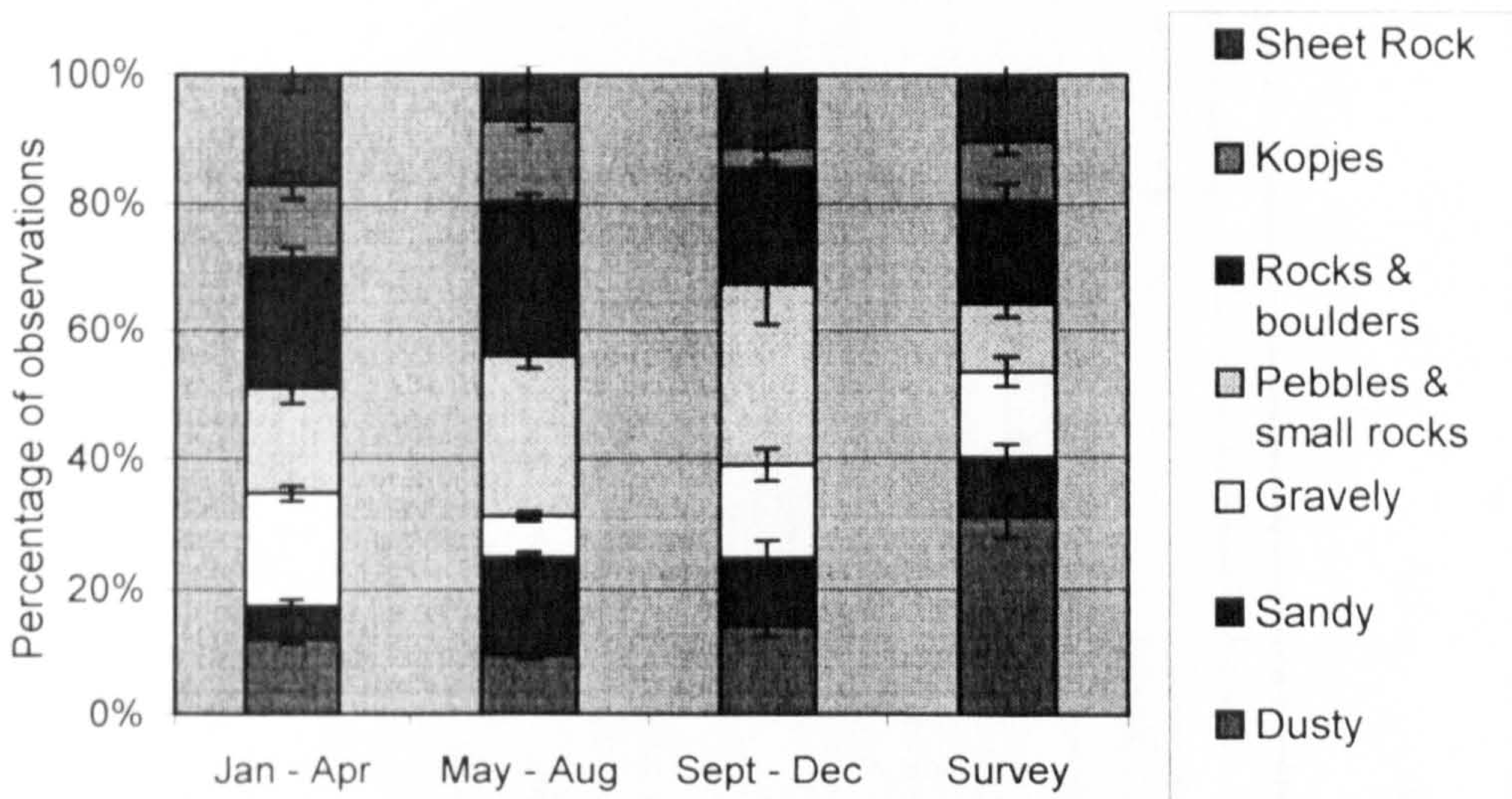


Fig. 6.51b Influence of Season on Substratum Type Selected by the Rhino

Table 6.22 Significant Differences for Activity and Season with Respect to Substratum Type Identified by Chi Square Analysis

Substratum Type	df	Test Result	Significance
Observed grazing observations, compared with expected survey observations	6	42.06	**
Observed walking observations, compared with expected survey observations	6	57.91	**
Comparison between main activities	18	18.26	NS
Observed selection between January to April, compared to habitat survey	6	593.86	**
Observed selection between May to August, compared with habitat survey	6	2571.60	**
Observed selection between September to December, compared with habitat survey	6	167.59	**
Comparison between three seasons	12	82.29	**

NS Not Significant
* $p<0.05$
** $P<0.01$

Table 6.23 Summary of Utilisation of Herbaceous Layer Parameters

Herbaceous Layer Parameters	GIS Analysis with Utilisation Ratios (section 6.3.1.1)		All Species Analysed with Pie Charts (section 6.3.3(i))		Individual Species Analysed with ANOVA (section 6.3.3 (ii))	
	Grazing	Walking	Grazing	Walking	Grazing	Walking
MVSP 8 class Detailed map	Class 2 negative Rivers positive	Class 2 negative Class 5 and water holes positive				
TWINSPAN 4 class Detailed map	Class 1 negative Class 4 and rivers positive	Type 1 negative Water holes positive				
MVSP 3 class Detailed map	Class 1 and 3 negative Rivers positive	Class 1 negative Water holes positive				
Schmidtia kalahariensis	Positive	Positive	Positive	No effect	Positive	Negative
Stipagrostis uniplumis	No effect	No effect	Negative	Positive	No effect	No effect
Eragrostis nindensis	Negative	Negative	Negative	Negative	No effect	No effect
Eragrostis porosa	No effect	No effect	No effect	Positive	No effect	No effect
Aristida adscensionis	No effect	No effect	Negative	Negative	No effect	No effect
Aristida species	No effect	No effect				
Eragrostis species	No effect	No effect				
Annuals					No effect	No effect
Cenchrus ciliaris					No effect	No effect
Biomass rating	Positive	Negative			Positive	Negative
Biomass in focal area					Positive	Negative
Density category	Positive	Positive				
Forage factor	Negative	Negative				

Positive	Activity and herbaceous parameter are directly related.
Negative	Activity and herbaceous parameter and inversely related.
No effect	Indicates that no relationships were identified.

Table 6.24 Summary of Results on the Relationship between Habitat and Activity

Habitat Parameter	GIS Analysis with Utilisation Ratios (section 6.3.1.2)		Rhino Observations Directly Compared to Habitat Survey with Chi Square (section 6.3.4)	
	Grazing	**Walking**	**Grazing**	**Walking**
Habitat class Detailed map	Rivers positive Class 3 negative	Class 1, 4 and water holes positive Class 3 negative		
Vegetation type	Grass and shrub savanna preferred	Grass and shrub, and high tree savanna preferred	Prefer grass and shrub savanna	Prefer grass and shrub, and high tree savanna
Distance from rivers	Very positive. Prefer areas close to riverbeds	Positive. Prefer areas close to riverbeds		
Distance from waterholes	Positive. Prefer areas close to water holes	Very positive. Prefer areas close to water holes		
Rockiness rating	Negative. Avoid increasing ratings of rockiness	Negative. Avoid increasing ratings of rockiness	Negative. Utilisation decreases as rockiness increases	Negative. Utilisation decreases as rockiness increases
Rocks, yes or no	Negative. Avoid areas with over 60% rock cover	Negative. Avoid areas with over 60% rock cover		
Soil	Type D positive. Rocky C2 negative	Type A and D positive. Type C1 negative		
Substrate			Prefer sandy substrates	Prefer sandy substrates
Slope			Negative. Avoid increasing gradients of slope	No effect

Positive — Activity and habitat parameter are directly related.
Negative — Activity and habitat parameter are inversely related.
No effect — Indicates that no relationships were identified.

Table 6.25 Summary of Results of Relationship between Trees and Activity

Tree Parameter	GIS Analysis with Utilisation Ratios (section 6.3.1.3)		Rhino Observations Directly Compared to Habitat Survey with Chi Squared (section 5.3.4 (ii))	
	Grazing	Walking	Grazing	Walking
Tree classification	Class 3 and rivers positive Class 1 negative	Class 3 and water holes positive Class 1 negative		
Tree cover	No effect	No effect	Negative. Avoid higher ratings of tree cover	No effect
Mopane species	Negative	Negative		
Acacia species	Positive	Positive		
Terminalia species	No effect	No effect		
Combretum species	Positive	Positive		

Positive — Activity and tree parameter are directly related.
Negative — Activity and tree parameter are inversely related.
No effect — Indicates that no relationships were identified.

6.3.6 Limitations

i) The number of locations where activity was analysed in Sections 6.3.3 and 6.3.4 was different to that analysed with GIS. This is because all GPS positions which fell outside the boundaries of Kaross were ignored in the GIS analysis as they could not be correlated with habitat of herbaceous layer classes inside the fence. However, GPS locations were not necessary for rhino observations, which were analysed without using GIS.

ii) Activity observations and utilisation patterns analysed in this Chapter do not take into account any possible differences in rhino behaviour between the sexes, e.g. territoriality or individual preferences.

iii) Although different techniques were necessarily involved in measuring herbaceous layer in the habitat survey and for tracker guided observations, they were intended to collect essentially comparable sets of information. During the habitat survey with the wheel-point apparatus, records of bare ground and unknown grass were recorded. When making rhino focal area observations of grass species, annual grasses and forbs were included, which were not recorded during the habitat survey.

iv) Assigning an average mass to a biomass rating is inherently imprecise since the rating actually represents a range of values between two levels. The rating was also influenced by the characteristics of the grass species. For example, *Stipagrostis uniplumis* as a stemmy, hard and rigid species which might cause the DPM disc to land higher than a soft and crushable species such as *Schmidtia kalahariensis*.

v) When comparing this study with other investigations of utilisation, it was noticeable that other studies were all based on direct observations of rhinos grazing. Consequently, more detailed comments on the heights of grass and the selection of shade grasses were possible. The results of this study are mainly derived from tracker guided data and are therefore less specific.

vi) This study has investigated the grazing preferences of rhinos, however it must be noted that these are only one of the various grazing animals in Kaross. There may be effects caused by other grazers, however these are considered to be insignificant.

6.4 Discussion

To investigate the utilisation of Kaross by the white rhino, it was first necessary to establish the characteristics of the available habitat. An extensive habitat survey was carried out across the area to provide details of the herbaceous layer and the distribution of other habitat parameters (Chapter 4). Habitat utilisation was then determined by relating rhino activity observations (Chapter 5), to the habitat survey data.

White rhino utilisation was discussed with respect to inter-relationships between habitat parameters and grass species. Ordination analysis and dendrograms, obtained in Chapter 4, were referred to where necessary to provide indications of these relationships.

In this discussion the results of the study were compared with other relevant investigations. The techniques applied were also evaluated, including the effectiveness of using GIS for analysing utilisation of a habitat by a species.

Inter-relationships between Chapters 4 and 5 were discussed here, together with a critique of methods. Key elements of this discussion were then included in the overall discussion, Chapter 7.

6.4.1 Utilisation Of Kaross By Rhinos

This assessment of utilisation assumes that the rhinos were aware of the specific habitat available within Kaross and were selecting areas to utilise according to this knowledge in such a way that best fulfils their ecological requirements. Utilisation may be primarily for nutrition but also relates to drinking, sleeping and social behaviour such as maintaining a territory and reproduction. The inter-relationships between habitat and grass species were also considered.

6.4.1.1 Herbaceous Layer

Analysis enabled the following observations on herbaceous layer utilisation and seasonal variations in grazing.

i) Herbaceous Layer Classification

Correspondence analysis identified homogenous areas of herbaceous layer characterised by certain species of grass. The classification systems were then processed using GIS analysis. The eight-class MVSP classification system indicated low utilisation of areas with higher than average levels of *Eragrostis nindensis* and *Aristida adscensionis*. The four-class TWINSPAN system indicated less use of areas with high levels of *Enneapogon cenchroides* and bare ground. Areas characterised by higher than average *Stipagrostis uniplumis* and bare ground were often associated with increased utilisation. Finally, the three-class MVSP system indicated a preference for areas characterised by higher than average levels of *Schmidtia kalahariensis*, *Eragrostis nindensis* and *Eragrostis annulata*. No consistent trends were readily apparent from these data.

The results of grass classification by multivariate techniques were compared with the results identified for individual species. TWINSPAN four-class grass classification results were not supported by individual species analysis. MVSP three-class grass analysis supported the rhino's observed preference for *Schmidtia kalahariensis*, however it also indicated that *Eragrostis nindensis* was preferred although analysis for this species indicated that it was not. Eight-class MVSP analysis identified avoidance of *Eragrostis nindensis*, which was supported by individual species analysis.

Multivariate techniques were in general able to identify discrete herbaceous layer areas and to a certain extent the grass classes have indicated rhino preference for certain species. However these classes were constructed on the basis of species which were identified as indicative of different grassland communities, and it is possible that rhino grazing preferences were not directly related to the same distinguishing species.

ii) Grass species

Schmidtia kalahariensis and *Stipagrostis uniplumis* were the most abundant species in the area and comprised 60% of the grass species in the focal area during grazing observations. This study identified twelve grass species which formed the most common constituents of the focal area during grazing observations, and these comprised 93% of the food intake of the rhinos. In the Umfolozi, the majority of the diet consisted of four species, of which the dominant twelve species comprised a comparable 95% of grass species ingested (Owen-Smith 1973). In the Pilanesberg, 36 grass species were recorded during grazing observations (Borthwick 1986). This compares to 18 different grass species recorded in grazing observations of the rhinos focal area in Kaross. Differences in the species composition of the herbaceous layer between Kaross and other study areas makes other comparisons difficult.

Analysis indicated that *Schmidtia kalahariensis* was consistently identified as selected for grazing and formed 43% of the grass species in the rhino's focal area during grazing observations. This is an annual grass, which has been described as unpalatable by Bothma (1989) and was allocated a forage factor of two (Du Plessis 1992), but occurs in abundance in this area. However, Müller (1984) described this species as grazed before the flowering stage and again later when dry, when it is reasonably valuable as fodder. Müller considered that the inflorescence in particular had a high nutritive value and provided a valuable supplement to the diet of stock. *Schmidtia kalahariensis* availability was found to decline as the year progressed, however the rhinos continued selecting this grass by eating broken off stems and leaves.

Stipagrostis uniplumis is a perennial species which was not significantly recognised as influencing rhino spatial utilisation, however focal area observations identified that it tended to be avoided during grazing activity. This grass is a medium-tall stemmy species, whose abundance remained reasonably consistent throughout the year. It has been described as palatable (Bothma 1989; Müller 1984) and it was allocated a forage factor of five by Du Plessis (1992). Müller (1984) describes this as a valuable grass species which is an important contributor to yearly pasture production in Namibia. Infrequent direct observations indicated that this species was occasionally grazed, especially during the rainy season when green leaves were sprouting. It would therefore appear that while this species does not exert a strong influence on selection it does form a component of the white rhino's diet.

Spatial patterns of rhino utilisation indicated avoidance of *Eragrostis nindensis*, which might be because this species is actually avoided or because where it is present another factor is deterring rhino utilisation. This is a small perennial grass species which generally occurs in clumps and was allocated a forage factor of four by Du Plessis (1992). Müller (1984) describes it as a valuable, palatable, drought-resistant species which shows a preference for bare, exposed areas and stony, sandy soil. Analysis of quantities of *Eragrostis nindensis* in the rhinos focal area indicated that greater quantities of this species were grazed at the end of the dry season. This implies that either this species or the habitat associated with it, was preferred at this time of the year. Observations of the herbaceous layer indicated that the abundance of this species declined towards the end of the year, possibly because it was heavily selected by other grazers. However it was also noted that it remained longer in increasingly rocky areas. It is therefore possible that the observed trend with *Eragrostis nindensis* was caused by the increased use of rocky areas at this time of year.

Spatial analysis indicated that *Eragrostis porosa* abundance did not influence rhino utilisation and had no detectable effect on grazing activity. It is a sparse, annual grass with a forage factor of two (Du Plessis 1992) and its availability declined throughout the year. However focal area analysis indicated that it was more frequently encountered during walking observations than its average occurrence across the area. This species may therefore be characteristic of areas which rhinos utilised but did not graze.

'Annuals' were only recorded during focal area observations at the start of the rainy season when the new growth of annual species could not be identified. Since they were separately identified later in the year, analysis was not relevant. Annuals were identified by Owen-Smith (1991) as more acceptable to grazers after the rainy season, although they were not able to sustain this grazing pressure throughout the year. The decline in *Schmidtia kalahariensis* and *Eragrostis porosa* as the season progressed (described above) would support this observation.

Aristida adscensionis is a spiky, unpalatable species except when it is in its young growing stages (Müller 1984). It was allocated a forage factor of one by Du Plessis (1992). Spatial analysis indicated that its presence did not exert a significant influence on rhino grazing activity and therefore did not influence utilisation. It was not sufficiently abundant in the observations of the rhino's focal area to establish any patterns of utilisation. These results would tend to imply that *Aristida adscensionis* abundance does not deter rhino activity. The abundance of *Aristida* species appeared to have no effect on grazing activity, which contradicts the study by Owen-Smith (1973) in the Umfolozi, where *Aristida* species were identified as strongly rejected by rhinos.

Cenchurus ciliaris is a riverine grass which occurred very infrequently. Direct observations indicated that it was selected for grazing, however, its rarity hampered statistical confirmation of these observations.

iii) Forbs and Sedges

A noticeable preference for grazing the riverbed sedge *Cyprus* was recorded, but no grazing of forbs was observed. Owen-Smith (1973) noticed that sedges were rare and insignificant in the rhinos food, whereas forbs comprised 1% of the rhinos diet. In most cases they appeared to be ingested accidentally when mixed with grasses. Differences in the herbaceous layer between these areas could explain these differing observations.

iv) Grass Biomass, Density and Forage Factors

Analysis indicated that where grass biomass was very low in the focal area, rhinos were generally found to be walking. As grass biomass increased, grazing activity took priority over walking and in areas with a medium or high grass biomass, grazing was preferred. Availability of medium and high biomass areas increased during the rainy season and decreased as the year progressed. The low category of biomass ratings formed the dominant class in all activities; at the time of the survey it encompassed the majority (61%) of the area of Kaross.

Spatial analysis indicated that areas with increasing density of grasses encouraged rhino utilisation, especially for grazing. Therefore grass density and biomass were identified as factors which strongly influenced rhino selection. In Kruger, Pienaar *et al.* (1993a) reported that white rhinos preferred landscapes with dense grass cover, avoiding areas with sparse grass. This study indicated that while areas with sparse grass were still utilised, they were not valuable as grazing areas.

Spatial analysis of utilisation also indicated that increasing forage factor apparently discouraged utilisation. This observation may be attributed to the low forage factor of the dominant grass species *Schmidtia kalahariensis*, which was associated with highly utilised areas, or may have been because grass species of high forage factors are associated with a parameter which is unfavourable to rhinos. In Kruger, Pienaar *et al.* (1993a) reported that white rhinos displayed a preference for good quality grasses which fulfilled their dietary requirements. Borthwick (1986) described rhinos preference for certain grass types on the basis of their palatability, which may refer to the physical structure or its forage factor.

Ordination analysis in Chapter 4 indicated that grass density and forage factor were quite closely related. This association may be because *Stipagrostis uniplumis* (high forage factor) grows in isolated clumps (low density) whereas *Schmidtia kalahariensis* (low forage factor) grows at random as plentiful separate plants (high density). *Schmidtia kalahariensis* and high grass density are preferred for utilisation which may explain why areas with high forage factor do not appear to encourage utilisation.

v) Grass Species Grazed

Identifying the species of freshly grazed grass was generally only possible until the grass had become almost completely dry or brown around May. Fresh tears were then less evident and grazing action sometimes pulled the grass out with the roots or broke the stem in a location other than where the bite occurred. Similar limitations to identifying freshly grazed grass were identified by Owen-Smith (1973).

vi) Seasonal Trends

During the rainy season in Kaross, plentiful food and seasonal water were available and the rhinos no longer found it necessary to spend time walking between water holes and grazing areas. The biomass of their preferred food species, *Schmidtia kalahariensis*, noticeably declined during the year presumably as a result of grazing pressure, while abundance of the other dominant species *Stipagrostis uniplumis* did not noticeably decline.

During the rainy season there was an increase in grazing observations as the flush of new grass spread. The study did not extend over the months of March and April when most grasses were drying out, and consequently no species preference was observed over this period. Owen-Smith (1973) noticed that as the dry season began, rhinos in the Umfolozi selected shade grasses and those which remained green the longest.

vii) Grassland height

Rhinos in Kaross generally grazed grasses which were short or medium height, although long grasses (average height approximately 200mm, Owen-Smith 1988) could be found along the fringes of riverbeds and may include larger plants of the species *Stipagrostis uniplumis*. The white rhino is regarded as a short grass grazer (Player and Feely 1960; Foster 1967). During a study on their feeding ecology in the Umfolozi, Owen-Smith (1973) described short grasses as rhinos most important food source during the wet season while during the dry season they transferred their attention to medium-tall grassland. This observation agrees with the study of Borthwick (1986), who observed that grass height was a major factor in rhino selection.

viii) Grazing and Nutrition

This study has identified the grazing preferences of white rhinos in Kaross. It has not investigated the nutritional quality of their diet, other than by broadly considering the forage factor of grass species. The main factors to be considered in nutrition studies to estimate dietary intake are described below, and provided grounds for deciding not to include this in the Kaross study.

O'Connor (1992), identified some of these additional factors as including plant structure and size, moribundness of tufts and stemminess resulting from grazing pressure. O'Reagain and Mentis (1990) also identified the amount of leaf and the leaf table height as important factors influencing the acceptability of a grass. Bothma (1989) detailed factors relating to herbaceous layer, which may influence the chemical composition of what a grazing rhino may ingest, as including the grass species (as a result of different physical and chemical properties), parts (leaves or stems), height, palatability, accessibility and growth phase (seasonal effects of palatability).

This study on the white rhino in Kaross has identified grass species composition and abundance as important factors affecting the selection of grazing areas. However the forage factor of grazing was not identified as an important parameter influencing grazing.

6.4.1.2 Habitat

Walking observations tended to utilise habitat types similar to the availability of those identified by the habitat survey, particularly with respect to tree cover and slope. Grazing observations however, indicated the use of habitat classes in different proportions from those available. Of the habitat which rhinos utilised, grazing and walking activities were equally likely to occur in areas with similar rockiness ratings and substratum type. Selection between seasons indicated that, except for rockiness ratings, rhino utilisation of habitat classes varied throughout the year.

Spatial and statistical analysis techniques enabled the following specific observations on rhino habitat utilisation:

i) Habitat Classification

Spatial analysis indicated that rhinos frequently utilised riverine areas for grazing. Walking observations were high around water holes, since the rhinos regularly visited these areas to drink. Utilisation of rocky areas was low since these areas were avoided. North and north-eastern plateau areas, undulating plains and open valley areas were all readily utilised, although they did not appear to exert a significant influence on activity. Overall, utilisation patterns in Kaross appear to be relatively broad and encompass a variety of habitats.

ii) Vegetation Type

Low tree savanna was the dominant vegetation type covering 92% of Kaross, and was therefore associated with the majority of observations. However, rhinos apparently prefer utilising grass and shrub savanna, and to a lesser extent high tree savanna than the dominant vegetation type. Therefore, while rhinos are frequently found in savanna with low tree density, they utilise open areas for grazing whenever they are available. Statistical analysis identified a significant selection for high tree savanna between May and August, possibly reflecting a preference for the riverine areas at this time of year. Borthwick (1986) described white rhinos as utilising a wide range of habitat types, both on an annual and seasonal basis in the Pilanesberg Game Reserve. This generalist behaviour is similar to the rhinos in Kaross. Vegetation structure was regarded as playing an important role in deciding whether an area is suitable habitat for white rhino in the Kruger National Park (Pienaar 1994a). White rhinos were described as preferring habitats where the shrub layer (<2m) is open to moderate and avoiding dense woody vegetation and open plains lacking shade in Kruger (Pienaar *et al.* 1993a).

iii) Rivers

Spatial analysis indicated a strong increase in rhino utilisation as proximity to riverbeds increased, indicating that these areas are preferred habitats. Although rivers flow infrequently in Namibia, river valleys often act as catchment areas for nutrients and with water more readily available, they provide distinctly different herbaceous species and vegetation. Trees often grow well in these areas and can provide animals with necessary shade. This preference for watercourses in the Kruger National Park was described by Pienaar *et al.* (1993a).

iv) Water Holes

Rhinos are dependent upon regular access to water holes, especially during the dry seasons (see discussion in Chapter 5). Consequently utilisation, especially for walking observations, increased around these areas. The areas around water holes are generally heavily grazed and trampled. Observations indicated that rhinos would sometimes graze lightly close to the water hole after drinking, possibly while waiting for other individuals. However, spatial utilisation patterns indicated that they preferred not to graze in these areas.

v) Rockiness

All analyses indicated a decline in utilisation in high rockiness areas. Observations predominantly occurred in areas with rockiness ratings between none and low throughout the year. Occasional observations did occur in areas with medium rockiness ratings, although these were generally avoided. Areas with over 60% surface rock were almost entirely avoided. However, on two occasions in the south-western corner of Kaross, rhinos were observed to walk through very rocky and hilly areas which could have been avoided, indicating that although they are not preferred, rhinos are still tolerant of these regions. Pienaar *et al.* (1993a) indicated that rhinos prefer areas without stones and rocks and would avoid areas if these became abundant on the surface.

vi) Soil and Substratum

Analysis indicated that the rhinos prefered the habitat associated with soils from fluvial sediments which were associated with riverine areas and soils of the 'Highveld and Otavi mountains' (Beugler-Bell 1996), which was typical of the north-eastern plateau areas.

Grazing utilisation was low on soils from the Kaross granite zone which have more than 70% of the surface covered with stones, boulders and bare rock, and are typical of the hilly and rocky areas to the west of KarossFontein. Analysis of substrata indicated that the rhinos tended to prefer sandy areas and avoid sheet rock substratum. This was in accordance with the observations of Pienaar (1994a), that white rhinos prefer sandy soils with few stones and rocks on the soil surface. The white rhinos in Kaross indicated no preference for soils which were derived from granite, which contradicted studies by Pienaar (1994a) that in the Kruger National Park, white rhinos displayed a preference for granitoid plains. Owen-Smith (1988) described white rhinos as selecting grasslands with soils derived from shale or dolerite, while they avoided soils derived from sandstone. However none of these soil types were recorded by Beugler-Bell (1996) as occurring in Kaross.

vii) Slope

Analysis of the results indicates a decrease in utilisation as the slope increased and the landscape became steep or mountainous. Slope ratings are generally closely associated with rockiness ratings (see ordination analysis Chapter 4) because as rockiness increases, slope also tends to increase. Consequently the results were very similar. Pienaar *et al.* (1993a) and Borthwick (1986) noticed that rhinos avoided mountainous areas probably as a result of their inaccessibly steep slopes. Most landscape utilisation was of undulating or flat areas, for which Pienaar *et al.* (1993a) also noted a preference.

6.4.1.3 Trees

i) Tree classification

Spatial analysis of rhino utilisation with respect to identified regions of similar tree classifications indicated high utilisation of areas where all tree species were present. In areas where *Mopane* was present with some *Catophractes* and *Boscia*, utilisation was low.

ii) Tree cover

In Kaross, tree canopy cover was not identified as a factor influencing utilisation, possibly because it was never either very dense or absent. However, there was a slight preference for grazing in more open areas with very low tree cover, particularly during the rainy season. Borthwick (1986) described tree canopy cover as a major factor in white rhino habitat selection throughout the year. He described rhino preference for wooded valley savanna and thicket, whereas Pienaar *et al.* (1993a) described white rhinos as preferring a moderate tree stratum.

iii) Tree species

Rhinos were found to avoid areas with an abundance of *Mopane* trees and shrubs, which may be reflecting their preference for riverbeds and erosion areas. Rhinos preferred to utilise areas with a high abundance of *Acacia* species, possibly because these areas sometimes had a very low basal cover. This was in accordance with the observation of Owen-Smith (1981) that rhinos in the Umfolozi were typically associated with *Acacia* savanna. Rhinos in Kaross also indicated a slight preference for the absence of *Combretum* species. Rhinos in Kruger National Park were found to display a preference for *Combretum* woodland (Pienaar 1994a). However, because the habitat in Kaross is very different from that in Kruger, the presence of this tree species may well be indicative of different habitat.

6.4.2 Critique of Methods

i) GIS

GIS analysis provides a powerful tool for spatially analysing the rhino utilisation of Kaross in relation to the habitat survey of herbaceous species and habitat types. Techniques and benefits utilised included:

- Plotting observed rhino locations from GPS readings.
- The extrapolation of habitat survey data for correlation with rhino locations.
- Following analysis of transect data, interpolation of the results of multivariate analysis, grass density, forage factor, *Aristida* and *Eragrostis* species.
- The incorporation of more accurate maps, including soil type, presence or absence of over 60% surface rock cover, distance from rivers and water holes, etc.
- The development of detailed maps, with basic homogenous areas, rivers, water holes and vegetation types all represented.

To investigate the accuracy of GIS analysis, identified trends were visually compared with the results of rhino monitoring observations and the survey data. Herbaceous species data were shown to agree for three of the four grass species, however GIS analysis was not sufficiently sensitive to identify a relationship between rhino activity and *Stipagrostis uniplumis* abundance. When comparing results of habitat analysis, all techniques agreed on the influence of vegetation type and rockiness. It was therefore concluded that the application of GIS analysis was particularly appropriate and useful in the context of this study.

Potential problems included the influence of the resolution of the survey grid when analysing utilisation. Kaross covers approximately 15,000ha and the herbaceous layer was surveyed with 100 sample positions in each of 257 transects. The influence of the sampling grid was tested by analysing the five-class soil map (Beugler-Bell 1996) with and without the assign-proximity function. The results identified the same trends, however some discrepancies between certain utilisation indexes were apparent. Although improved resolution could have been achieved by increasing the number of transects, the survey grid applied was considered to provide adequate detail. Studies by Smith *et al.* (1997), into Lemur abundance and distribution in western Madagascar measured and identified microhabitats by investigating only 64 stratified sites in an area of 94,000ha. They found that a sampling intensity of less than 0.1% was sufficient to provide an objective foundation for regional biodiversity planning.

ii) Grazing Observations and the Focal Area Technique

Assessing the grazing preferences of a free-ranging herbivore may be achieved with various techniques. Those selected for use in this study are discussed below, together with their benefits and limitations.

Direct observation of grazing involves accompanying an animal in the field and recording its feeding preferences. This requires noting the location the animal had been grazing and then visiting the spot to record grass species eaten (Lamprey 1963). This technique was used by Owen-Smith (1973) for studying grazing of rhinos. Rhinos occur at high densities in the Umfolozi and they usually ignore disturbance by nearby humans. In Kaross however, low rhino density and infrequent human contact made them difficult to locate on a daily basis and once located they were very easily disturbed. Time spent conducting direct observations was therefore limited. In addition, rhinos are nocturnal, remaining active only during the cooler hours after sunrise and just before sunset. Consequently, it was unlikely to be feasible to collect continuous feeding observations of specific individuals. To ensure that direct observations provide the most accurate results, observations at close proximity are preferable. Results are also highly dependent on the sampler (Erasmus *et al.* 1978).

Tracker guided observations led to the development of the **focal area technique.** This method was based on the research of Owen-Smith (1973) who stated the rhino's feeding site as 'within an area defined by what I could touch with my fingers while standing with legs straddled'. The extent of this feeding site was substantiated by the observation that white rhinos appeared to use olfactory information to detect certain grass species which were avoided during grazing (Owen-Smith 1988). Tracker observations enabled the location of the rhinos feet to be pinpointed. Grass species in the area in front of this could be recorded with respect to activity and then investigated for evidence of freshly grazed grass. These observations indicated that analysis of the rhinos 'focal area' was appropriate for investigating utilisation patterns and grazing preferences.

Other techniques used include the identification of grass species eaten by microscopic analysis, from fragments of leaf epidermis in faeces (Stewart 1967). This technique is most applicable in areas with few available grass species and has been undertaken with limited success. With captive animals it is possible to analyse pasture of enclosed areas before and after grazing (Stoddard 1952), which is not possible when studying wild animals.

Overall the most appropriate of these techniques was considered to be a combination of direct observations and the adaptation of techniques for tracker guided information. However, it was only possible to assess the grazing of white rhinos by using focal area observations to indicate species preference and not the nutritional quality of the diet.

The focal area analysis technique is very insensitive to small grazing preferences and is far more applicable for the identification of basic patterns of selection of habitat type, grassland type, etc. More direct observations could have helped refine the technique but were not possible with this study group of rhinos.

iii) Grass Biomass

Converting biomass ratings taken with the Disk Pasture Meter to an approximate weight of grass enabled ratings of the percentage of each grass species in the focal area to be quantified. This provided a value for the approximate biomass of specific grass species in the area, for statistical analysis. However, when analysing the influence of grazing on grass biomass, it was unexpectedly found that biomass ratings in the focal area compared with the surrounding area were not measurably reduced as a result of grazing activity. However, biomass ratings do provide a rather crude estimate of grass quantity and this result is probably a consequence of this.

iv) Analysis

During statistical analysis, emphasis was placed on pure grazing and pure walking observations where appropriate, to simplify the results. This approach proved appropriate since the graphs showing 95% confidence limits identified significant trends which could then be compared with other studies.

Chapter 7

Overall Discussion

7 Overall Discussion

Following the recovery of the white rhinoceros from being close to extinction earlier this century, it is estimated that in 1997 there were approximately 9,000 animals world-wide (UK Rhino Group 1998; Frädrich 1997). The relative success of the conservation efforts involved has resulted in CITES listing of the white rhinoceros being amended in 1994 to permit the controlled export of live animals and hunting trophies from South Africa (CITES 1994).

However, this research has shown that although the species has a broad habitat and grazing preference, the success of a population depends upon a combination of environmental, ecological and management factors. Case studies of populations on game farms and National Parks in Namibia have highlighted management requirements and identified the principal factors which influence population success. Utilisation patterns of these grazing megaherbivores in a semi-arid environment have been investigated to establish the limitations of a potentially marginal habitat. The results are discussed with respect to the global status of the species to provide a basis for assessing future white rhino introductions in Namibia.

7.1 Global Status

All white rhinos existing in the 'wild' are located in Africa, with South Africa having the largest populations. In captivity, white rhino are kept in several hundred zoos and wildlife parks world-wide, although few are attempting any captive breeding programme (Frädrich 1997).

7.1.1 Namibia

Namibia is predominantly a semi-arid environment, which is often only marginally suitable for white rhino. Since introductions to game farms (Chapter 2) began in the 1970's, a total of 103 white rhino have been introduced, of which in 1997 only 69 animals could be accounted for (although some others may have been sold on outside Namibia). The main decline occurred prior to 1987, and since then numbers have recovered at a marginal 0.9% per annum.

The principal reasons for the decline in numbers on game farms include poaching, hunting, drought, mismanagement and a small but unknown number of live sales. Monitoring and security have often been insufficient to deter poachers, although this situation is improving on farms which are most at risk. On occasions, animals have been introduced to properties where the conditions are inherently unsuitable. Vulnerable to drought, farm management has sometimes not been sufficiently responsive to ensure their survival. In the past, populations have also been exploited to maximise financial gain through hunting. However following the increase in the value of the animals in 1989, more responsible management are now providing adequate monitoring , protection and support.

Introductions to the National Parks began in 1975 (Chapter 3). A total of 32 rhinos have been released and in 1997, 60 individuals were present. The main reasons for the increase include good management, avoidance of over-stocking of other grazers, more recently organised monitoring, regular security patrols and the de-horning of rhinos in some areas. However, recruitment has still not been as high as expected and there have been 18 recorded deaths. The principal causes of these mortalities include poaching, which mainly occurred before present security measures were introduced, and capture-related stress, which was partly a consequence of transportation problems during the introduction.

Overall between 1987 and 1997, there was an annual increase of 3.0% in the numbers of rhinos on game farms and National Parks in Namibia.

7.1.2 South Africa

In the Umfolozi-Hluhluwe Complex, Owen-Smith (1981) estimated that the white rhino population expanded at a rate of 9.5% per annum between 1960 and 1971, which indicates very successful recruitment. However, this rapid population growth resulted in increased grazing pressure and the need to control the numbers of white rhino. Over-utilisation was leading to areas of medium-tall grassland being converted to short-grass grassland (grazing lawns), with increasing areas of exposed soil and erosion (Owen-Smith 1981).

From 1961 onwards, white rhinos were translocated from Umfolozi to the Kruger National Park (Pienaar 1970). Over a 12 year period, 345 were released and by 1991 this number had increased to 1,565 (Pienaar *et al.* 1992).

Early introductions to private land in South Africa were less successful. White rhinos were first surveyed in 1987, which showed that numbers had significantly declined since they were initially released due to over-exploitation (Buijs & Anderson 1989). Consequently in 1989, NPB allowed rhinos to fetch a much higher, full market value at auction, with the expectation that this would encourage owners to conserve their animals. By 1996 there had been a substantial increase in the numbers of rhino on game farms in South Africa to 1,475, one fifth of the country's total (Buijs & Papenfus 1996).

The above data demonstrates that in favourable circumstances white rhino will breed relatively rapidly. The proposal by South Africa to CITES in 1997, to remove trade restrictions and commence sustainable utilisation of the populations (Buijs 1997), highlights the continued expansion of white rhino numbers and the current success of the species in South Africa.

7.1.3 Zoological Parks World-Wide

Conversely, white rhinos in zoo environments are at present barely self sustaining. The International Studbook for African Rhinoceroses (Frädrich 1997), indicates that since 1940, 601 white rhino have been exported to zoos and in 1997, 697 were listed in captivity world-wide. Bertschinger (1994) recorded the overall increase in numbers of white rhinos in captive breeding programmes worldwide as only 2% over the three year period 1987 - 1990. The American Zoo and Aquarium (AZA) organisation describe the southern white rhino in its breeding programme as not self-sustaining (Fouraker & Wagener 1996). Only 3% of the population were captive born and bred, many individuals were not reproducing and the average age was increasing. Fouraker noted that the percentage of wild-born individuals breeding was significantly greater than captive-born individuals.

The long-term future of captive populations in zoos world-wide is also uncertain due to the genetic implications of breeding in small isolated populations. Another factor is that captive breeding programmes in zoos are relatively expensive. The annual cost of captive conservation of white rhino was found to be 2.8 times higher than in well funded and managed field-based programmes (Balmford *et al.* 1995), although this may be offset by the zoo's income from visitors.

The increasing trend for conserving animals in their natural habitat is illustrated by the introduction, in 1996, of a captive-born white rhino bull to Etosha from a German zoo (Böer *et al.* 1997). This zoo has a good record of breeding success, however this bull became a problem because he was increasingly aggressive towards his father, the dominant breeding bull. His translocation to Etosha was arranged as his parents were apparently bought from a game farm in Namibia (P. Erb, EEI, MET *pers. comm.*).

7.1.5 Social and Economic Aspects

Compared with the vast size of the country, Namibia's human population is small at 1.6 million, but it is expanding rapidly (Ashley 1996). Most Namibians depend upon natural resources, particularly agricultural land, for much of their livelihood. Poverty is widespread, and this is exerting increasing pressure on the country's economy and resources. This could increase the incidence of poaching, since in relative terms, the potential profits are high. Although international legislation controls trade in endangered species, demand for rhino horn continues to exist and fuels an illegal trade.

It is therefore likely that the long-term survival of many species and habitats depends upon their protection within fenced boundaries. Approximately 13.6% of Namibia's total surface area has been designated as conservation areas (Baker 1996). In addition to these conservation areas, a further 43% of Namibia's land area is occupied as privately owned commercial farm land (Barnes & de Jager 1996). In recent years an increasing number of farms have changed to wildlife farming instead of livestock. Since these fenced areas are smaller and more fragmented than the original ranges of most species, they also require more expensive active management.

Since Independence in 1990 the number of tourists visiting Namibia has increased significantly (Holm-Petersen 1996). Tourism has now become the second largest generator of foreign exchange in Namibia and is essential to the national economy (Jacobsohn 1996). Wildlife, including white rhinos, are an important element of the tourism experience and many farms are now seeking to benefit from this by offering various safari-type holidays. Most game farm owners would prefer to introduce black rhinos which are an indigenous browser and are well suited to the country's thorn bush savanna. However, because they are very rare, endangered, expensive and are only available under a MET custodianship scheme (Lindeque 1994), white rhinos are usually introduced as a substitute species.

7.2 Habitat Utilisation

7.2.1 Kaross

Kaross covers an area of approximately 15,000ha and comprises a variety of habitat types (Chapter 4). The south and north-western areas comprise undulating plains, dotted with rock kopjes and riverbeds which stretch for kilometres. Distinct plateau areas exist in the far north and east of the area, and towards the southern and western regions, rocky valleys line dry river beds. Annual rainfall in Kaross has averaged 365mm over the last few decades, which was lower than other study areas and less than the average annual rainfall recommended for this species by Pienaar (1994a).

During the study period, a small population of five (later four) white rhinos were present (Chapter 5). This is an extremely low density when compared with other game reserves and National Parks where rhinos have been studied (Owen-Smith 1973; Pienaar 1993c; Borthwick 1986). Because of the low density of white rhino, there were minimal constraints on how the rhinos utilised the area, therefore study techniques had to be developed to accommodate infrequent direct observations.

Herbaceous layer and habitat parameters (Chapters 4) were analysed with respect to rhino movements (Chapter 5) to establish patterns of utilisation (Chapter 6). This combined information enabled the determination of rhino preferences and assessment of the effectiveness of GIS as a tool for ecological analysis. The results of Chapter 6 have been summarised here, with occasional references to other Chapters.

7.2.2 Herbaceous Layer Preference

Analysis of rhino utilisation indicated preferences for high grass density, high grass biomass and abundant *Schmidtia kalahariensis*, which is a common short grass in semi-arid areas. The ordination of grass species and habitat data indicates that *Schmidtia kalahariensis* abundance is unrelated to most habitat parameters, however its presence does tend to vary with grazing pressure. As the year progressed the available biomass of this species declined, which supports the observation that it forms a major part of the diet of rhinos and probably other animals in Kaross.

The rhinos avoided areas associated with high levels of *Eragrostis nindensis*, which may be because the abundance of this species increases as areas become steeper and more rocky, which are habitat characteristics that they tend to avoid. Whether or not the rhinos avoid the spiky unpalatable species *Aristida adscensionis* was uncertain as this species only occurred infrequently in Kaross. They preferentially utilised river-beds, but it was not possible to detect any preferences for specific riverine grass species. The forage factor (or quality) of grazing was not identified as a parameter affecting utilisation.

This group of white rhino concentrated their grazing on the abundant short-grass areas, and where medium and tall grasses did occur in small isolated areas they were not positively selected. White rhinos are commonly regarded as a short-grass grazer (Player and Feely 1960; Foster 1967). Owen-Smith (1973) described them as primarily short-grass grazers, but exhibiting seasonal selection of grasslands of different heights.

It would appear that while rhinos have certain grazing preferences, they are relatively general in their selection, utilising abundant species growing in the most accessible and available areas. This selection of abundant grasses is in accordance with their description as a gross feeder, adapted for the rapid intake of large quantities of food (Owen-Smith 1981). Borthwick (1986) also described a similar broad selection of grazing.

The rhino's habitat selection was therefore relatively broad with the exception of the areas avoided due to extreme or adverse factors. Selection appears to be more a function of grazing preferences and less related to habitat characteristics.

7.2.3 Habitat Preference

Spatial analysis indicated that almost all of the available habitat types in Kaross which were accessible to rhinos were visited at some time during the study period. However, utilisation of these areas varied and grazing activity was apparently more selective of habitat type than walking activity.

Preferred areas include undulating plains, open valleys, rivers and the plateau regions in the north and north-east of Kaross. Utilisation was not greatly influenced by tree canopy cover, possibly because it was never too dense or sparse to affect their behaviour. Trees which provided shade for their midday rest appeared to be plentiful and easily found. The rhinos preferred grazing in grass and shrub savanna and also clearly selected riverine areas for grazing, which incorporated observations of high tree savanna, sandy soils and *Acacia* species.

As the terrain became increasingly steep and the level of surface rock increased, rhinos appeared to avoid these areas, especially for grazing. However, only high rockiness areas were clearly avoided for grazing.

The rhinos visited water holes to drink with an average frequency of two days, which was more often than rhinos in the Umfolozi or Kruger (Owen-Smith 1988; Pienaar 1994a). They generally did not graze or sleep close to water holes, and consequently during the dry season often walked distances of over 5km to reach water. Drinking frequency greatly increased in the rainy season when plentiful water was available from temporary sources. Although the rhinos did not exhibit a preference for particular water holes, they are clearly dependent upon regular access to water sources for survival.

7.2.4 Seasonal Effects

Observations of the movements of the white rhinos in Kaross highlighted the influence of the seasons on their utilisation patterns. After the rains, the rhinos quickly utilised the first flush of grass, drinking from temporary water sources and spending more time grazing than at other times of the year. They concentrated on grazing in a small area during this time, however they occasionally carried out exploratory walks of the region apparently to locate other sites which may have been more preferable grazing.

During the dry season, they continued to select the common grass species *Schmidtia kalahariensis*, despite its declining availability, and when the species was practically all grazed, they began to pick up broken leaves of this grass lying on the ground. During the dry season months, they made particular use of areas close to riverbeds, but not necessarily of the long grasses growing on the banks of the river. Higher daytime temperatures resulted in rhinos resting for longer periods over the mid-day period.

During the rainy season, mud wallows were widely available and were often used by the rhinos. In the dry season they took regular dust baths.

7.3 Influences On Populations

The principal influences on an enclosed rhino population are management, habitat and population structure. These parameters are interrelated and variations in one will often influence the others.

7.3.1 Management

The quality of white rhino care and management, in terms of knowledge and commitment, on both game farms and National Parks has improved over the last decade. The management and running of National Parks is totally different from game farms since conservation of both species and habitat is the prime purpose of management, and economic pressures or the need to generate income are not relevant. Also, in general, the costs needed to carry out essential works are usually made available.

i) Monitoring

Regular monitoring of a rhino population is important for several reasons including:

a) to check the health and general well-being of the animals,
b) to establish animal condition and indicate when it is necessary to supplement feed,
c) to identify social groups and inter-relationships. This will help to identify animals suitable for possible trophy hunting and the identity of parents of offspring to avoid inbreeding in the future,
d) as part of security for physical protection of the animals.

Methods of identifying rhinos for monitoring purposes include recording distinguishing marks which occur naturally, for example patterns of creases in skin above the lips and also spoor patterns, alternatively animals may be marked by ear notches. This is particularly useful for nocturnal water hole monitoring, although after death a carcass may not be identifiable as the ears have often been removed by scavengers. Game farms however, usually prefer techniques which do not disfigure the rhino's appearance for tourists. For serious studies possibly following the introduction of a new population, radio transmitters, which can be received at distances of up to 10 km, can be attached by a collar or ear-tag or implanted into the horn (Pienaar & Hall-Martin 1991).

Establishing a monitoring team by employing local Africans to locate rhino by using indigenous tracking techniques is often appropriate (Owen-Smith & Jacobsohn 1989). Many Africans have a deep and inherent understanding of their natural environment which has the potential to significantly contribute to wildlife management and scientific investigations (Stander *et al.* 1997).

ii) Protection from Poaching

Appropriate measures for protection from poaching, which include regular patrols to locate the rhinos and checking perimeter fencing, depend mainly on the location of the farm or park. The considerable size of most farms and the wandering movements of rhinos make effective security expensive and it is very difficult to prevent or catch a poacher until it is too late. The level of poaching in Namibia was described as relatively small-scale and opportunistic in the past, however pressure may intensify in the future (Martin 1993). National Parks have protection techniques and anti-poaching teams well established.

A controversial method of deterring poachers is the de-horning of rhinos, which appears to be effective in Namibia. However, the process of immobilising and de-horning is expensive and horn regeneration in white rhino suggests a minimum de-horning interval of 1.2 to 1.5 years (Rachlow & Berger 1996). The ecological implications of de-horning are subject to debate and it has been suggested that de-horning may affect a mothers ability to protect young calves, thereby reducing population viability in the long term (Berger *et al.* 1993; Berger & Cunningham 1996; Martin 1993; Lindeque 1990; Lindeque & Erb 1995; Loutit & Montgomery 1994; Rachlow *et al.* 1993).

iii) Sustainable Utilisation

One major reason for the early decline in the number of rhinos on game farms was found to be excessive hunting which was apparent in Namibia before the 1990's, due to relatively low animal values (Adcock & Emslie 1994). South African surveys of white rhinos on private land in 1987 (Buijs & Anderson 1989) found similar evidence of over-utilisation.

The value of white rhinos has varied considerably over the years. As the biggest supplier of white rhino, the Natal Parks Board of South Africa fixed low sale prices until 1989 when prices were allowed to reach their true market value at auction and the average price increased to N$53,000. In 1992, prices had fallen to N$ 26,000 but in 1998 they had risen to N$ 116,000 (P. Erb *pers. comm.*).

Following these increases in value, owners have become motivated to conserve and manage their animals for sustainable utilisation through hunting, live sales and tourism. Hunting has been justified as helping to bring the economics of rhino ownership towards profitability and promoting the ownership of larger overall populations (Adcock & Emslie 1994). Without hunting, farmers may return to cattle farming without keeping rhino, or to pure tourism which needs fewer rhino (Adcock & Emslie 1994). Providing ethical hunting practices are followed, preferably in conjunction with an understanding of the group's social structure, hunting is a sustainable practice which should have no detrimental effect on a population. In Namibia, MET regulate trophy hunting by registering professional hunters and confirming which animals which may be trophy hunted, although the export of trophies from Namibia, unlike South Africa, is still prohibited by CITES regulations.

Eco-hunting or rhino-darting safaris have been described by Chilvers (1993). Despite associated problems on the Otjiwa game ranch, darting safaris are undoubtedly in accordance with the concept that game must be economically sustainable in order to be conserved, and many hunters are also genuinely interested in participating in conservation activities.

7.3.2 Habitat Suitability

Habitat suitability may be quantified by measuring the extent to which an area fulfils the ecological requirements of the white rhino, which include a suitable quantity and type of grass, water and shade. To date in Namibia, all rhino introductions have been to semi-arid savanna habitats.

Historically, the white rhino had an extensive natural range across Southern Africa, encompassing a variety of habitats. However, since the creation of reserves, parks, farms and other restricted areas, animals have been increasingly confined by fences. Habitat changes have consequently occurred, with grasslands modified by overgrazing, and climatic fluctuations, especially rainfall, causing further changes (Owen-Smith 1981). As a consequence, no area in Namibia now represents a habitat which may be described as entirely 'natural'.

Information on the historical distribution of white rhino provides an indication of the extent of natural habitats, historically present in Namibia, which previously satisfied the animal's ecological requirements. White rhino distribution in the past almost certainly extended into the central semi-arid area of Namibia but did not include very arid areas in the southern half of the country. Distribution in the north of the country across a range of rainfall gradients is uncertain.

Introductions of species on the periphery of, or to areas beyond their historical range are often unsuccessful, whereas releases of a species within the core area of its historical range have a good success rate (Novellie & Knight 1994; Griffith *et al.* 1989). This implies that introductions of rhinos to game farms in the semi-arid central areas of Namibia are more likely to be successful. However, in this study, introductions to this region were found to have mixed success due to variations in farm management and population size.

i) Indicators of Habitat Suitability

Possible indicators of habitat suitability may be obtained by analysing parameters such as the recruitment success and mortalities of a rhino population in relation to factors such as overgrazing indications, rainfall gradients, periodic droughts and the frequency of supplementary feeding. On every game farm studied with adult cows and bulls, calves had been born at some time although overall recruitment success had not always been good. Unfortunately, each population studied had been subject to significantly differing management regimes and founder population sizes. These factors, combined with the limited number of sample farms, introduced too many variables to permit analysis of the data to indicate habitat suitability. Waterberg certainly showed successful recruitment which apparently confirms the suitability of this habitat.

ii) Overgrazing and Supplementary Feeding

Maintaining animal numbers at levels above the carrying capacity of land results in overgrazing, which has led to vegetation changes in many areas of Namibia. Affected areas have exhibited a reduction of the herbaceous layer, soil erosion and increasing bush encroachment. Bush encroachment is a thickening of woody thorn bushes and trees, which intensifies the decline in the carrying capacity of the affected areas (Bester 1996). If the veld is in poor condition from overgrazing, the carrying capacity of an area may be many times lower than if it is in good condition (Bothma 1989). In the Umfolozi, white rhino population growth was found to be not self regulating and increased grazing transformed habitats and depressed the availability of food resources (Owen-Smith 1988).

Over-utilisation and over-grazing can be avoided by controlling animal numbers. However, in arid areas, stocking rates for game animals are difficult to determine and animals will often lose condition and die before they noticeably affect the vegetation by over-utilisation (Bothma 1989). In situations where animals are losing condition, farmers normally begin supplementary feeding to sustain animals through the year. In Namibia, approximately 78% of game farms provide their rhinos with supplementary feeding. However, if the number of animals continues to remain above the carrying capacity, degradation of the habitat will almost certainly continue.

iii) Access to Water

This study has shown that in semi-arid environments, white rhinos become increasingly dependent upon regular access to water holes. Access to permanent water sources is therefore critical for survival in these areas. Rhinos also require shade to lie in during the hottest part of the day.

iv) Disease

Anthrax is endemic to certain regions in Namibia and has been responsible for the deaths of white rhinos on game farms, as well as black rhinos and ungulates in Etosha (Lindeque 1991). This is a factor which should be considered prior to releases, to determine whether precautionary measures such as immunisation should be taken. No other diseases have been reported to have affected rhinos in Namibia.

v) Rainfall and Drought

Rainfall is possibly the most critical factor in determining the habitat characteristics of an area. In Namibia the rainy season normally extends between December and April but is notoriously erratic, both spatially and temporally. Over the past decade the country has experienced lower than average rainfall, resulting in widespread drought. The average annual rainfall on game farms studied was between 200mm and 400mm.

Rainfall and habitat in Namibia are different from that in areas of South Africa where white rhino have been studied (Owen-Smith 1973; Pienaar *et al.* 1992, 1993a&b). During low rainfall periods in South Africa, relatively few additional deaths of white rhino were recorded (Owen-Smith 1988). However, over 100 white rhino reportedly died in the Umfolozi during the very severe drought year 1933, when the total population only numbered about 300 animals (Player & Feely 1960).

Pienaar (1994) commented that the distribution of white rhino in the west of their historic range seems to coincide with the 400mm rainfall isohyet. He concluded that they should therefore not be moved to areas where the annual rainfall is less than 400mm without cautious consideration. Many of the introductions in Namibia were to areas with rainfall below this level.

vi) Game Farms

On game farms, some mortalities due to drought were found to be related to inadequate management and monitoring. In most cases, the provision of water and supplementary feed by management prevents inherently unsuitable or marginal habitat being a problem. On the other hand, the rhinos on O'vita had high recruitment levels, despite apparently poor habitat and with no supplementary feeding.

During the 1987 South African survey, Buijs and Anderson (1989) identified game farms in regions which were dry and regularly suffering from severe droughts, as not suitable for future relocation of white rhino because of the need for supplementary feeding. In other areas where supplementary feeding was required as a result of overstocking and not due to low rainfall, the problem was attributed to poor management. In these cases, possible future introductions should be approached with caution. D. Buijs (DuToit Game Services, Randburg, S.A. *pers. comm.*), reviewed the 1987 situation with respect to the white rhinos present population size. He considered that although introductions to the more arid areas will require intensive support, so long as the motives of the farmer are appropriate, there is no reason why permission should not be given.

vii) National Parks

National Parks in Namibia differ from game farms in a number of ways. They are managed to maintain the habitat as naturally as possible, with minimum intervention, which can provide a clearer indication of habitat suitability. To date, none of the National Parks in Namibia have needed to provide supplementary feed and it would appear that food availability is not at present a factor limiting the success of the Etosha rhinos. The viability of the introduction of white rhinos to Etosha seems promising according to the study of Gasaway *et al.* (1996), who found that food availability was not a limitation for the numbers of plains ungulates in Etosha. White rhinos sighted in Etosha have all been in good condition (P. Erb *pers. comm.*). Other encouraging indications for Etosha include the success of rhinos on a game farm on the southern boundary of Etosha, which have not been supplementary fed.

Waterberg National Park is part of the northern Kalahari sand-veld which is common in north-eastern Namibia. The leaching of nutrients through the soil has led to a sour-veld habitat type which has been identified as avoided by rhinos (Pienaar *et al.* 1993a & Pienaar 1994). However the recruitment of rhinos has been very successful here despite this habitat type. Salt licks with bonemeal were regularly utilised by rhinos, possibly to compensate for mineral deficiencies in the natural habitat. Rhinos also often feed in areas where soil nutrients accumulate, for example in valleys where water collects after it has drained from surrounding slopes. Owen-Smith (1988) noted that during the dry season, white rhinos avoid sour-veld areas and feed in the areas where nutrients accumulate.

viii) Kaross

In Kaross the population of white rhinos has decreased over the years since introduction, which might be taken to indicate an unsuitable habitat. However, this study of the behaviour of the rhinos showed that their interactions were similar to those of other rhinos populations, except that the Kaross rhinos were not regularly mating. The rhinos exhibited relatively broad grazing preferences and habitat utilisation, which tends to indicate that most of the available habitat types in this area were acceptable.

The condition of the rhinos in Kaross was consistently good to excellent throughout the year, except for a brief period at the end of the dry season where their condition was described as fair. During the rainy season the rhinos became noticeably 'fatter', a condition which indicated that reserves of fat were being stored. This build up of subcutaneous fat has been described by Selous (1899), Owen-Smith (1988) and Smithers (1983). Roan antelope, which are particularly sensitive to the state of the herbaceous layer, remained in good condition throughout the year in Kaross.

Investigations indicate that most or all of the rhinos in Kaross, which were from the founder population on Ohorongo, were sub-adults when they were initially released between 1975 and 1980. This correlates well with the ages of the two females (25 to 32 years) which died just before the study began. This age range is reasonably old for a white rhino.

Reasons for the lack of known births is uncertain. Explanations include the possibility that the age or sex structure of the individuals in the group was not conducive to reproduction, or there may be chance reproductive abnormalities within the group resulting in an unproductive social unit.

Although not successfully reproducing, the condition of the rhinos and other grazers would indicate that, at present, the rhinos are not nutritionally limited in Kaross and therefore the habitat may be described as suitable. Further long-term studies would be necessary to draw more definitive conclusions on habitat suitability.

7.3.3 Population Composition

In Namibia, several introductions of under five rhinos have apparently been successful, but the optimal population composition is considered to depend upon specific circumstances. The Natal Parks Board usually sell rhinos in groups of two males and four females, and this ratio is a good basis for the average farm. For captive breeding in zoos, Fouraker & Wagner (1996), recommended the optimal group composition to be one male and two or more females. In each case it is necessary to consider optimum group size with respect to the farm area and habitat before introductions, as well as likely social groupings and the space available for territorial males.

It would appear from this study that small population size has not had a detrimental effect on reproductive success in several game farms, and no problems due to inbreeding have been recorded to date. On Waldeck farm, two individuals have bred successfully. This study indicates that populations of only one or two females and a single male are potentially viable, although in these situations additional genetic input is desirable in the long term. However this study has identified deaths to young rhinos apparently caused by aggressive lone adult bulls on game farms, which is a potentially serious matter that needs to be considered. Other problems associated with small populations, especially those of endangered species, include increased vulnerability to habitat destruction and greater risk from over-exploitation.

When establishing or managing a small population, to encourage its long term survival, factors to be considered should include:

- Genetic details, including founder effects, genetic drift and in-breeding depression reducing genetic viability (also described by Lande 1988).
- Demographic considerations from random variations in birth and deaths rates. A small population is more vulnerable to successive unpredictable negative events from either high death rates or low birth rates, which consequently increases the risk of a population becoming extinct.

7.4 Future of White Rhino in Namibia

In reviewing the future of the white rhino in Namibia, the status of the species elsewhere in the world is a relevant consideration. Populations in zoos world-wide are having mixed success, whereas in South Africa, populations on private land have recently been particularly successful. This supports the continued introduction of animals to private land in southern Africa under appropriate circumstances.

When considering an introduction it is important to determine whether the area is ecologically suitable for the species. Although indigenous wildlife is adapted to the arid and semi-arid conditions in Namibia, species introduced to the margins of their historical distribution may require more intensive management to survive. From this study it is also apparent that in Namibia, the density of grazers, and in particular bulk grazers, must be limited to conserve the herbaceous layer.

In the long term, the benefits of maximum geographical distribution of white rhino are also relevant. Despite the apparent cost-effectiveness of field-based conservation, there remains the long-term risk that possible regional problems such as economic, political, security or environmental disasters within Africa could seriously affect a species which is concentrated within the region. For this reason, the continued world-wide distribution of conservation efforts is believed to be important.

7.4.1 Game Farms

The growth of tourism in recent years has increased the economic value of wildlife and led to an rise in the number of game farms (Holm-Petersen 1996; Barnes & de Jager 1996). Consequently, it is expected that ownership of white rhino will continue to increase. The policy of the MET in Namibia is to encourage farming of rare game by providing information and permits when appropriate, but without excessively strict controls.

Before any introduction, an understanding of the animal's biology, awareness of correct management techniques and careful consideration of the long-term financial commitment are all important. Managing white rhino to maximise financial benefit involves sustaining a viable population in the long term, by maintaining good condition, protecting individuals and encouraging reproduction. If correctly undertaken, this goal is entirely compatible with sustainable utilisation for economic benefits, via hunting, photo-tourism and live sales.

Findings from this study confirm that management requirements will vary according to whether the farm is above or below the 400mm rainfall isohyet (previously identified as a critical boundary by Pienaar (1994)). Minimal management intervention can be expected with introductions to areas receiving an average annual rainfall of greater than 400mm, providing the farm is not overgrazed and is not subject to severe drought periods. In these locations it will still be necessary to monitor, protect and provide water for the rhinos, although provision of supplementary feed is unlikely.

Areas receiving less than 400mm average annual rainfall or where periodic droughts occur, particularly where there is a problem with overgrazing, should expect to feed the rhinos on a regular and possibly even on an intensive basis. Under these conditions, regular observation of the animals is essential to ensure that their condition remains good, otherwise supplementary feeding should begin immediately. However if the farm's carrying capacity has been managed to keep the veld in good condition, it is possible that the habitat will sustain rhinos without supplementary feeding.

i) Ownership Requirements

Following this research, it was possible to assess whether existing guidelines and standards for private ownership of white rhino are appropriate. A flow-chart (Fig. 7.1), illustrates the relevant factors when an introduction is being considered.

This study has indicated that suitable owners should be identified from their management history, awareness of the ecological requirements of white rhinos and their economic capability of managing and if necessary supporting the animals into the foreseeable future. Motivation for ownership is an important factor since farmers will generally be introducing rhinos for personal benefit, either as an attraction for photo-tourism or for hunting. Potential owners who are unaware of the basic facts of rhino ownership and unprepared for managing them adequately should not be permitted to purchase the animals. At present, before issuing an import permit, MET refers to records of the ownership and past management history of a game farm to assess whether the applicant is suitable. With respect to the present white rhino status globally, these controls are considered to be adequate.

To prevent the exploitation of rhino populations, Buijs and Anderson (1989) and Du Toit (1994) recommended criteria for screening farms applying to import white rhinos, to encourage the establishment of more potentially viable populations. They proposed that critical factors should include a founder population of at least ten rhinos and a grazing area of not less than 10,000ha, which should have physical boundaries to prevent dispersion. Following the survey of white rhinos on private land in South Africa, Buijs and Papenfus (1996) suggested having privately owned white rhinos monitored on a regular basis. From the results of this study, given the limited number of game farms in Namibia, most of these conditions are not thought to be appropriate at present.

ii) Further Information

Although owners were enthusiastic about owning white rhinos, they were often unaware of who to contact for advice on management and protection. In addition, purchasing of rhinos was often undertaken without full consideration of how suitable the farm was and how best to carry out an introduction. It appeared important to increase the knowledge of potential and existing owners and managers, to encourage best practice. To assist this aim an information booklet has been compiled based on the findings of this research, with an additional compilation of papers which provide information on introducing white rhinos (See Appendix VIII). This was to be distributed by MET on receipt of an enquiry for an import permit. The booklet was also intended to make potential owners more aware of the implications of introducing and maintaining rhinos in a semi-arid environment. Specialist support may then be sought from experts or organisations listed in the booklet including the MET rhino co-ordinator, the PRU and the African Rhino Owners Association (AROA), a South African organisation linking rhino owners.

The possibility of setting up a Namibian rhino owners association was discussed during this research. Benefits of such an organisation would include establishing and managing a data book to document the history of populations and to help minimise genetic in-breeding.

7.4.2 National Parks

When assessing the future of introductions to National Parks, the inherent suitability of the habitat is more important because providing long term supplementary feeding is not a viable option in these areas. Although introductions had been successful overall, there were too few populations to provide definite indicators for this study. More precise data on habitat suitability will require further investigations into the existing rhino populations in National Parks (see Chapter 8).

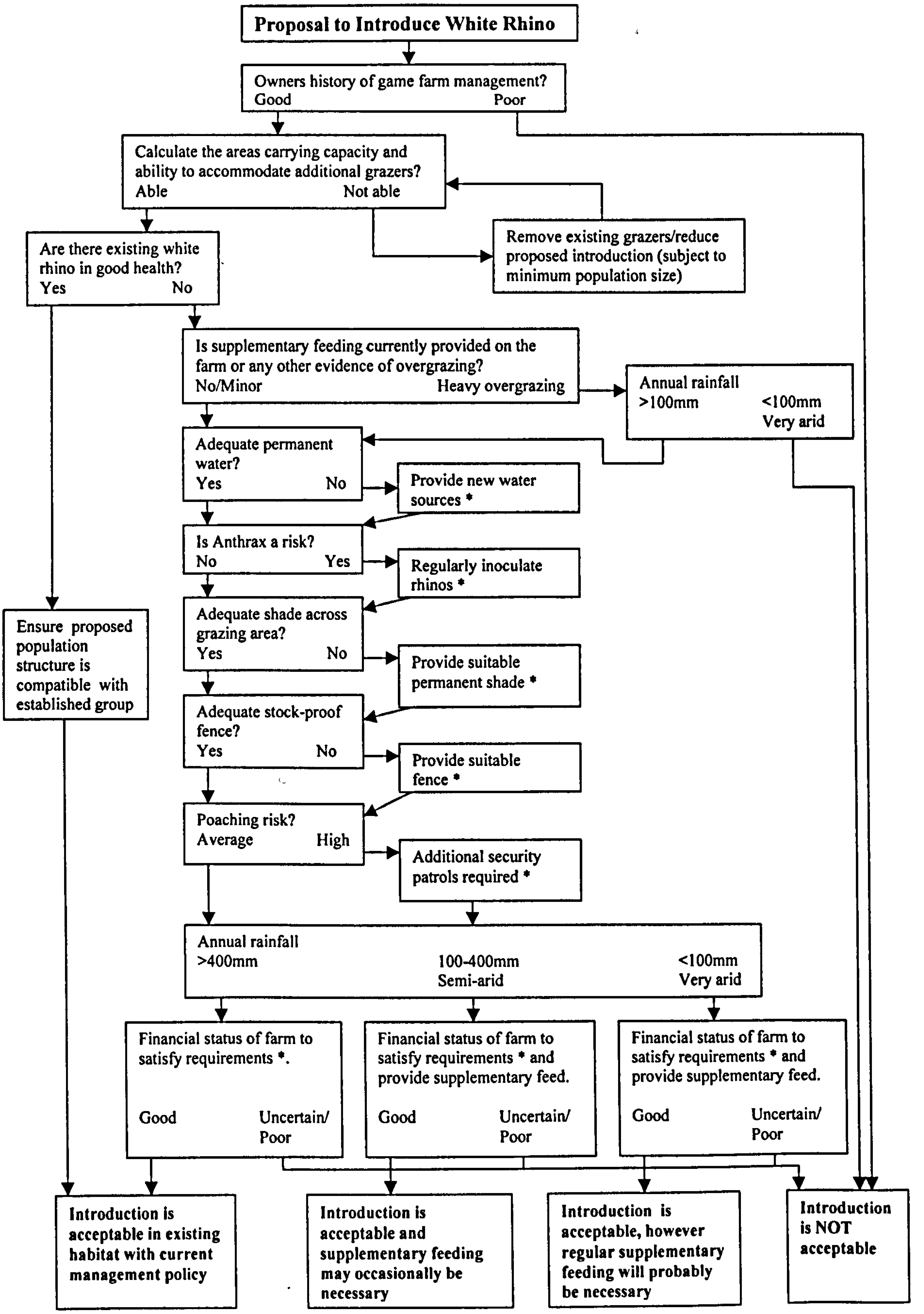


Fig. 7.1 Flow Chart to Indicate the Acceptability of Rhino Introductions

7.5 Conclusions

- This study has established a comprehensive history and the current status of introduced white rhinos in Namibia, information on habitat preferences and key factors relating to the success of populations. Management has been identified as the critical factor influencing the success of white rhino populations, which require protection from poaching, regular monitoring, adequate food, water and shade.

- White rhinos have proved to be sensitive to their habitat and vulnerable to drought in the semi-arid environment of Namibia. Introductions to areas receiving less than 400mm average annual rainfall or where the habitat is overgrazed, have been found to require more intensive management to ensure the persistence and successful recruitment of the rhinos. The majority of game farms in this semi-arid environment regularly provide supplementary feeding and this requires greater economic commitment. However, despite the limitations of semi-arid areas, the study in Kaross has shown that white rhinos have successfully adapted to utilise this environment in north-western Namibia without supplementary feeding. The very arid regions of Namibia, where the annual rainfall is less than 100mm, are not considered suitable habitat for white rhino.

- Habitat preference studies in Kaross showed that grazing was concentrated on areas which fulfilled the animal's herbaceous layer preferences. The main preferences were for the abundant grass *Schmidtia kalahariensis* and areas with high biomass and density. Of the two dominant grass species, the rhino preferentially selected *Schmidtia kalahariensis*, which is a soft grass whose occurrence is typical of deteriorating habitat in semi-arid areas, as opposed to *Stipagrostis uniplumis* which is a valuable forage species but is a tall grass with rigid stems. During the rainy season, the rhinos concentrated their grazing on areas with the best flush of grass. During the dry season, they regularly utilised areas close to rivers.

- Habitat utilisation was broad, except for steep and highly rocky areas which the rhinos generally avoided. Grazing preferences were more specific than general habitat utilisation. Rhino utilisation was not influenced by tree density in the area.

- White rhinos become increasingly dependent upon access to permanent water sources in a semi-arid environment. It was found that rhinos do not intensively graze close to water holes, and during the dry season they walk considerable distances after visiting water sources. Seasonal utilisation of temporary water sources was observed. At times when mud wallows were unavailable, the rhinos had regular dust baths.

- Population size and structure analysis showed that in Namibia, introductions of less than five animals and also pairs of animals have bred successfully, which is contrary to the reported situation in South Africa and in zoos. However, without additional genetic input, the viability of these populations is uncertain in the long term. There is also concern over the incidence of excessive aggression by lone males, which were found to have caused the deaths of calves and females in Namibia. Consequently, the recommended minimum population is two males and four females.

- White rhinos have been shown to be susceptible to Anthrax. If this disease is endemic to an area, regular inoculations are essential.

- Considering the present global status of the white rhino, further introductions to semi-arid areas should be encouraged, and supported with additional information on the implications of ownership. To provide this, a booklet containing information pertaining to purchasing, introducing and managing rhinos has been compiled.

- This study has established various techniques for conducting habitat surveys using GPS satellite navigation to locate transect positions and using GIS as a tool to process and correlate the habitat survey and rhino observation data. Indigenous tracking techniques were utilised for a significant part of the study, both for locating the animals and for indirect observations of their activities. Rhino tracking and the focal area technique were found to be appropriate for studying grazing preferences with minimum disturbance. These techniques were shown to be compatible with the limitations of studying animals which are wild, easily disturbed and occur at a very low density in a large area.

- It is recommended that an annual update of the progress and status of the white rhino populations on game farms in Namibia is carried out, either by questionnaire or by telephoning all farms concerned. To minimise in-breeding, data books with the genetic identity of all individuals, the origin of imported animals and if possible the identities of parents of individuals born, should also be established and regularly updated. Useful information could be obtained if facilities for genetic analysis from rhino samples were made available to game farms in Namibia.

Chapter 8

Further Research

8 Further Research

i) Habitat Suitability of Game Farms and National Parks in Namibia

This survey has provided a database of current information on Namibia's white rhino, upon which future studies may be based. To more fully investigate the inherent suitability of Namibia's habitat for white rhino, it would be preferable to study the introduced populations over a period of several years. The condition of individuals should be regularly monitored and the precise circumstances of all supplementary feeding noted. If animals became habituated to being observed by researchers, direct observations of feeding and nutritional analysis of dietary intake may be feasible.

Details of all recruitment should be noted to allow the reproductive status of each group of animals to be assessed objectively, since all female rhinos over 5 to 6 years of age and in a viable population should produce a calf during a study period of more that 3 years, unless the calf was lost to predation, disease or was aborted (Owen-Smith 1988). Mortalities should be promptly investigated to determine the cause of death.

Both game farms and National Parks should be covered, and arrangements established for routine reports on all populations and reporting of all incidents. Annual survey updates would be beneficial. The Rhino and Elephant Foundation now carry out routine annual surveys to monitor the progress of rhino populations in South Africa.

National Parks provide the most appropriate indicators of habitat suitability and the Etosha population would provide a good reference study since the question of the habitat suitability of Etosha for white rhino remains uncertain. However research in this area is complicated by the low density of individuals within the extensive area of Etosha. Regular monitoring could only be realistically achieved by attaching radio transmitters to each individual, then locating them from a vehicle or from the air. Without monitoring, details of reproductive success and vulnerability to Anthrax, which is endemic to the area, will remain uncertain.

ii) The Carrying Capacity of Waterberg

The white rhinos on the Waterberg Plateau Park are presently thought to be approaching the maximum number of individuals the area can support. This population would benefit from research into the recruitment rate, genetic links within the present population, determination of the carrying capacity of the park and the effect of removing surplus individuals. Because individuals are easily identifiable on the plateau, it should also be possible to investigate social behaviour and activity in detail.

iii) The Influence of Population Size and Composition

A large quantity of data has been collected world-wide on the success of white rhinos in National Parks, game farms and zoos. One of the most important factors identified during this study was the influence that population size and sex composition has on the viability of breeding groups in differing circumstances. In addition, the influence of management patterns and enclosure size in relation to numbers of individuals remains largely speculative. A comparison of reproductive success of game farm populations with those in wildlife parks and zoos would greatly contribute to the long term conservation and management of the species.

iv) Assessment of the Nutritional Quality of Grazing

Techniques exist for assessing the nutritional quality of the diet of free-ranging animals. However with physically large, wild and nocturnal animals, accurate evaluation of the animal's intake is very difficult. Possibly the most accurate technique is chemical analysis of the plants and parts of plants ingested by the animal, following direct observations. Some relevant techniques were used in this study, and it is considered that a programme providing regular and detailed observations of grazing at close proximity would provide valuable data.

Alternatively, an indication of the nutritive values of the veld may be obtained from chemical analysis of the quantities of nitrogen and phosphorus in faeces. This technique was used to study the condition and movements of the main ruminants in the Kruger National Park (Grant *et al.* 1995). However, comparison samples are required from other populations, habitats or landscapes, and samples must be collected and stored correctly to protect their quality (Wrench *et al.* 1996).

It was intended to carry out this technique during the course of this study, by organising regular collection of faecal samples from Waterberg Plateau Park, Kruger National Park, Otjiwa Game Ranch and Waldeck game farm to compare with those of the rhinos in Kaross. However, it was found that while samples had regularly been collected in Kruger National Park, at the other locations they had been collected or stored inadequately. With only one comparison, meaningful analysis was not possible.

Appendix I

References

Appendix I

References

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Appendix II

(a) Glossary

(b) Explanation of Terms

Appendix II(a)

Glossary

APU	Anti-Poaching Unit, under the Ministry of Environment and Tourism.
AROA	African Rhino Owners Association, an organisation of rhino owners based in Bedfordview, South Africa.
AZA	American Zoo and Aquarium Association, Fort Worth Zoo, Texas.
CITES	Convention on International Trade in Endangered Species. **Appendix I** Species threatened with extinction which are, or may be affected by trade. No commercial trade of these species is permitted, but certificates of exemption and export permits may be issued under restricted circumstances, such as specimens bred in captivity or artificially propagated, or for scientific research. **Appendix II** Species which may become threatened with extinction unless trade in specimens is subject to strict regulations. Commercial trade is closely controlled by the issue of export permits and some restrictions may operate such as marking of products and imposition of export quotas.
EEI	Etosha Ecological Institute, Etosha National Park, Namibia.
ENP	Etosha National Park, Namibia.
GIS	Geographical Information System
GPS	Global Positioning System.
KNP	Kruger National Park, South Africa.
MET	The Ministry of Environment and Tourism, based in Windhoek, Namibia.
NPB	Natal Parks Board, responsible for the management of National Parks in the Natal province of South Africa.
PRU	Protected Resources Unit, branch of the Namibian Police who investigate all cases of poaching of endangered species.
REF	Rhino and Elephant Foundation, an organisation dedicated to conservation of these species, based in South Africa.
STR	Save The Rhino, an international organisation dedicated to rhino conservation, with a branch in Namibia.
UTM	Universal Transverse Mercator. A grid system used on most large and intermediate scale topographic maps.
WPS	Wildlife Protection Service, an anti-poaching team in MET.

Appendix II(b)

Explanation Of Terms

Arid	An area where the annual average rainfall is below 400mm (Bothma 1989).
Biomass	Dry mass or weight of grass, measured in grammes.
Boma	A fenced enclosure used to keep animals captive.
Bush Encroachment	Rapid growth of a variety of thorn bushes under conditions such as over-grazing, under-browsing and too frequent burning (Bester 1996).
Carrying capacity	The ability of an area to sustainably maintain a quantity of animals with respect to the resources available, space, food, mates, etc.
Eco-hunting	Non-lethal form of hunting in which the hunter pays to temporarily immobilise the animal. A professional hunter and qualified vet should be present. (This technique is also known by other names).
Environmental parameters	For the purpose of this study, these include habitat variables and grass species composition.
Ephemeral	Short lived, transitory.
Ethology	The science of animal behaviour (Joubert 1996).
Etosha	Etosha National Park.
Focal area	The area used to investigate the diet composition of feeding white rhinos. This is a semi-circle of one metre diameter, with an area of approximately $0.4m^2$ and located directly in front of the rhino.
Forage factor	Values assigned to grass species occurring in Etosha by Du Plessis (1992). Factors range from 1 (minimum) to 10 (maximum) and represent the perceived sustainable forage production potential of a species, i.e. a species potential to produce acceptable forage for grazers.
Forbs	Broad-leaved herbs (Riney 1982) or non-grass herbaceous species (Du Plessis 1992).
GIS	A computer based system for correlating, analysing and mapping geographical or spatial data (Johnston 1998).
Hectare	One hectare of ground area equals an area of 100m by 100m.
Herbaceous	In a plant, the property of having a relatively thin, soft, non-woody stem.
Herbaceous standing crop	The grass biomass recorded using a disc pasture meter.
Influorescence	The part of a plant that consists of the flower bearing stalks.
Inter-specific	Interactions between members of different species.
Intra-specific	Interactions between members of the same species.
Kruger	Kruger National Park, South Africa.
Lucerne	Grass species which is provided to grazing animals as supplementary food.
Over-grazing	A situation where an excess of grazers is modifying the herbaceous layer causing soil erosion which threatens the overall productivity and stability of an ecosystem. It tends to lead to bush encroachment.
Phenology	Greenness of grass (Du Plessis 1997).
Savanna	Open grasslands, usually with scattered bushes or trees, characteristic of much of tropical Africa.
Semi-arid	For the purpose of this study refers to parts of Namibia receiving more than 100mm and less than 500mm average annual rainfall. This therefore excludes the desert coastline and woodland savanna of the Caprivi strip.
Sheet erosion	Gradual loss of the top layer of soil.
Sour veld	A habitat type in which the most important forage species become unpalatable and lose their nutritional value at maturity (Bothma 1989).
Spoor	The track or marks left by an animal including footprints, urine, faeces, crushed or altered vegetation.
Stocking rate	The number of livestock units grazing a particular area of land (Bothma 1989).
Sustainable utilisation	Harvesting only a certain proportion of a population, so that future use is not affected (Spellerberg & Hardes 1992).

Sweet veld	A habitat in which the most important grass forage species remain palatable and nutritious throughout their entire life cycle (Bothma 1989).
Tracker	An indigenous person possessing the skill to follow an animals spoor and to analyse and describe its activities.
Tracking	The identification, following and interpretation of signs, such as spoor, of animals (Stander *et al.* 1997).
Translocation	The intentional movement and release of animals in the wild.
Umfolozi	The Umfolozi Game Reserve in South Africa.
Veld	An open grassland habitat.
Very arid	Areas receiving less than 100mm annual rainfall including the desert coastal regions (For the purpose of this study.)

Appendix III

Survey Form -
White Rhinos on Game Farms in Namibia

Survey Form - White Rhinos on Game Farms in Namibia

FARM NAME ....

General

1) How confidential would you like this information to remain?
....(With respect to my thesis and MET)

2) Why did you introduce white rhinos to the farm?
....(Hunting, photo tourism or other)

3) Was the outcome of the release worthwhile and would you like to acquire more in the future?
....

Information Relating To Rhinos:

4) How many rhinos were initially released?
....

5) What was the age and sex of these individuals?
....
....

6) When were they released?
....

7) Where were they purchased from, and who organised the capture and transportation?
....

8) Were they boma trained before or after transportation?
....
(And for how long?)..

9) What supplementary feed was provided for them in the bomas?
....

10) How did you judge the farm habitat to be suitable?
....
....(For example a pre-release survey?)

11) Any other comments?
....
....(Dehorned, transportation times, unusual histories?)

Were there any subsequent releases, and if so:

12) How many rhinos were released?

....

13) What was the age and sex of these individuals?

....

....

14) When were they released?

....

15) Where were they purchased from, and who organised the capture and transportation?

....

16) Were they boma trained before or after transportation?................................
(And for how long?)............. ....

17) What supplementary feed was provided for them in the bomas?

....

18) Any other comments?

....

....(Dehorned, transportation times, unusual histories?)

****

19) How many animals are there in the present population?

....

20) What sex and age are these animals?

....

(Reliability of information?)..

21) How many calves have been born? When were they first seen and what sex?

....

....

22) Have rhinos ever broken out of the farm? When did it occur, where did they go and how long before they were recaptured?

....

....

23) Have there been any mortalities, if so when and what was the cause?

....

....

(How many trophy hunted, any post-mortem results?)..

24) Have rhinos ever been sold on? Who were they sold on to and for how much?

....

25) Have you had any problems with poachers on the farm, and what precautions do you take to guard against this threat?

....

26) How often do you see the rhinos (ie is there a monitoring project)?

....

....

27) Can you identify any habitats which are preferred by the rhinos in the dry and the rainy seasons?

....

....

28) Can you identify any habitats which are avoided by the rhinos in the dry and rainy seasons?

....

29) Have you noticed any changes in the condition of the animals since you bought them?

....

....

30) Are you providing supplementary feeding for the rhinos at the moment, or have you done so in the past? If so how much, how often and what kind of grass?

....

....

....

Knowledge

31) Where did you gain your knowledge of white rhinos?

....

32) Do you have any idea how many white rhinos there are in Namibia and world-wide?

....

33) Do you know how much, or can you estimate, how much it now costs to buy, maintain and hunt white rhinos?

....

34) Would you be interested in a fact sheet on the species and are there any specific aspects you would like included?

....

35) Do you think the Ministry should be more involved, either by giving more advice or being more interested?

....

....

Farm Details

36) Would it be possible to have a map of the farm? ....

37) What size is the farm? ....

38) What is the rainfall average or figures for the years rhinos were on the farm up to the present?

....

....

39) What other animals are there on the farm, and numbers?

....

....

....

40) What are the main vegetation types (units) on the farm?

....

....

41) Do you know what the main tree, shrub and grass species are on the farm?

....

....

42) How many permanent and temporary waterholes are there on the ranch?

....

43) How would you describe the landscape in terms of topography and any distinguishing features?

....

44) What is the soil type?

....

45) What kind of fence does the farm have?

....

Other

Name. ....

Position and duration.

....

Farm name, address and number.

....

Telephone number.

....

Other notes.

....

....

....

....

....

....

....

Appendix IV

Case Studies of Game Farms

Appendix IV

Case Studies of Game Farms

This information was principally compiled from discussions with the owner or manager of each farm, who have been named at the beginning of each section. If the owner or manager could not be contacted or to supplement the information they provided, comments from other sources have been included. These sources are acknowledged accordingly.

Otjiwa

Date of visits – 9/2/96 – 4/97

Annatjie Bonthuyes and Fredrich, Game Managers.

Due to frequent changes in management staff at Otjiwa, the present rangers are uncertain how many rhinos were originally released on the farm. A fax from K Miklejohn (Natal Parks Board (NPB) Game Capture Division) to P. Erb in 1992 advises that 12 rhinos were delivered in 1971 and another six rhinos were released in 1973. The founder population is known to have flourished, peaking at approximately 31 animals in 1988, and subsequently the population has been maintained just below this number of individuals. The present population on the farm is 23 animals. The farm is located next to the main road between two large towns in Namibia and knowledge of the presence of rhinos in this area is common. This may have contributed to the poaching of approximately nine rhinos to date. The latest case of attempted poaching occurred late in 1996, with the dominant bull being fatally wounded. Regular rhino monitoring is currently practised on the farm by a team of guards. The number of animals sold on to other farms at auction in the past is uncertain, but numbers at least eleven animals according to records of animals received by other farms in Namibia. It is also not possible to establish the number of animals which have been hunted, but this is estimated to be about 16 animals. At present it is the farm's policy to hunt an animal every five to six years to help finance managing and protecting the animals.

White rhinos have bred very successfully on Otjiwa, despite the fact that the farm has been severely overgrazed for several decades. In 1996, supplementary feeding began in March, immediately after the rainy season. Management on the farm has fluctuated in quality in the past, but has stabilised in recent years with the rhino population becoming one of the management priorities. Attempts to collect faecal samples for Dr C. Walzer of Salzburg Zoo, Austria, to establish the oestrus cycle length of the cows on the farm were unsuccessful as sampling limitations resulted in insufficient data. Eventually Otjiwa is hoping to collect dung samples to look at the genetic composition of the individual rhinos to address their concerns about genetic inbreeding.

Rhinos are protected from Anthrax by annual immunisation of animals using drop-out darts. One calf died prematurely due to Anthrax late 1996, consequently all animals were inoculated again.

In 1995, two white rhino were darted as a trial eco-hunt. The rhinos were darted by a person connected with the farm, for sale at auction later. The darting and capture operation were described as difficult, but successful. However, one animal subsequently died from an infection in a boma. The second rhino was released and was not sold.

WABI

The owner of WABI during the period the white rhinos were on the property was Mr Delfs who was known to be a game dealer (P. Erb, *pers. comm.*). The farm has subsequently been sold and it is now under new management. It was not possible to contact Mr. Delfs during the survey as he now lives in Europe, however his daughter P. Dillman was contacted.

According to NPB, 16 rhinos were released during 1973 on WABI. Some of these individuals were hunted (MET permits indicate at least one or two animals), others died in droughts and the remaining animals were sold on before the farm was put on the market in 1987/88. The buyer of the remaining animals is not known (P. Dillman, PO Box 5055, Windhoek *pers. comm.*). It is also possible that one animal was exported to Korea in 1983 (P. Erb, *pers. comm.*).

Ohorongo

It was not possible to contact the present manager of the farm or the owner, however an indication of the situation on Ohorongo has been compiled from MET officials and communications from Natal Parks Board to P. Erb. It is understood that 18 rhinos were released on Ohorongo between 1975 and 1980, although it is possible that as many as 25 animals were released overall. This may have included a bull from West Germany in 1988. However by 1989 it was thought that only 13 animals were left on the farm. It is believed that since the animals release, very few or no calves have been born (B. Gasaway, Wildlife Services, Muskegon, USA ; Prof. J. Berger, Dept. of Envt. Resource Sciences, Univ. of Colorado, USA *pers. comm.* from R. Haylock).

Rhinos were probably introduced to Ohorongo for hunting and not for conservation purposes. This was common in the 1980's as rhinos were relatively inexpensive at the time (R. Loutit, MET, Khorixas ,*pers. comm.*). Kallie Venzke (c/o EEI, MET *pers. comm.*) recalled frequent changes in managers. The present owner inherited the farm. Records of poor management include a period at the beginning of the 1980's when all the water holes were allowed to dry up and many animals died. In this period a white rhino carcass was found just outside the farm. It is thought that as many as 12 animals may have been hunted, six or more died during droughts and at least three were poached.

In February 1994, the remaining seven white rhinos were moved to part of Etosha in exchange for Sable antelope (*Hippotragus niger*). Before they were relocated, R. Loutit sent anti-poaching guards from Save The Rhino (STR) to protect the remaining animals prior to relocation. The vet responsible for the capture operation (H. Winterbach, MET Game Capture Windhoek, *pers. comm.*) commented that the rhinos were all in very poor condition and he had not expected them to survive. During the capture operation he noticed overgrazing on the farm.

Mt Etjo

Jan Oelofse, Owner.

Date of visit – 26/2/96, 24/4/96, 10/96
Contacted - 4/97

A total of 16 white rhinos were released on this farm during 1976, 1979 and 1982. Numbers increased to a maximum of about 22 to 25. The current herd of 13 rhinos walk in one group of 11 and one pair. The estimated number of calves born since these introductions varies. However, no calves have been born within the last few years. This is because there have been no adult bulls on the farm since the last of these individuals was trophy hunted approximately four years ago. Reports of the number of animals on the farm at any time also vary and the figures compiled during my research visit were by no means conclusive. Deaths of animals were attributed to hunting, fighting injuries and deaths during drought.

The circumstances surrounding the death of an adult female on the farm were noted. A non-oestrus cow had been observed walking with a bull accompanying a cow which was in oestrus. The bull was evidently agitated by the non-oestrus cows presence or interference. The following day bloody spoor and drag marks were seen and followed. This led to the discovery of the non-oestrus cow lying in dense bush with a paralysed back. She was put to sleep and it was discovered that her back had been broken by a horn entering through her rectum and breaking her spine. The same bull and oestrus cow were seen again later, the bull having a bloody horn (L. Geldenhys, c/o MET Head Office, Windhoek *pers. comm.*). The bull was later trophy hunted leaving no adult males in the population.

Before the farm came under the present owner, it was described as a well-eroded cattle farm (R. Loutit *pers. comm.*). The farm may still be described as well-eroded due to being overstocked and the animals there have been provided with supplementary feed since 1984-5 (K. Venzke; R. Loutit *pers.comms.*). All these rhinos were in excellent condition due to the frequent provision of supplementary feed. This farm provides readily accessible viewing of white rhinos for tourists.

To an extent the precise history of the white rhino population at Mt Etjo remains uncertain as the owner was unwilling to divulge any detailed information concerning his animals. However, there has undoubtedly been a good deal of success in recruitment, as there are many sub-adults of all ages on the farm. Consequently the population has successfully managed to sustain a high level of trophy hunting over the years. There was no justification given for the hunting of the last adult bull, or how a hunting permit was obtained for an individual of this status.

O'Vita

Date of visit – 21/2/96

Claus Nebe, Owner.

A pair of sub-adult rhinos were bought from Otjiwa in 1981. They were familiarly known as 'Charles' and 'Di' as they were purchased in the year of the royal wedding. The male was reported to be very large, with a shoulder height of 1.96m. The first calf was born six years after they were released, and thereafter calves were born with an inter-calving interval of two years or less.

The deaths of two of the calves was attributed to the bull, killing them by breaking their backs. The first death was a sub-adult, the first female calf born, which was found lying on her front with her back broken. The third calf died when it was one to two months old and was found in the same position. As a result of these deaths and the deduction that it was the bull that was responsible, he was de-horned in 1991. Following his de-horning the cow was described as no longer being afraid of the bull.

These rhinos were apparently never provided with supplementary feed despite the low rainfall on the farm (100 to 200mm). When the farm was visited in 1996 overgrazing was evident and the farm was suffering from bush encroachment.

Although the initial population at O'vita comprised only one male and one female, the recruitment rate of this pair of animals was excellent. The remaining four rhinos were poached at the end of 1993.

Okatumba

Date of visit – 23/2/96

Claus Bergmann, Owner.

Originally a lone sub-adult bull was released on the farm in 1981 and was joined by four females from Otjiwa in 1984. The rhinos remained together in a group except when the females came into oestrus, when the male often left the group, occasionally breaking out of the farm. It was noted that the rhinos mixed very well with cattle. No calves were born until six years after the females were released. Two female calves were born, both of which were found dead at around seven months with broken backs. The carcasses were lying on their front and the owner was uncertain how these animals died but suggested that the bull may have killed them. Subsequently three of the cows and the bull were found dead within the first week of March 1992. Their deaths were diagnosed as due to Anthrax by the Veterinarian Laboratories in Windhoek and all the carcasses were destroyed. It is now known that high concentrations of Anthrax occur in the area. The remaining female was trophy hunted in 1995.

Despite favourable sex ratios, the reproduction rate on Okatumba was considerably lower than what could have been expected although this may be due to unknown problems with the lone bull.

Waldeck

Mr Briedenhann, Joint Owner.

Date of visit – 15/2/96, 18/4/97
Contacted - 18/4/98

Originally two animals were purchased from Otjiwa but soon after their release the female died. This was caused by the needle from a drop-out dart which remained in her skin after she received a shot to immunise her against Anthrax. This formed an absess which was treated by a vet but she lost condition and subsequently died. Another female was brought from Otjiwa and currently the pair are breeding well with two calves being born to date. The second calf was under a year old when seen in 1996. Her mother's condition was described as fair. Following a conversation with the owner in 1997 all animals were reported as being well. He commented that the bull is notoriously aggressive, especially when the cow is in oestrus. He has been known to charge vehicles and has been fighting with the younger bull calf. There have also been fights with young elephants (*Loxodonta africana*) on the farm and wounds have been observed on the rhinos. Supplementary feed was provided at the end of 1996, which the rhinos readily fed on, but not in the quantity that had been expected.

Safari

Date of visit – 20/2/96, 24-26/5/96
Contacted – 4/97

Fritz Flachberger, Owner, and Alan Cilliers, Game Consultant.

Six rhinos were introduced to the farm in September 1993 and are all still healthy. Their diet has been supplemented throughout the year except during the rainy season, with nominal additional feed. However the animals still prefer to graze the plains and do not appear to concentrate on the feed provided at the water holes. In early 1997 one calf was born.

The farm is in quite an isolated position away from main roads and is not open to tourists. Its isolation leads to little knowledge of its existence and this appears to have been an effective protection for the rhino population.

Safari is on the southern boundary of Etosha, between the central and western parts of the Park. The vegetation is identical to that part of Etosha called Groot Vlakte, which is an area where animals congregate after the rains as it produces a flush of sweet grass and excellent grazing.

Ongava

Date of visit – 9/8/96
Contacted – 4/97

Alan Cilliers and Ken Morris, Senior Managers; Jan Frieder and Werner Oder, Short Term Managers.

Ongava is situated just outside the main central gate to Etosha. Six white rhinos from NPB were released in 1993 and these have since had three calves. According to Jan Frieder the dominant male tends to walk with two females, the sub-dominant male alone, and the other two females with their calves.

Another white rhino was released in January 1994. He was born in an English zoo where he was hand reared with a Beagle dog as a mate. After the Beagle died the rhino, now named 'Brutilis', was described as uncontrollable and aggressive. This resulted in his transfer to a series of zoos, before being brought to Namibia. Being a relatively tame animal, Brutialis continues to be a large tourist attraction at Ongava. He has been welcomed into the ranger's houses and generally treated like a pet. This is despite the fact that he has proved to be an expensive attraction on the farm, frequently causing broken windows, damage to cars and other objects. His bad temper and strength have resulted in the death of a gemsbok (*Oryx gazella*) and a hartebeest (*Alcelaphus buselaphus caama*) and he recently injured the farm manager causing several broken bones and bruising. Brutialis always walks separately from the other rhinos and on the odd occasions when they have met, he has sustained considerable injuries in the ensuing fight.

Management of the farm has varied and at times has been criticised as inadequate. Some years ago there was little or no effective management, however this situation has since improved. In 1995, Save The

Rhino (STR) sent men to help train the farm's rangers in following and protecting rhinos, with useful results (R. Loutit, *pers. comm.*). Concern has been expressed by previous managers over Anthrax (W. Ouder, c/o Epako Game Ranch, Omaruru, Namibia *pers. comm.*), but up to August 1996, there had been no mortalities.

In August 1994, two white rhinos from Ongava were found wondering in Etosha. It had been suggested that the rhinos had walked a very considerable distance in a few days (W. Ouder, *pers. comm.*).

Grazing selection notes of J. Frieder include the avoidance of *Aristida* grass species which grow especially around the water holes on the farm. The rhinos appear to positively select the grass species *Anthephora schinzii, Eragrostis nindensis, Stipagrostis uniplumis* and *Urochloa brachyaria.* No supplementary feed is provided for the animals at any time of the year.

Schmidt

Mr Schmidt bought two rhinos from Otjiwa in 1993/4, but unfortunately it was not possible to contact him for an interview. He bought the rhinos in conjunction with a variety of other game species, presumably when establishing the farm. The game capture vet (H. Winterbach, *pers. comm.*) who delivered the rhino, commented that the owner did not appreciate the size of the animal he had purchased. Following the release, one rhino immediately broke out of the farm and ran over the hills. It was unable to find water on the neighbouring farm and by the time the animal was bought back it was too weak to survive. The sex of the remaining animal is not known.

Epako

Date of visit - 22/2/96 & 4/97

Nick Nolte, Game Manager.

The farm originally intended to import five white rhinos from South Africa. However, following the death of the dominant bull in bomas in Kruger, only four rhinos arrived in September 1994. The remaining male was a young sub-adult who was still too young to mate with the adult females, consequently since their release there has been no reproduction in the group. The farm has a noticeable problem with overgrazing and the rhinos are currently supplement fed at the water hole in front of the lodge for a substantial part of the year. When the rhinos were first released they moved into the hills and were later found thirsty and apparently with sores on their feet. Once they moved down from the hills, they made a quick recovery and have not returned into this area since. Soon after this, one of the cows became ill and was put into bomas to recover. The problem was found to be ingestion of sand in her supplementary food (which she had picked up together with the *Lucerne* provided on the ground by the water hole). She was provided with clean food for a period and released.

By the time the young bull reaches sexual maturity in approximately 1999, the adult females will have spent several years without reproducing and it would be interesting to see whether this has any subsequent effect on their calving.

Oropoko

Date of visit - 24/4/96
Contacted - 4/97

Mr Risser and Mr Hafner, Managers.

Six rhinos were introduced in 1994 and one calf was born in August 1996. The farm covers an area of 11,000ha, but the rhinos are kept in a camp of approximately 1,000ha adjacent to the lodge. In the evenings the guests may walk down through this area to the water hole. The rhinos are successfully breeding.

Appendix V

Case Studies of National Parks and Protected Areas

Appendix V

Case Studies of National Parks and Protected Areas

Waterberg Plateau Park

Date of visits – 4-11/3/96 & 22/12/96

(T. Cooper, Chief Control Warden; P. Erb & W. Kileran, Researchers.)

Waterberg Plateau is located to the north east of the centre of the country and although the park encloses 41,800 ha, only 30,000ha (300 km^2) is accessible to animals on the plateau (see Fig. 1). Rainfall is relatively high compared with other parts of the country and heavy leaching on the plateau has lead to sour-veld vegetation.

Between 1975 and 1976, twelve animals were released on the plateau. This release was originally planned to consist of 16 animals, however three died due to capture related stress after a long journey and one other hooked his horn in the water trough at the bomas and drowned before he could be released (P. Erb *pers. comm.*; Joubert 1996). Recruitment among the remaining twelve animals during the early years was slower than expected with the first calf being born in 1979 and the second in 1980. It is thought that by 1981 five calves had been born.

A further release was made in 1990. Initially six animals were captured by the Mozambique border of Kruger National Park and transported directly to Waterberg apparently without being boma trained or familiarised with captivity before transportation. By the time they arrived the animals were stressed and refused to eat or drink in the bomas. A few days later the situation had not improved and they had to be released early. Four subsequently died for various reasons and only two survived. This increased the numbers to an estimated 36 animals and by 1996 the population had increased to 44 individuals. It is assumed that the population is now approaching carrying capacity and the removal of surplus animals in the future is anticipated.

As a precaution against poaching all the rhinos on the plateau were de-horned in 1993 and marked with ear notches to enable individual identification.

Waterberg has experienced the occasional break-out of rhinos, generally from the western and northern boundaries. The rhinos often remain close to where they left the fence but occasionally travel far. Sometimes they return of their own accord, but generally they have to be captured and brought back. One or more animals may leave at a time, and sometimes the same animal leaves repeatedly.

During one week spent on the Plateau, rhinos were observed from the vehicle and they were most often sighted on open grassy areas. At night during the full moon period, water holes were watched and a range of behaviour seen, including a bull accompanying a cow in oestrus to the water hole and then trying to block her attempts to leave his territory. The Park's management were most helpful with this study and provided a tracker for a day, which was spent following the old footprints of two rhinos. It was observed that the rhinos selected the greener and softer grass and did not graze high biomass tough grasses growing around these areas.

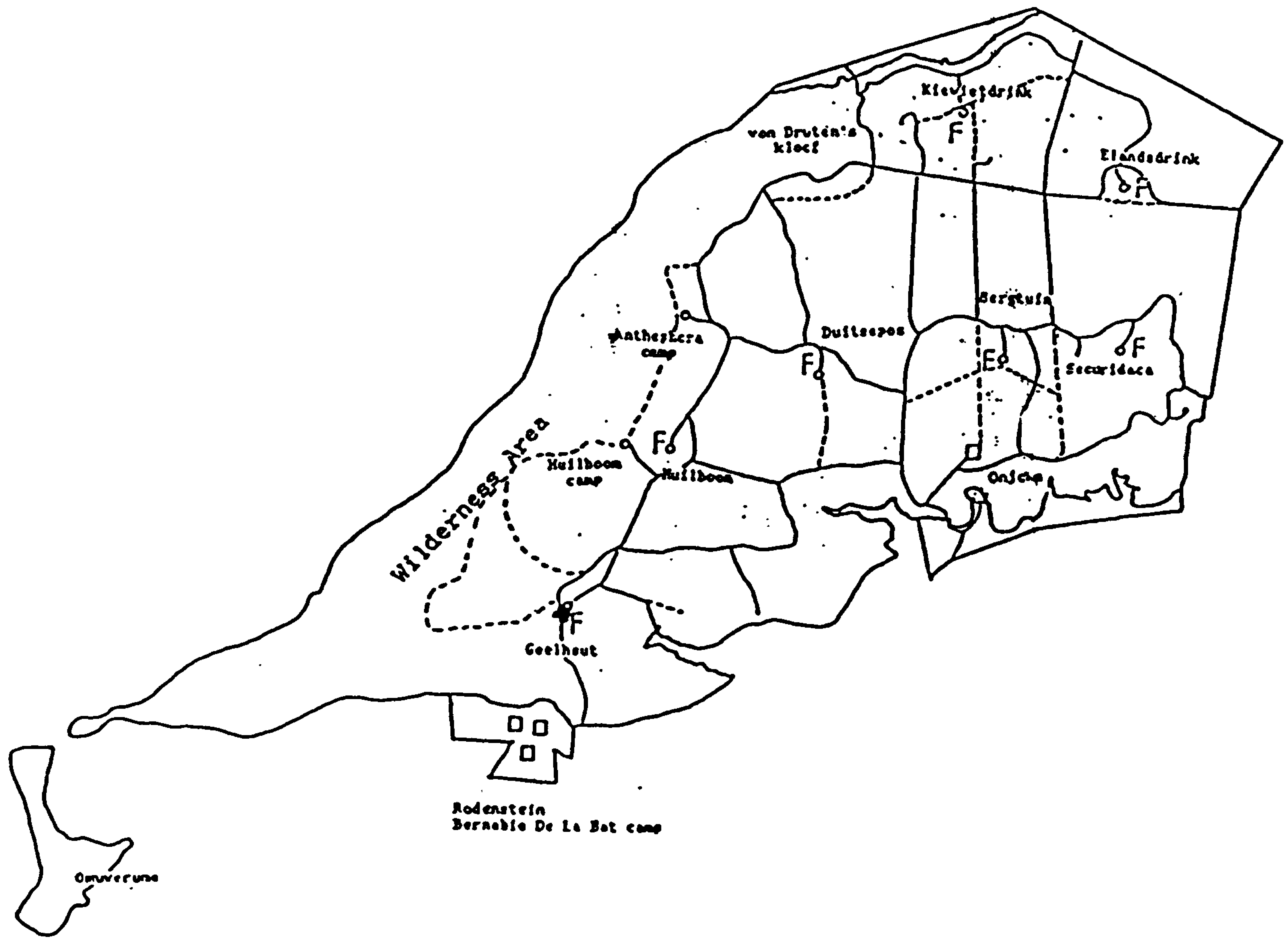

Fig. 1 Map of Waterberg Plateau Park (courtesy of MET)

Etosha National Park

Period of study – 5/95 to 2/97

(Personally, P.Erb Researcher)

Etosha is located in the north of Namibia and covers an area of 22,300km^2 (Sannier *et al.* 1998), see Fig. 2. Saline pans, the largest being the main Etosha Pan, cover 20% of the total area. Almost all of Etosha can be described as semi-arid savanna with a rainfall gradient increasing from around 300mm in the west to 450mm in the east (Le Roux *et al.* 1988).

Ten sub-adult white rhinos, (five males and five females) were released in Etosha near Halali (central tourist rest-camp) during May and June 1995. These animals were translocated from Kruger National Park. They arrived in two groups of five and were both released about a month after their arrival. Before the release of the second group, radio transmitters were attached to the rhinos using five ear tags and one collar for monitoring purposes. However one ear tag was pulled off almost immediately while the rhinos were still in the bomas and signals from the others failed soon after release, the last signal being lost in January 1996.

Monitoring of the rhinos released with transmitters was undertaken by park staff with a light aircraft suitable for efficiently searching Etosha's vast area. General sightings were also recorded by management staff, researchers and tourist sightings. From this a rough indication of the distribution of animals has been constructed. It is possible to see that the introduced rhinos have generally remained in the area between Halali and Namutoni (eastern tourist rest-camp), with one male moving into the western area.

In October 1996, the Etosha population was supplemented with Kai, a young bull white rhino which was a surplus animal bought to Etosha from the Serengeti Zoo Park, Hodenhagen, Germany (Bőer *et al.* 1997). A German researcher (Thomas Cantzler), accompanied him. The rhino was kept in a boma near Halali for a few months then released in early March 1997 and a few days later he was reported to be continually moving around, walking and grazing in an unusually straight line and occasionally falling over trees. After release, he headed south before following the fence around to the north east in the direction of Namutoni. He was last seen near Andoni (a water hole north of Namutoni).

Kaross

Date of study - 4/96 to 2/97

(Personal study)

Kaross is a fenced area of 150km^2 (15,000ha) located in the south western corner of Etosha National Park. The area and rhino population were studied in depth and the results are detailed in Chapter 4 to Chapter 6.

Seven adult rhinos (two males and five females) were moved from the Ohorongo game farm to Kaross in February 1994. Ohorongo's population of rhinos was declining from deaths due to drought and recent poaching, therefore to protect the remaining animals they were acquired by MET in exchange for Sable antelope (*Hippotragus niger*). When the rhinos were captured and relocated, the game capture vet commented that he was surprised that none of the animals had died as they were all in very poor condition (H. Winterback, Game Capture Division, MET *pers. comm.*).

Following their release they were re-immobilised to be de-horned, marked with ear notches and to have collars with radio-transmitters fitted. Due to the contours of the rhino's neck and head it was difficult to make these secure. Some weeks later it was seen that the collars were tending to slide off and damage the rhino's ears, so they were immobilised again and the collars removed.

Two animals were found dead of unknown causes in early December 1995. Since their release it is thought that no calves have been born. A possible explanation was that the dominant bull was infertile

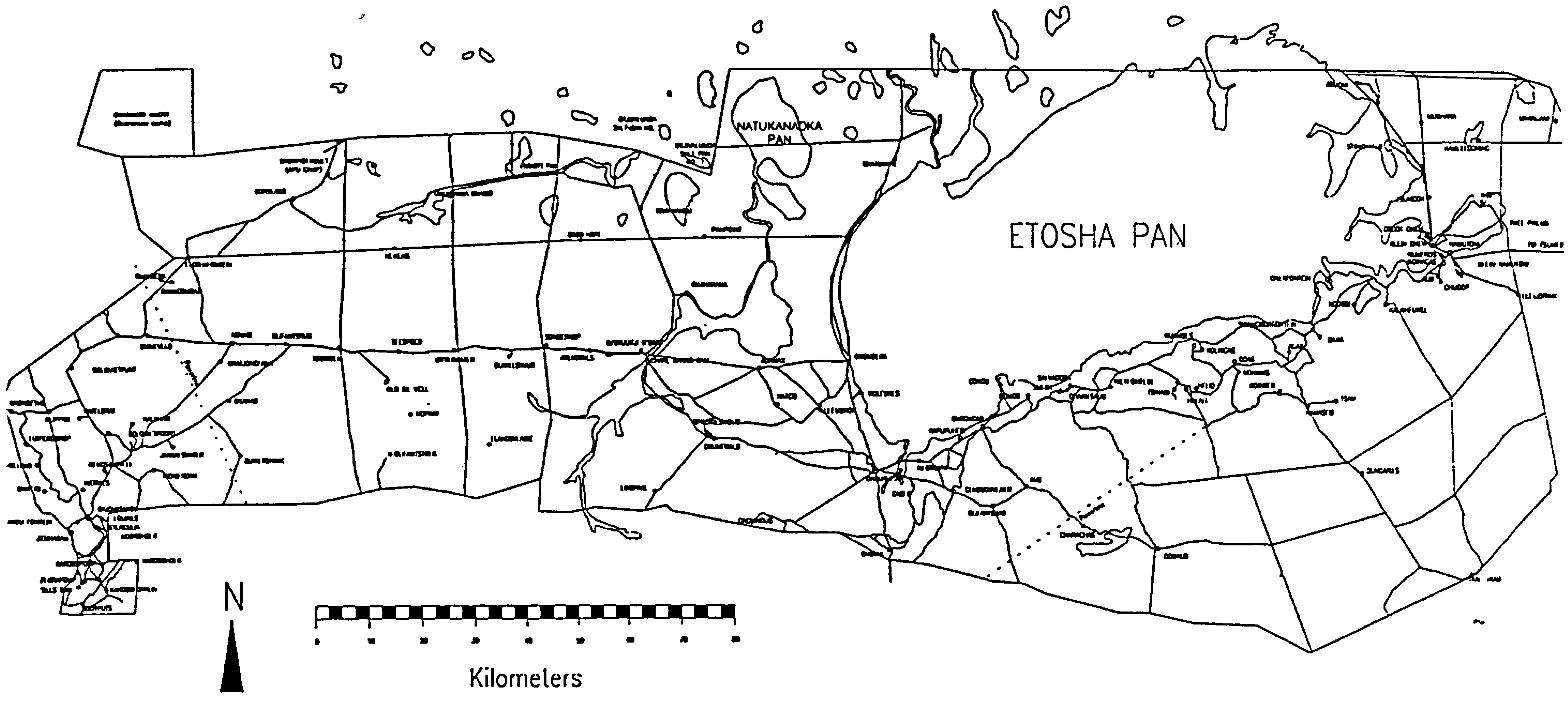

Fig. 2 Map of Etosha National Park (courtesy of Etosha Ecological Institute)

and prevented the subordinate bull access to the cows. Consequently MET decided to relocated the dominant bull to Mangetti in July 1996 and are considering the possibility of introducing another bull.

Mangetti

The dominant bull from Kaross was moved to Mangetti in July 1996 and is the only white rhino in this area. This park is owned by the MET and forms part of the Caprivi strip parks, but it was not possible to visit the park during this research.

Appendix VI

Kaross Habitat Survey - Supporting Tables and Figures

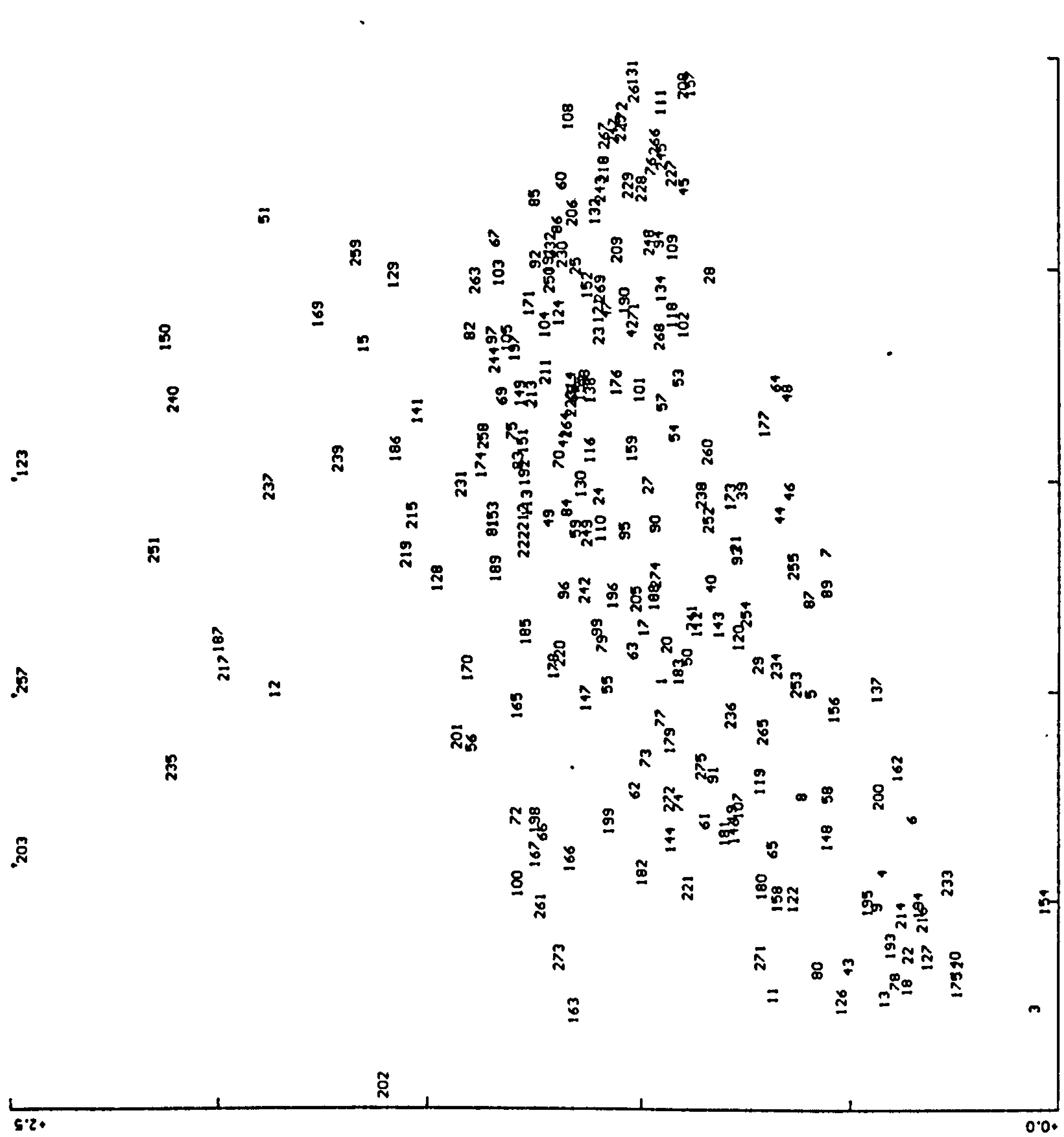

Fig. 1 Ordination Plot of Transects Analysing Grass Species

Fig. 2 TWINSPAN Analysis of Grass Species

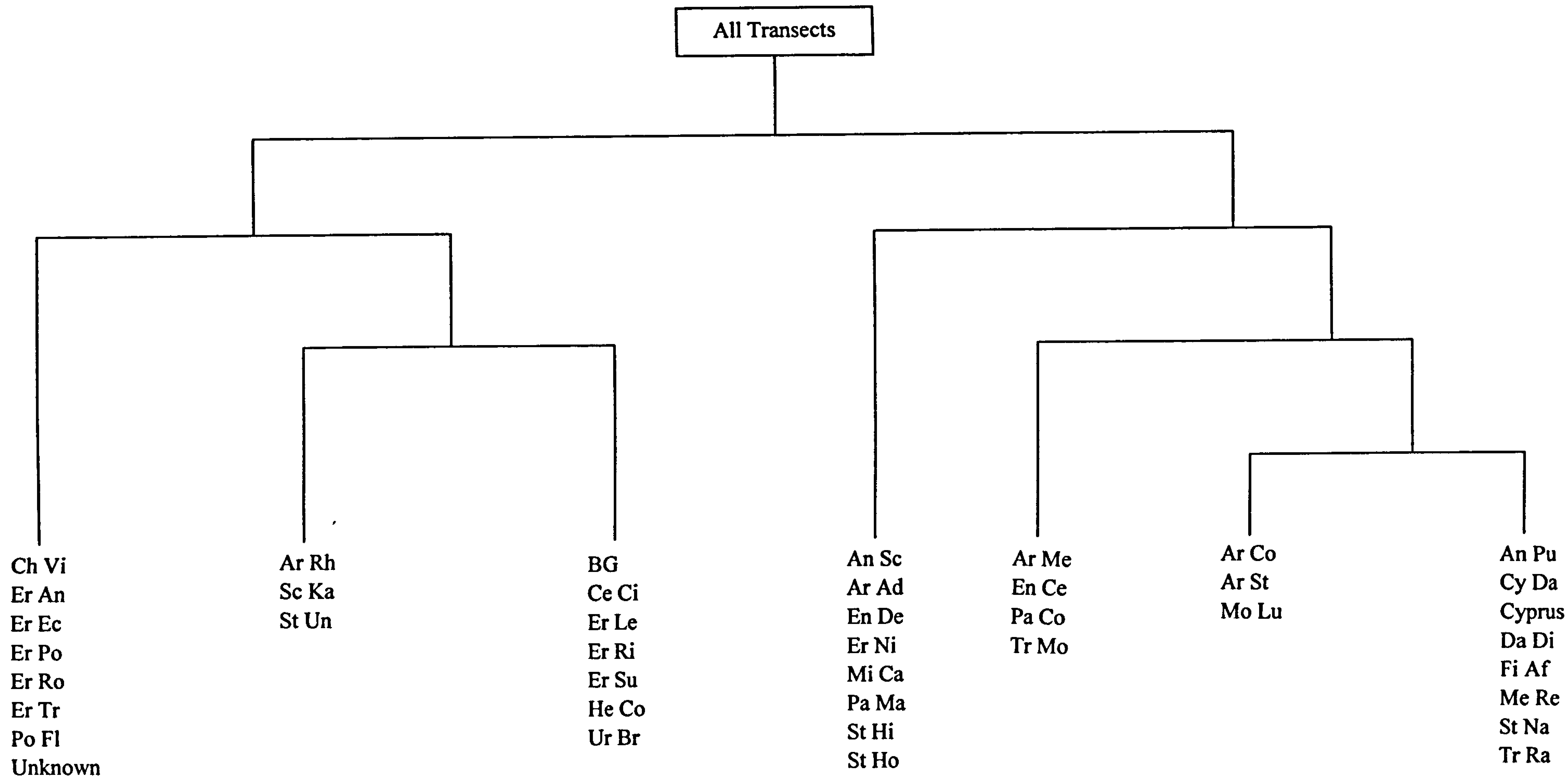

Fig. 3 TWINSPAN R-Mode Analysis to Group Grass Species

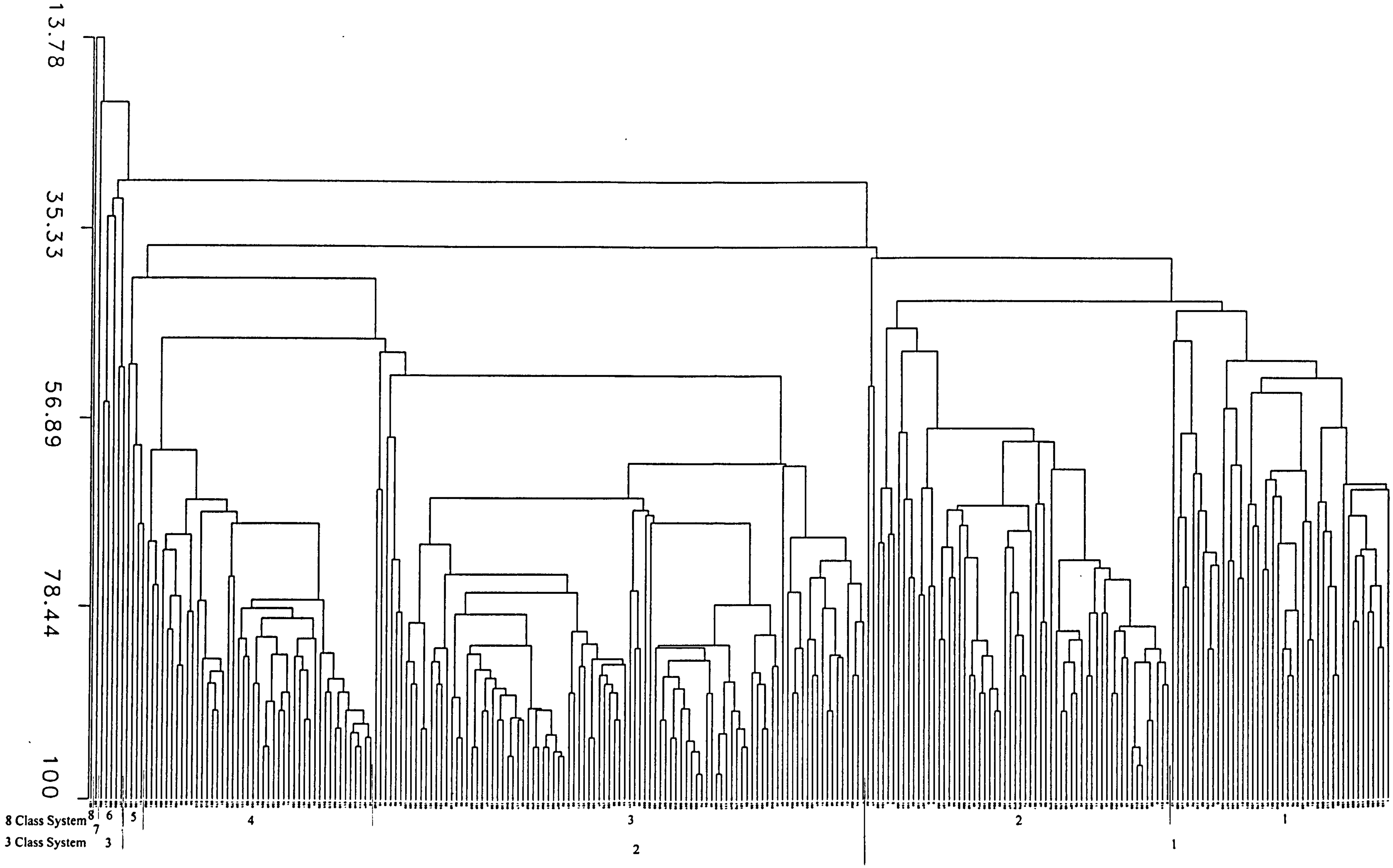

Fig. 4 MVSP Dendogram of Grass Species

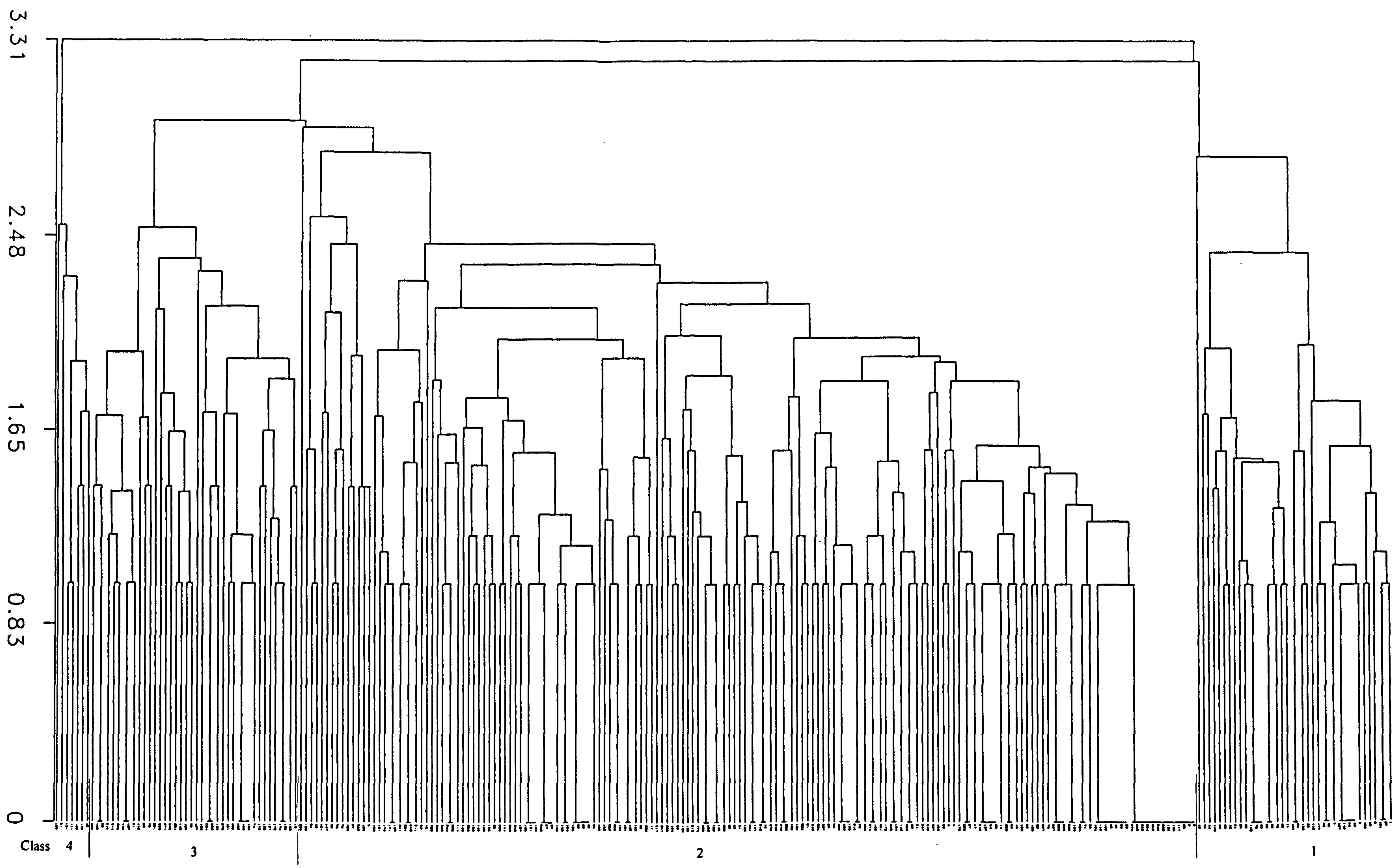

Fig. 5 MVSP Dendogram of Habitat Data

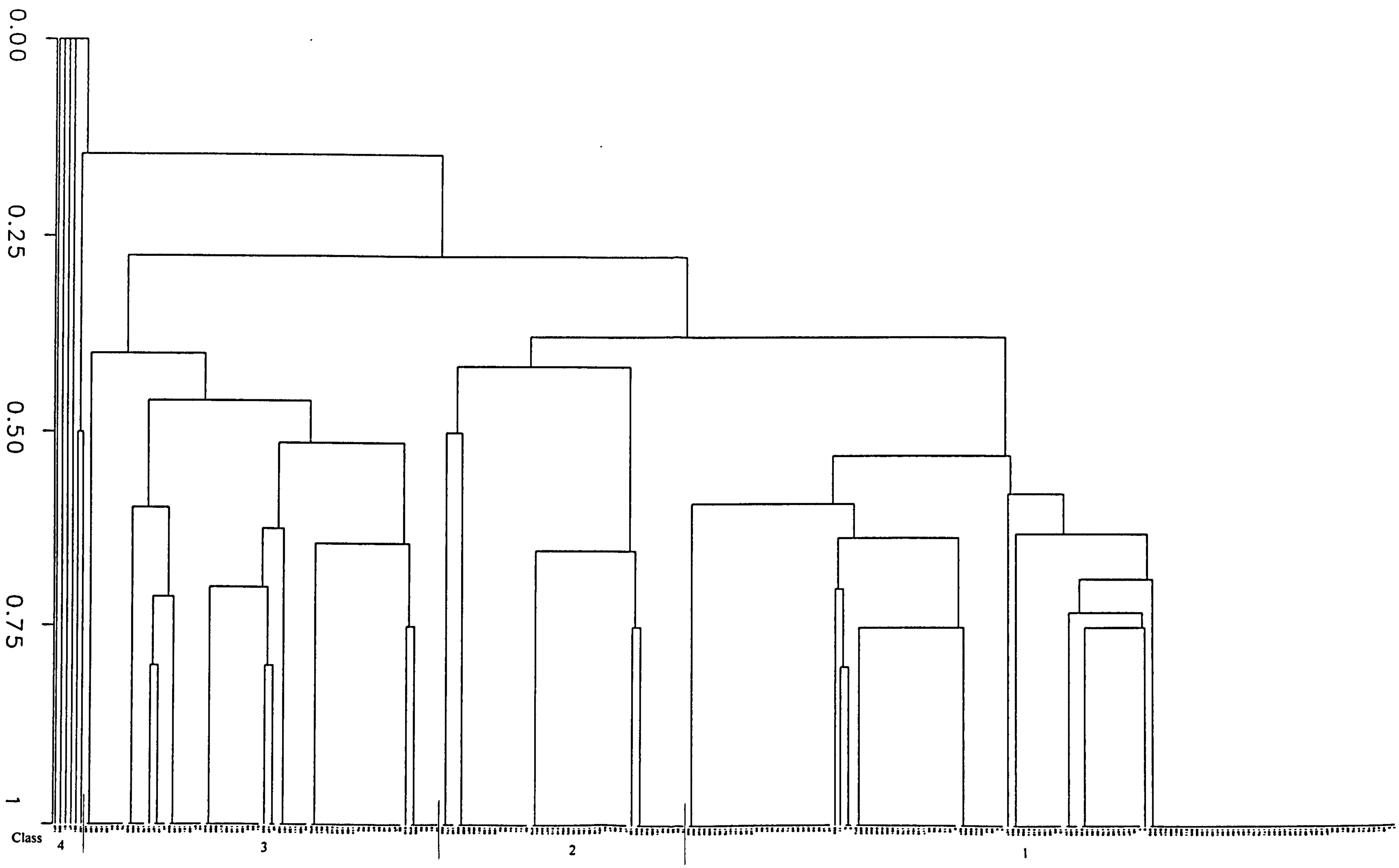

Fig. 6 MVSP Dendogram of Tree Species

Table 1 Grass Species Occurrence in Kaross

Transect	Number of recorded occurrences	Percentage of total
An Pu	43	0.17
An Sc	907	3.53
Ar Ad	1462	5.69
Ar Co	2	0.01
Ar Me	144	0.56
Ar Rh	98	0.38
Ar St	5	0.02
Bare Ground	324	1.26
Ce Ci	92	0.36
Ch Vi	6	0.02
Cy Da	1	0.00
Cyprus	5	0.02
Da Di	66	0.26
En Ce	428	1.67
En De	84	0.33
Er An	68	0.26
Er Ec	16	0.06
Er Le	16	0.06
Er Ni	3567	13.88
Er Po	846	3.29
Er Ri	32	0.12
Er Ro	465	1.81
Er Su	36	0.14
Er Tr	1	0.00
Fi Af	15	0.06
He Co	2	0.01
Me Re	271	1.05
Mi Ca	760	2.96
Mo Lu	3	0.01
Pa Co	43	0.17
Pa Ma	3	0.01
Po Fl	101	0.39
Sc Ka	7965	30.99
St Hi	48	0.19
St Ho	241	0.94
St Na	2	0.01
St Un	6841	26.62
Tr Mo	22	0.09
Tr Ra	243	0.95
Unidentifiable	277	1.08
Ur Br	149	0.58

Table 2 Herbaceous Species Occurrence in Each Transect for Correspondence Analysis

Tran.	An Pu	An Sc	Ar Ad	Ar Co	Ar Me	Ar Rh	Ar St	BG	Ce Ci	Ch Vi	Cy Da	Cyperus	Da Di	En Ce	En De	Er An	Er Ec	Er Le	Er Ni	Er Po	Er Ri	Er Ro	Er Su	Er Tr	Fi Al	He Co	Me Re	Mi Ca	Mo Lu	Pa Co	Pa Ma	Po Fi	Sc Ka	St Hi	St Ho	St Na	St Un	Tr Mo	Tr Ra	Unknown	Ur Mi
1		36	9															5	5								7					6		2		29			1	
2		1	6															51	3								17									22				
3			24			2													39	1		1						30					2				1				
4		10	18			4		1								4			17	5								35					3							3	
5		5	25			1													17	6								10				6	20				8			2	
6		22	4															38	3								13					15				2			3	
7		2	15															20	3								8				5	42				5				
8		14	14												2			32	15								8					11				2			2	
9			2															55	10								5				1	2				25				
10		9	6			1								1					3	2													66				10			2	
11		2	3		12			2						1					52						4		4		1				7				10		1		1
12		2	28			10		24						1	2	1				6	2								3					2				12			9	
13			2		1									3	2					59	1							5	4					3				18		1		1
14		6							1						3				2	4								1					44				39				
15		6							18												6		4						1					34		2		29				
16							1		3												4							1						37				54				
17			8						2											17	53								7					10							3	
18		3	7											2					66	4		1					1	1					3				10			2	
19		3	6						6	1									42									1					12				25		3		1
20			15			3													20	18		1												14				29				
21			11															21	10												6	32				20				
22			6															65															4				25				
23			4			4								1					2	5													3	45				36				
24		3	1						2											12	2								1					24				55				
25																																		58				41				1
26																				1								1					86				11				1
27		1																	4	21								13					23				38				
28			2															14	2														69				13				
29			2															36	9														20				33				
39																				29	7													1	44				19				
40			1		3														30	4														31				31				
41			1													2						6													5	19				67				
42			1					1								1	1			11	9		1						1					53				19			2	
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44		4	4															19								3	7				2	42		1		18				
45			7											2					4			1												79				7				
46		2	9								6				1		1		2	20		6		1				18					27				4			1	
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50			28			2											2			21	5		13									1		5	15				3			5	
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54			2		1														19	11		7							1					2	42				15				
55			4			3		3												24	4		6												2	1				53				
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57			2											1					16	2		10											1	41				26			1	
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81		1	1		9															2						1							1	13				72				1
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85			1														1						4		11											3	56				19			4	1
86																				5	4		13												56				19			3	
87			2															44			9												40				5				
89		2	7			1									1					35	1								4					45				4				
90		2	8		1			1						5					23			12						1								38				9				
91		23	15											2					24	10											1			7				18				
92		1	4					3												5			1						1			1		55				22			5	2
93		36	3															15									1	1					35				9				
94		3	4															5	4							1								74				6			3	
95			11											4					8	1								8								41				21		6		

Tran.	An Pu	An Sc	Ar Ad	Ar Co	Ar Me	Ar Rh	Ar St	BG	Ce Cl	Ch Vi	Cy De	Cyprus	Da Di	En Ce	En De	Er An	Er Ec	Er Le	Er Ni	Er Po	Er Ri	Er Ro	Er Su	Er Tr	Fi Al	He Co	Me Re	Mi Ca	Mo Lu	Pa Co	Pa Ma	Po Fi	Sc Ka	St Hi	St Ho	St Na	St Un	Tr Mo	Tr Ra	Unknown	[illegible]
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98			8		1									1					1	3													1	45		1		38			1	
99			10		8															10								1	4					13				54				
100		1	20											9	30				12										5					1				21		1		
101			2																	6	4		2						5				3	37				40			1	
102			3											1					15		5					3						64				8		1		
103																				2	1		18										1	39				35			3	1
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108								1												1	3		15												73				7				
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138			4			2															2												6	37				46			2	1
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Tran.	An Pu	An Sc	Ar Ad	Ar Co	Ar Me	Ar Rh	Ar St	BG	Ca Ci	Ch Vi	Cy Da	Cyprus	Da Di	En Ca	En De	Er Ah	Er Ec	Er La	Er Ni	Er Po	Er Ri	Er Ro	Er Su	Er Tr	Fl Al	He Co	Me Ne	Mi Ca	Mo Lu	Pa Co	Pa Ma	Po Fl	Sc Ka	St Hi	St Ho	St Na	St Un	Tr Mo	Tr Ra	Unknown	Ur Br
187		13	7		6			5	3			5		10	1			3		2							1						17		9		12	3	1		2
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191																			1	2													52				40			1	4
192		1	7					4											9	1	3												28				41			2	4
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246		1																	2	3													66				28				
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258		6						3												2							1						18				67			3	
259		4												1						1													65		21		2				6
260		28	2																11	2								2					42				10			3	
261		8	2					3					23	2					10								5						8				25		13		1
262																						3											60				37				
263		1						3														16											39				39			1	1
264		2	2			1													1			4											29				61				
265	2	26	18		1									2	1				17									6					20				7				
266			4																	6		1											77				12				
267			2											1								4											76				17				
268		21	5											6						1								1				1	56				9				
269																				4								1					55				40				
270																				1							1	6					58				33				1
271	1	4	6					7						6					38								1	12					3				15		7		
272		4	9		2			3						9	1				27			1					1	6					8				28		1		
273			1					6	6					5					55			2	8					2							10		4		1		
274		1	3					3						2					25			2											26				38				
275			13					1						8					33			4											11				29		1		

Table 3 The Two-Way Table Generated From TWINSPAN Analysis Indicating Community Divisions of Transects

Transects are columns, n = 257.
Species are in rows, n = 41.

```
               11222  112     1111111222222222     1111111111122222222222221112            111111111112222222            1112  11111122  11112222       122  2   11              1111111111111111112222222222      111112222 1111122      2   1111111122  112222  111111212222
               152413519684112694577999113334455561227781111333355011222334467256622344555788890000334567900136662244555667882362469112357244803570124   12675646325700  1244456789002234444455799990113345557      19911168046671468822667990179222577882718994677676667880801 57
               2131971579600647291141273501947089445656314561234359013592838909083899053471567834585929120678426713190598901248062047816268674107382755797747306650622723923488549909077034568465345604636124544681813023285958397539011375613802688890125108921122936702527 3773

40 Unknown     354---2-35122--23-33-12-2-2-21--2---------1-2-22-1----1---------4-1-------1-22-121--11-1-23-11-------23-2------21-2321-212-----1----1-22--2--1-21--------------2-1--------1-----1---------------22212----2------22---42--------------1--------2--------1---------  11
32 PoFl        ---------1--------1-------------------1---------------1---------------1---21-2--11---21-2---------3233323-211-13-------1--1--1-21------331---1-------1-------2--2--------1------1----------------------1---------1--------------------11------1-1-----1-----1-----  11
24 ErTr        -------------------------------------------------------------------------------------------------------------------------------------------1--------------------------------------------------------------------------------------------------------------  11
22 ErRo        -5-3---2-3-------3-----------2----2-----------------------11--5544----12342443-4544-33--11-2-2212----433212-1-----12---2-----2222-21222---------3--12233-1----2-------------2-3---------112---22----1--31-------2------------2--4333-12--22-------1----------1--2  11
20 ErPo        3221-223312222223-221212--324---21-2-14-13-2-311---1--322-1-221432-2332-342422-212222-224225-4--3-4333323355-452443222322-212--22-1--3-3246532-25--443-121--1-12-11--1----22-11-121-21--1--1--1-324324-2212--2-122232----1112111---2--221----121---1-433-21-222--  11
17 ErEc        --3-----3--1----------------------------------------------------------------------------------------------------------------------------------1---------------------------------------------------------------------------------------------------------1--  11
16 ErAn        1351----1------2----------------------------------3-----------------1----------------------222---1--------1---------12---------------------------------------------2-2---------------12--------1-----------------------------------------------------------  11
10 ChVi        -----------------------------------------------------------------------------------------------------------------------------------------3-----------------------------------------------------------------------------------------------------------------  11
37 StUn        4226665545634665566556666565645626655464616653565665666645555455315545453445344355555356455345545544556426655565555545355555545565625164333 5-53554255544345155442455265453455535434354564554564645-225443435454533435455654535544334145545355445545455534554554455 2  101
33 ScKa        2525-4455545656655565546555364556564565565565565655566455655566556666555565556556665555565665665666665666545413555455555566666665556665645565636655245 65555-143164-242256444541654525232435324345234335455244323555455555644 3441-555555235435354254433125323452214 44-43---  101
 6 ArRh        4-1---------11-1-1-------1--------1-----------------------------------3--------------2-222-311---211-------1-----1-----1---------3-232-2-2--------1----------1--3--------------2------21---1-----1-------------2----------12----------------  101
41 UrBr        ------1-2-13---12--2222123-2-2---3--111-1--2----1--1--1-----1-12--1---------1---1-------1----2-----------1--1-122--------11-------12-----------------1-1--1-1--------1-----1-2-2-211---2---12----------11---1-----311-1-----11---1--12--1-11-2-1----312--22213--  100
26 HeCo        --------1-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------1--  100
23 ErSu        ---------------1-------------------------1----4-------2-----2-----------------------------------------1------------------------------------------------------------------------------------------------------------------------------------------3-3  100
21 ErRi        21------------1---1--21-3-------------------------------------1----------------------------------1-----------------------------------------------------------------------------------------------------1---------------1----------1-----4--  100
18 ErLe        ------2---1--------------1------------------------2-----------------------------------------------2-------------------------------------------------------1-------------------------------------------------------------------------------------21-1-  100
 9 CeCi        --31-1-41125---------------------1----1-----------------2---------------------1-------------------------------------1-------------------2--1----1---------------------------------------------------------------------------------------1---22223  100
 8 BG          5-5-344------22-2--11-21---142212----------------1---------------2512--------1-------1---1----1-------2-21--3-22--21--1--1--1----1-1--11---2---------24----3-----------------1--2-1-----12---11---21-----------------2--1------13-11-1-12-1111223232321--322-1134--3  100
35 StHo        --233452--32---2----------------5---------------------------------1---------------------2-----------------1---------------------3-42------21--------1---------------1-------2-----2-----1---------22--22-----------21---2----3-------------3-164  01
34 StHi        --------------------------------1-------1-----------1-----------------------------------1--------------------------------------35-----------------------4-2--------------------------------------------------------------------------------------  01
31 PaMa        ---------------1-----------------------------------------------------------------------------------------------------------------1------------------------------------------------------1-------------------------------------------------------  01
28 MiCa        2-----212-----1-1-------------------1-1--2--12---332--12---1-313----------1-----------------------------2--------1--11-2122-23333533334333444-2431-12--451-33442-223---43-42415532222342334352-54331-1---52-431122-21-3------2-------------4-3--4321222--11--2-2  01
19 ErNi        -11-1-2-31--2-41--11113-3111-1----12----1--------1-2-------4--------455524444-35123-13-24-24---5---52-25533-42-1-11413233-13-2113213-2--45642435424355445655664355554445656556555666645666535355455365424-42224-44434-454453336656626345525654534554244325 12--216  01
15 EnDe        22-------1-----------------------2----2--------1--------------1---------------------------------------------1----1--1---2----------------11----------2-------5-----2--2--------------------------------1-1-2-22-21----1-1---------1--------1----11---1-3--  01
 3 ArAd        51232----11-3-112--3--31-1111-1---2---112---1--1---2-2----112--224-22-13222-1-23-34--13-2-3--21-22421552222112222 21-22233332-2223---22-5423-22223524352535332243433453343-224543444343-242-23-32424334253444334356451533344443243-34235323422233233343343 13133121  01
 2 AnSc        2------332343-2-1-3---1----212213223---2--1-5-44---4-222-1422---221-----------------11-------------------1----1-122-11-1111--2---1--32--1-2252-------1-2-22--1-2-1---11-2--4-------2----3---145452553553553553-144444-32-22-12-1---1--4-22-143222344443514----  01
38 TrMo        -------------------------2----------------------------------------------------------------------------------------------------1----------------------------------------------------3-----------------------24---  001
30 PaCo        ----------2---------------------------------------------------1-----------------------1----------------------1-----------------------------------------------1--------------------1--2----2--------------------22--2-5---  001
14 EnCe        12-2-23-22-21--1-1-11--221121-12-1-----12-----------2---11-1----2-----2--1----1----------2------1-1-1---------------------1---1------------33-1112----1--1131-31-2--22221--2--1-21-12-3--2----22-2-33234233-32-223-33233213324222 3333122-22332323221 3344423  001
 5 ArMe        ----------------------------------1-----------------1----2--1-----1------------------2--1---32------------22-------------------22------------3--3--1----1----------1---------------1---------1------1-21-2---2--1--11-12-31-2----4-2----2---42233332---  001
29 MoLu        --------------------------------------------------------------------------------------------------------------------------------1---------1--------------------------------------------------------------------------------1---------------------  0001
 7 ArSt        -------------------------------------------------------------------------------------------------------------------------------------------------------------3---------------------------------------------------------------------------------------  0001
 4 ArCo        -----------------------------------------------------------------------------------------------------------------------------1----------------------------------------------------------------------------------------------------1----------  0001
39 TrRa        -----------------------------------------------------------------------------------------------------------------------------121---2---------1--1---1----------1-------------------2------------21---2---22--4-333412-32-1-123-11432-4314342434-51---1  0000
36 StNa        -------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------1-------------------------------------1--  0000
27 MeRe        --------22---1----------------1--------1-----1-----------------1-------------1----------------------1--2-----1-----1-2---------------------2---122----22--13-1---1--2-1---------2-------------1-121-211------1---254233433 1221232-32-22223311432342 3331----  0000
25 FiAf        ----------------------------------------------------------------------------------------------------1-------------------------1-------------2-------------------------------------------2----------------22--2-----1-----------  0000
13 DaDi        ------------------------------------------------------------------------------------------------------------------------------------------------------------------------------1-------2-----142-3----41-5----2-----------  0000
12 Cyprus      -------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------3----  0000
11 CyDa        ---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------1---  0000
 1 AnPu        ----------------------------------------------------------------------------------------------------------------------------------------------------------------------2---------21--2-----------------2--1-1241--2-3-----  0000

               00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000001111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
               00000000000000000000000000000000000000000000000000000000000000000000000000001111111111111111111111111111111111111111111111111111111111111111111111111110000000000000000000000000000000000000000000000000000000000000000000011111111111111111111111111111111
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                         0000000000000000000000000111111111111111111111111111111     00000000000000000000000000000000000111111111111111100000000000001111111111100000000001   000001111111111111111111111111111111111111111111111   00000000000000011111110000000111111111111100000000111111111

                               Class 4                                                        Class 3                                                  Class 2                                                Class 1
```

Table 4 TWINSPAN Four-Class Grass Classification

Grass Species	Class 1 (n=41)		Class 2 (n=71)		Class 3 (n=82)		Class 4 (n=63)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Sc Ka	13.44	11.08	16.42	15.90	44.76	21.00	40.92	22.30
St Un	19.95	10.16	20.77	14.32	25.63	17.08	38.83	21.66
Er Ni	21.49	19.67	27.39	18.93	8.12	12.42	1.19	4.32
Ar Ad	7.00	5.14	10.89	9.04	3.78	5.55	1.46	4.73
An Sc	4.51	6.54	6.56	12.39	0.85	5.36	2.95	5.53
Er Po	1.24	2.07	2.17	4.41	6.04	8.24	2.32	2.92
Mi Ca	1.59	4.58	6.56	9.51	2.17	5.45	0.81	2.04
Er Ro	1.12	3.24	0.76	2.14	3.80	6.40	0.84	6.41
En Ce	4.90	3.08	2.25	3.15	0.16	0.48	0.86	1.27
BG	2.37	3.49	0.52	2.59	0.74	3.96	2.05	8.63
Unknown	0.12	1.15	0.54	2.33	1.07	2.44	2.32	7.79
Me Re	5.15	4.76	0.61	1.29	0.10	0.52	0.14	0.49
Tr Ra	5.34	7.92	0.34	1.07	0.00		0.00	
St Ho	2.44	22.70	0.69	3.35	0.06	1.15	1.38	7.30
Ur Br	0.80	1.42	0.46	1.36	0.28	0.83	0.95	2.09
Ar Me	1.95	3.46	0.52	2.54	0.32	2.46	0.02	
Po Fl	0.15	0.00	0.13	0.49	1.00	2.00	0.06	0.00
Ar Rh	0.12	0.58	0.59	2.25	0.41	1.91	0.27	3.18
Ce Ci	0.49	1.75	0.07	1.15	0.07	1.73	0.97	9.06
En De	0.34	1.67	0.70	8.48	0.10	0.82	0.19	0.89
Er An	0.02		0.14	1.29	0.26	2.00	0.57	9.44
Da Di	1.59	7.63	0.01		0.00		0.00	
St Hi	0.00		0.63	9.74	0.01		0.03	0.00
An Pu	1.00	5.27	0.03		0.00		0.00	
Pa Co	0.93	8.22	0.01		0.02	0.00	0.03	
Er Su	0.41	0.71	0.00		0.05	1.41	0.24	4.86
Er Ri	0.39	6.00	0.00		0.02	0.00	0.22	1.53
Tr Mo	0.46	3.51	0.01		0.00		0.03	
Er Ec	0.02		0.00		0.01		0.22	3.21
Er Le	0.12	1.15	0.01		0.05		0.10	0.58
Fi Af	0.27	1.10	0.04	0.71	0.01		0.00	
Ch Vi	0.00		0.00		0.07		0.00	
Ar St	0.00		0.07		0.00		0.00	
Cyprus	0.12		0.00		0.00		0.00	
Mo Lu	0.02		0.03	0.00	0.00		0.00	
Pa Ma	0.00		0.03	0.00	0.00		0.02	
Ar Co	0.02		0.01		0.00		0.00	
He Co	0.02		0.00		0.00		0.02	
St Na	0.05	0.00	0.00		0.00		0.00	
Cy Da	0.02		0.00		0.00		0.00	
Er Tr	0.00		0.00		0.01		0.00	

Table 5 Three-Class Grass Classification

Grass Species	Class 1 (n=104)		Class 2 (n=146)		Class 3 (n=7)	
	Mean	SD	Mean	SD	Mean	SD
Sc Ka	18.47	16.05	41.82	22.49	13.50	10.15
St Un	22.83	15.54	29.52	19.55	28.86	16.11
Er Ni	25.22	19.17	12.24	15.04	11.50	19.91
Er Ro	3.61	2.99	6.59	6.37	4.00	2.83
Mi Ca	7.29	7.69	6.10	7.54	1.67	1.15
An Sc	9.12	10.61	6.10	7.30	4.00	3.61
Ch Vi			6.00			
Ce Ci	2.33	1.97	5.25	8.43	3.75	0.50
St Ho	4.77	3.75	5.22	6.48	21.25	31.34
Er Po	4.97	7.55	4.93	5.02	1.67	0.58
Ar Ad	10.01	9.15	4.90	4.10	2.67	2.34
Er An	2.25	1.28	4.17	6.83		
Tr Mo	4.67	4.73	4.00	2.83		
Tr Ra	4.46	4.13	4.00	3.79	21.00	19.00
BG	3.78	4.58	3.86	6.00	3.50	3.54
Er Ec			3.75	3.20	1.00	
Unknown	3.59	5.93	3.58	4.61	1.00	
Ar Me	3.76	3.42	2.83	2.66	3.50	2.08
En Ce	4.02	3.05	2.59	2.42	6.67	3.33
Me Re	4.26	4.38	2.40	2.66	7.67	3.51
Pa Co	6.00	10.10	2.25	0.96	2.00	0.00
Po Fl	2.11	1.94	2.22	1.72	1.00	
Ar Rh	3.05	2.57	2.00	1.81		
Er Le	2.00	1.41	2.00	1.22	1.00	0.00
Ur Br	1.88	1.90	1.81	1.31	2.25	1.89
En De	3.05	6.57	1.73	0.90	3.50	3.54
Er Su	9.50	2.12	1.60	0.89	9.00	
Da Di	8.00	7.76	1.00	0.00		
St Hi	6.67	4.04	1.00	0.00	25.00	
Er Ri	2.40	1.67	1.00	0.00	7.00	8.49
Fi Af	2.00	1.00	1.00			
Pa Ma	1.00	0.00	1.00			
Er Tr			1.00			
He Co			1.00		1.00	
Ar St	5.00					
Cyprus	5.00					
An Pu	3.36	5.24			6.00	
Ar Co	1.00	0.00				
Cy Da	1.00					
Mo Lu	1.00	0.00				
St Na					1.00	0.00

Table 6 MVSP Eight-Class Grass Classification

Grass Species	1(n=44) Mean	SD	2 (n=58) Mean	SD	3 (n=99) Mean	SD	4 (n=45) Mean	SD	5 (n=4) Mean	SD	6 (n=5) Mean	SD	7 (n=1) Mean	SD	8 (n=1) Mean	SD
Sc Ka	20.39	13.20	17.30	18.19	48.85	21.03	25.25	18.30	33.25	5.74	14.67	12.10			10.00	
St Un	20.20	13.62	25.07	16.73	22.04	13.49	45.67	20.82	26.50	24.58	33.20	17.38	21.00		15.00	
Er Ni	14.95	13.57	32.83	19.54	11.94	13.11	14.18	18.73	2.50	2.12	4.00	1.41	1.00		52.00	
An Sc	13.74	11.91	3.81	5.34	6.63	8.23	5.24	5.50	4.00		4.00	3.61				
Da Di	11.25	9.03	4.75	5.56	1.00		1.00									
Ar Ad	10.49	8.79	9.67	9.67	5.04	4.05	4.34	3.67	9.33	7.64	2.60	2.61	3.00			
Pa Co	6.75	11.50	3.00		2.25	0.96					2.00	0.00				
Mi Ca	6.11	8.11	8.15	7.63	5.05	4.84	7.86	10.65			1.67	1.15				
Tr Ra	5.89	4.28	2.87	3.38	3.57	3.64					29.00	18.38			5.00	
Unidentified	5.82	9.00	2.00	0.93	3.26	3.12	2.73	3.24	27.00		1.00					
Me Re	5.46	5.46	2.76	1.64	2.53	2.85	2.25	2.50	1.00		9.50	2.12			4.00	
BG	5.44	6.63	2.73	2.00	3.00	5.80	4.95	6.08	1.00		3.50	3.54				
Ar St	5.00															
Cyprus	5.00															
Tr Mo	4.67	4.73					2.00		6.00							
En Ce	4.35	3.24	3.73	2.84	2.18	1.74	2.92	2.40	4.50	5.69	8.25	2.63	2.00		5.00	
Er Ro	4.33	4.00	3.28	2.49	5.73	5.37	7.64	8.63	11.50	7.19	2.00				6.00	
Ar Me	3.90	3.57	3.64	3.44	1.73	1.01	4.80	3.77	4.00	4.24	3.67	2.52			3.00	
An Pu	3.78	5.76	1.50	0.71							6.00					
Er Po	3.55	2.74	4.52	5.60	6.23	7.84	3.93	3.88	2.67	0.58	1.67	0.58				
St Ho	3.29	2.81	5.20	3.03	4.85	5.94	7.33	8.02			5.67	4.04	68.00			
Ar Rh	3.00	2.83	2.44	1.42	2.56	2.61	1.75	0.96	1.00							
Er Ri	2.67	2.08	2.00	1.41	1.00	0.00	1.00		1.00		7.00	8.49				
Po Fl	2.50	2.46	1.67	1.12	2.00	1.49	2.75	2.19			1.00					
Ur Br	2.33	2.66	1.50	0.79	1.81	1.52	1.82	0.95			2.25	1.89				
Er An	2.20	1.30	2.33	1.53	4.25	8.41	3.67	2.89	5.00							
Er Le	2.00	1.41			2.33	1.53	1.50	0.71			1.00		1.00			
Ce Ci	1.75	0.96	3.50	3.54	6.33	9.58	2.00	1.73			3.67	0.58	4.00			
Fi Af	1.67	0.58	2.25	1.26			1.00									
En De	1.38	0.74	4.27	8.57	1.43	0.79	2.33	1.15	2.00		3.50	3.54				
Ar Co	1.00				1.00											
Cy Da	1.00															
Mo Lu	1.00		1.00	0.00												
Pa Ma	1.00				1.00	0.00										
Ch Vi					6.00											
Er Ec					3.75	3.20					1.00					
Er Su			9.50	2.12	1.25	0.50	3.00				9.00					
Er Tr					1.00											
He Co					1.00						1.00					
St Hi			6.67	4.04	1.00	0.00	1.00				25.00					
St Na											1.00	0.00				

Table 7 Habitat Data Analysed by Correspondence Analysis

Transect	Veg class	Tree Cover	Rockiness	Soil	Grazing	Slope	G. Biomass	G. Density	Forage
1	2	3	1	1	1	1	2	2	2
2	2	2	1	3	1	1	2	2	2
3	2	2	1	3	2	1	3	1	1
4	2	3	1	2	1	1	2	2	1
5	2	3	1	1	1	1	2	1	1
6	2	3	1	3	2	1	2	1	1
7	2	2	1	2	1	1	2	1	1
8	2	2	1	1	1	1	2	2	1
9	2	2	1	3	1	1	2	2	2
10	2	2	1	3	1	1	1	1	1
11	2	3	3	2	1	2	2	1	2
12	2	3	1	1	1	1	1	3	1
13	2	2	3	4	1	3	3	1	2
14	2	2	1	4	1	1	2	1	2
15	3	3	1	4	2	1	3	2	3
16	2	2	1	3	1	1	2	3	3
17	2	1	1	3	1	1	1	3	2
18	2	3	2	2	1	1	2	1	2
19	2	2	2	1	1	1	2	2	2
20	2	2	1	3	1	1	2	2	2
21	2	3	1	3	1	1	1	2	2
22	2	3	1	3	2	1	1	2	2
23	2	2	1	3	2	1	2	2	2
24	2	2	1	3	2	1	2	2	3
25	2	2	1	3	2	1	2	2	2
26	2	3	1	3	1	1	2	1	1
27	2	2	1	3	1	1	2	2	2
28	2	2	1	3	1	1	2	1	2
29	2	2	1	3	1	1	1	2	3
39	2	3	1	3	1	1	2	1	2
40	2	2	1	3	2	1	2	2	2
41	2	2	1	4	1	1	3	2	3
42	2	2	1	3	2	1	2	2	2
43	2	2	2	2	1	2	2	1	2
44	2	2	2	2	2	1	1	1	2
45	2	2	1	2	3	1	2	1	1
46	1	1	1	3	3	1	2	1	1
47	2	2	1	2	2	1	2	1	2
48	2	2	1	1	2	1	2	1	1
49	2	2	1	1	1	1	2	1	1
50	2	2	1	1	2	1	2	1	1
51	1	1	1	1	3	1	1	1	1
53	2	2	1	3	1	1	1	1	2
54	2	2	1	3	1	1	2	1	2
55	2	1	1	3	1	1	1	3	3
56	2	3	1	4	1	1	1	3	2
57	2	2	1	3	1	1	2	2	2
58	2	2	1	4	1	1	1	2	2
59	2	3	1	4	3	2	2	3	3
60	2	2	1	3	2	1	2	2	2
61	2	2	3	2	1	3	2	1	2
62	2	3	3	2	1	2	2	2	2
63	2	3	3	2	1	1	2	1	2
64	2	2	1	1	1	1	2	1	1
65	2	2	2	2	1	2	3	1	2
66	2	3	2	1	1	2	2	1	2
67	2	2	1	1	1	1	2	2	2
68	2	3	1	1	1	1	3	1	2
69	2	2	1	4	1	1	2	2	3
70	2	1	1	3	1	1	2	3	2
71	2	3	1	3	1	1	2	2	2
72	2	3	2	4	1	2	1	3	1
73	2	3	2	4	2	2	2	2	1
74	2	3	3	4	1	2	2	2	2
75	1	1	1	4	1	1	2	2	3
76	1	1	1	4	2	1	2	2	2
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79	2	2	2	2	1	2	2	2	2
80	2	2	3	2	1	2	2	2	2
81	2	3	1	2	1	1	2	2	3
82	2	1	1	3	1	1	3	2	2
83	2	2	1	3	1	1	3	1	3
84	2	2	1	1	1	1	3	2	3
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86	1	1	1	3	2	1	2	2	2
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89	2	3	2	3	2	1	2	2	1
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91	2	3	2	4	1	3	2	1	2
92	2	2	1	3	2	1	2	2	2
93	2	2	2	4	1	2	2	1	1
94	2	1	1	3	3	1	2	1	1
95	2	2	2	2	2	2	2	1	2
96	2	2	3	2	1	2	2	2	2
97	2	1	1	3	1	1	2	2	1
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99	2	2	2	3	1	1	2	2	3
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102	2	2	1	4	1	1	3	1	1
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104	2	2	1	4	2	1	2	2	2
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117	2	2	1	3	1	1	2	2	2
118	2	1	1	1	2	1	2	1	2
119	2	2	1	1	1	1	2	1	1
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121	2	2	1	4	1	1	2	2	2
122	2	2	3	4	1	3	1	2	2
123	1	1	2	3	3	1	1	3	1
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126	2	2	3	4	1	2	2	2	2
127	2	3	2	4	1	2	2	1	2
128	2	2	3	3	2	3	2	2	2
129	2	2	1	3	2	1	2	2	2
130	2	2	2	3	3	1	2	2	3
131	1	1	1	3	3	1	1	1	1
132	2	3	1	3	3	1	2	2	2
133	2	2	1	3	2	1	2	2	3
134	2	2	1	3	2	1	1	3	2
135	2	2	1	3	1	1	2	2	2
136	2	2	1	3	1	1	2	2	2
137	2	2	1	3	1	1	2	1	2
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139	2	2	1	4	1	1	3	3	3
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141	2	2	1	4	1	1	2	3	3
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143	2	2	1	4	2	1	2	2	2
144	2	3	1	4	1	1	2	1	2
145	2	2	2	4	1	1	2	1	2
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147	1	1	1	3	2	1	3	2	2
148	2	3	2	4	2	1	2	1	2
149	2	2	1	4	2	1	2	2	3
150	2	2	1	3	3	1	1	3	1

151	2	1	1	3	2	1	3	1	3
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153	2	2	1	3	2	1	3	2	3
154	2	3	1	3	1	1	1	2	1
155	2	2	1	3	2	1	3	2	3
156	2	2	1	3	1	1	3	2	1
157	2	2	1	1	1	1	2	1	1
158	2	2	3	4	1	2	2	2	2
159	2	2	1	4	1	1	1	3	2
160	2	2	1	4	1	1	2	3	2
161	2	2	1	4	1	1	2	3	2
162	2	2	2	4	1	2	2	1	1
163	2	1	3	4	1	2	2	3	3
165	2	2	1	4	1	1	2	2	2
166	2	2	3	4	1	1	2	2	2
167	2	1	3	4	1	3	2	2	2
168	2	2	2	3	2	1	2	2	2
169	1	1	1	3	3	1	1	2	1
170	2	2	3	4	2	3	2	3	2
171	2	3	1	3	3	1	2	2	2
172	2	2	1	3	3	1	1	2	1
173	2	2	1	3	2	1	1	3	2
174	2	2	1	3	2	1	3	3	3
175	2	3	1	3	2	1	2	1	2
176	2	3	1	3	2	1	2	2	2
177	2	2	1	1	2	1	2	1	2
178	2	2	3	4	1	3	2	2	2
179	2	2	3	4	1	3	1	2	2
180	2	3	2	4	1	1	2	2	3
181	2	3	3	4	1	1	2	2	2
182	2	2	3	4	1	2	2	2	2
183	2	2	2	4	1	1	2	2	2
185	2	2	2	4	2	1	2	2	2
186	1	1	1	3	2	1	3	2	3
187	3	2	1	4	2	1	2	2	2
188	2	2	3	4	2	3	3	2	2
189	2	3	2	4	3	1	1	2	2
190	2	2	2	3	3	1	1	1	1
191	2	3	1	3	3	1	1	2	2
192	2	3	1	3	1	1	1	3	2
193	2	2	1	3	1	1	1	2	2
194	2	2	1	3	1	1	3	1	2
195	2	2	1	3	1	1	3	2	2
196	2	3	1	3	1	1	3	2	3
197	2	2	1	1	1	1	3	2	3
198	1	1	3	4	1	3	3	3	3
199	2	3	2	4	1	2	1	3	2
200	2	2	2	4	1	1	3	2	2
201	2	2	2	4	1	2	1	3	2
202	2	2	3	4	1	3	2	3	3
203	3	2	2	4	2	2	1	3	2
205	2	3	2	3	1	2	2	2	2
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210	1	1	1	3	1	1	1	2	3
211	2	3	2	3	2	1	1	3	3
212	2	3	1	3	2	1	2	3	3
213	2	1	1	3	2	1	2	2	3
214	2	3	2	3	1	2	2	1	2
215	2	2	1	3	1	1	1	2	3
216	2	3	1	3	1	2	2	1	2
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221	2	3	2	3	1	3	1	2	2
222	2	3	1	3	2	1	3	3	2
223	2	3	1	3	1	1	2	3	3
225	2	2	1	3	1	1	1	3	2
226	2	3	1	3	1	1	2	3	2
227	2	2	1	3	1	2	1	2	1
228	2	2	1	3	1	1	2	2	1
229	2	2	1	3	1	1	1	2	2
230	2	2	1	3	1	1	1	2	2
231	2	3	1	3	2	1	2	3	3
232	2	2	1	3	2	1	1	2	2
233	2	3	2	3	1	1	2	2	2
234	2	3	1	3	1	1	2	2	2
235	2	2	2	3	1	1	3	1	3
236	2	3	1	3	1	1	2	2	3
237	2	2	1	3	1	1	1	3	3
238	2	2	1	3	1	1	2	2	2
239	3	3	1	3	1	1	2	3	2
240	3	2	1	4	2	1	3	2	2
241	2	3	1	4	2	1	2	3	3
242	2	2	3	4	1	2	1	3	1
243	2	2	1	3	1	1	2	2	2
244	2	3	1	3	1	1	2	3	3
245	2	1	1	3	1	1	1	2	1
246	2	2	1	3	1	1	2	2	2
247	2	1	1	3	1	1	2	2	1
248	2	3	1	3	1	1	1	2	1
249	2	3	2	3	1	1	1	2	2
250	2	2	1	3	2	1	1	3	2
251	2	3	1	3	2	1	1	3	2
252	2	3	1	3	2	1	1	2	2
253	2	2	1	3	1	1	2	2	2
254	2	2	1	3	1	1	2	2	2
255	2	2	1	3	1	1	1	1	2
257	3	2	1	3	1	1	3	2	3
258	2	3	1	3	1	1	1	3	3
259	3	2	1	4	1	1	2	2	2
260	2	3	1	4	1	1	2	2	1
261	2	2	3	4	1	3	2	3	3
262	2	2	1	3	1	1	2	2	2
263	2	2	1	3	1	1	1	3	2
264	2	2	1	4	1	1	2	3	3
265	2	3	2	4	1	2	1	1	1
266	2	2	1	3	1	1	3	2	1
267	2	2	1	3	1	1	2	2	1
268	2	2	1	3	1	1	2	1	1
269	2	2	1	3	1	1	2	2	2
270	2	2	1	3	1	1	2	2	2
271	2	2	3	4	1	1	1	3	2
272	2	3	2	3	1	1	2	2	2
273	2	3	3	3	1	2	3	2	2
274	2	3	1	3	1	1	1	3	2
275	2	1	2	3	1	1	2	3	2

Table 8 Analysis of Habitat Classes Following MVSP Analysis

Rating	Class 1 (n=38)					Class 2 (n=172)					Class 3 (n=40)					Class 4 (n=7)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Veg Class	0	100	0			0	100	0			3	95	3			57	43	0		
Tree cover	3	68	29			12	62	26			8	53	40			57	43	0		
Rockiness	50	32	18			88	11	1			5	43	53			71	29	0		
Soil	55	45	0	0	0	0	2	59	23	17	0	0	13	83	5	14	14	71	0	0
Grazing Rating	82	18	0			61	33	6			95	5	0			0	14	86		
Slope	66	32	3			98	2	0			13	55	33			100	0	0		
Grass Biomass	5	82	13			24	61	15			30	58	13			86	14	0		
Density	63	34	3			16	62	22			25	48	28			71	14	14		
Forage	29	66	5			15	59	26			23	68	10			100	0	0		

Table 9 Tree Species Occurrence Analysed by Correspondence Analysis

Transect	MT&MS	A-MIX	TER	COM	CAT	MOS
1	3	1	3	3	1	1
2	1	1	3	3	1	3
3	3	1	3	3	1	1
4	3	1	3	3	3	1
5	3	1	3	3	3	1
6	3	1	3	1	3	3
7	3	1	3	3	1	3
8	3	1	3	1	3	3
9	3	1	3	1	3	1
10	3	1	3	1	3	1
11	3	1	3	3	3	3
12	3	1	3	1	1	1
13	3	1	1	3	1	1
14	3	1	3	1	3	1
15	3	1	1	3	3	1
16	3	1	3	1	1	1
17	3	1	1	1	3	1
18	3	1	3	3	1	3
19	3	3	3	1	1	1
20	3	3	1	1	1	1
21	3	3	3	1	1	1
22	3	1	3	1	1	1
23	3	1	3	3	3	1
24	3	1	1	1	3	1
25	3	1	1	1	3	1
26	3	1	1	1	1	1
27	3	3	1	1	1	1
28	3	1	1	3	1	1
29	3	1	1	3	3	1
39	3	1	1	3	3	1
40	3	3	1	1	1	1
41	3	1	1	1	1	1
42	3	3	1	1	1	1
43	3	3	1	3	1	1
44	3	1	1	1	1	1
45	3	3	3	3	1	1
46	1	3	1	1	3	1
47	3	1	1	1	3	1
48	3	1	3	3	1	1
49	3	3	1	3	3	1
50	3	3	1	1	1	1
51	3	3	1	1	3	1
53	3	1	3	1	1	1
54	3	1	1	1	1	1
55	3	1	1	3	3	1
56	3	1	3	3	3	1
57	3	3	1	1	1	1
58	3	3	1	1	1	1
59	3	1	1	3	3	1
60	3	3	1	1	1	1
61	3	1	3	3	1	1
62	3	1	3	1	1	1
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66	3	1	3	1	1	1
67	1	1	1	1	1	1
68	3	3	1	1	3	1
69	3	1	3	1	1	1
70	3	1	3	1	3	1
71	3	1	3	1	1	1
72	3	1	3	1	1	1
73	3	1	3	3	1	1
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75	3	3	1	1	1	1
76	1	3	1	1	1	1
77	3	1	3	3	1	1
78	3	1	3	3	1	1
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126	3	1	3	3	1	1
127	3	1	3	3	1	1
128	3	3	1	3	1	1
129	1	3	1	1	1	1
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132	1	3	1	1	3	1
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134	3	1	1	1	3	1
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138	3	1	1	3	3	3
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143	3	1	3	3	1	1
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148	3	1	3	3	1	1
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151	1	3	1	1	3	1
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153	3	1	1	1	3	1
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156	3	1	3	1	3	1
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165	3	1	3	3	1	1
166	3	1	3	3	1	1
167	1	1	3	3	1	1
168	1	3	1	1	1	1
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197	3	3	3	3	1	1
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199	3	1	3	3	1	1
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202	1	1	1	1	1	1
203	1	3	1	3	1	1
205	3	1	3	3	1	1
206	3	1	1	1	1	1
207	3	1	1	1	1	1
208	3	1	1	1	3	1
209	3	1	1	1	3	1
210	3	1	1	1	3	1
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218	3	1	3	3	1	3
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220	3	1	3	3	1	1
221	3	1	3	3	1	1
222	3	1	1	1	1	1
223	3	1	3	1	1	1
225	3	1	1	3	3	1
226	3	1	1	1	1	1
227	3	1	1	1	3	1
228	3	3	3	1	1	1
229	3	1	3	3	3	1
230	3	1	3	3	1	1
231	3	1	3	1	3	1
232	3	3	1	1	3	1
233	3	1	1	3	1	1
234	3	1	1	3	1	1
235	3	3	1	1	3	1
236	3	1	3	1	1	1
237	3	3	1	1	1	1
238	3	1	3	1	3	1
239	3	1	1	1	1	3
240	1	3	1	3	1	1
241	3	1	3	3	1	1
242	3	1	3	1	1	1
243	3	1	3	1	3	1
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246	3	1	1	3	3	1
247	3	1	3	3	1	1
248	3	1	3	1	3	1
249	3	1	3	3	1	1
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251	3	3	1	1	1	1
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253	3	1	1	3	1	1
254	3	1	1	3	3	1
255	3	1	3	3	3	1
257	3	3	1	1	1	1
258	3	1	3	1	1	1
259	3	3	1	3	1	1
260	3	1	3	1	1	1
261	1	1	1	3	1	1
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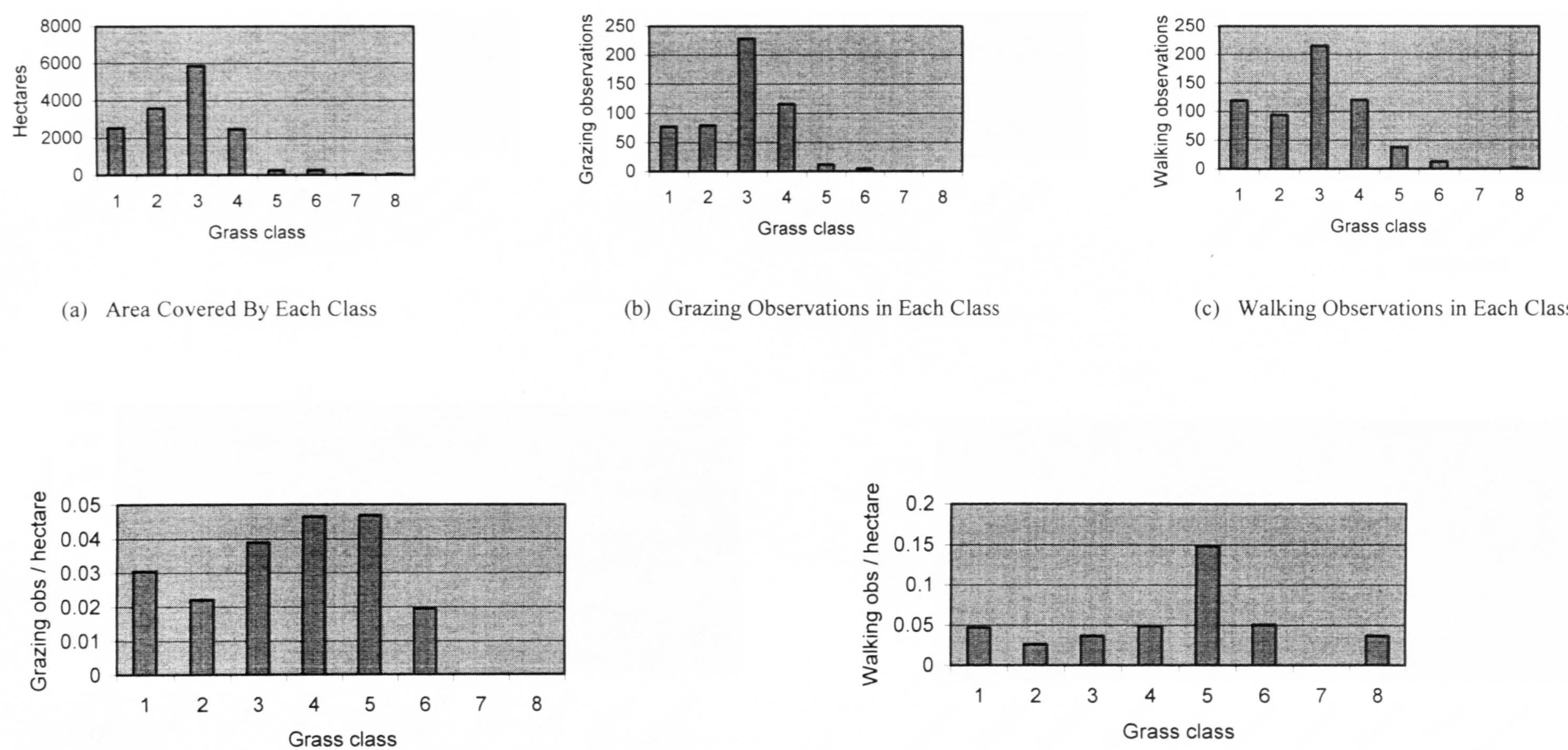
265	3	1	3	3	3	1
266	3	3	3	3	3	1
267	3	1	3	3	3	1
268	3	1	1	3	3	1
269	3	1	1	1	3	3
270	3	1	1	1	3	1
271	1	1	1	1	1	1
272	3	1	3	3	1	1
273	3	3	3	1	1	1
274	3	1	3	1	3	1
275	3	3	1	1	1	1

Table 10 Percentages of Observations Forming Tree Classes

Tree Species	Class1 (n=136)		Class 2 (n=47)		Class 3 (n=68)		Class 4 (n=6)	
	Absent	Present	Absent	Present	Absent	Present	Absent	Present
Mopane	1	99	0	100	26	74	100	0
Acacia sp.	99	1	98	2	3	97	100	0
Terminalia sp.	12	88	98	2	81	19	100	0
Combretum sp.	38	62	79	21	85	15	67	33
Catophractes	74	26	40	60	69	31	100	0
Boscia sp.	86	14	94	6	96	4	83	17

Appendix VII

Kaross Utilisation -
Supporting Tables and Figures



(a) Area Covered By Each Class

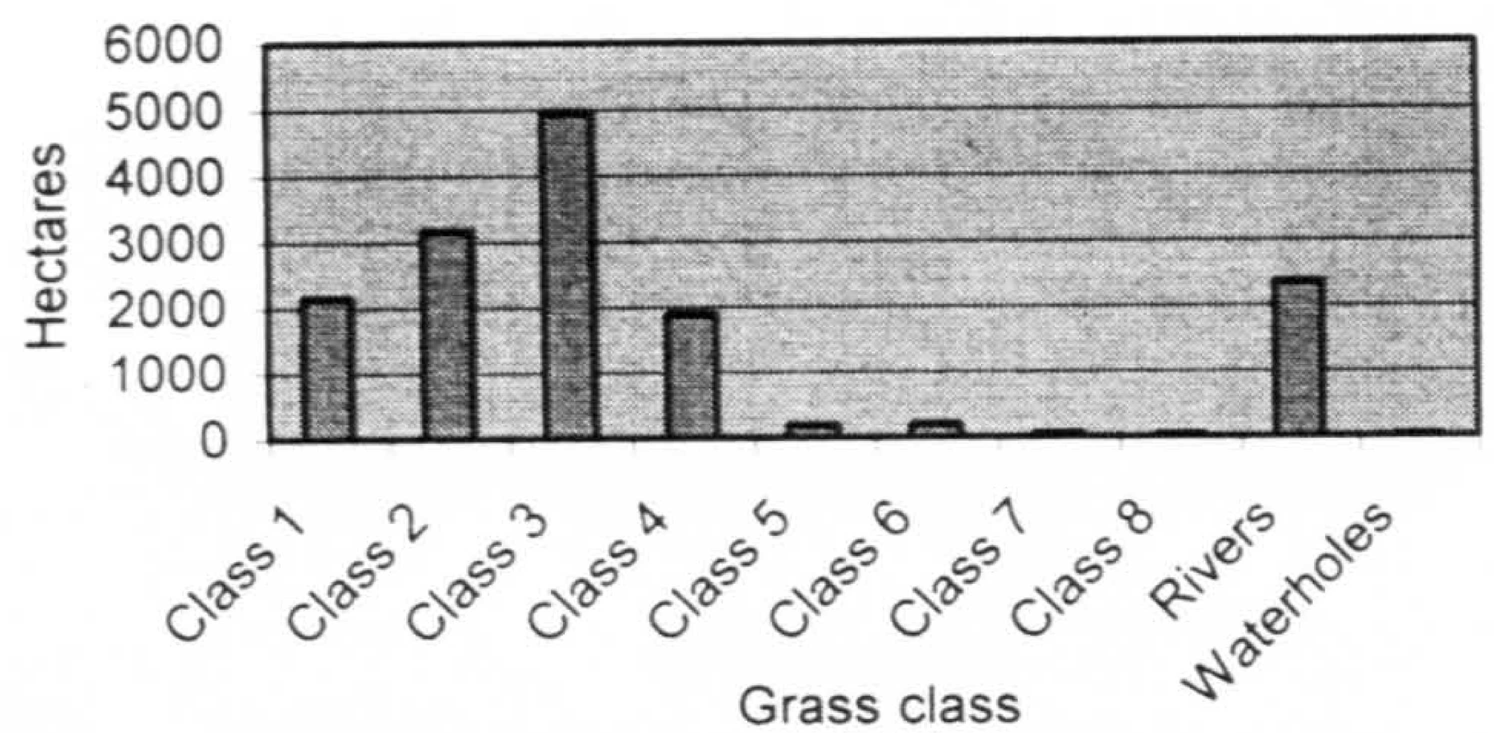
(b) Grazing Observations in Each Class

(c) Walking Observations in Each Class

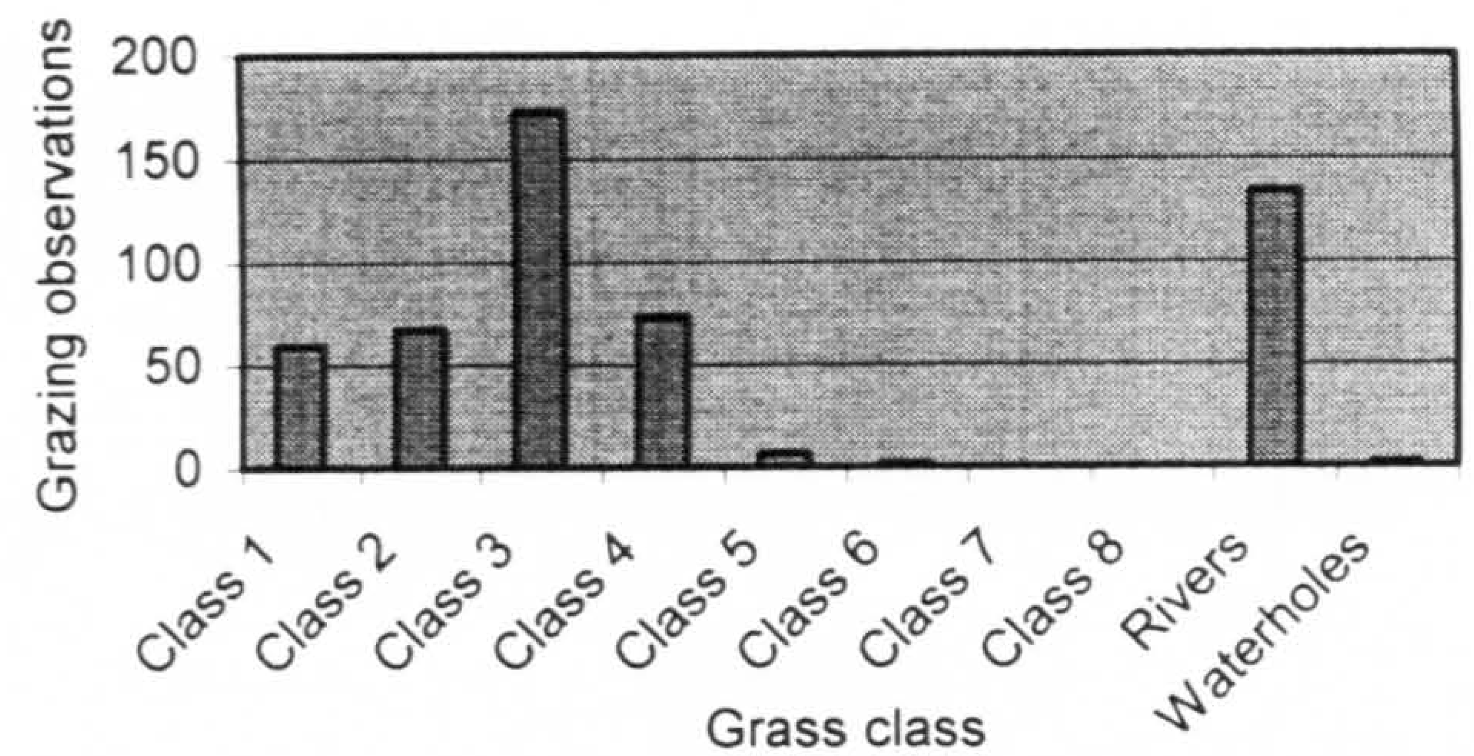
(d) Grazing Observations per Hectare in Each Class

(e) Walking Observations per Hectare in Each Class

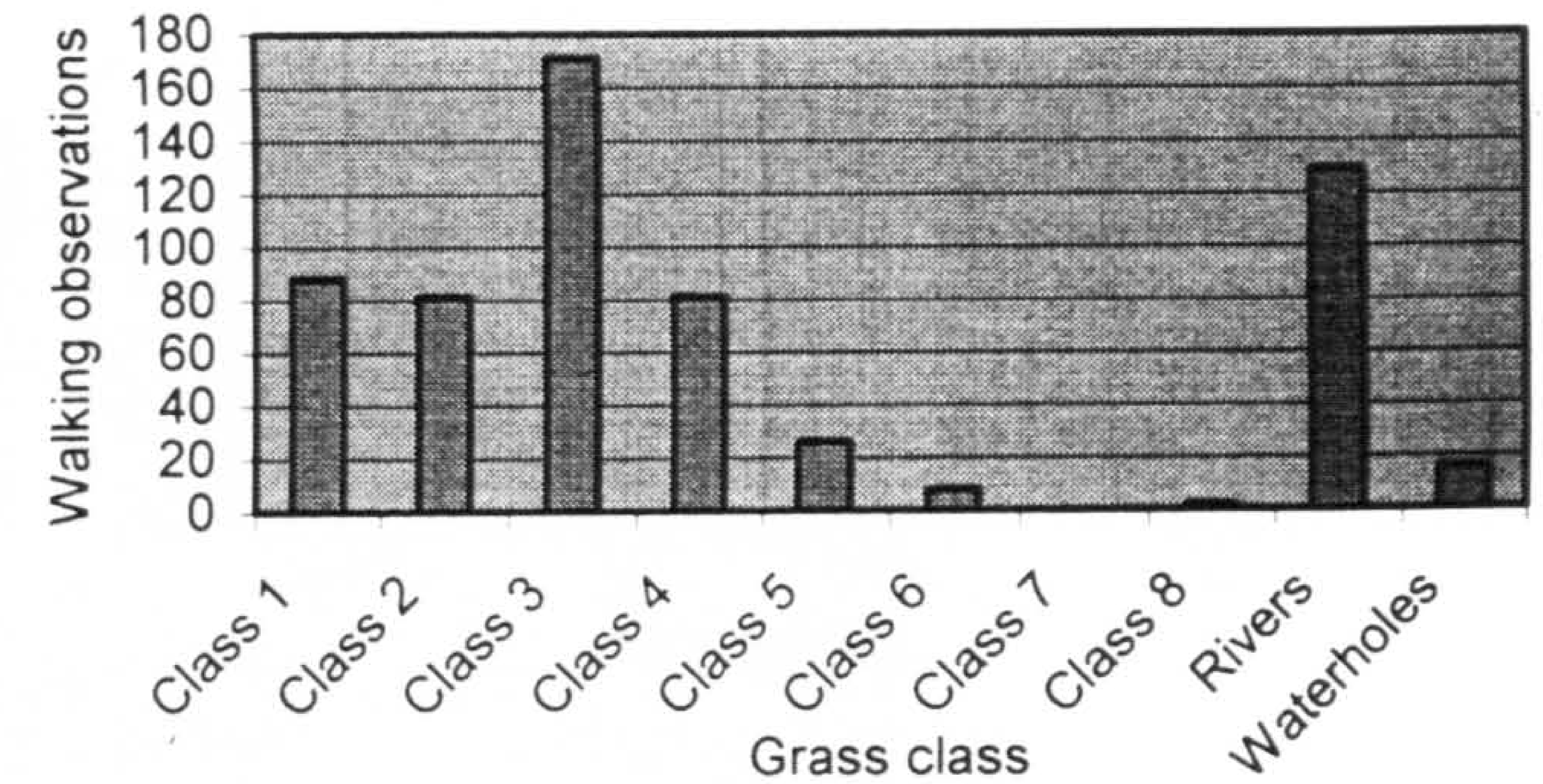
Fig. 1 Analysis of Utilisation of MVSP Eight-Class Herbaceous Layer Classification



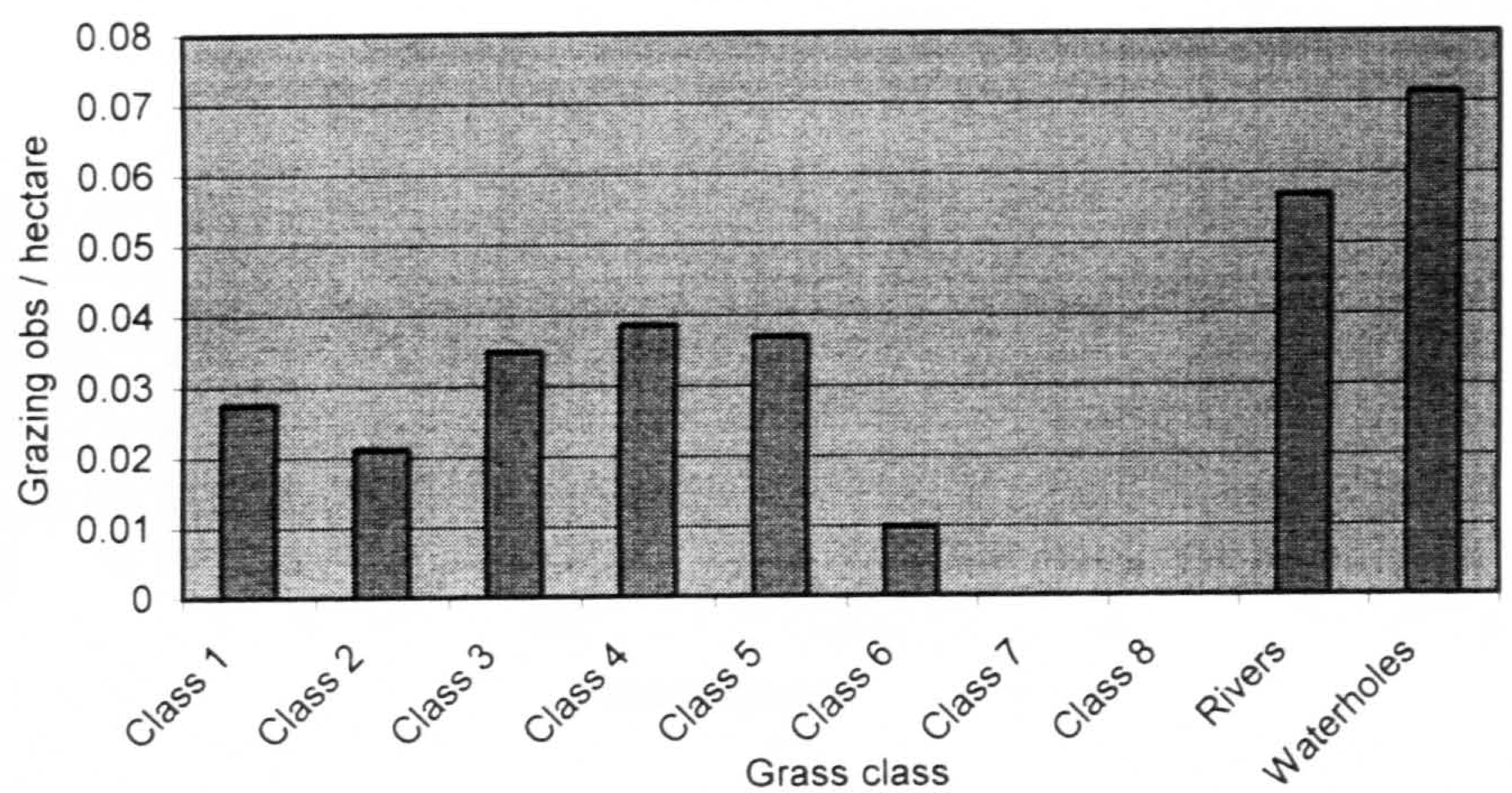
(a) Area Covered By Each Class



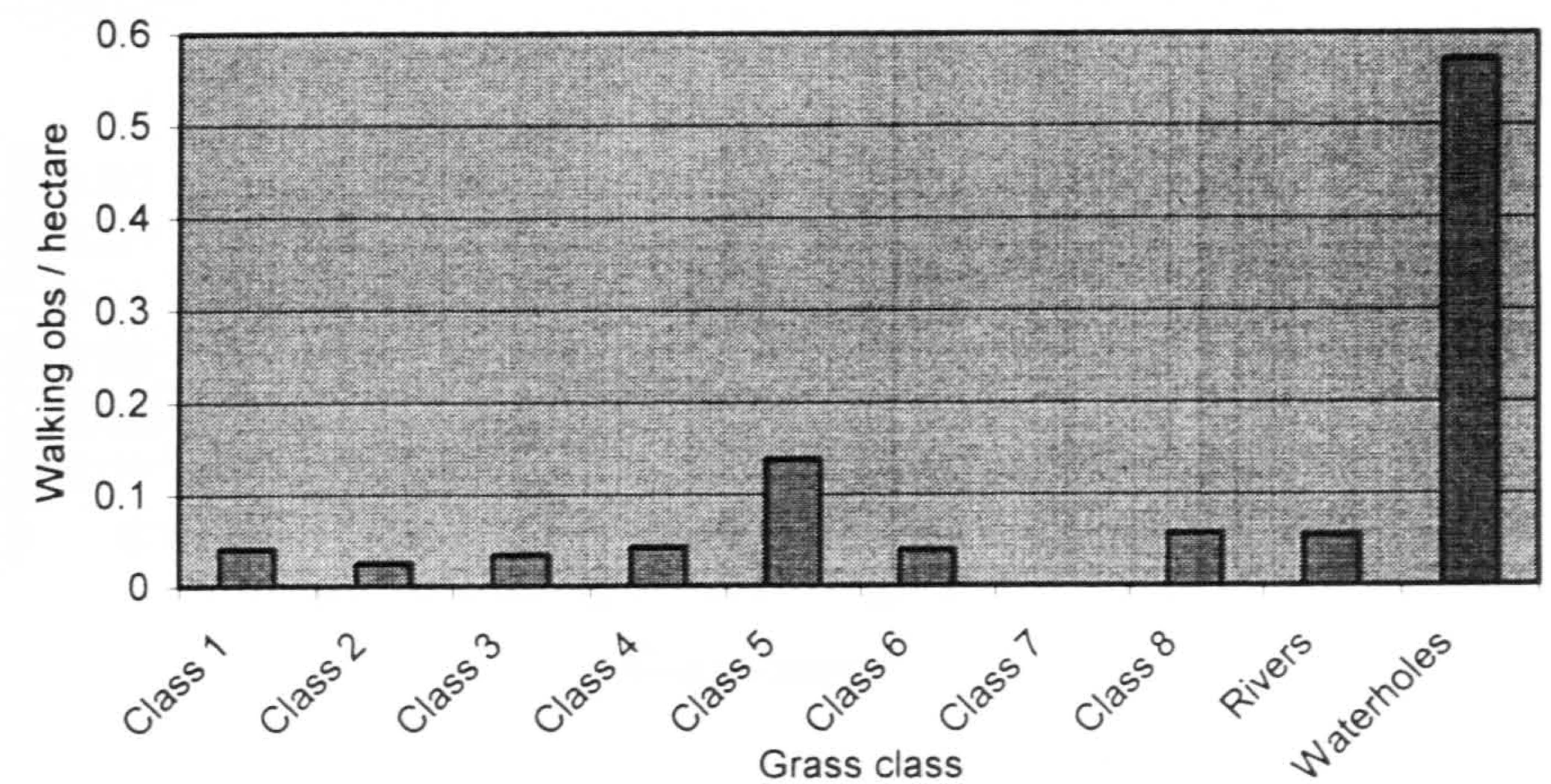
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

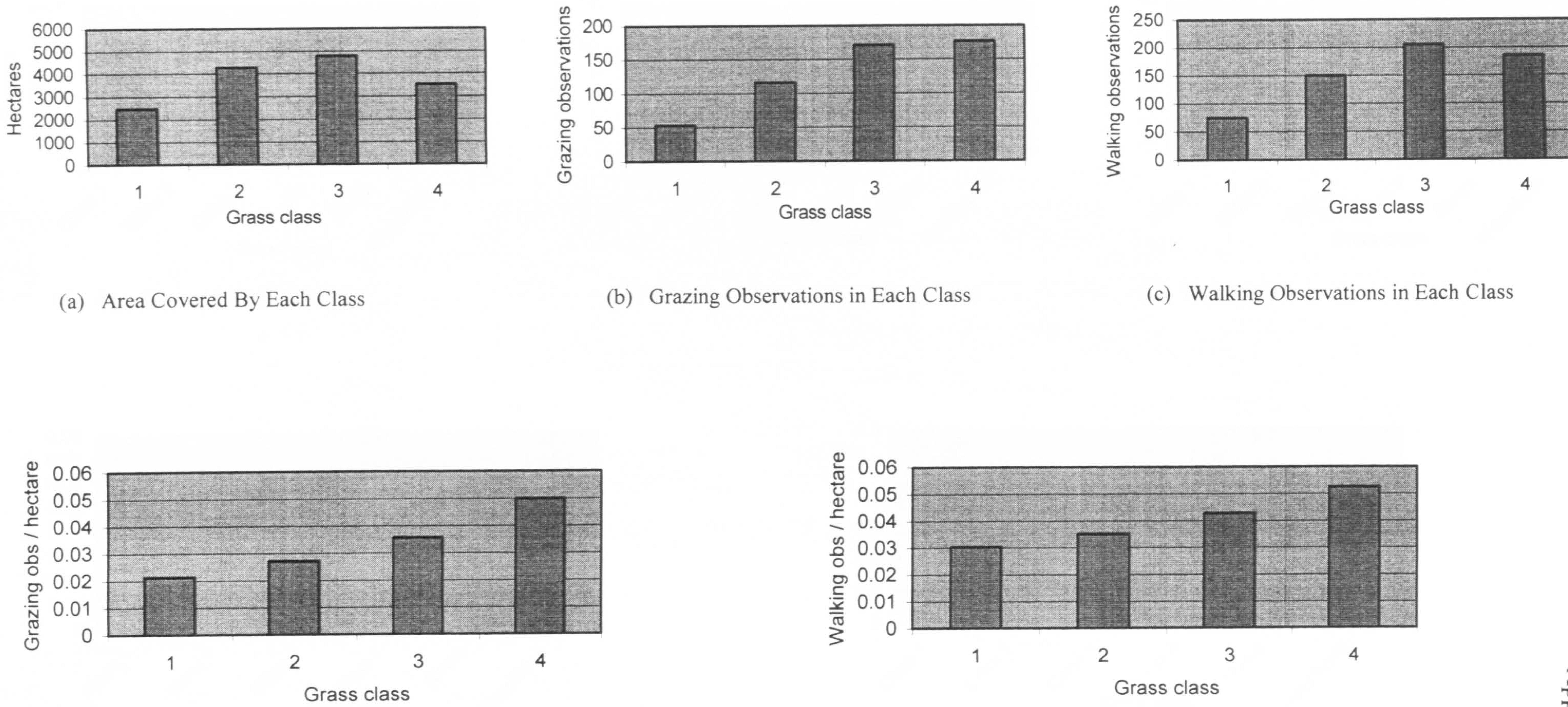


(d) Grazing Observations per Hectare in Each Class



(e) Walking Observations per Hectare in Each Class

Fig. 2 Analysis of Utilisation of Detailed Eight-Class Herbaceous Layer Classification



(a) Area Covered By Each Class

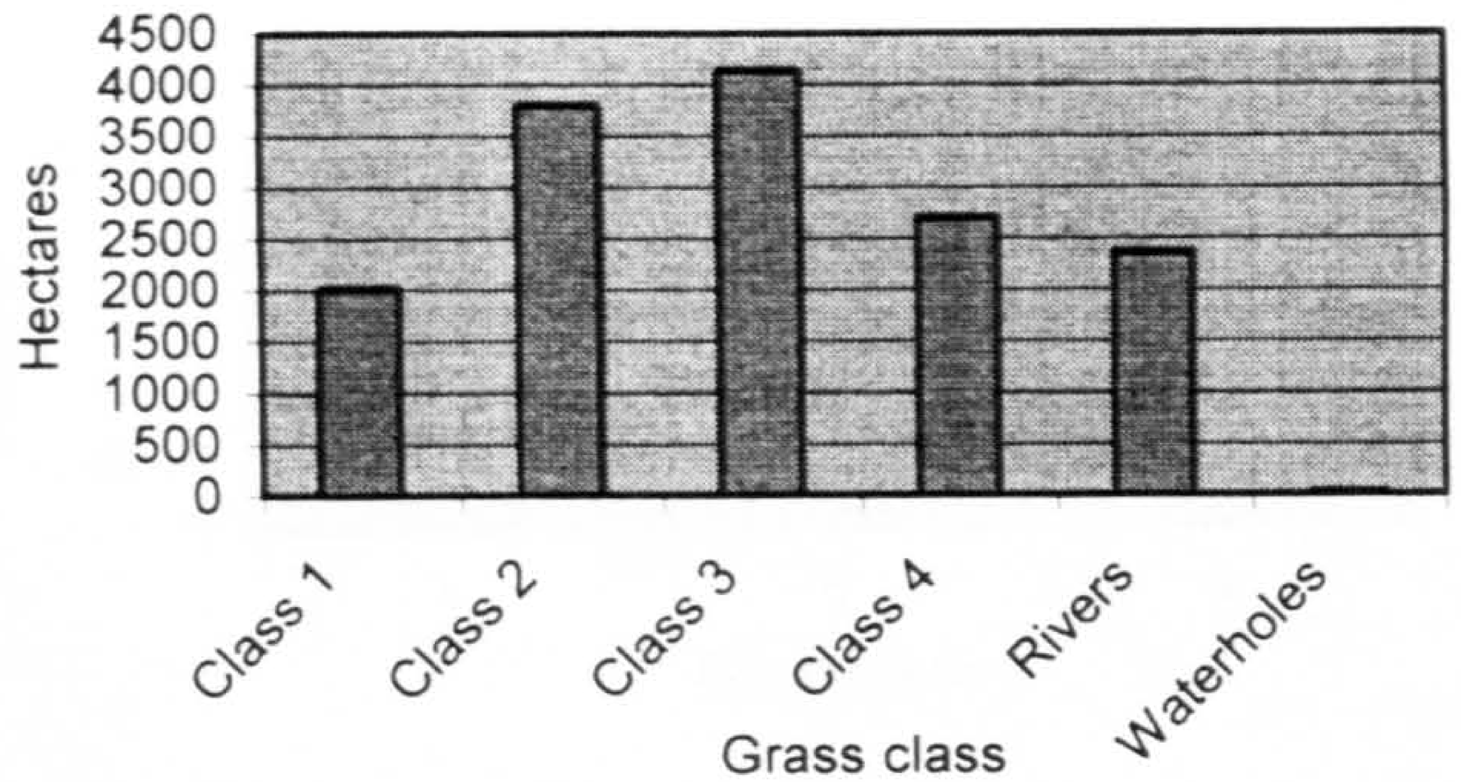
(b) Grazing Observations in Each Class

(c) Walking Observations in Each Class

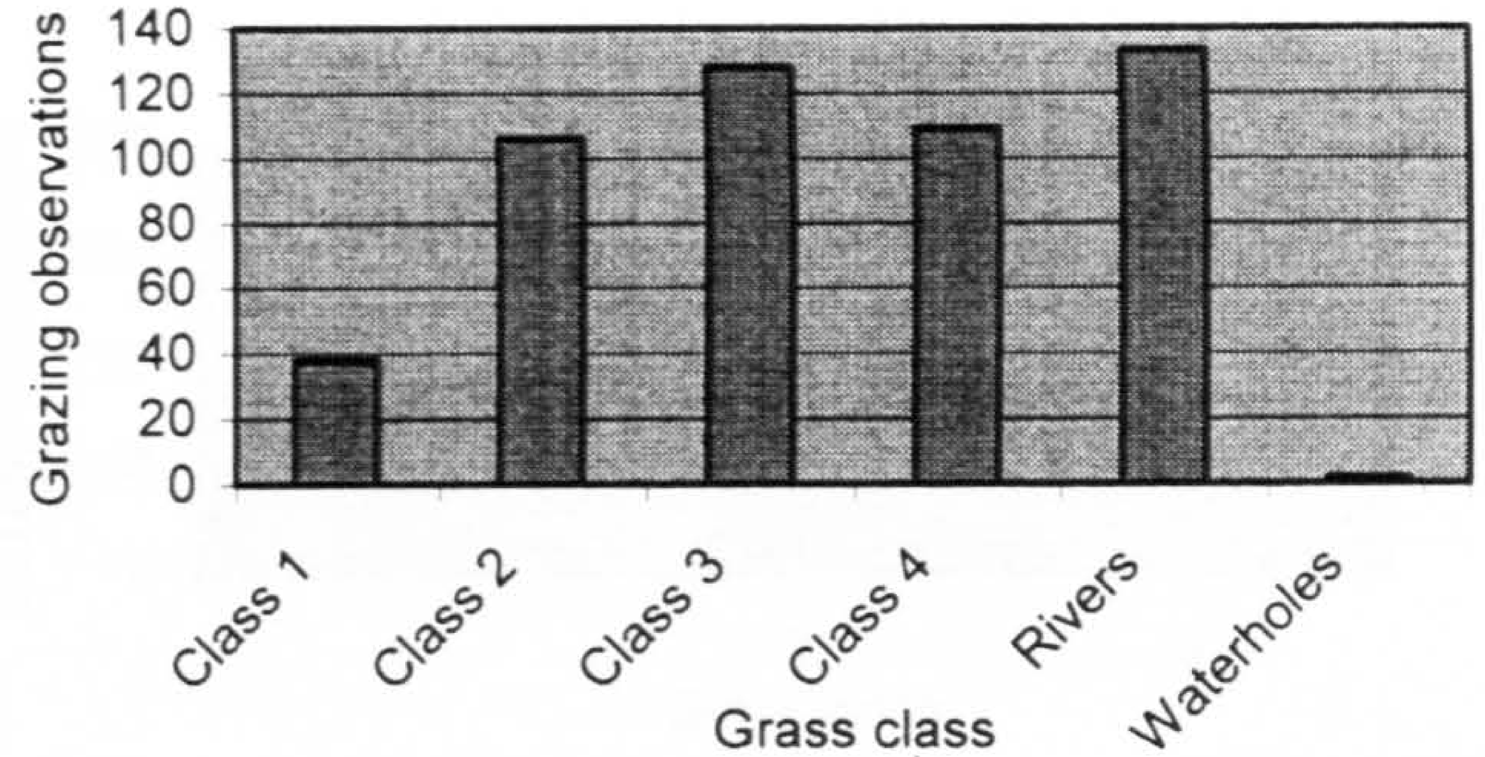
(d) Grazing Observations per Hectare in Each Class

(e) Walking Observations per Hectare in Each Class

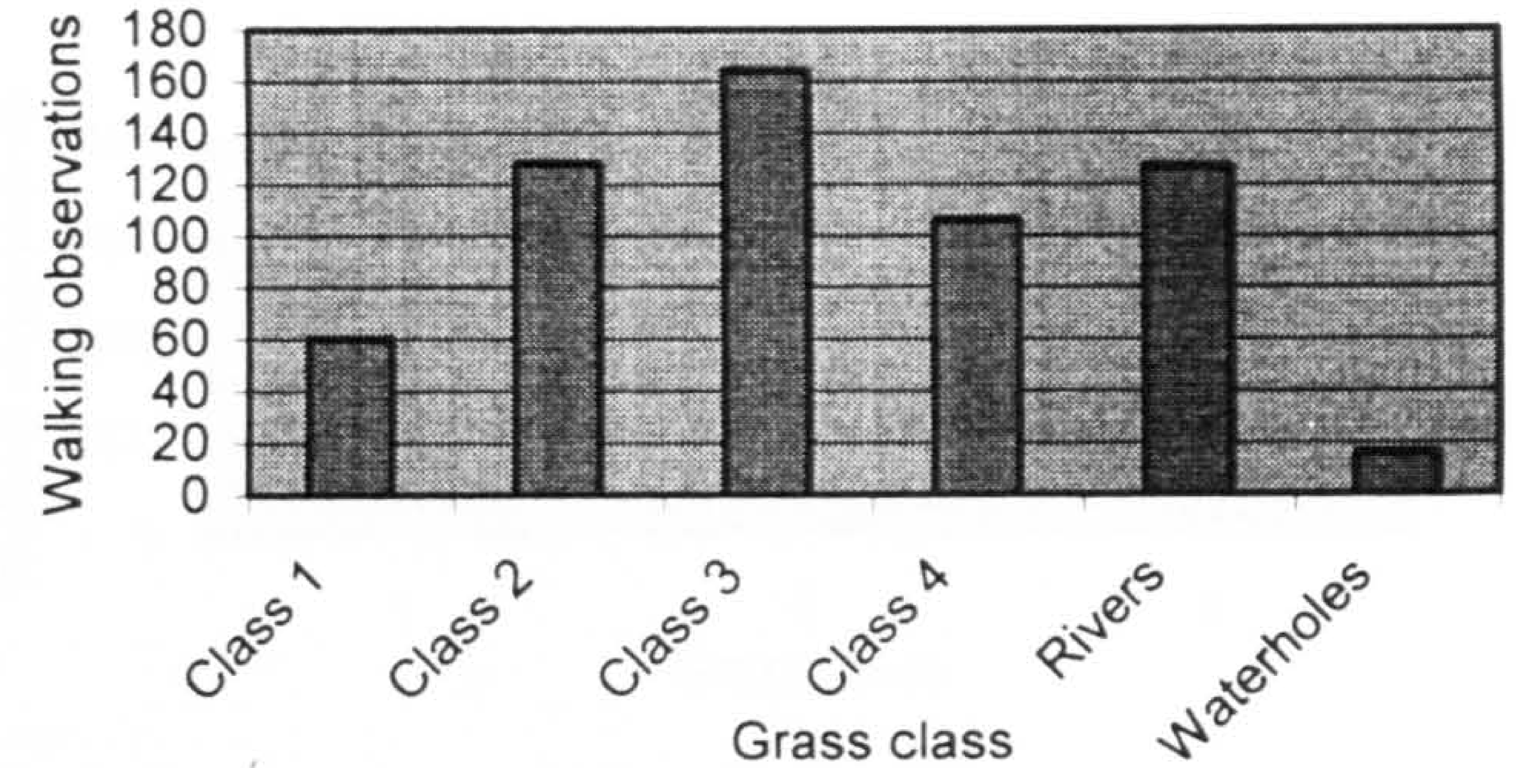
Fig. 3 Analysis of Utilisation of TWINSPAN Four-Class Herbaceous Layer Classification



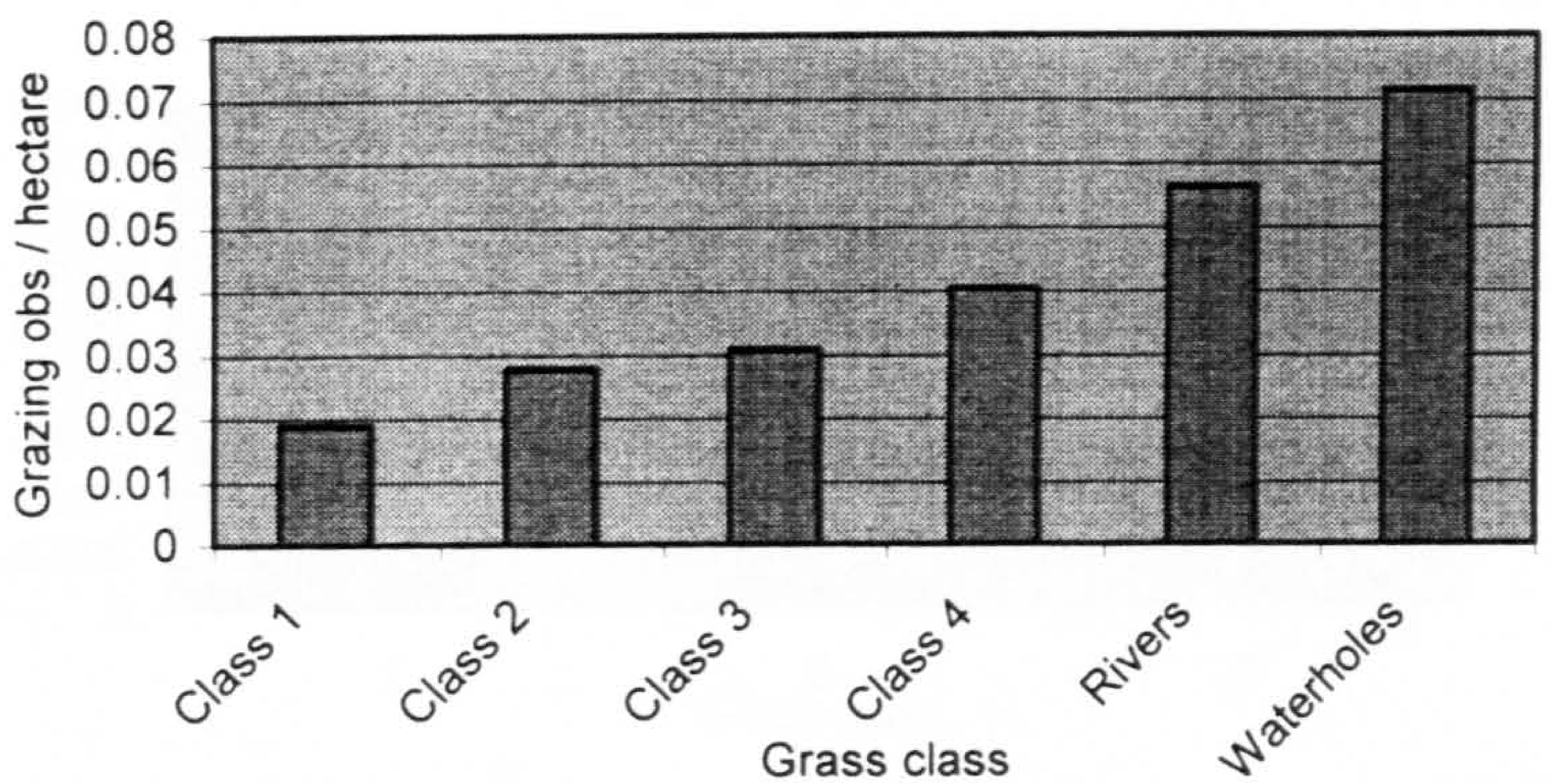
(a) Area Covered By Each Class



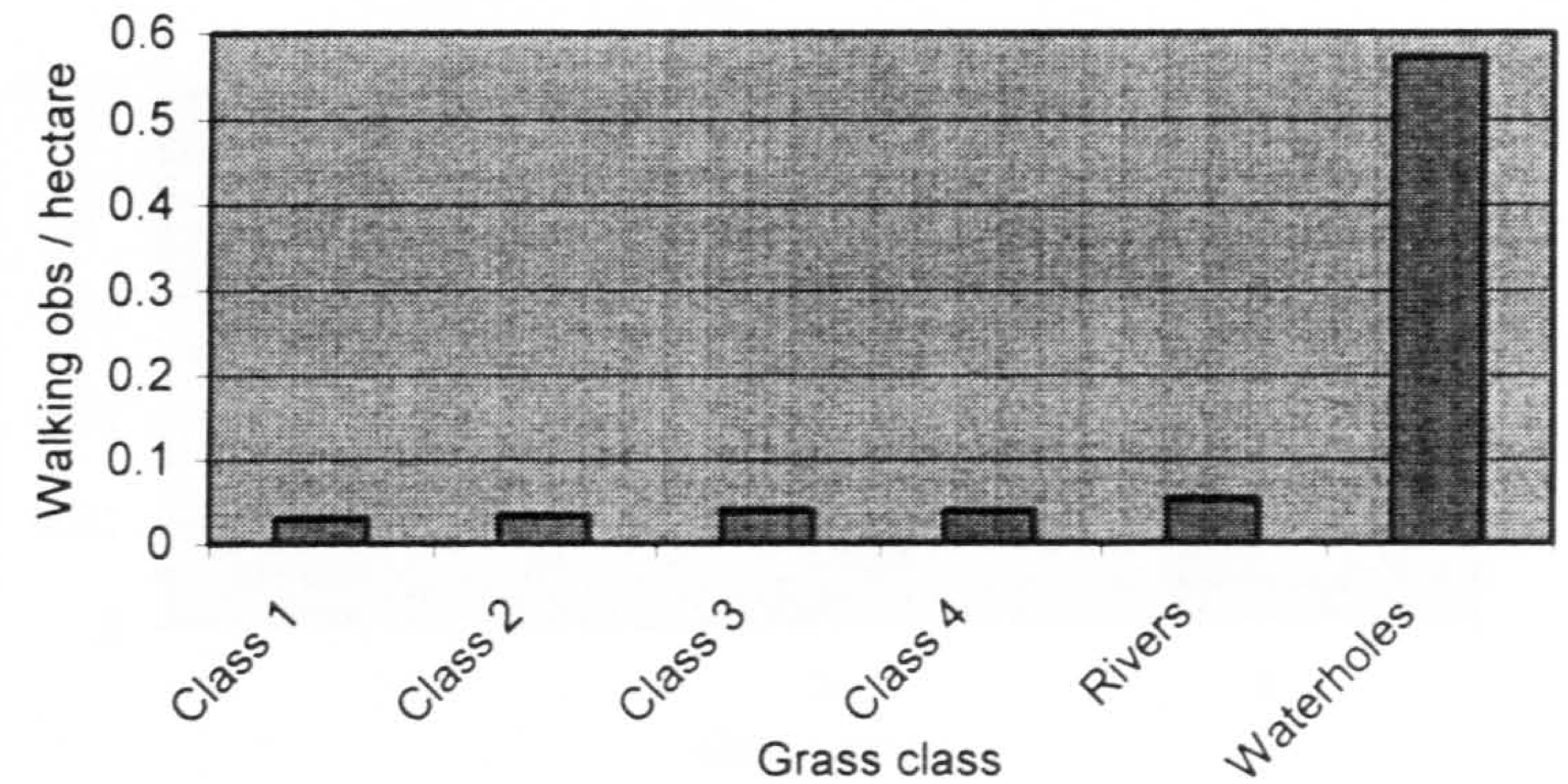
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

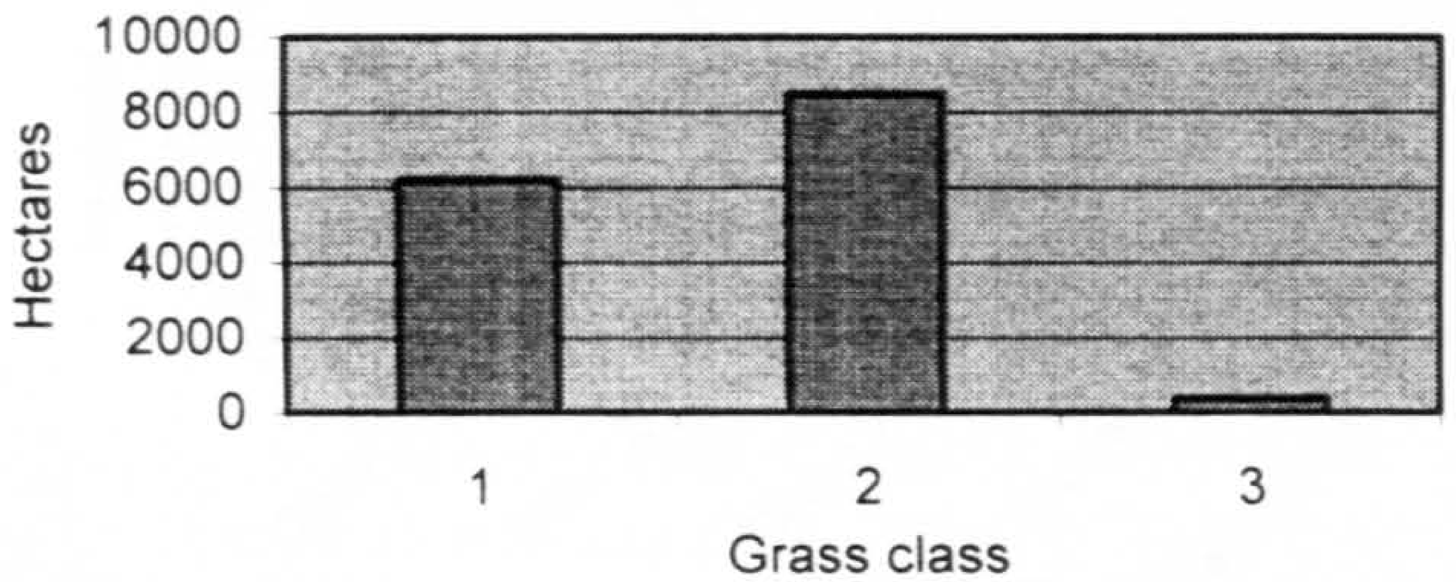


(d) Grazing Observations per Hectare in Each Class

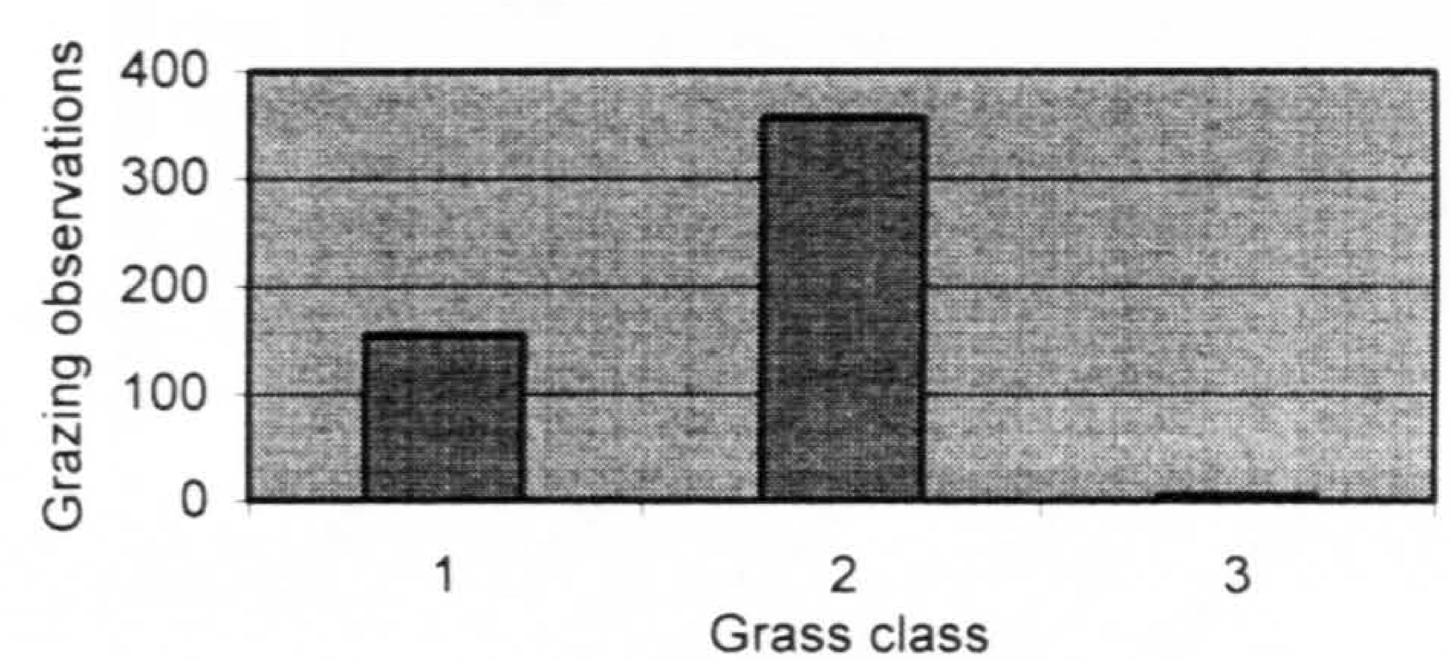


(e) Walking Observations per Hectare in Each Class

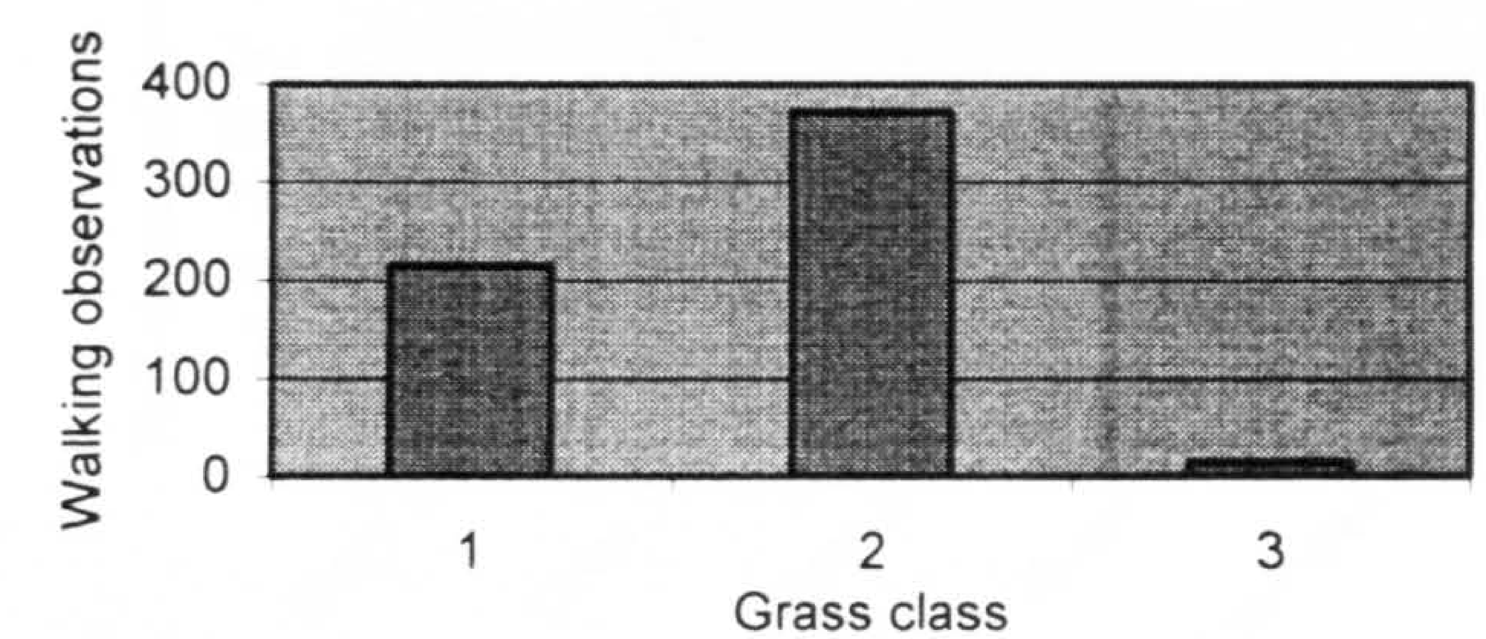
Fig. 4 Analysis of Utilisation of Detailed Four-Class Herbaceous Layer Classification



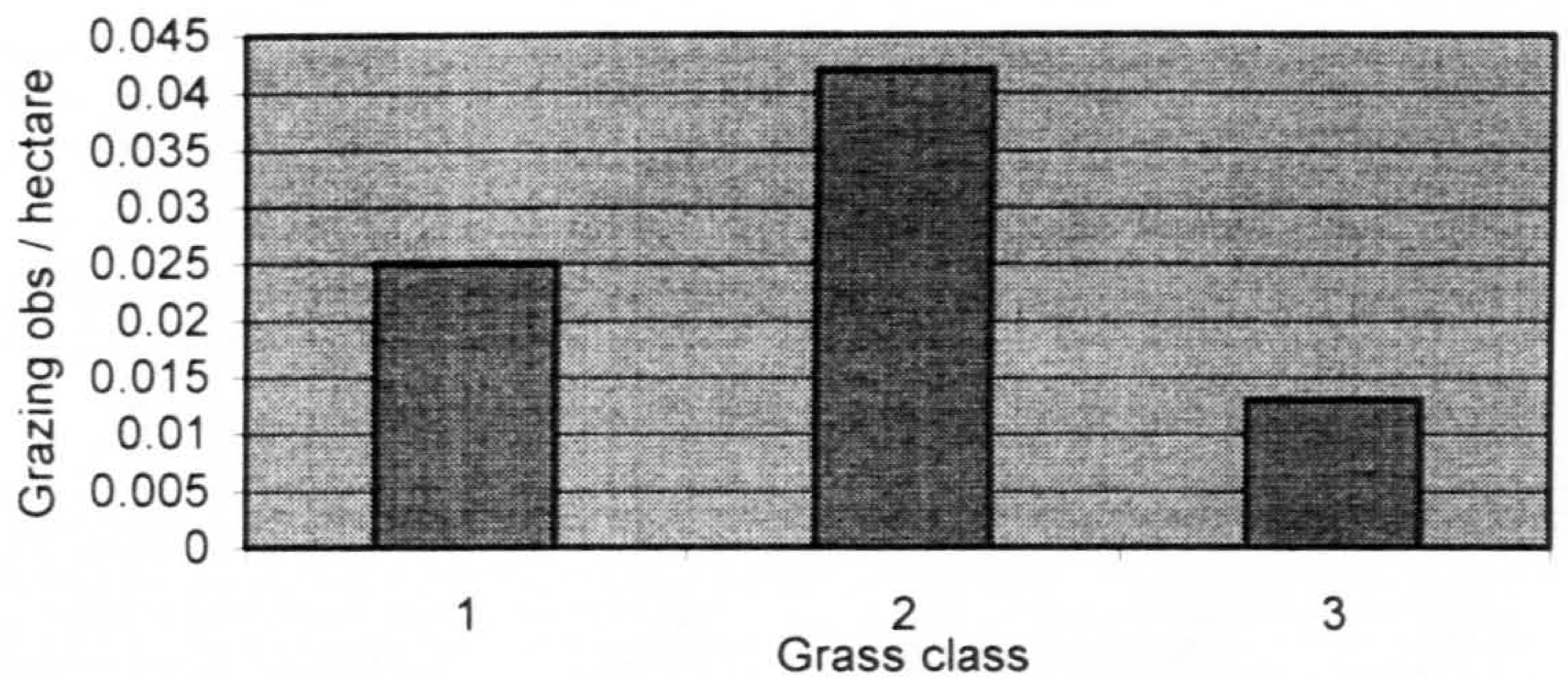
(a) Area Covered By Each Class



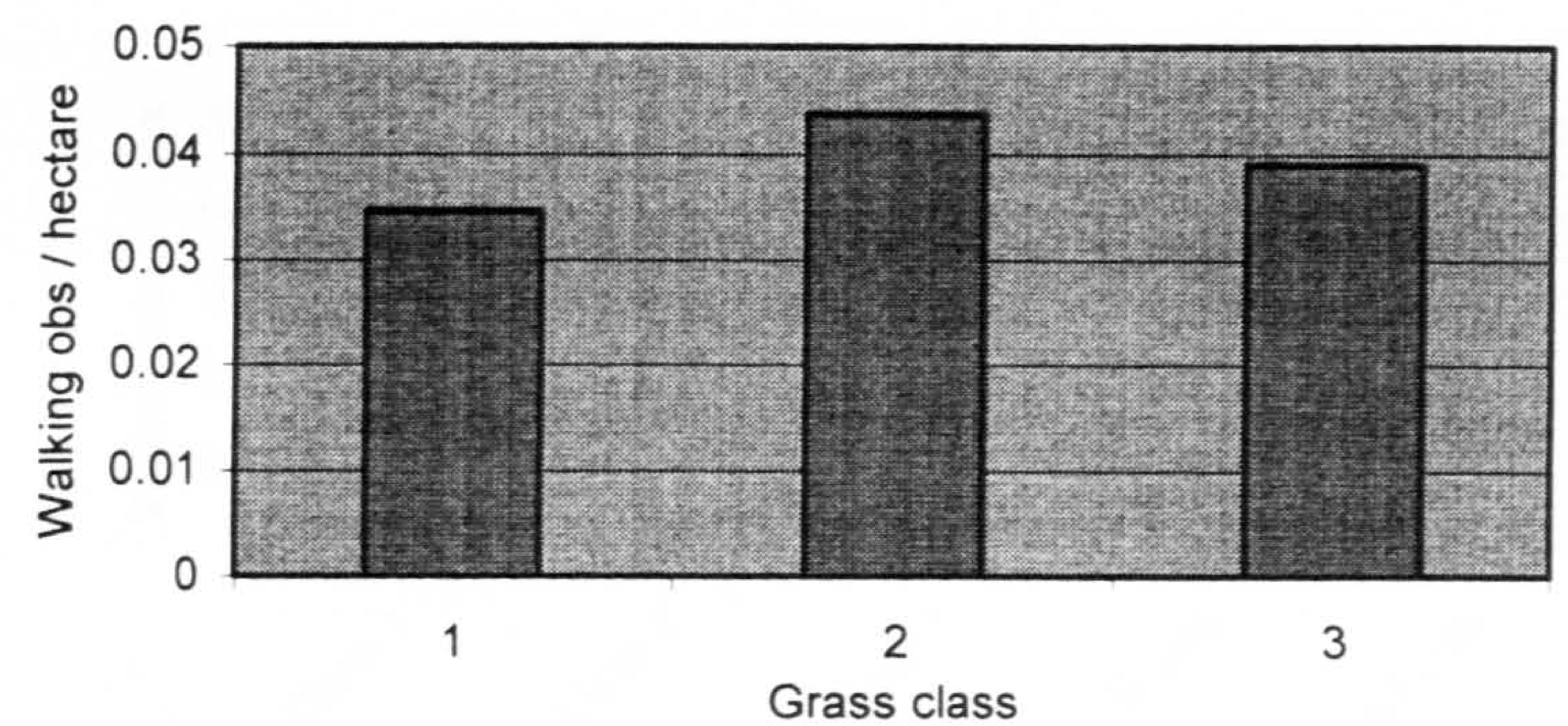
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

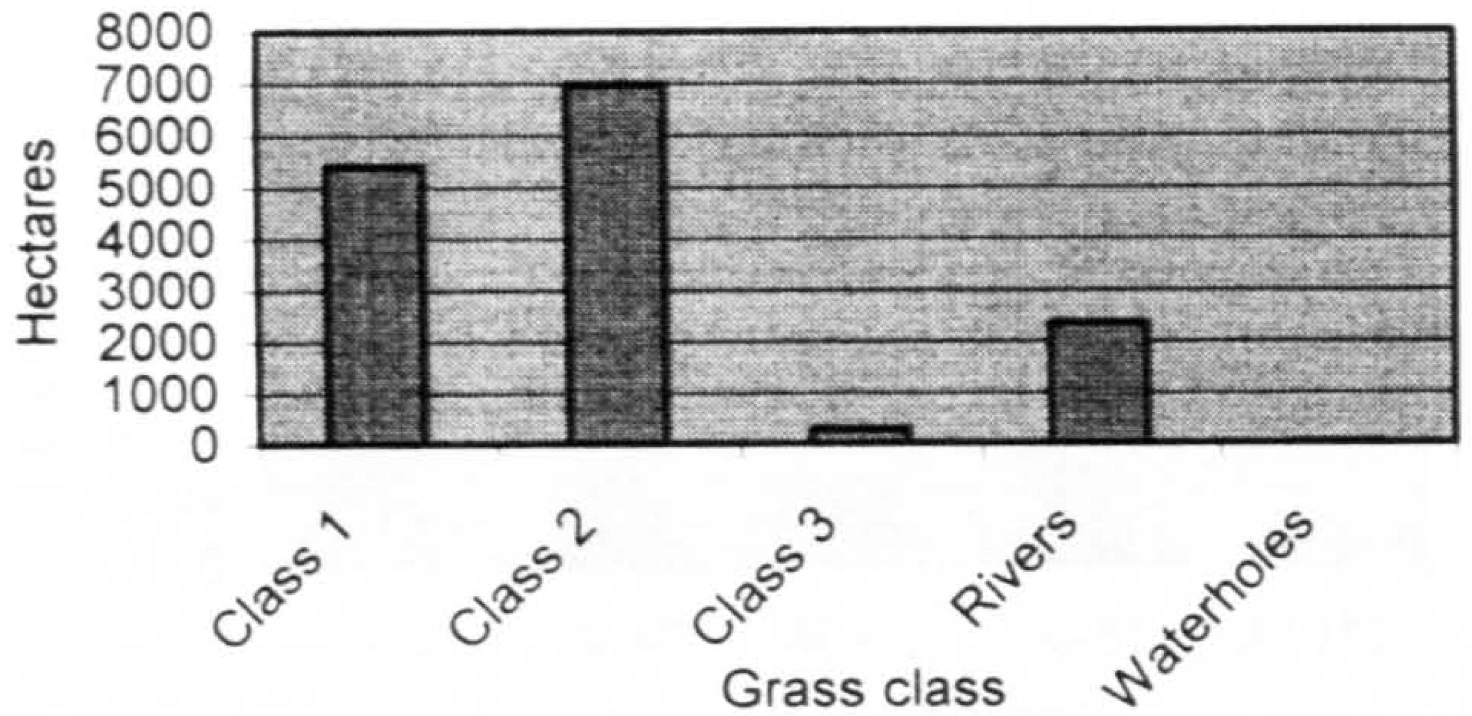


(d) Grazing Observations per Hectare in Each Class

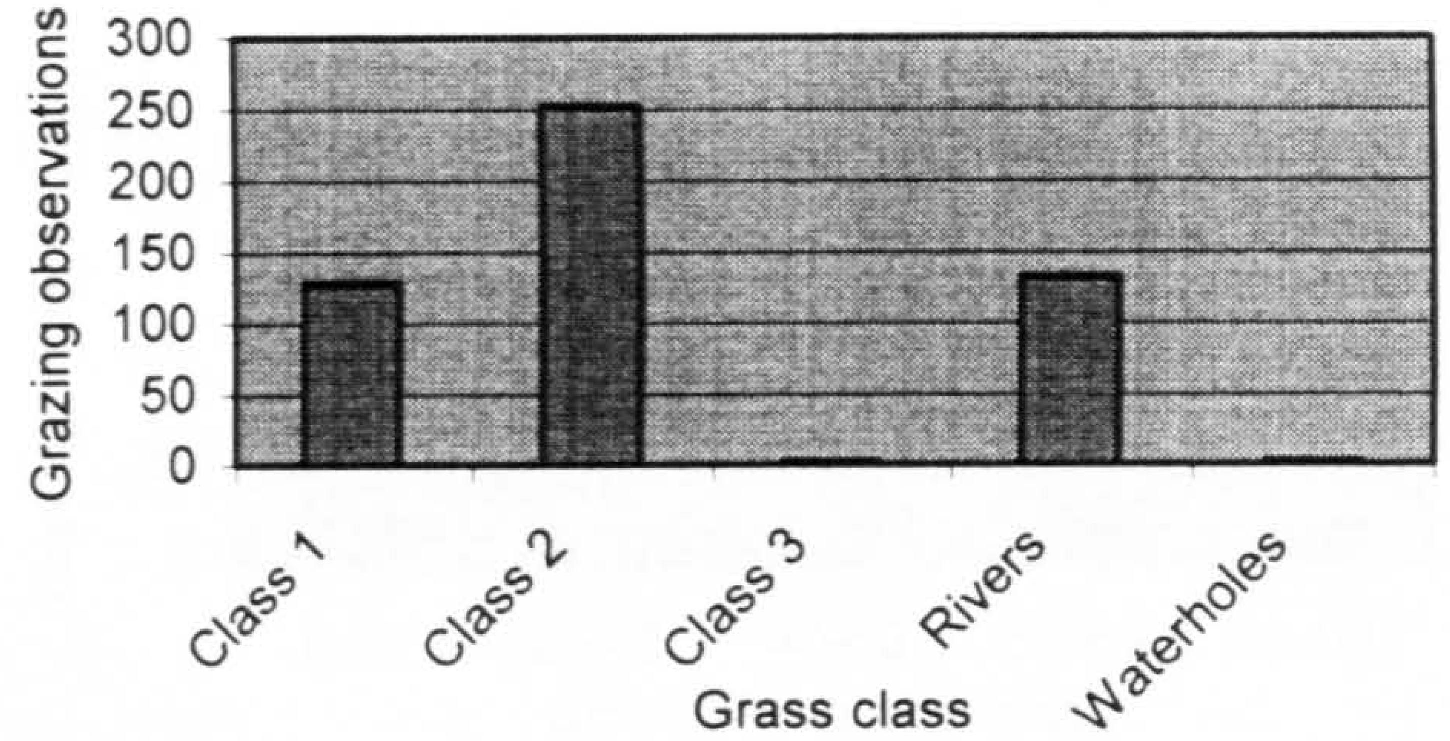


(e) Walking Observations per Hectare in Each Class

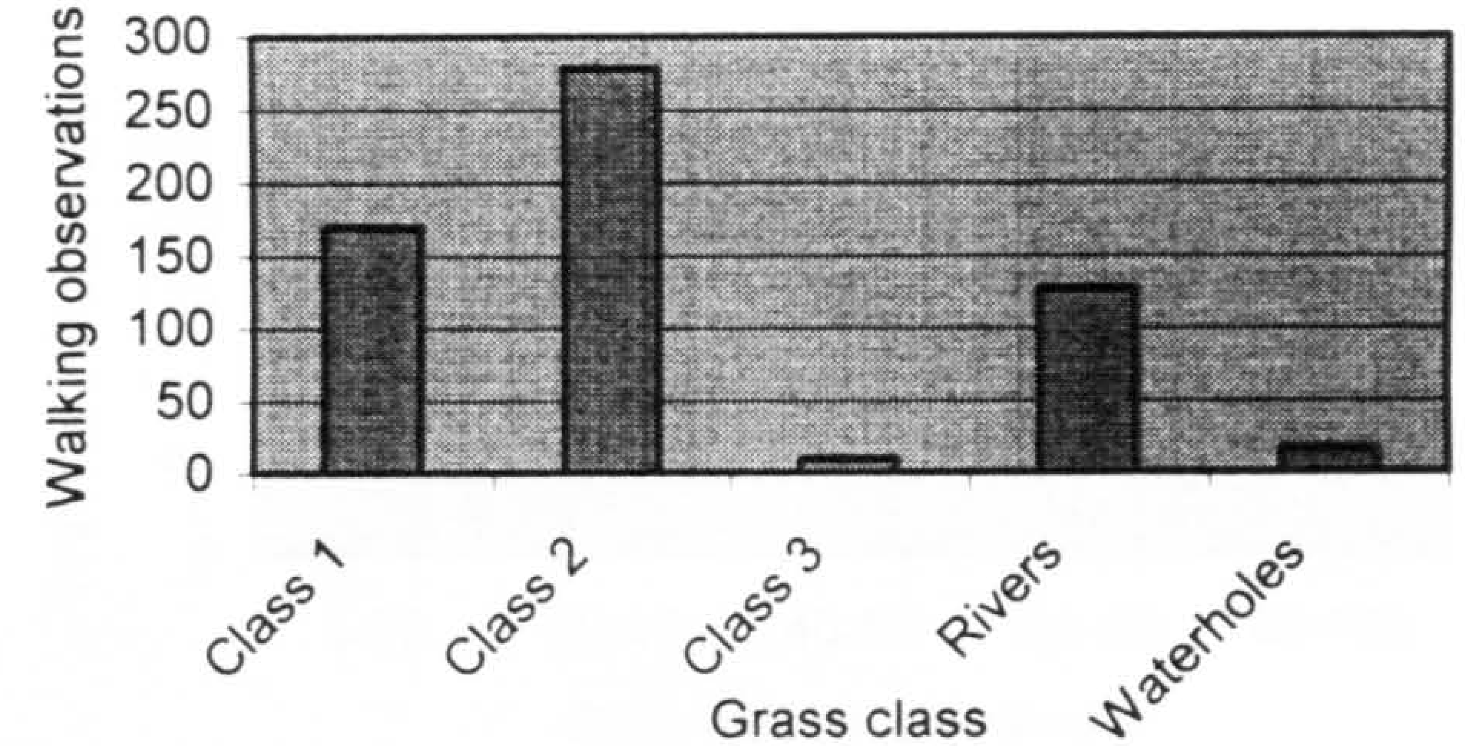
Fig. 5 Analysis of Utilisation of MVSP Three-Class Herbaceous Layer Classification



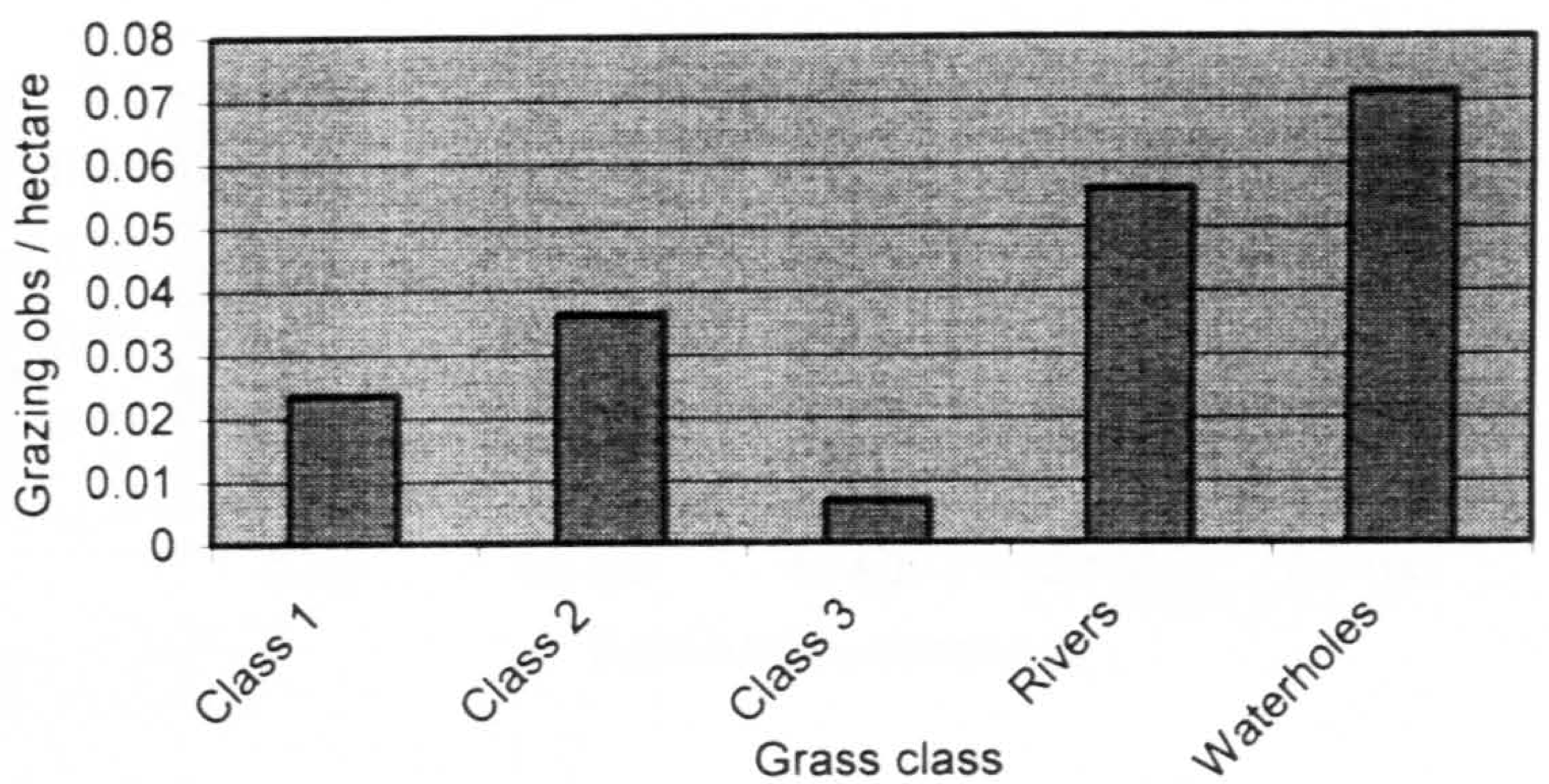
(a) Area Covered by Each Class



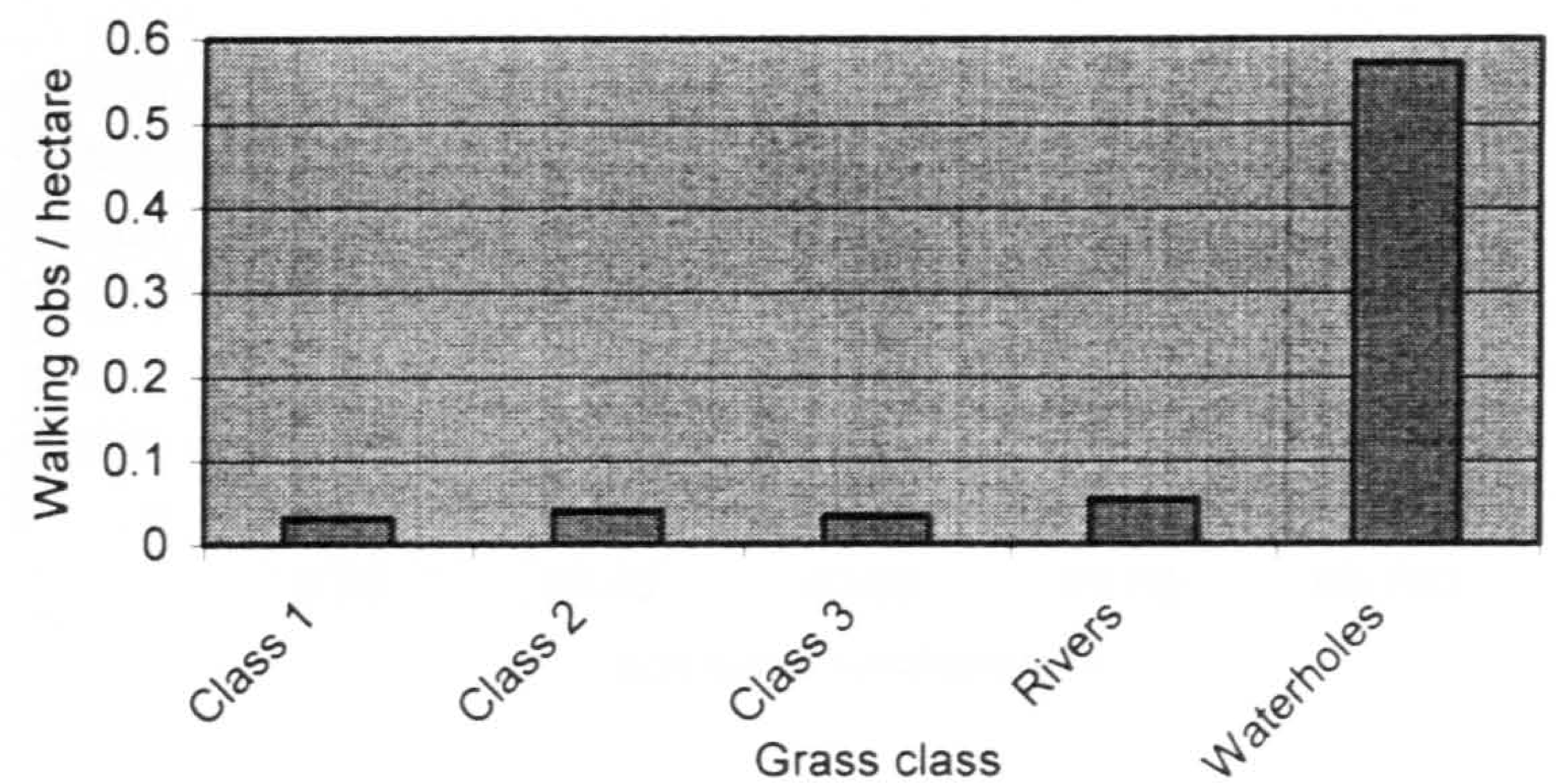
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

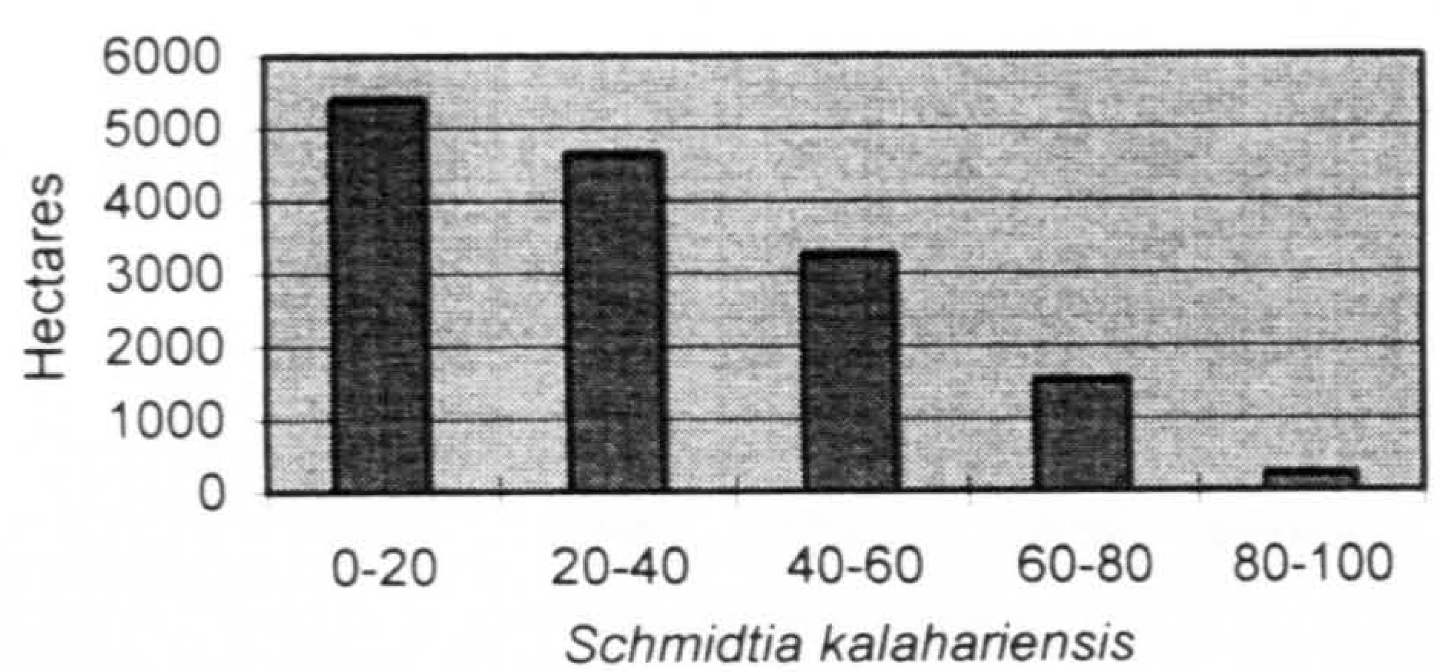


(d) Grazing Observations per Hectare in Each Class

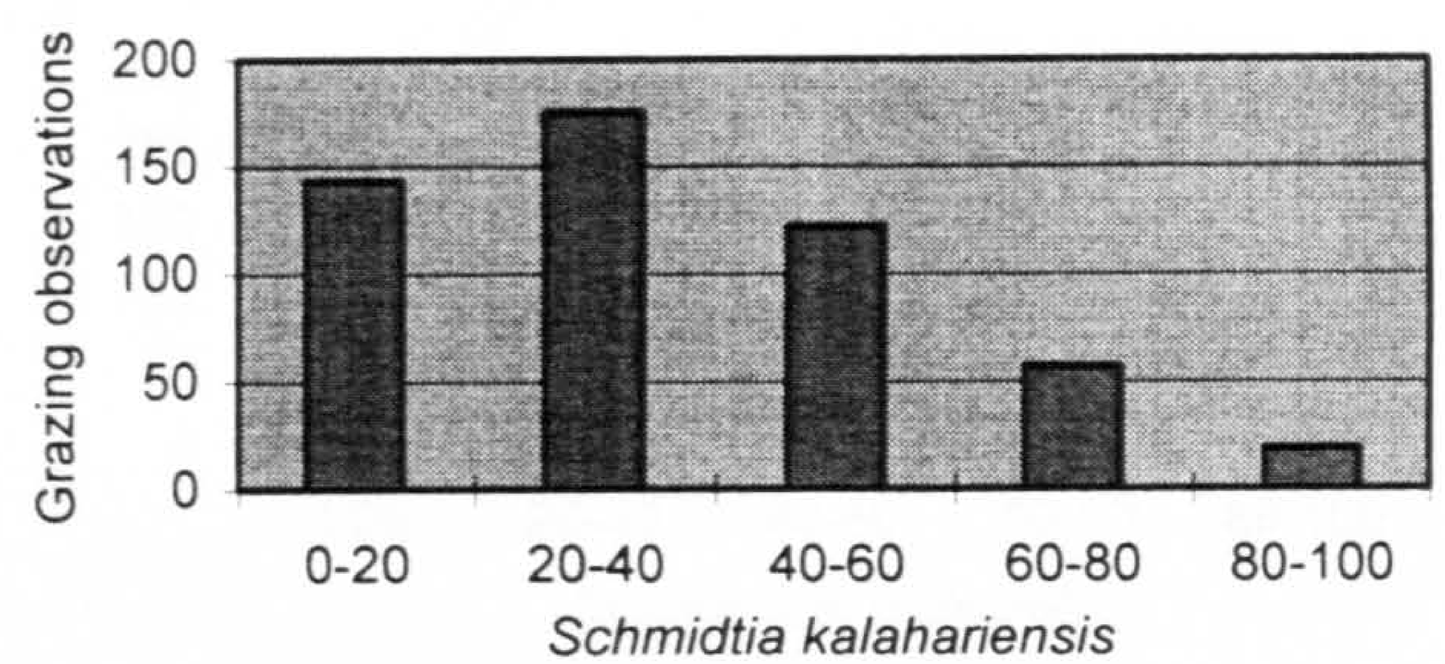


(e) Walking Observations per Hectare in Each Class

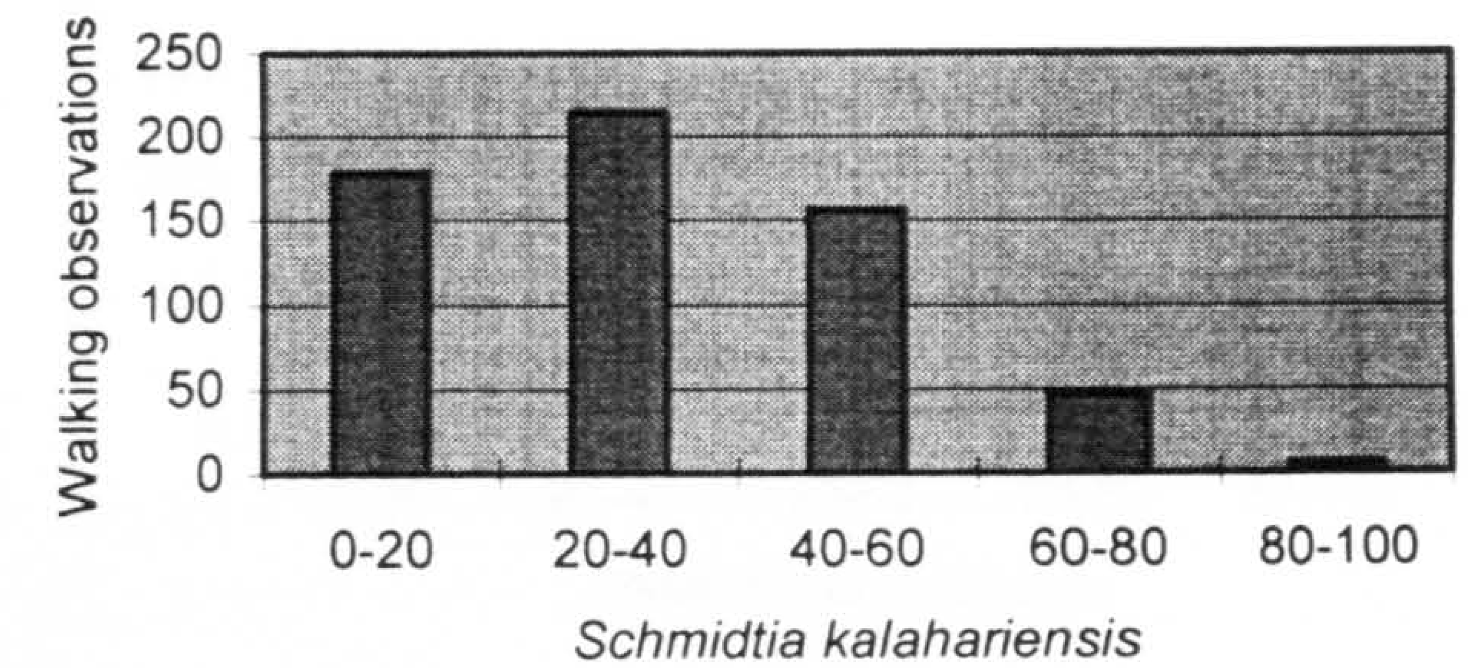
Fig. 6 Analysis of Utilisation of Detailed Three-Class Herbaceous Layer Classification



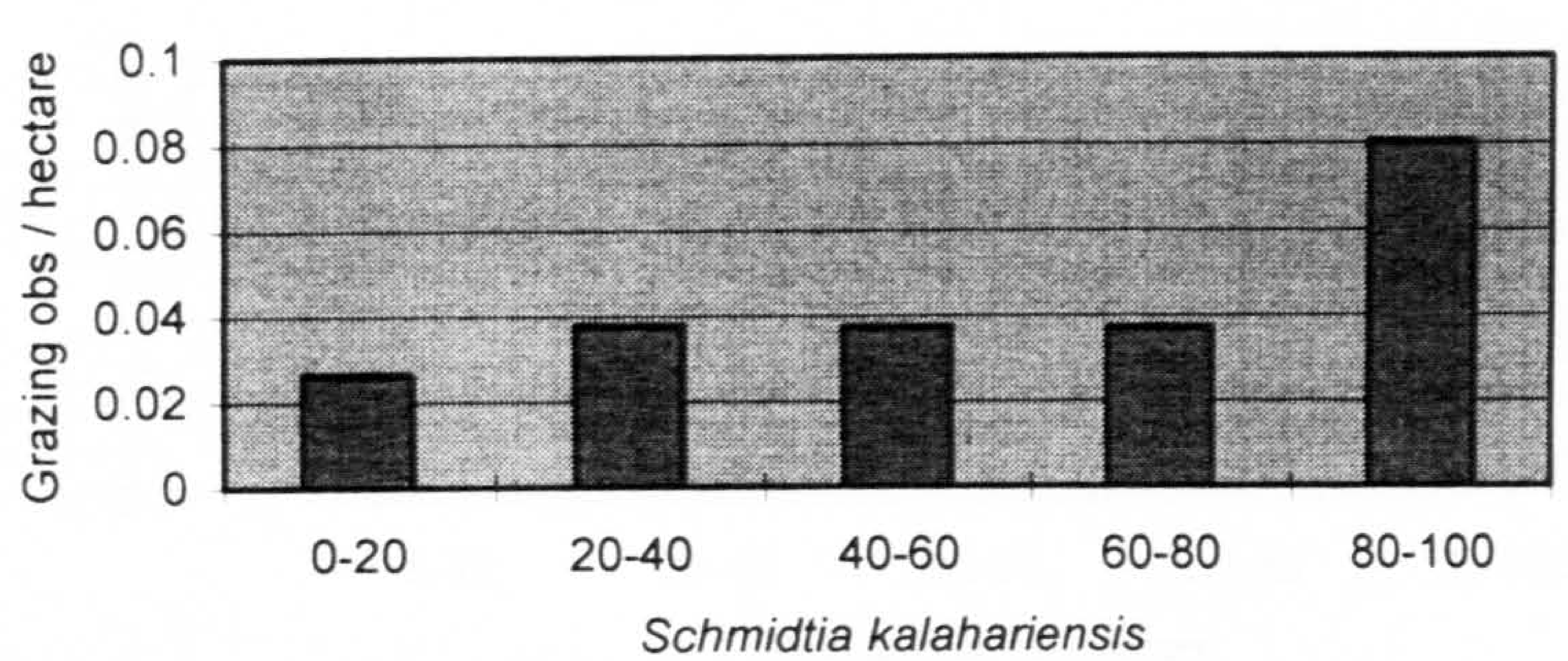
(a) Area Covered by Each Class



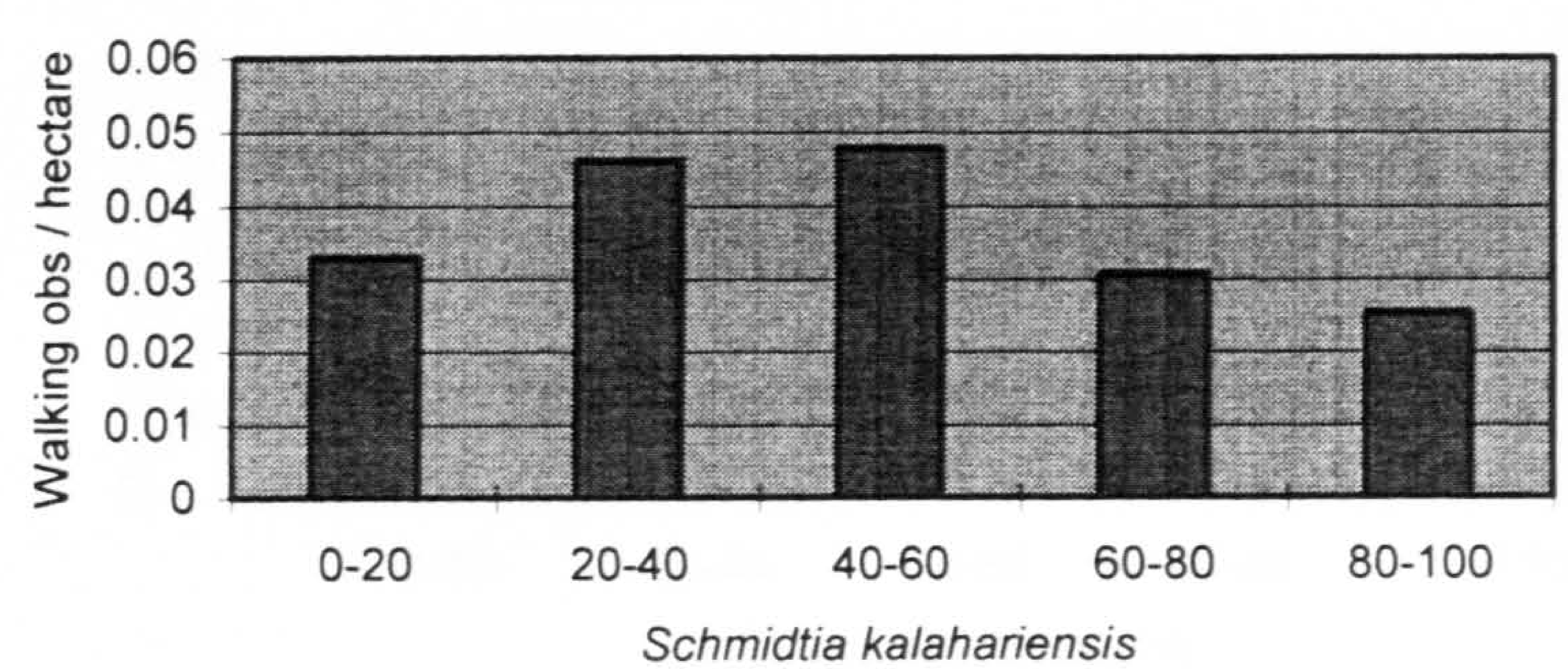
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

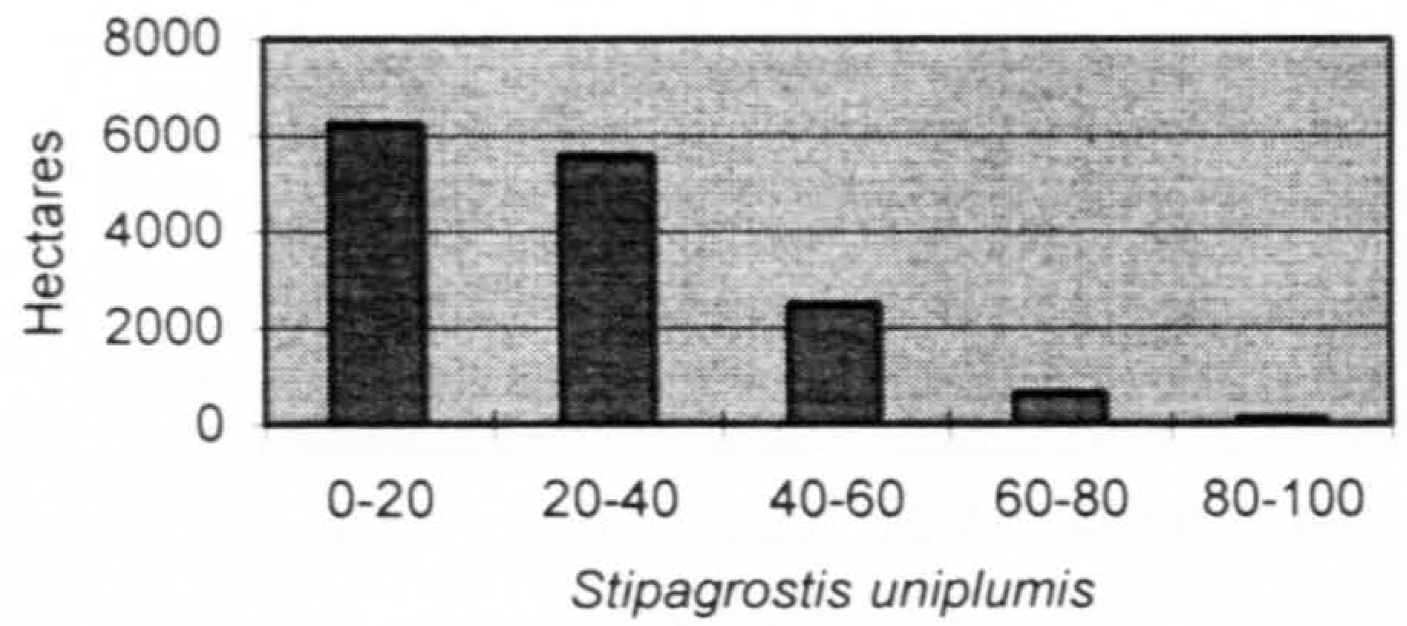


(d) Grazing Observations per Hectare in Each Class

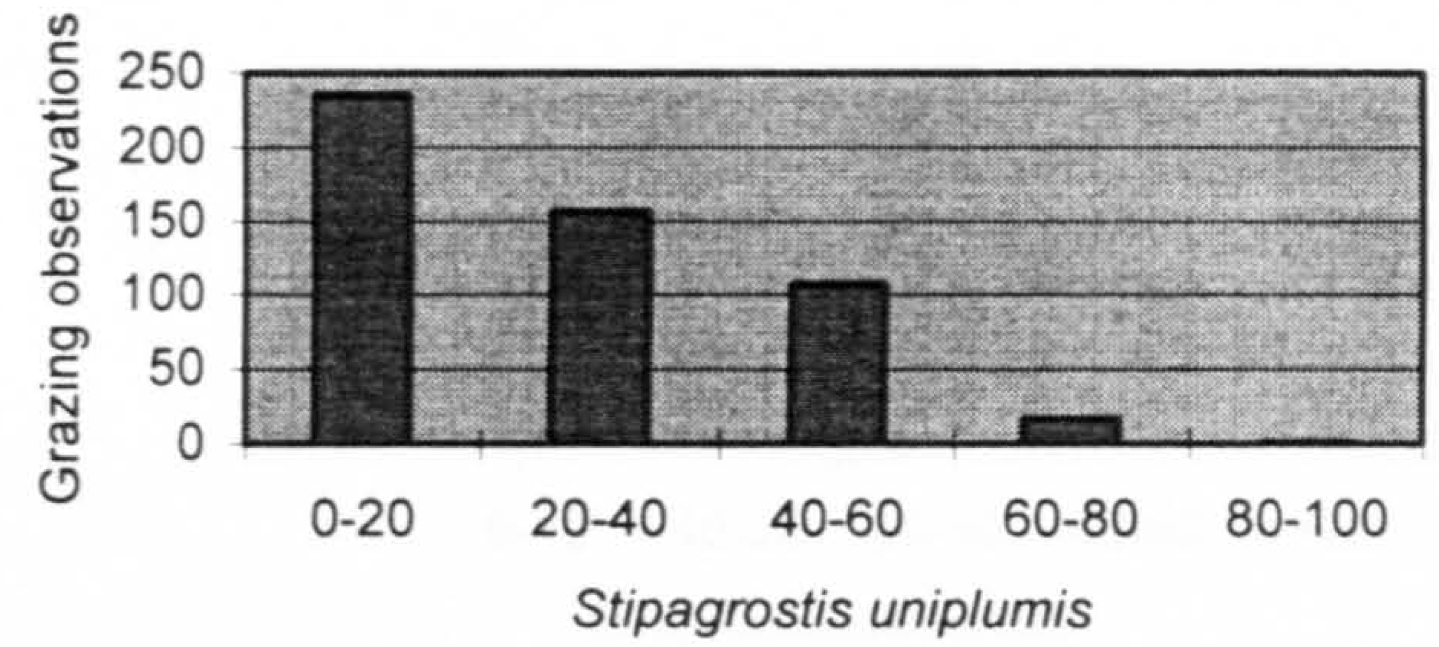


(e) Walking Observations per Hectare in Each Class

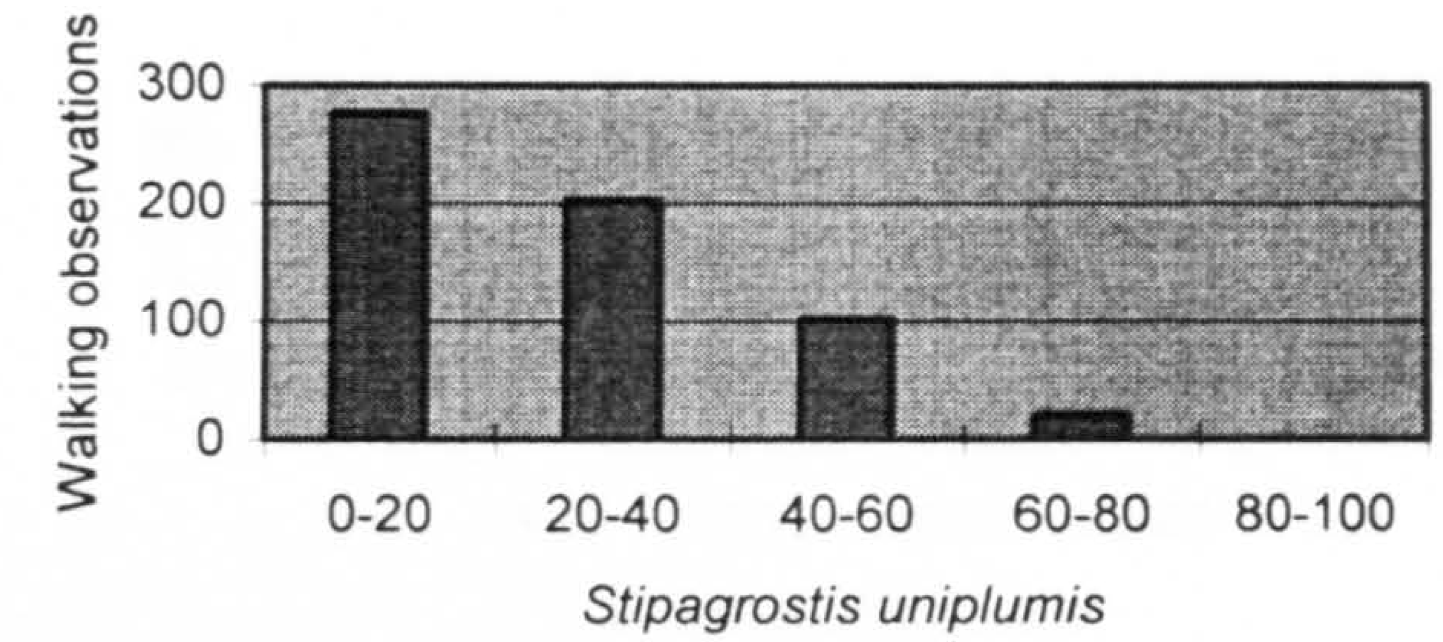
Fig. 7 Analysis of Utilisation of *Schmidtia kalahariensis* Abundance



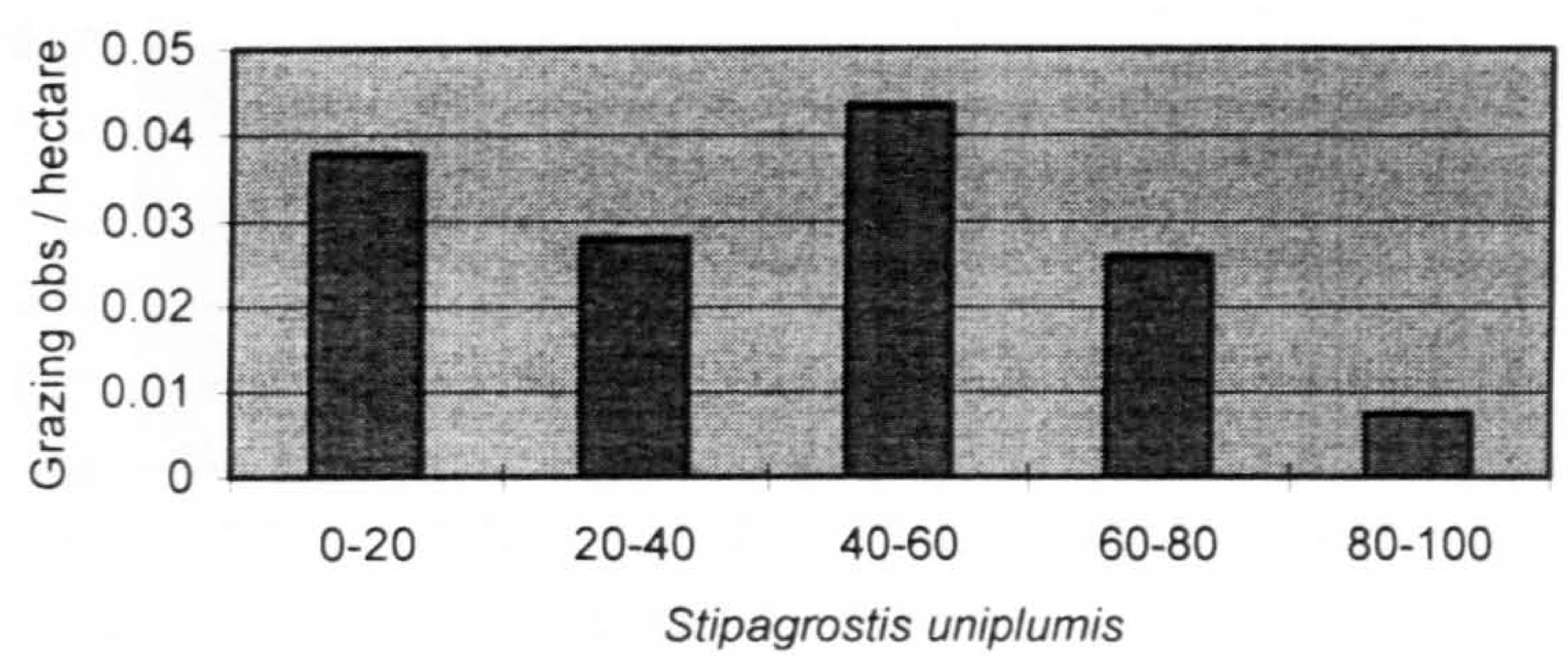
(a) Area Covered by Each Class



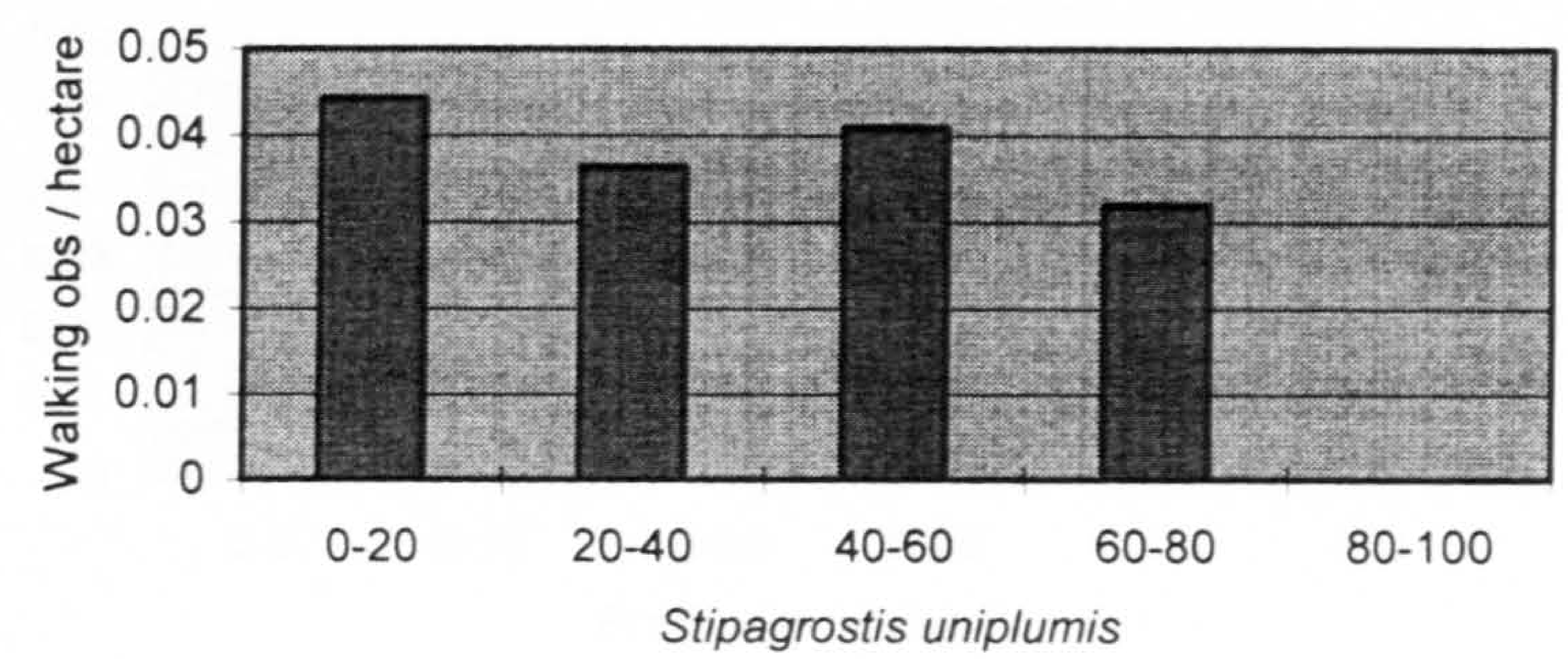
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

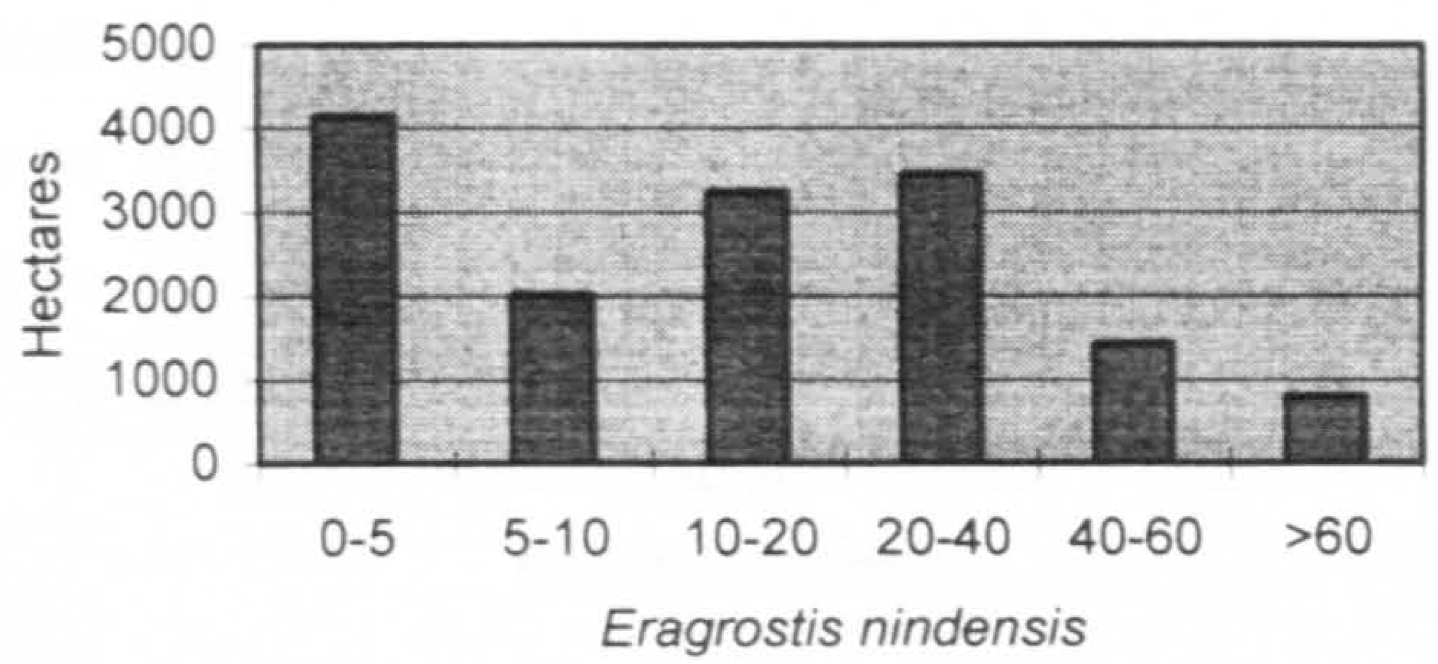


(d) Grazing Observations per Hectare in Each Class

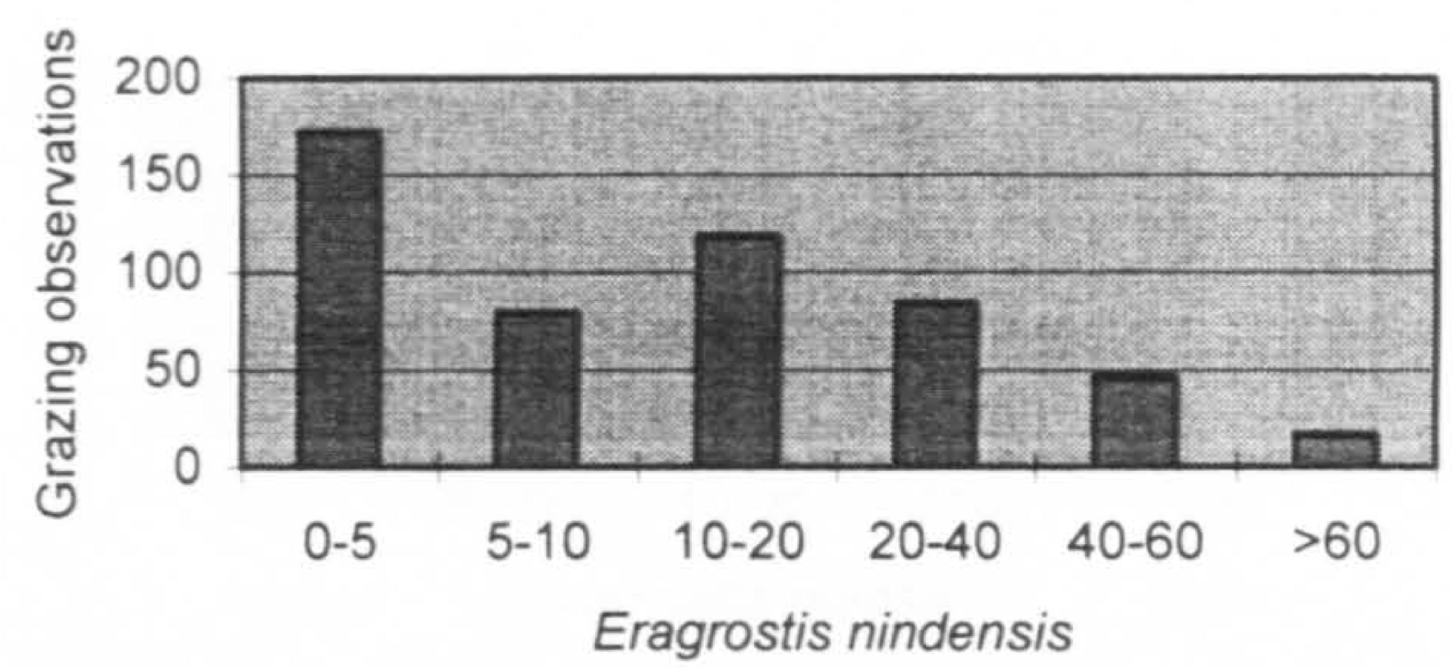


(e) Walking Observations per Hectare in Each Class

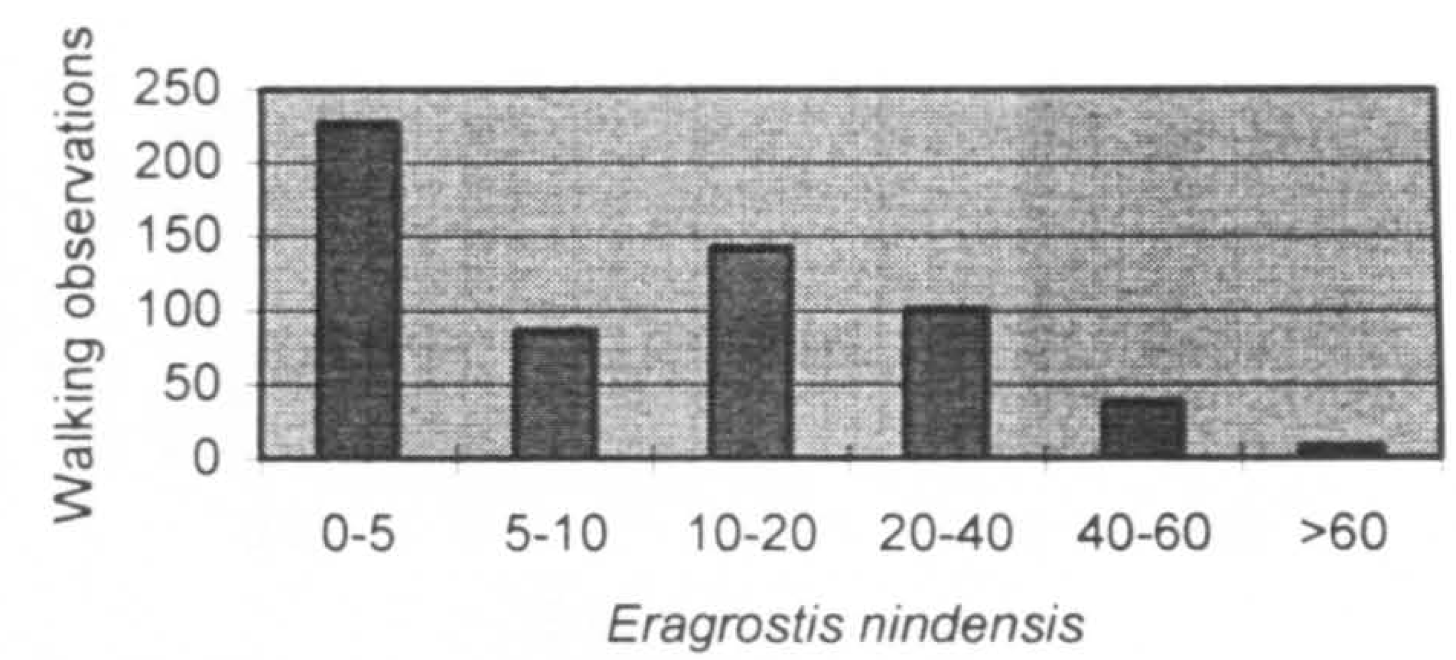
Fig. 8 Analysis of Utilisation of *Stipagrostis uniplumis* Abundance



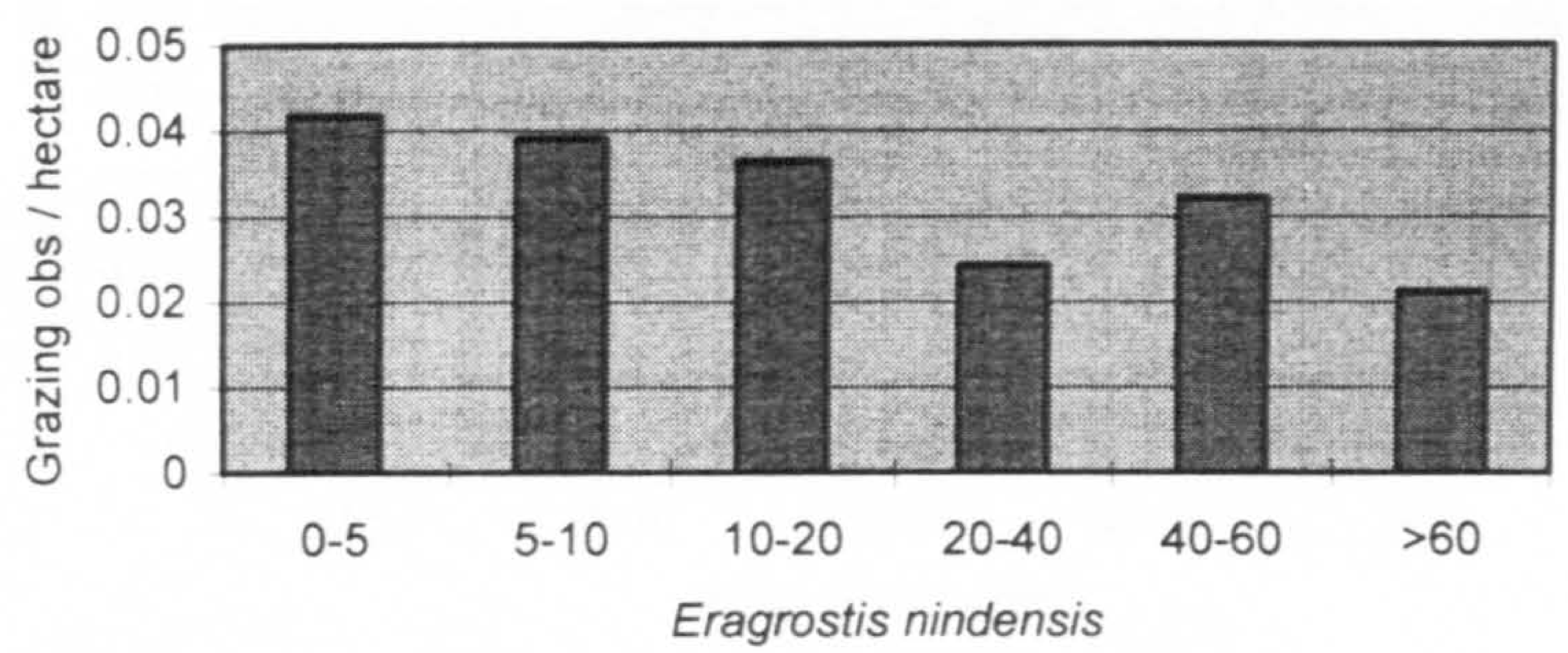
(a) Area Covered by Each Class



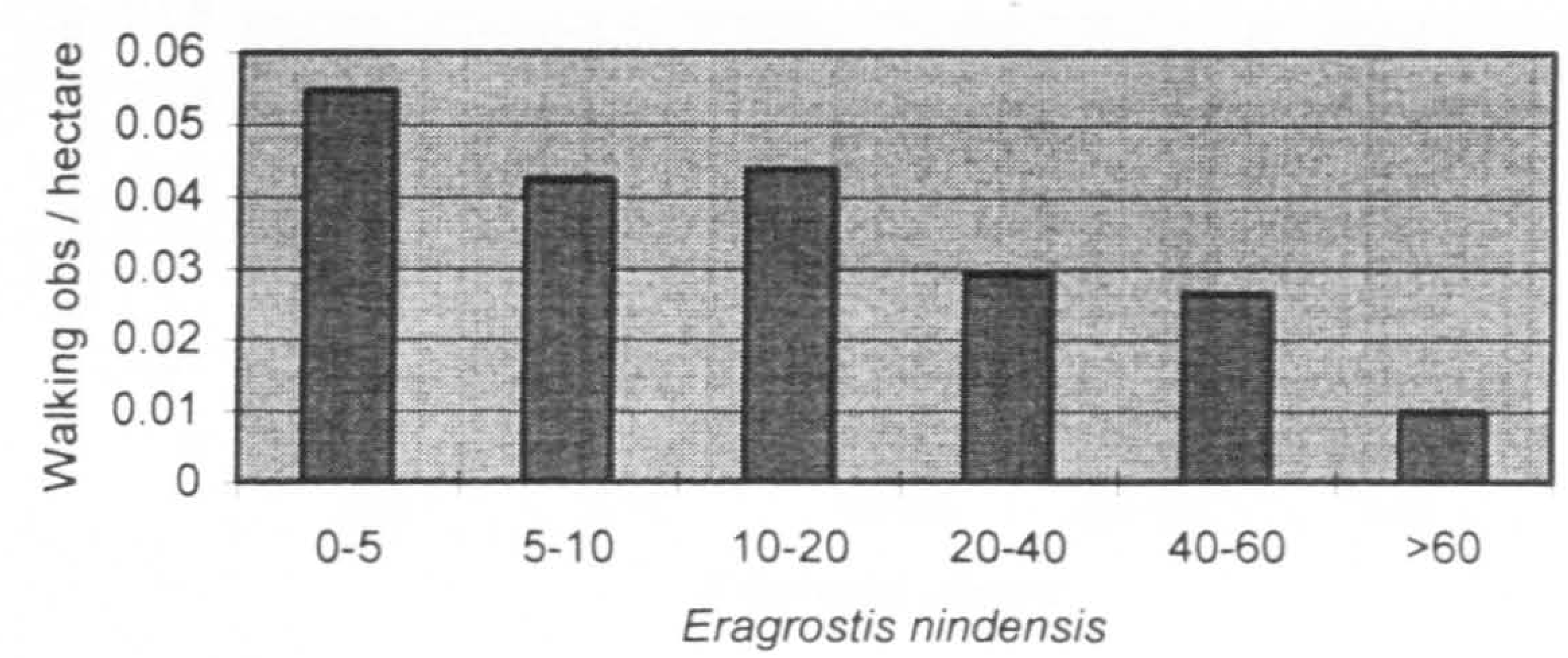
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

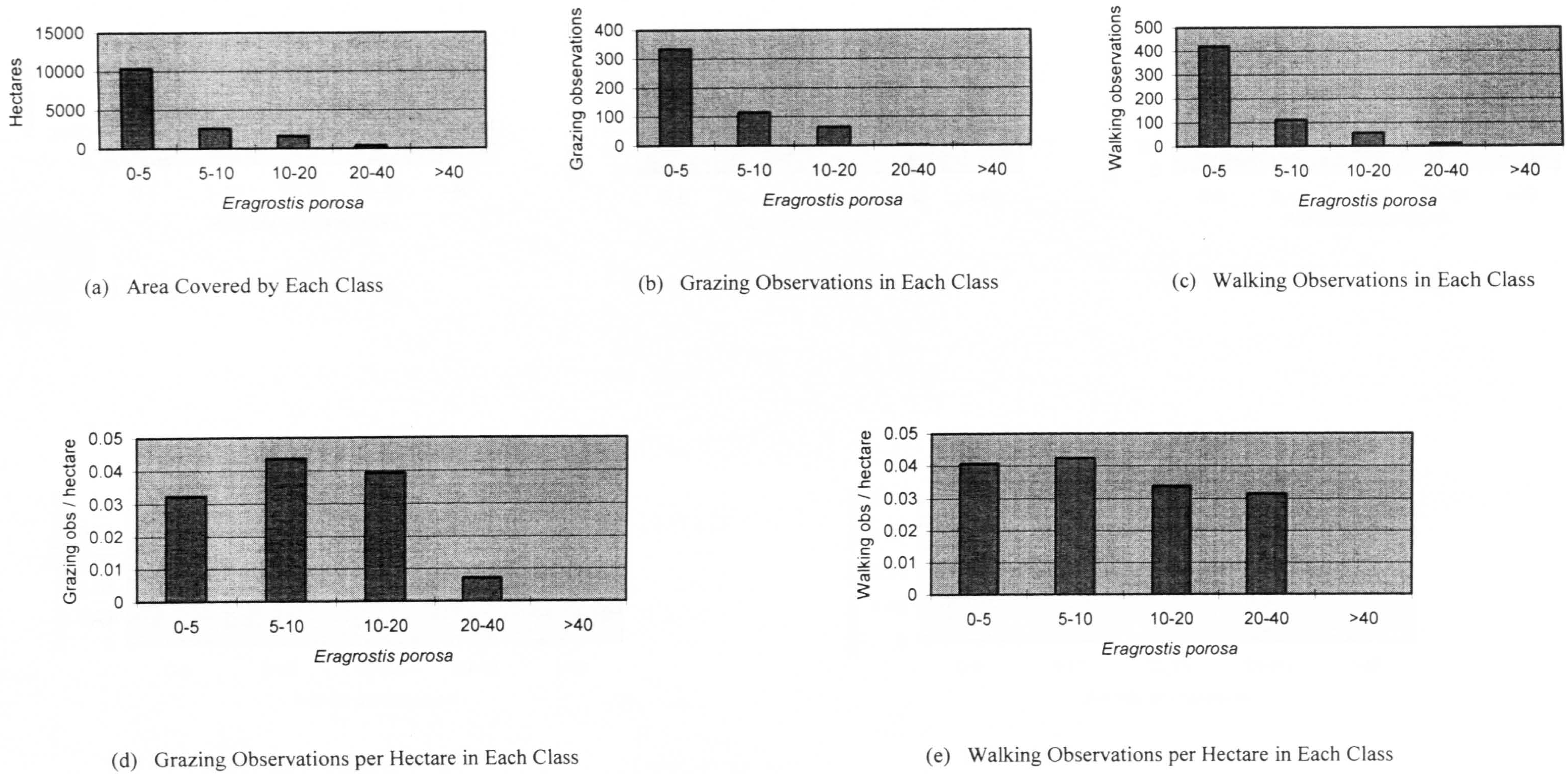


(d) Grazing Observations per Hectare in Each Class



(e) Walking Observations per Hectare in Each Class

Fig. 9 Analysis of Utilisation of *Eragrostis nindensis* Abundance



(a) Area Covered by Each Class

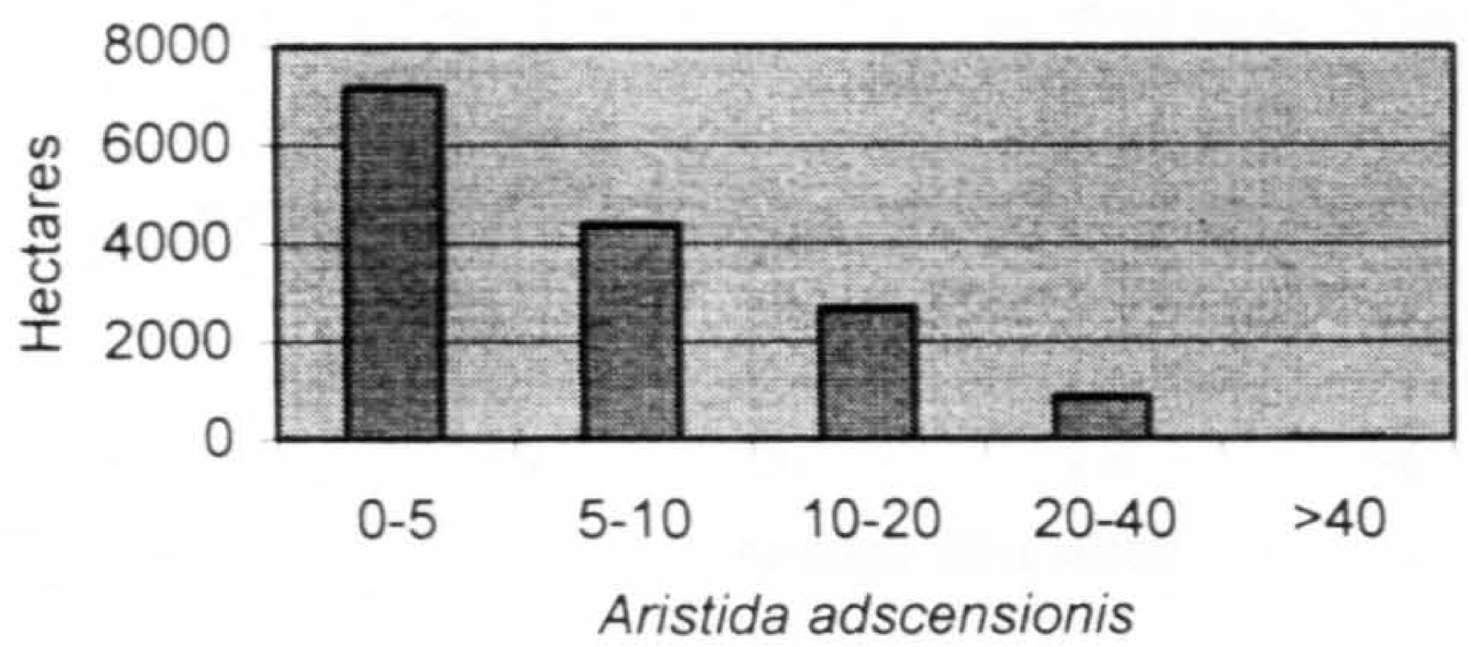
(b) Grazing Observations in Each Class

(c) Walking Observations in Each Class

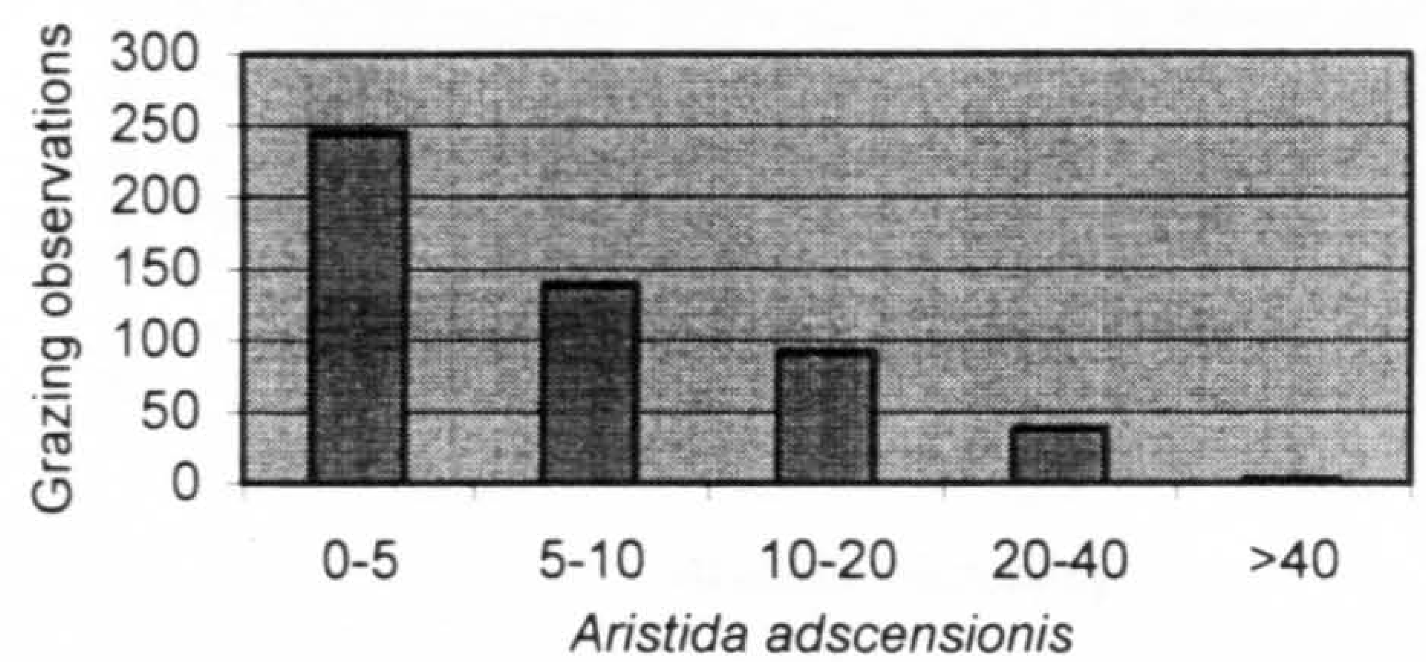
(d) Grazing Observations per Hectare in Each Class

(e) Walking Observations per Hectare in Each Class

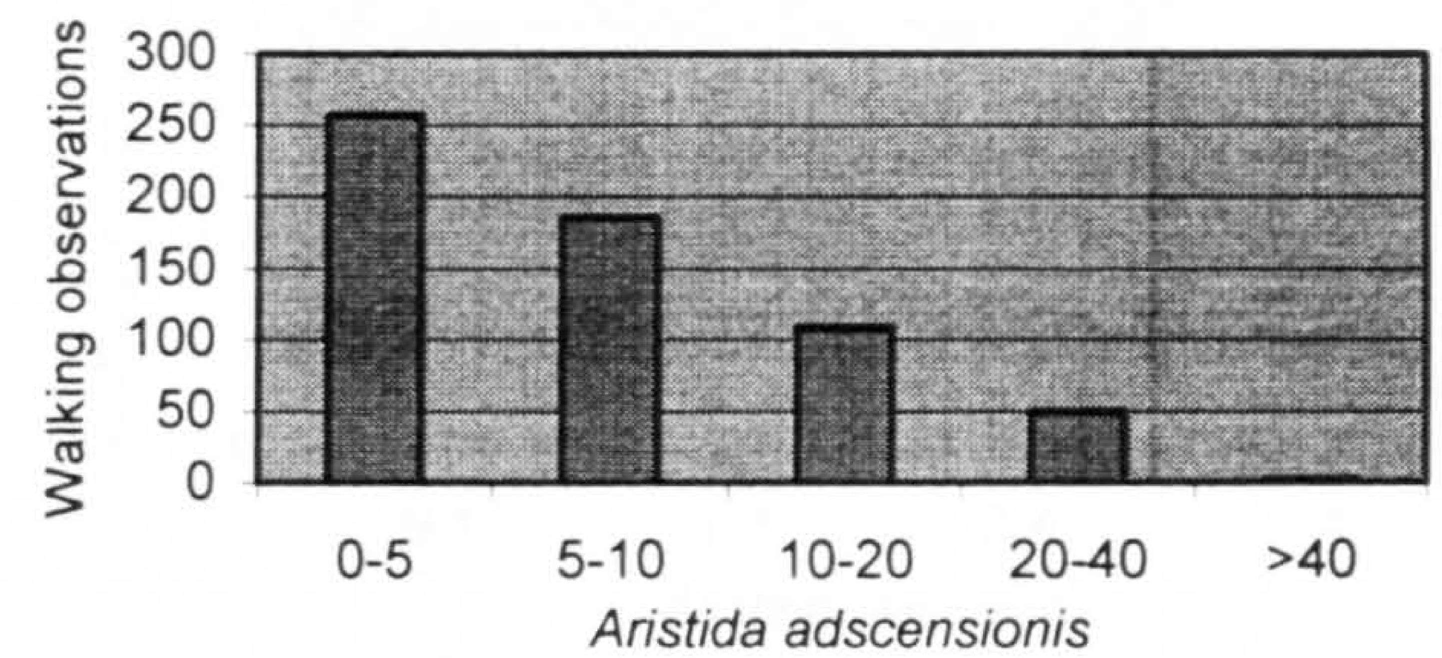
Fig. 10 Analysis of Utilisation of *Eragrostis porosa* Abundance



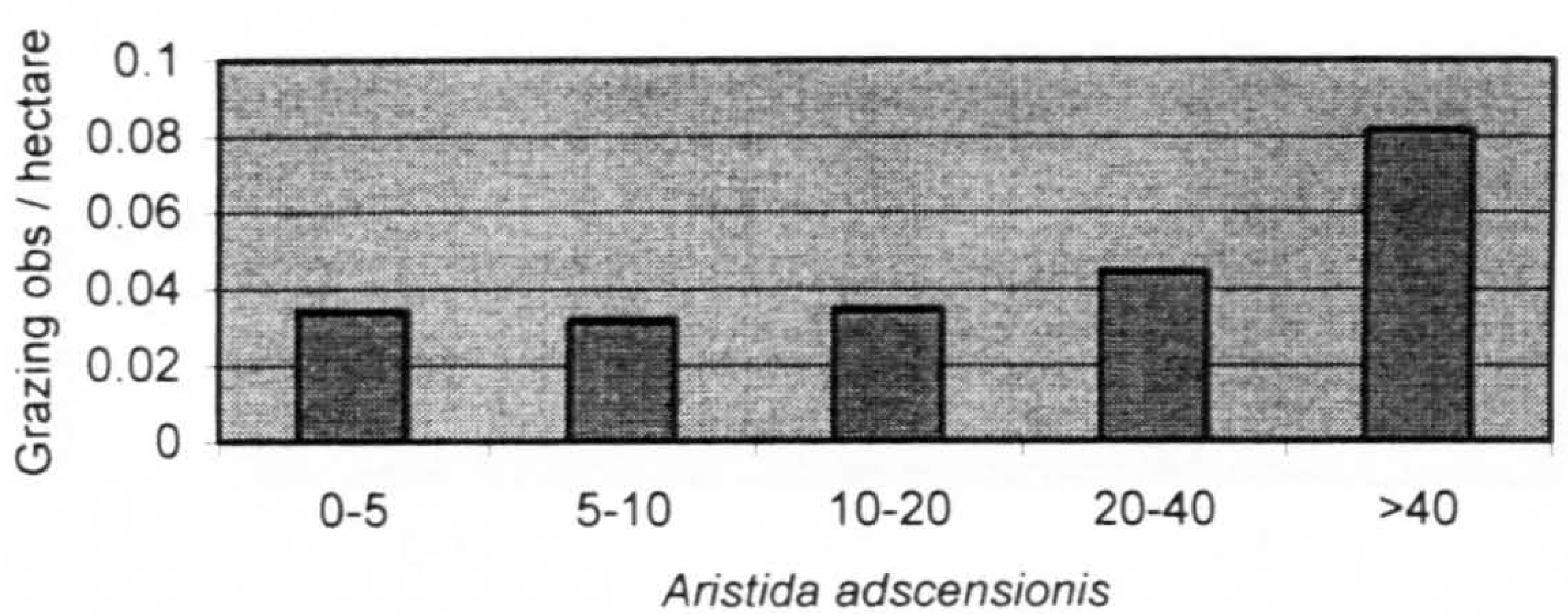
(a) Area Covered by Each Class



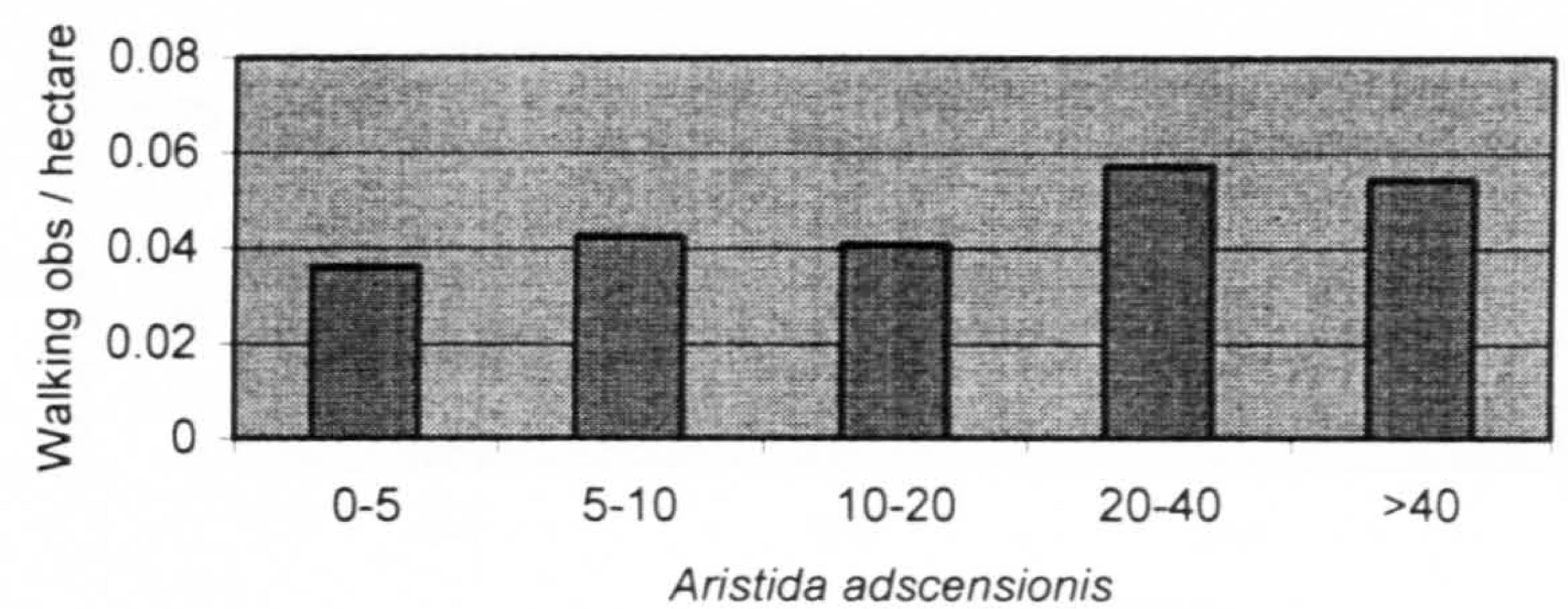
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

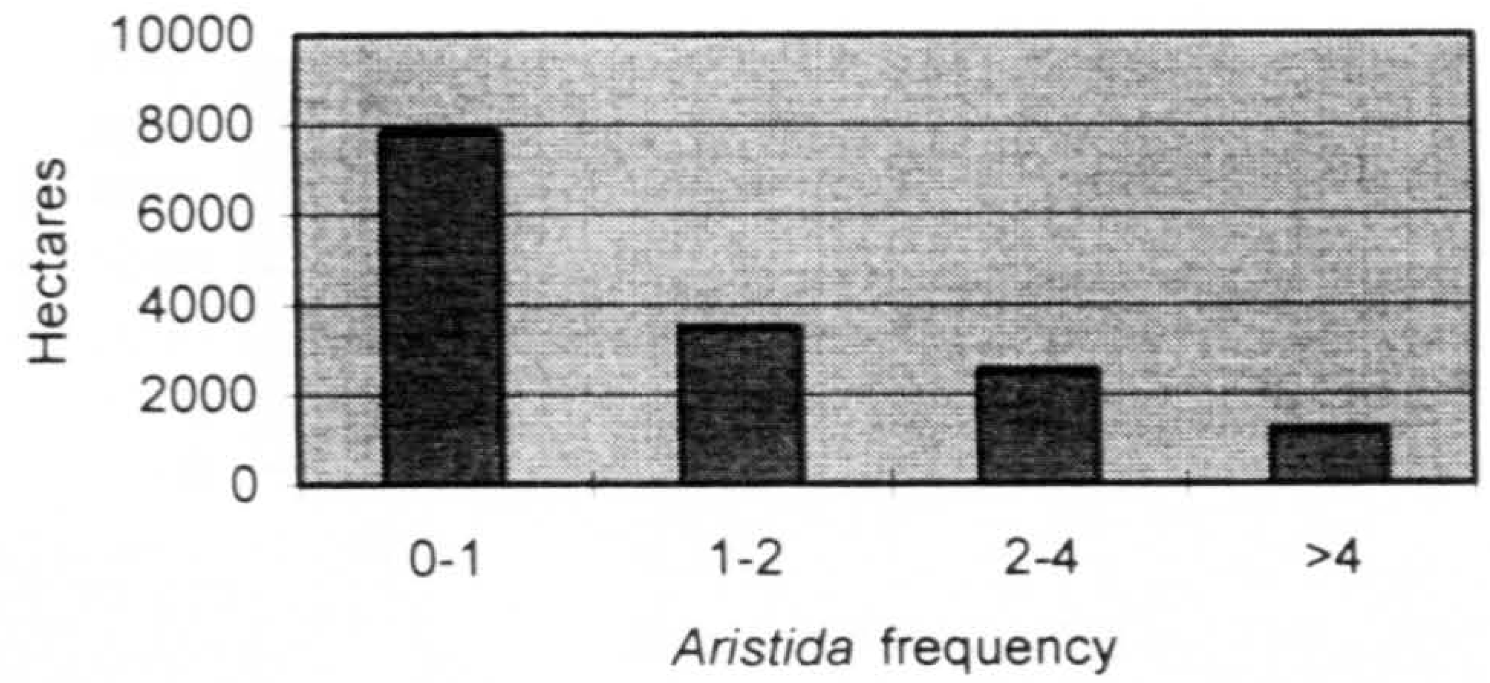


(d) Grazing Observations per Hectare in Each Class

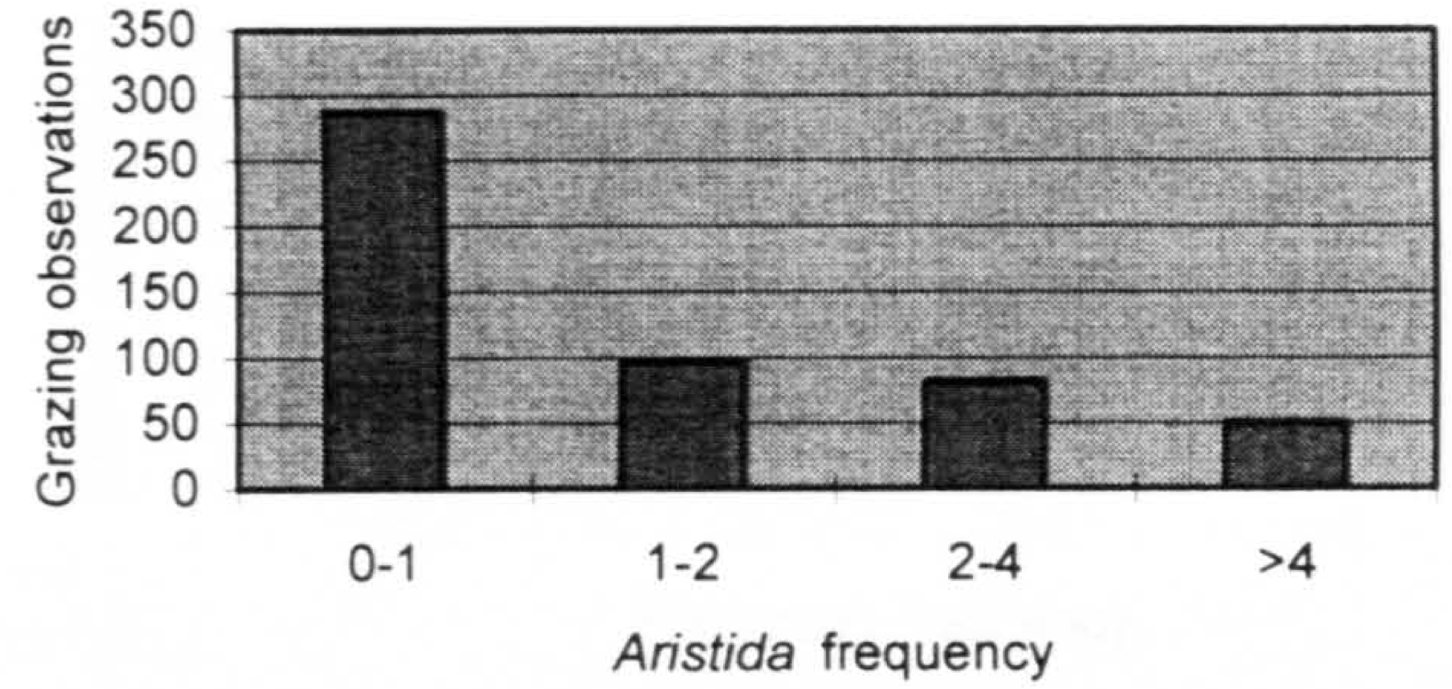


(e) Walking Observations per Hectare in Each Class

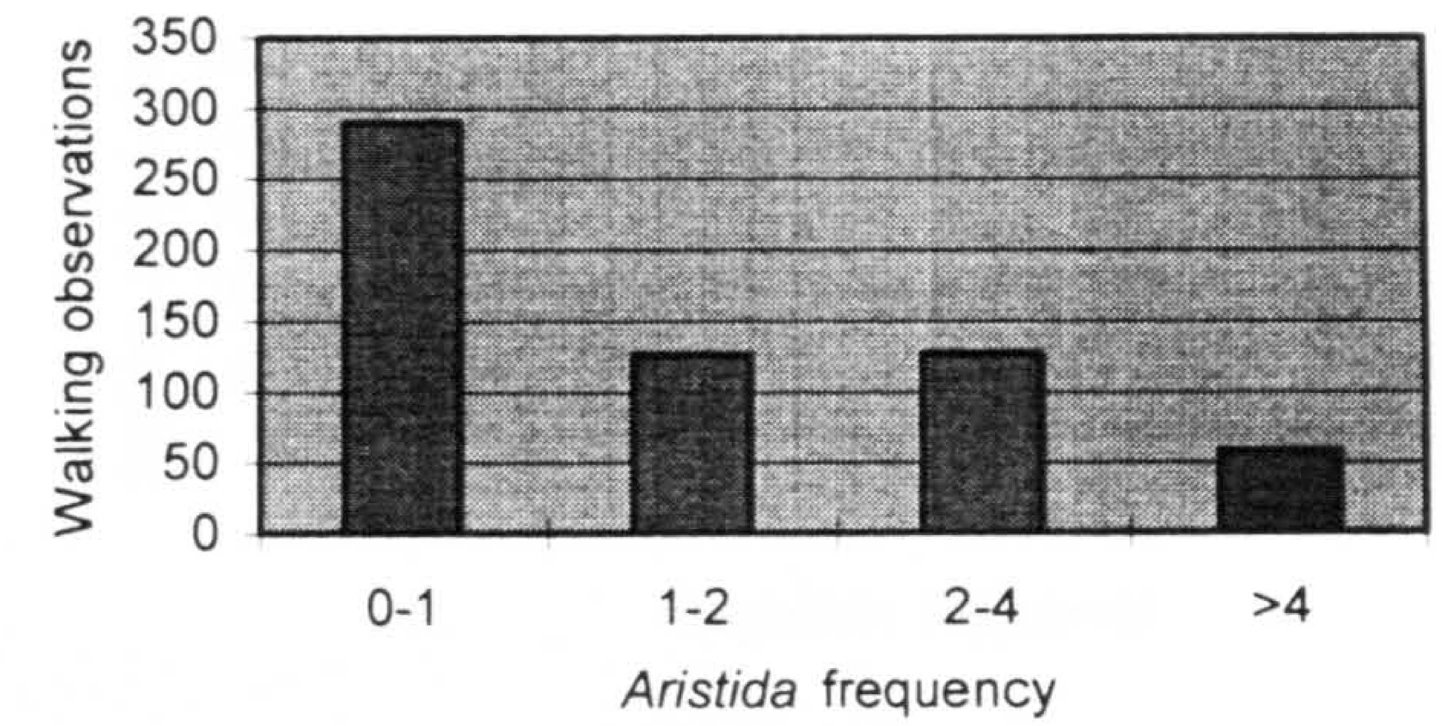
Fig. 11 Analysis of Utilisation of *Aristida adscensionis* Abundance



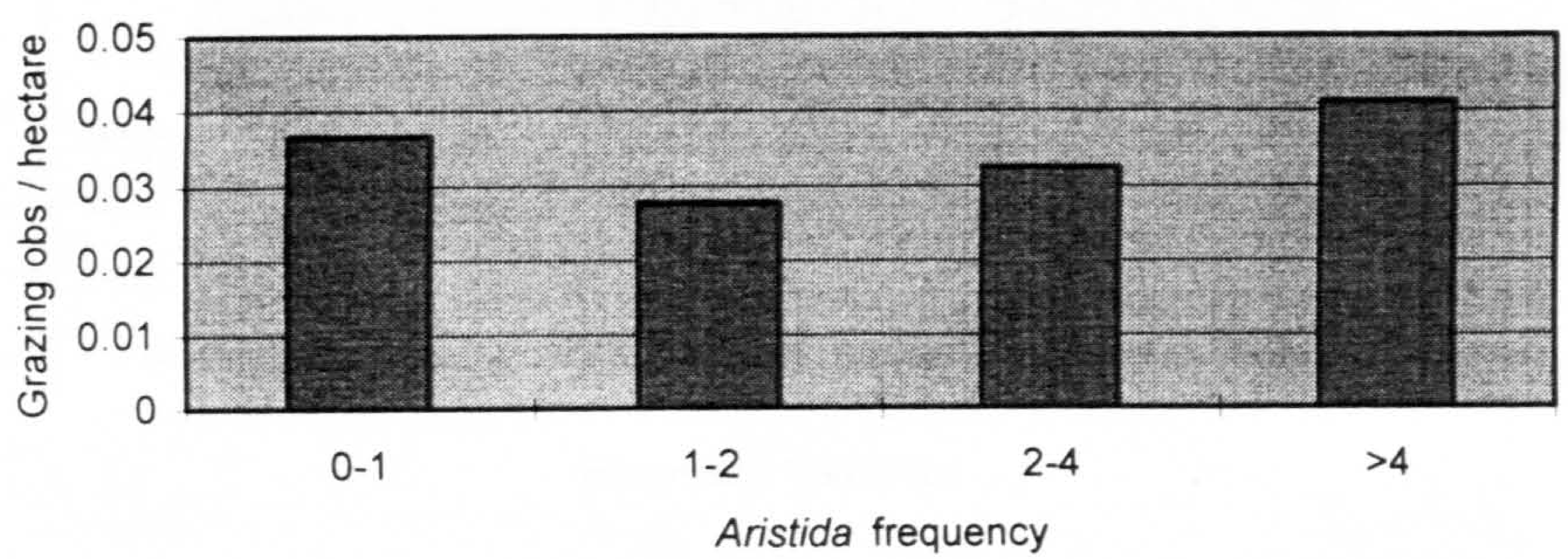
(a) Area Covered by Each Class



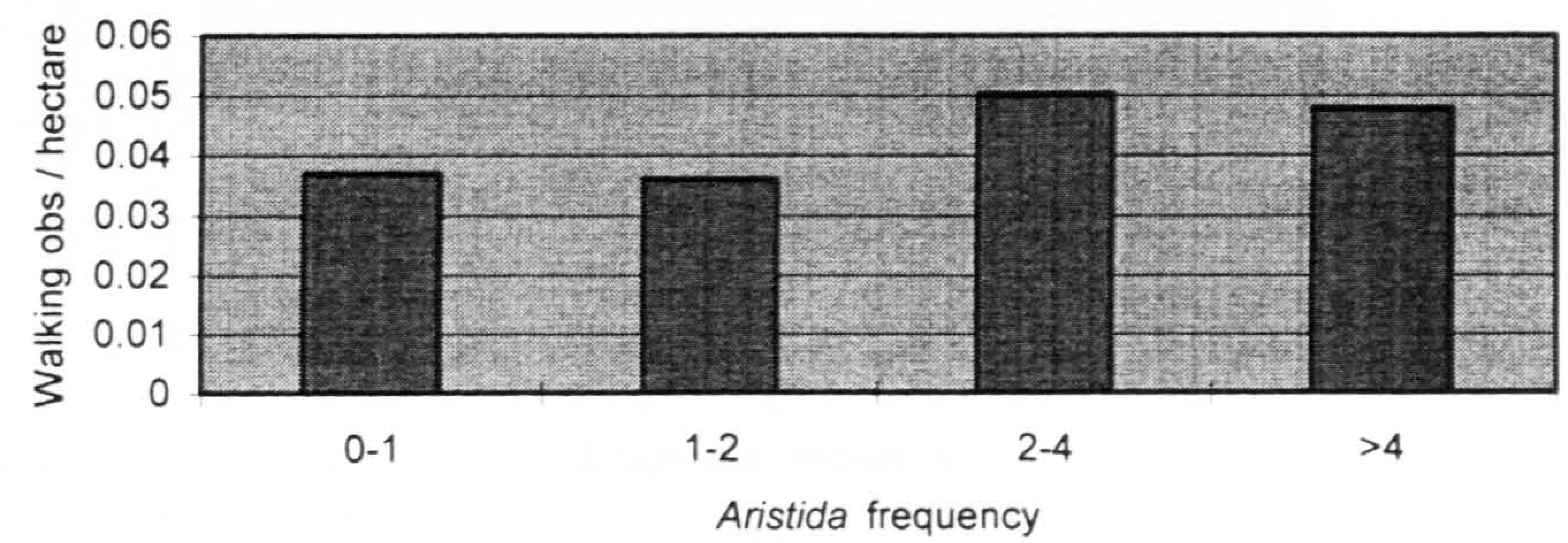
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

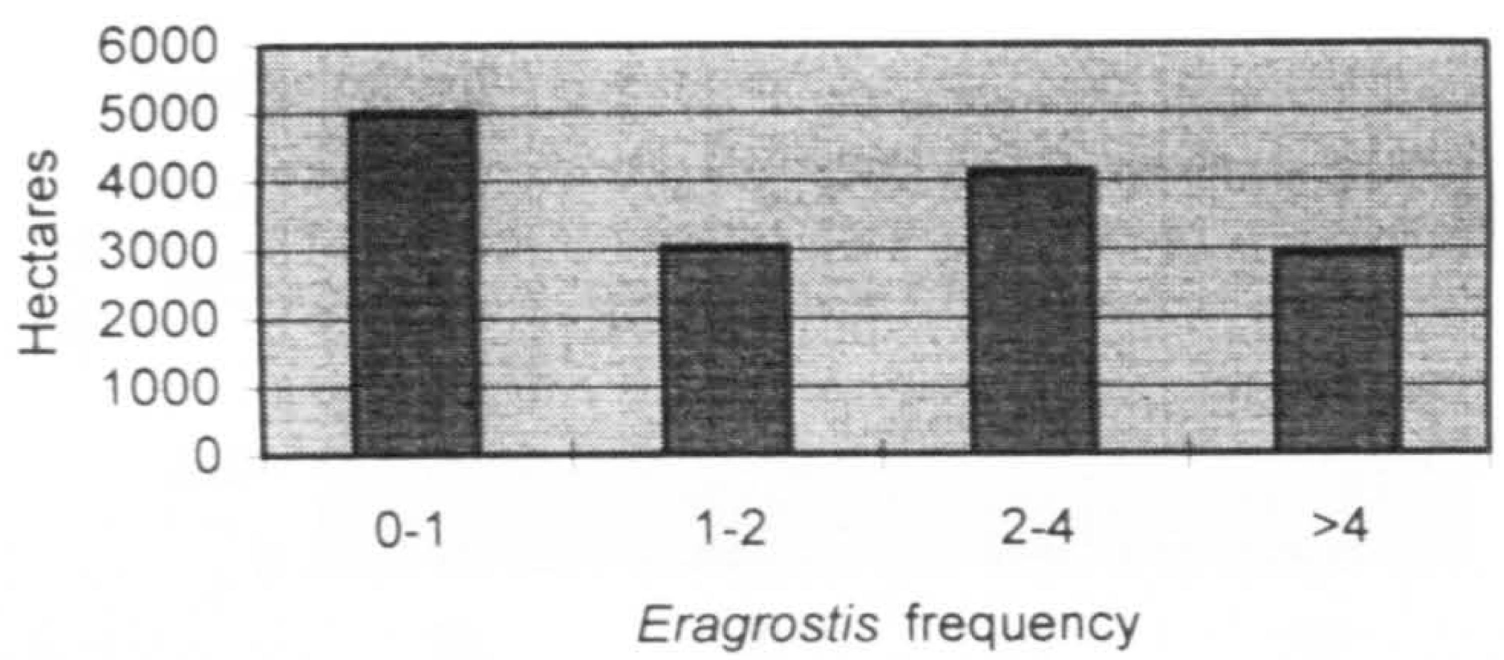


(d) Grazing Observations per Hectare in Each Class

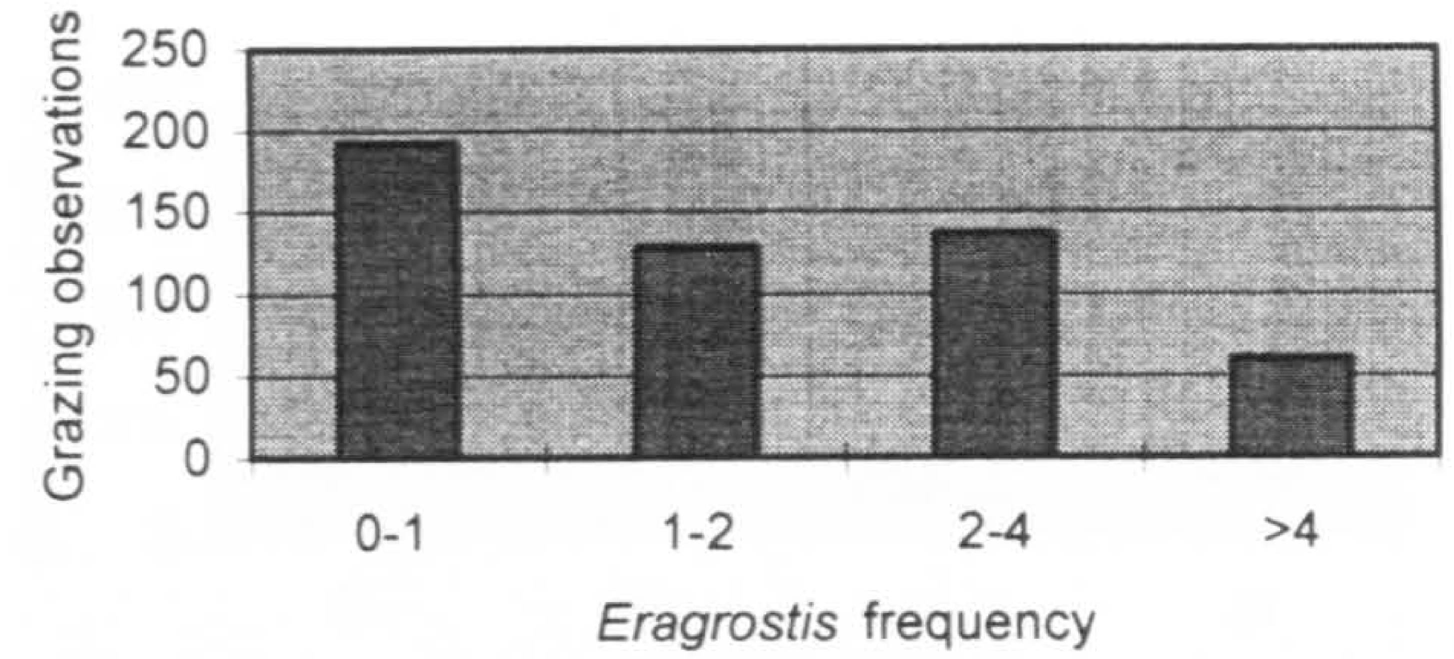


(e) Walking Observations per Hectare in Each Class

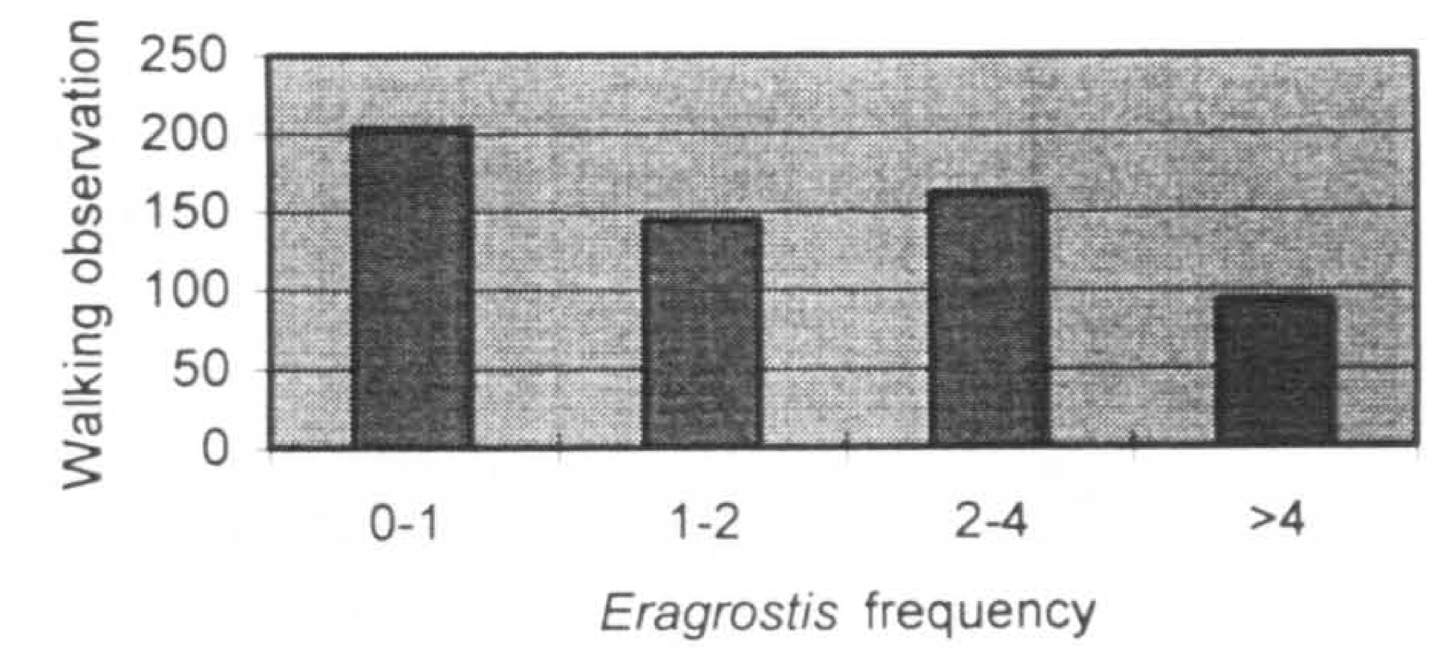
Fig. 12 Analysis of Utilisation of *Aristida* Species Abundance



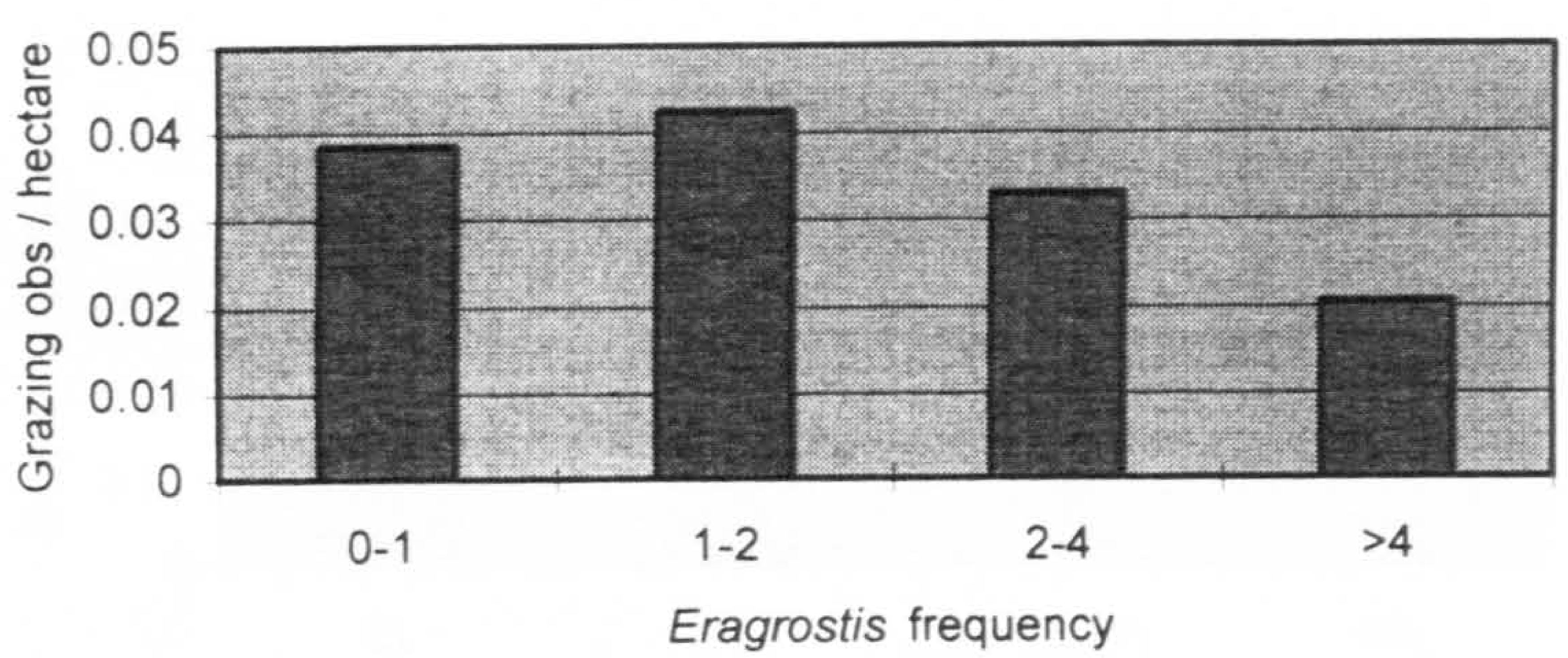
(a) Area Covered by Each Class



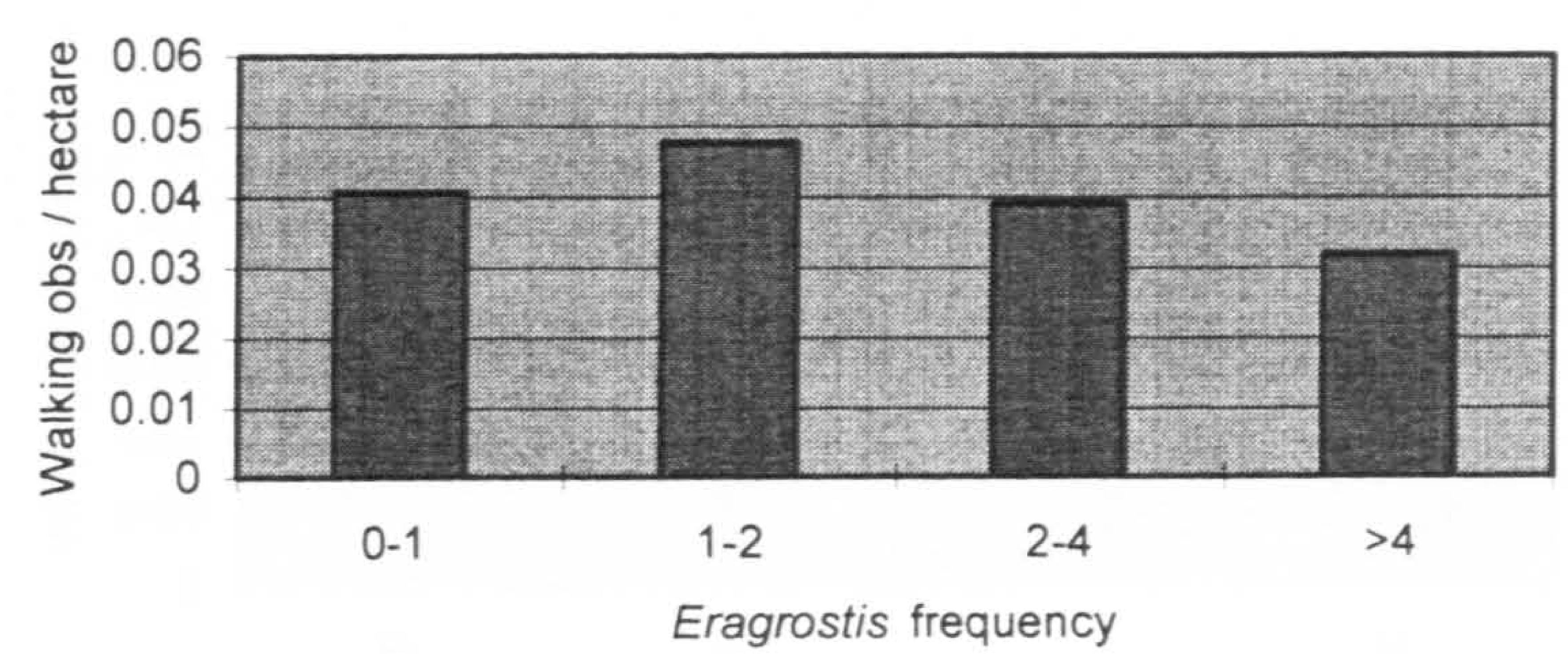
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

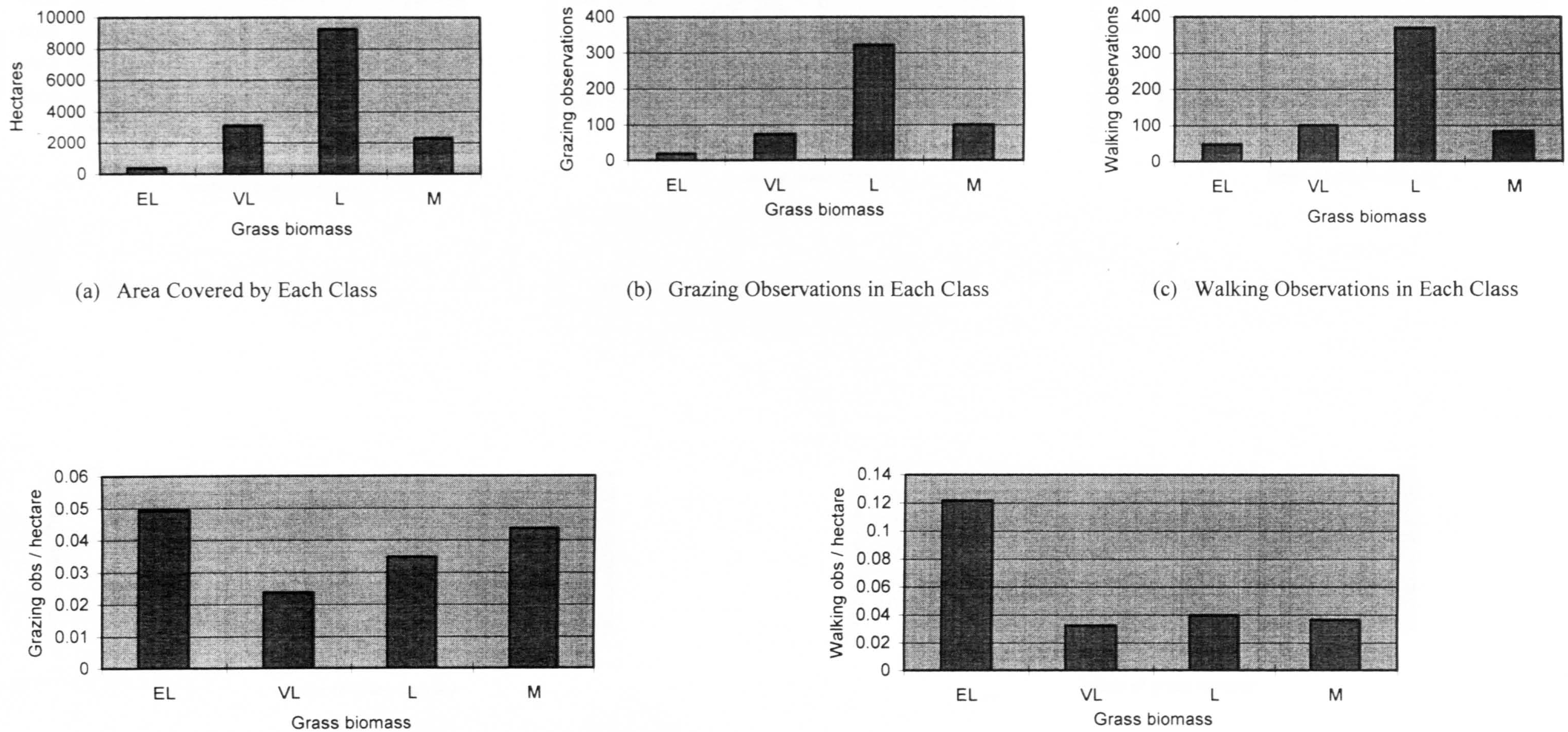


(d) Grazing Observations per Hectare in Each Class



(e) Walking Observations per Hectare in Each Class

Fig. 13 Analysis of Utilisation of *Eragrostis* Species Abundance



(a) Area Covered by Each Class

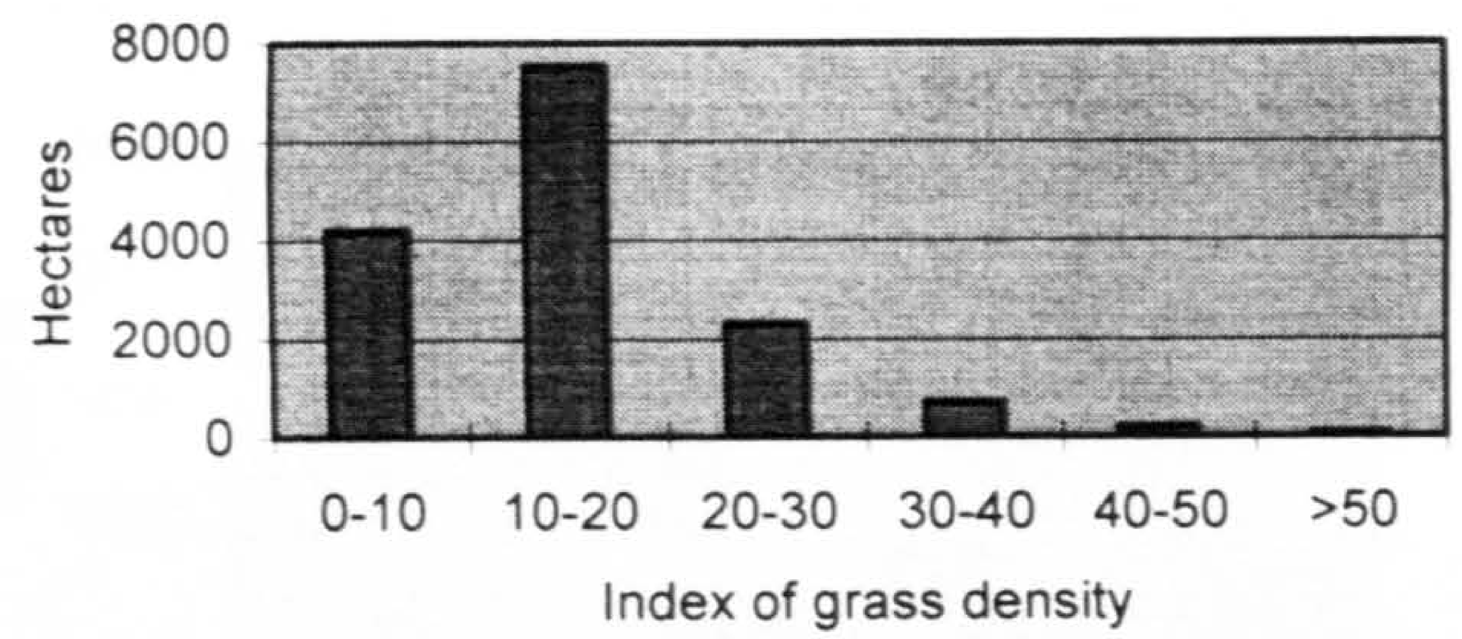
(b) Grazing Observations in Each Class

(c) Walking Observations in Each Class

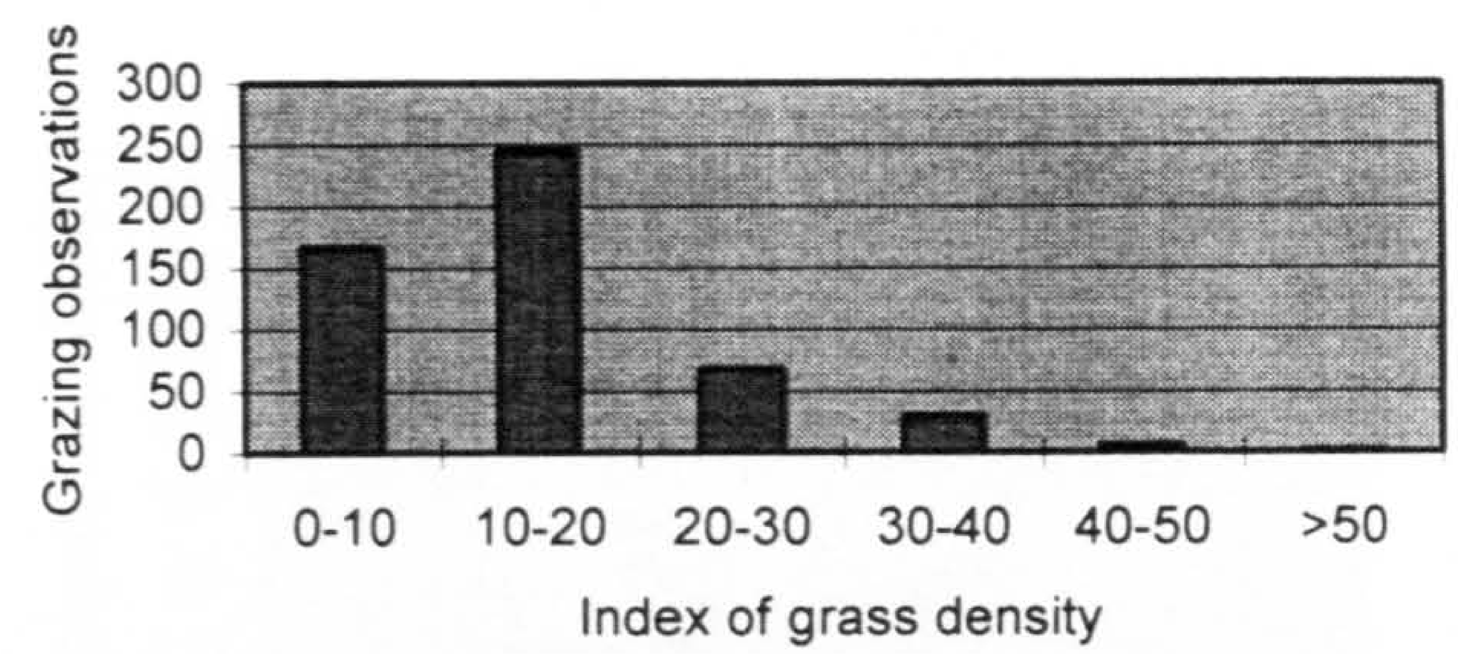
(d) Grazing Observations per Hectare in Each Class

(e) Walking Observations per Hectare in Each Class

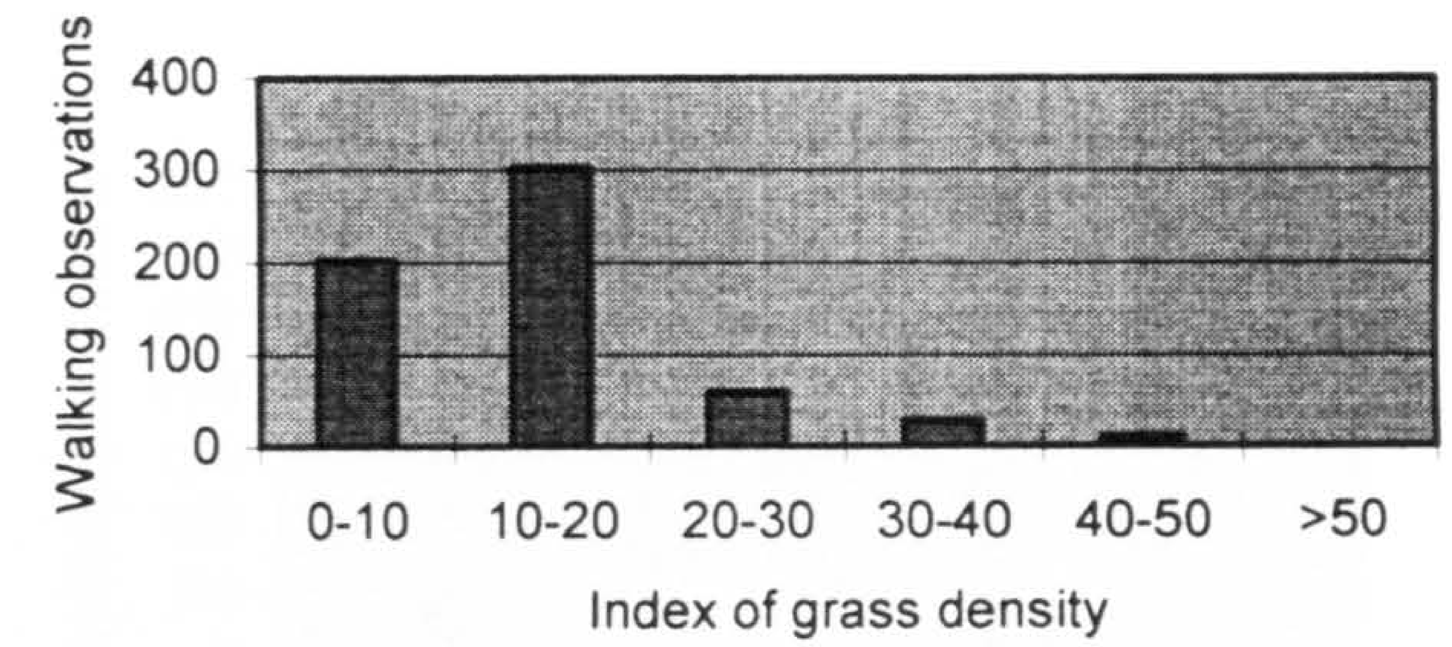
Fig. 14 Analysis of Utilisation of Grass Biomass Ratings



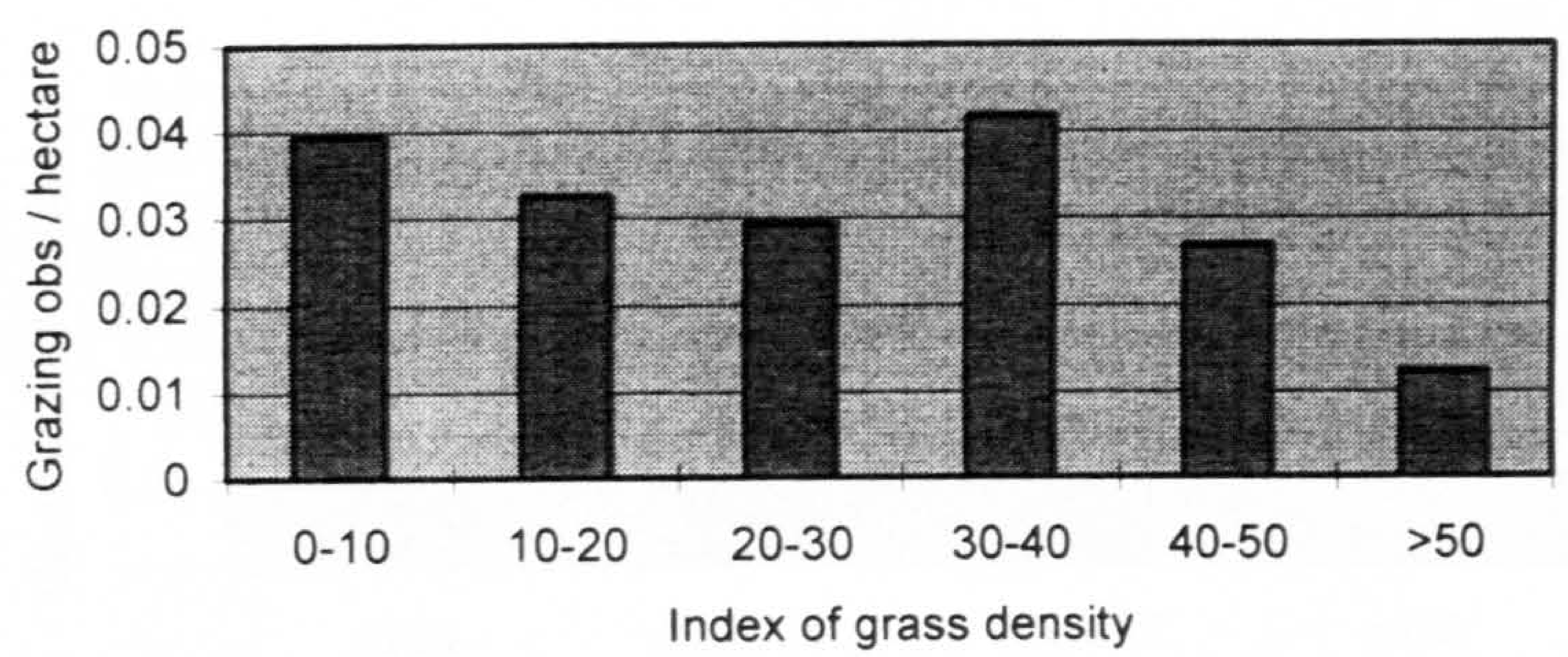
(a) Area Covered by Each Class



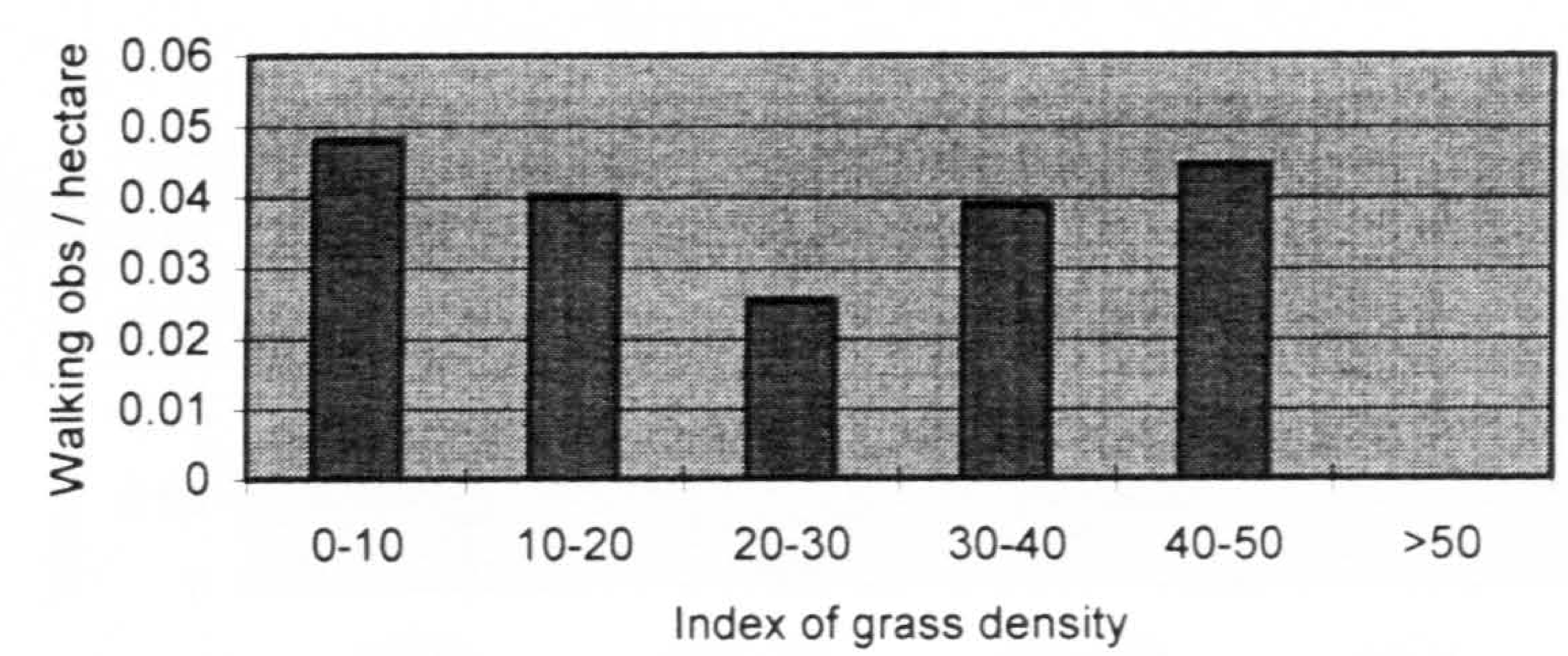
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

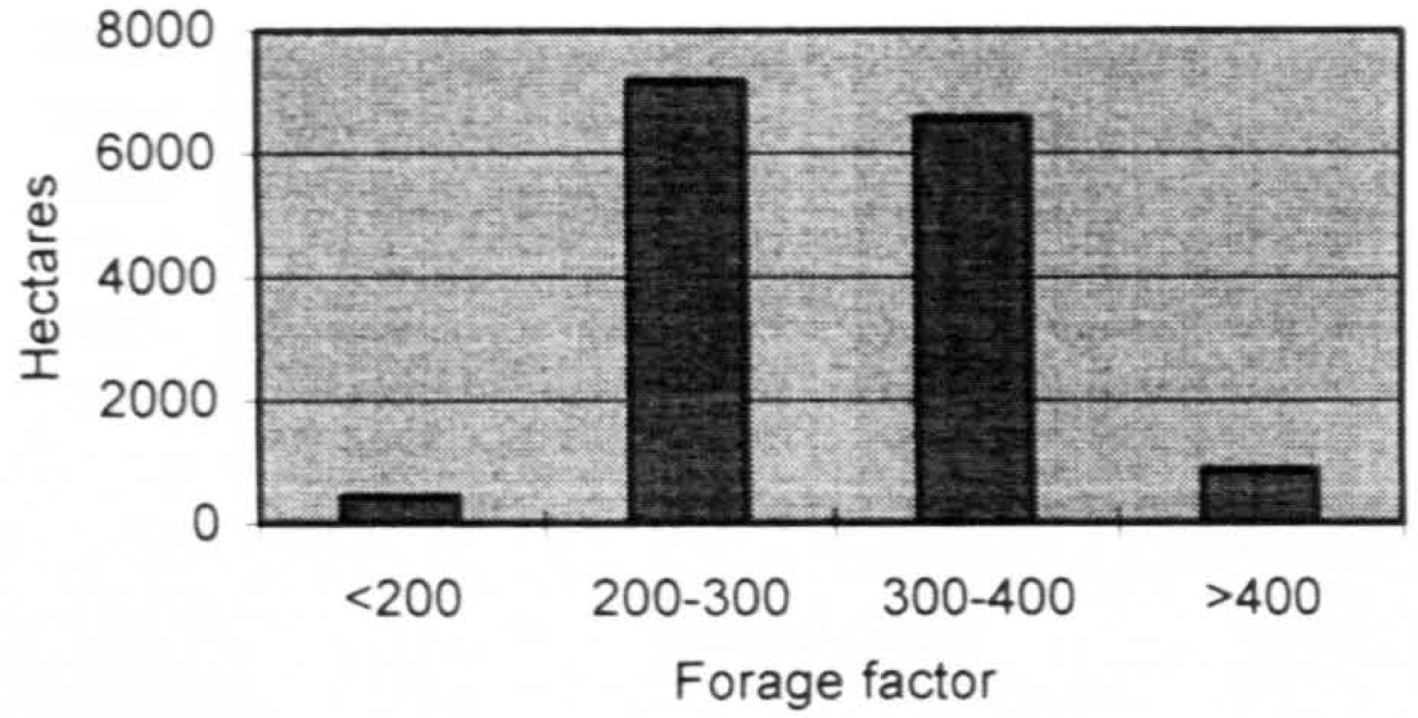


(d) Grazing Observations per Hectare in Each Class

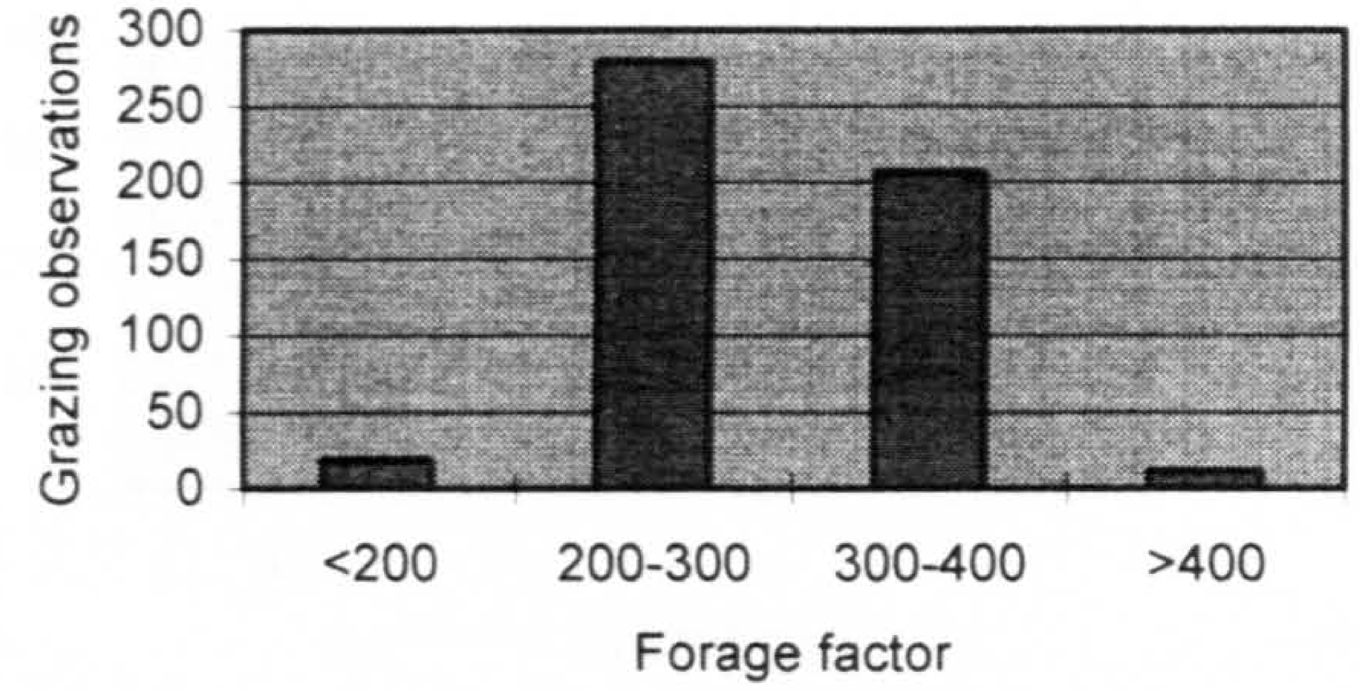


(e) Walking Observations per Hectare in Each Class

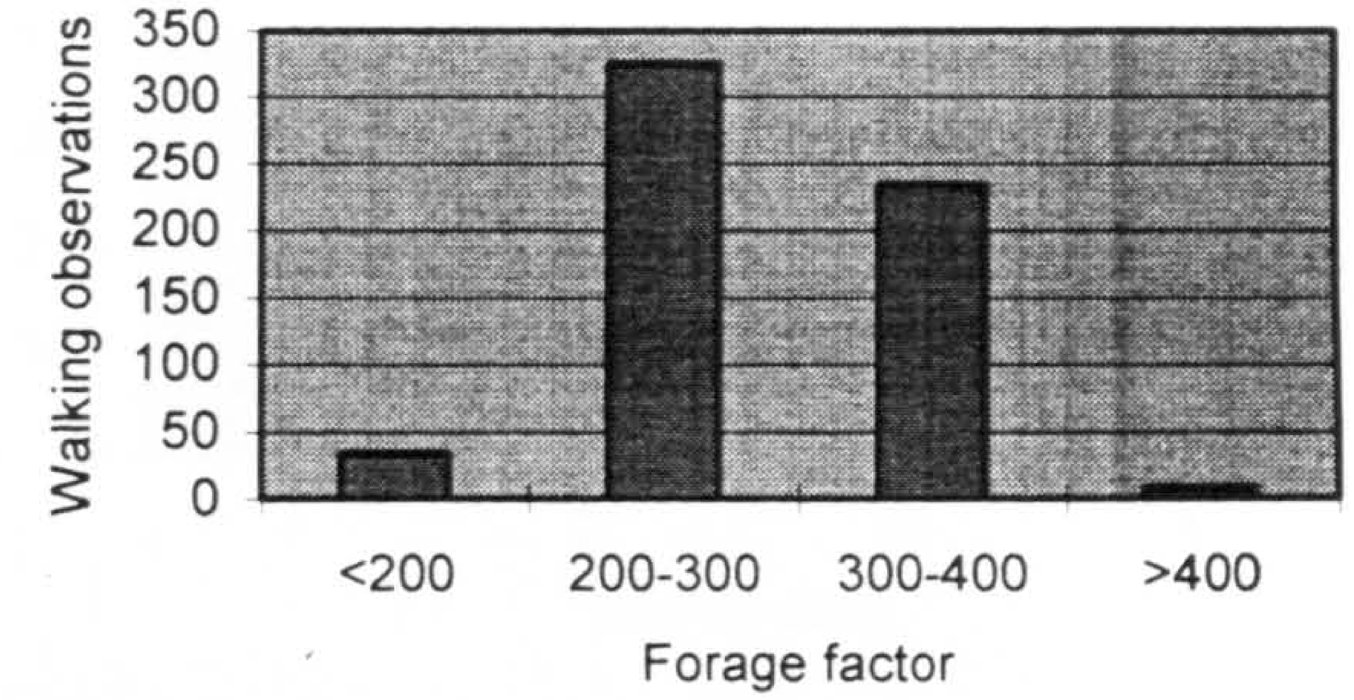
Fig. 15 Analysis of Grass Density Classes



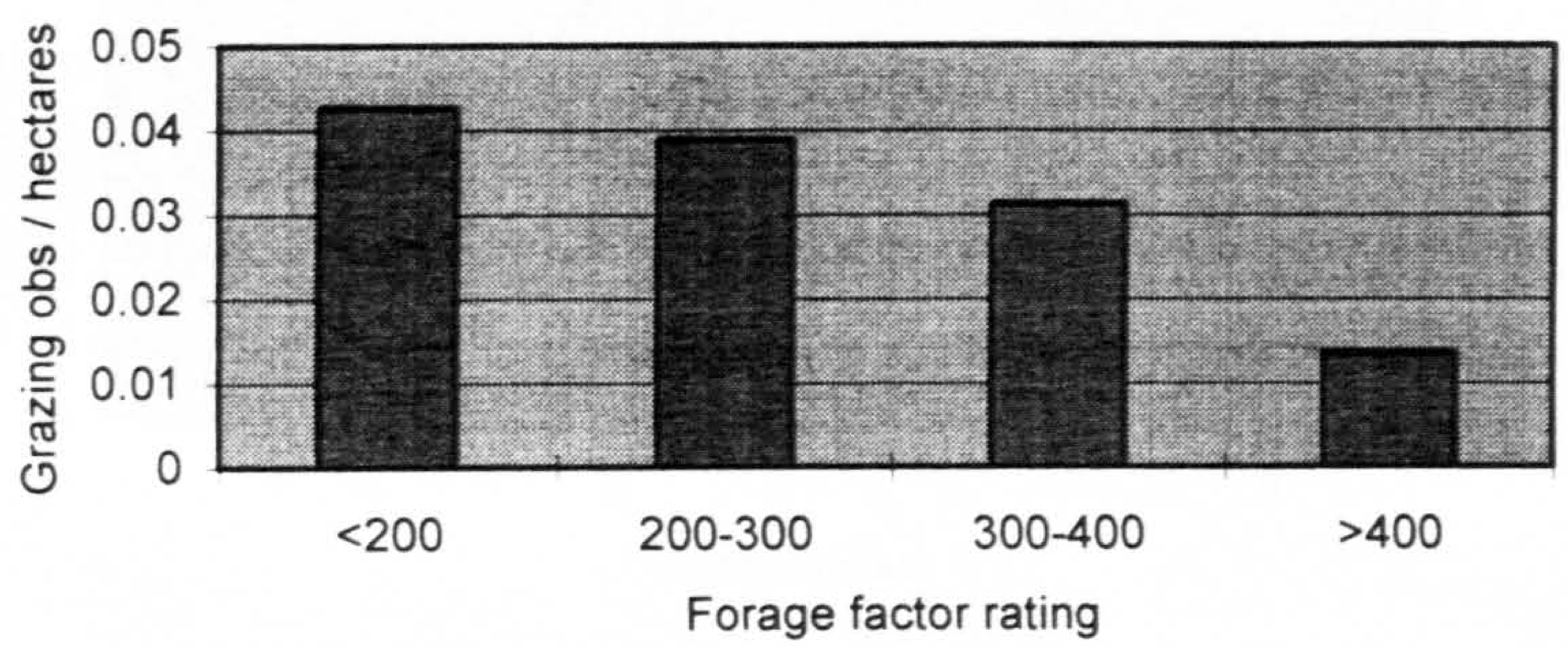
(a) Area Covered by Each Class



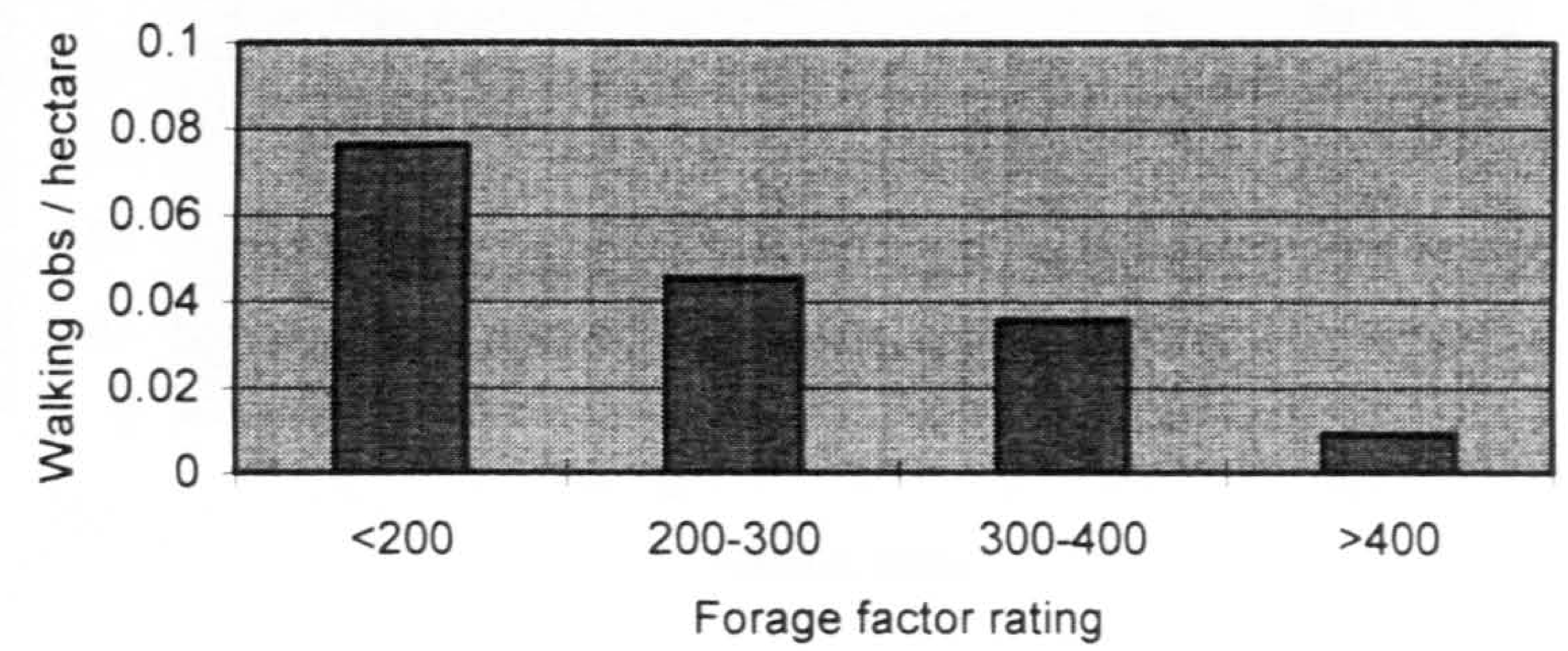
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

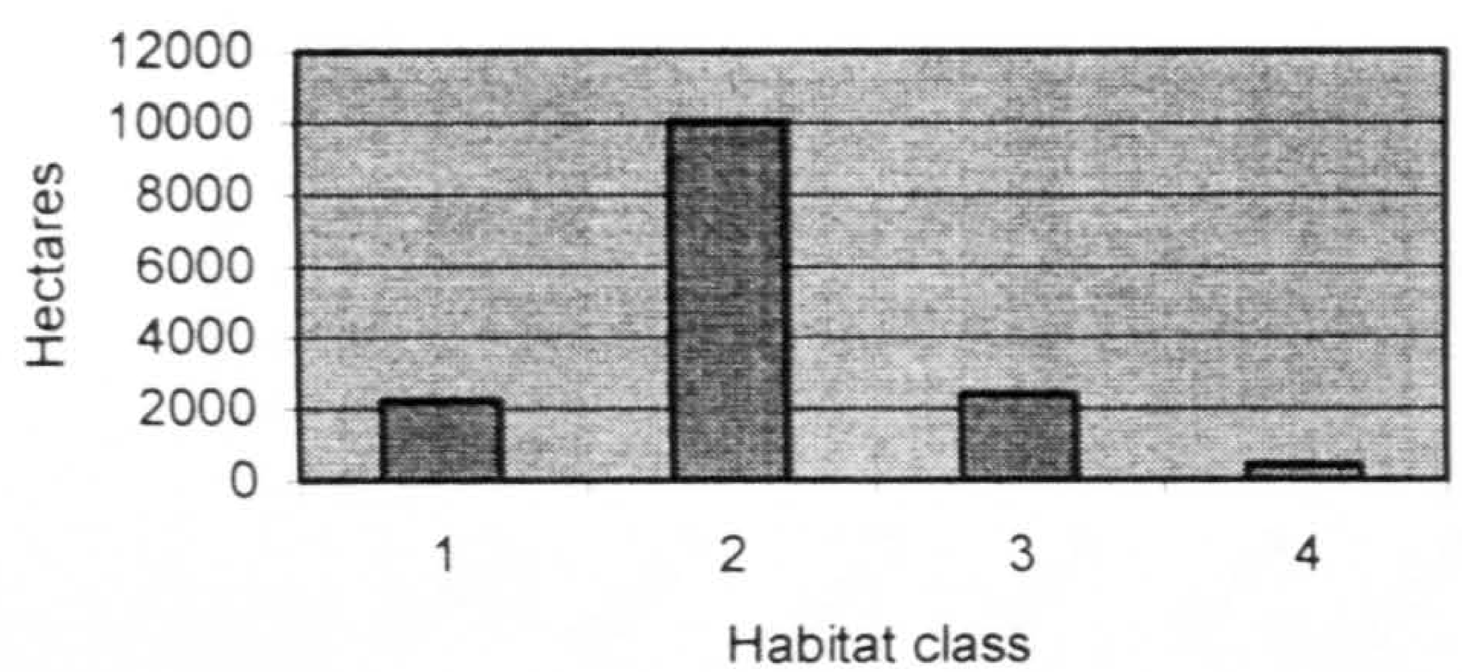


(d) Grazing Observations per Hectare in Each Class

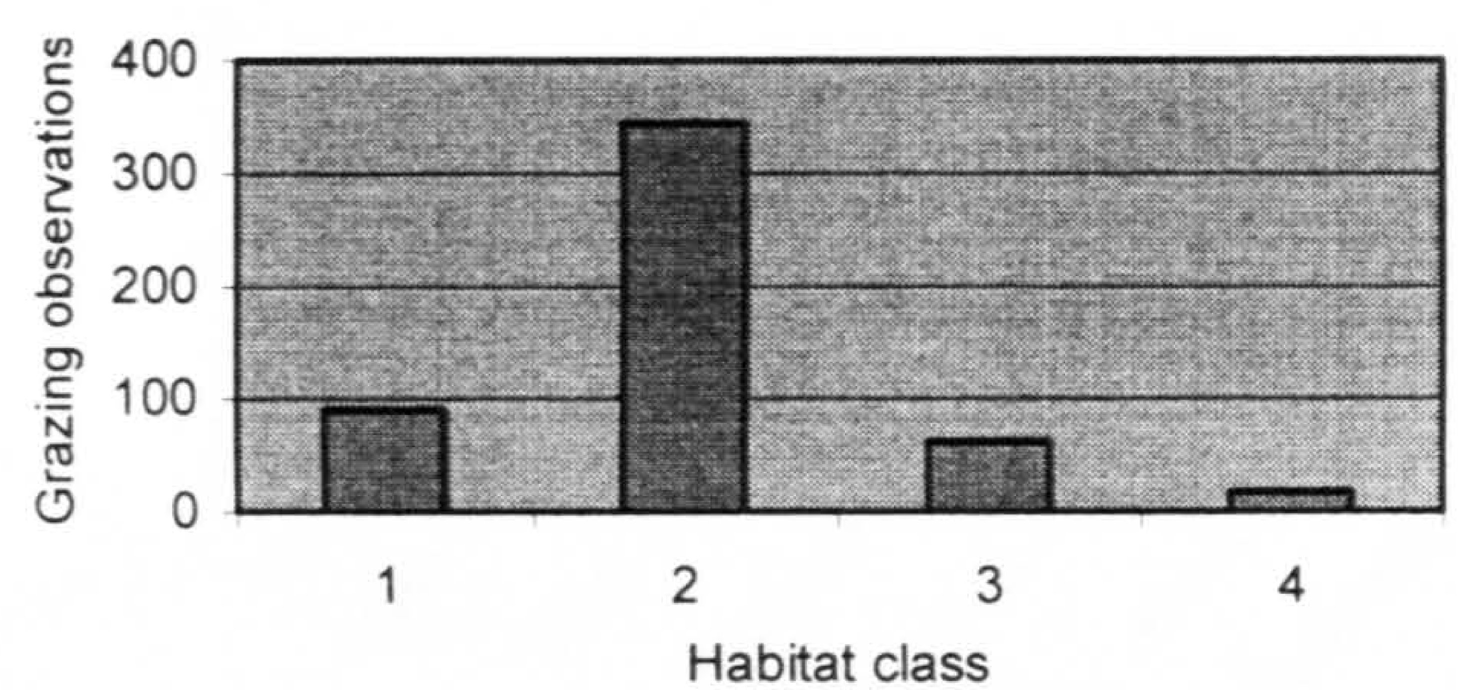


(e) Walking Observations per Hectare in Each Class

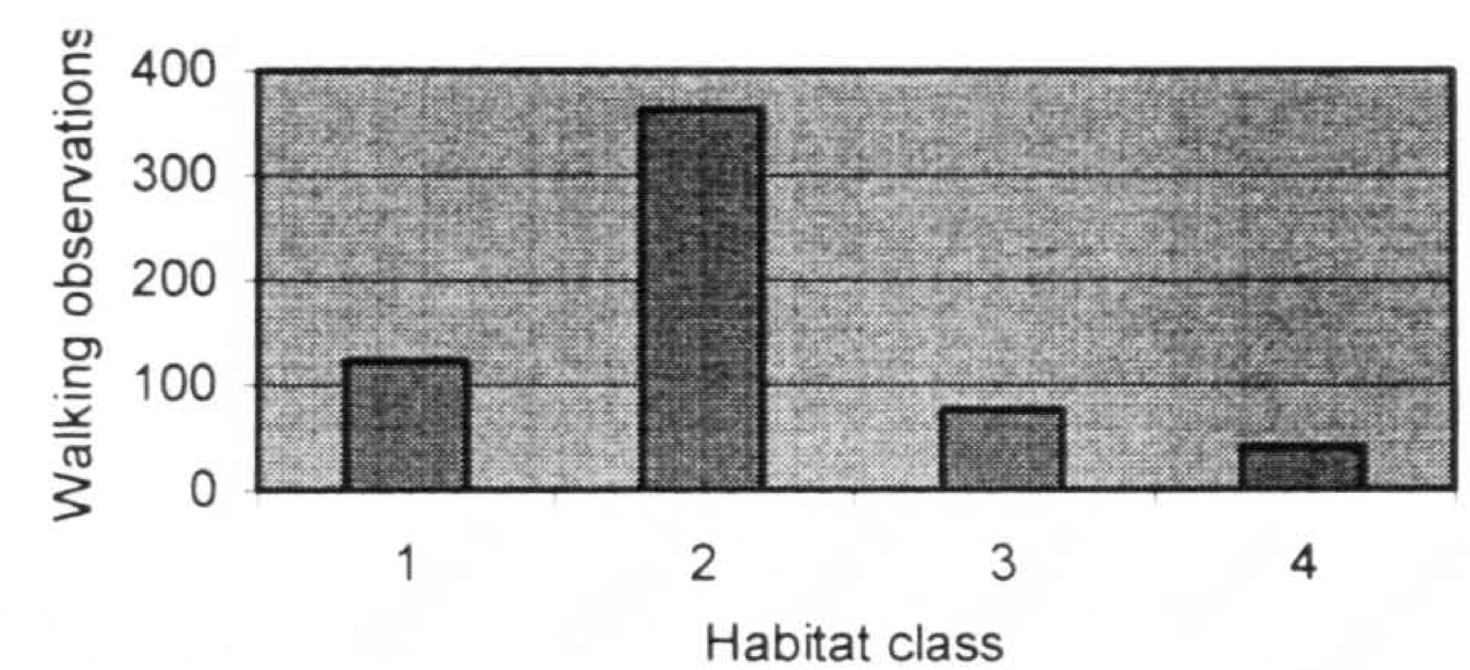
Fig. 16 Analysis of Forage Factor Classes



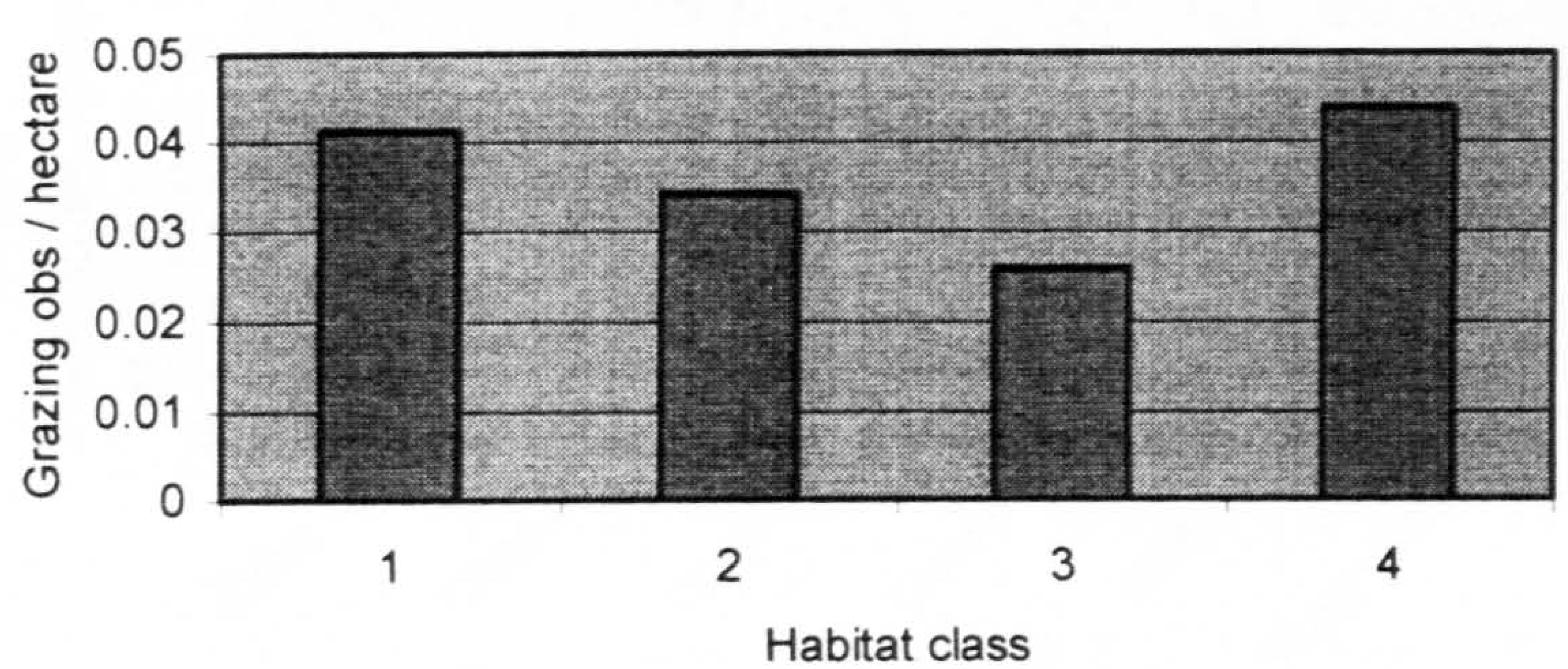
(a) Area Covered by Each Class



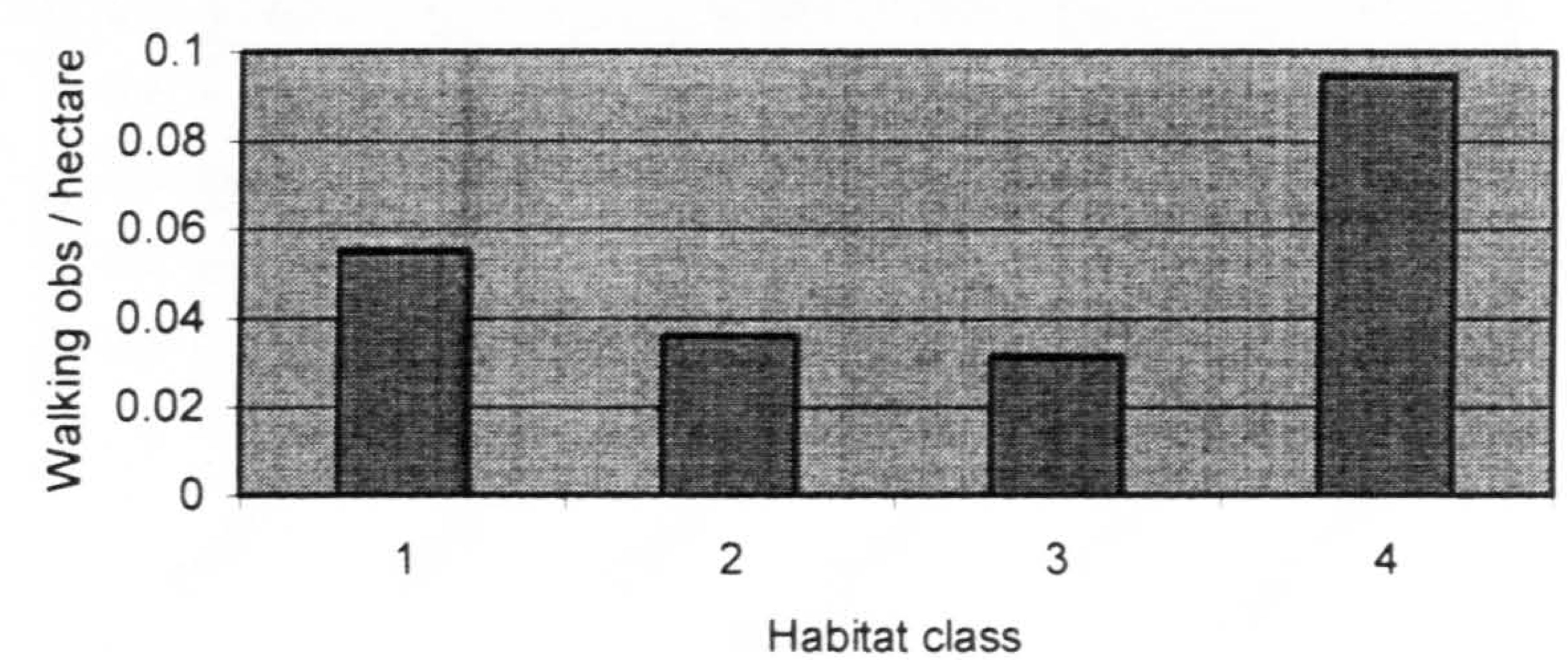
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

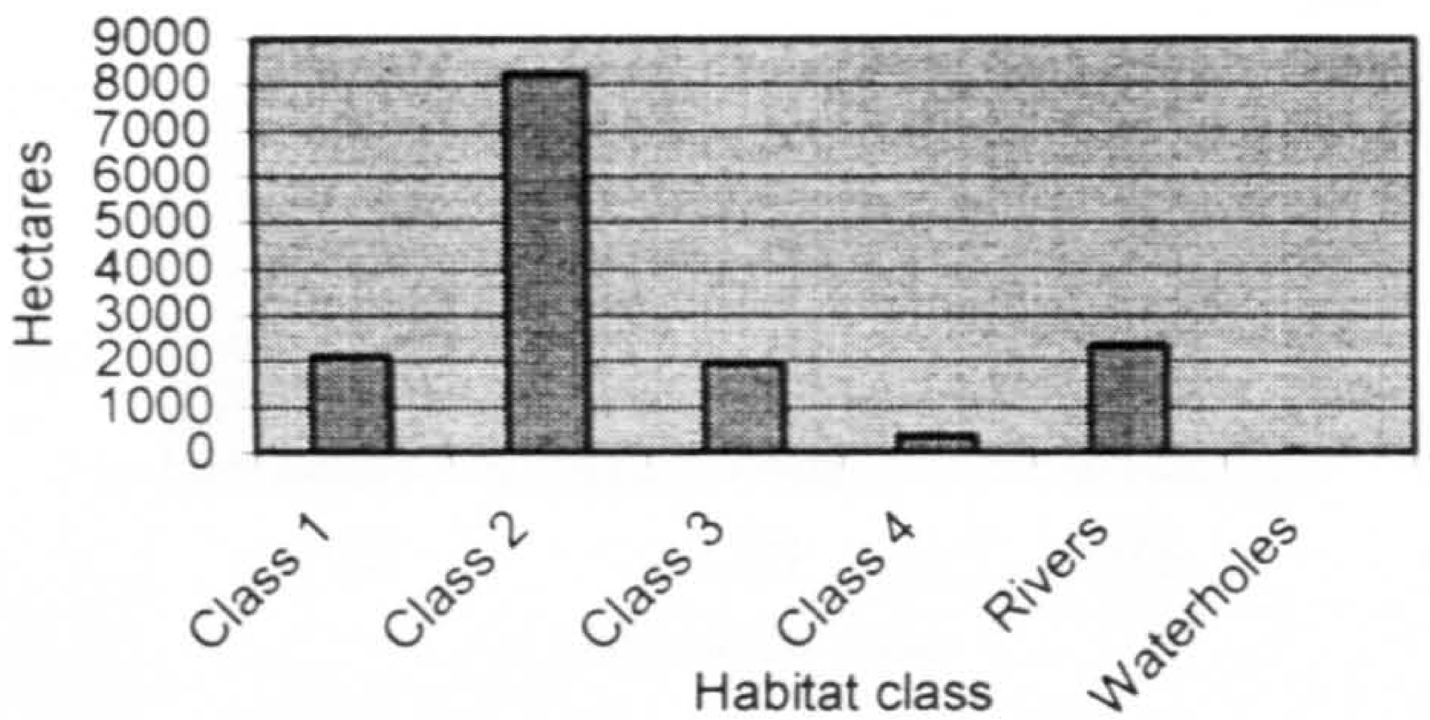


(d) Grazing Observations per Hectare in Each Class

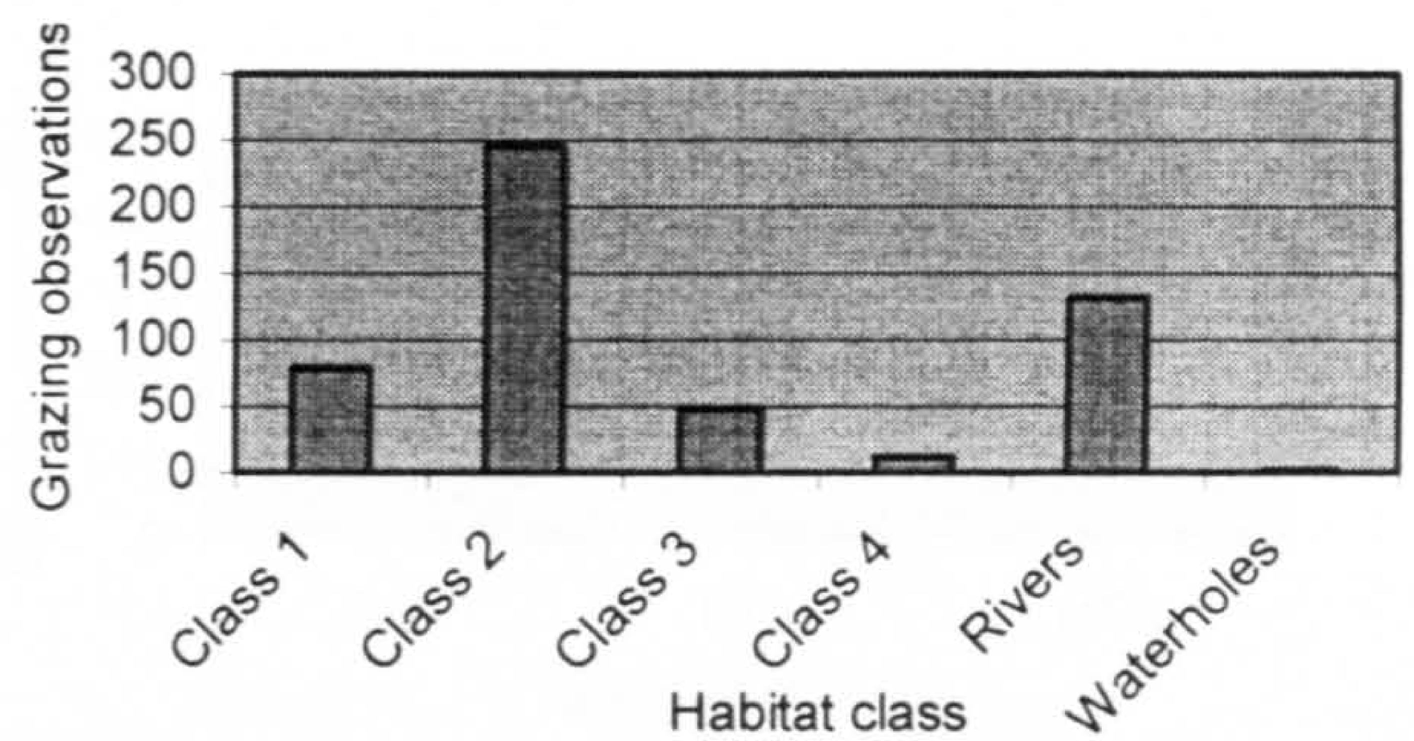


(e) Walking Observations per Hectare in Each Class

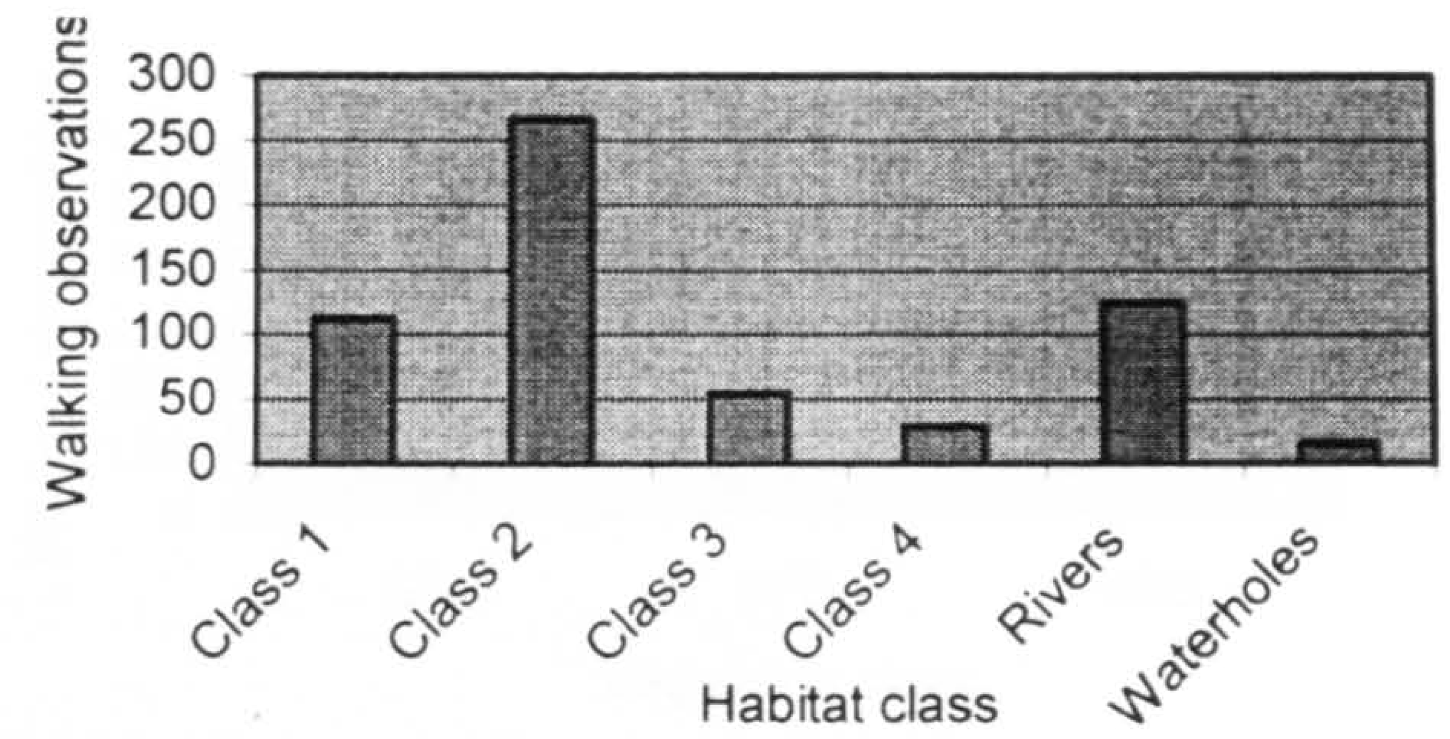
Fig. 17 Analysis of Utilisation of Four-Class Habitat Classification



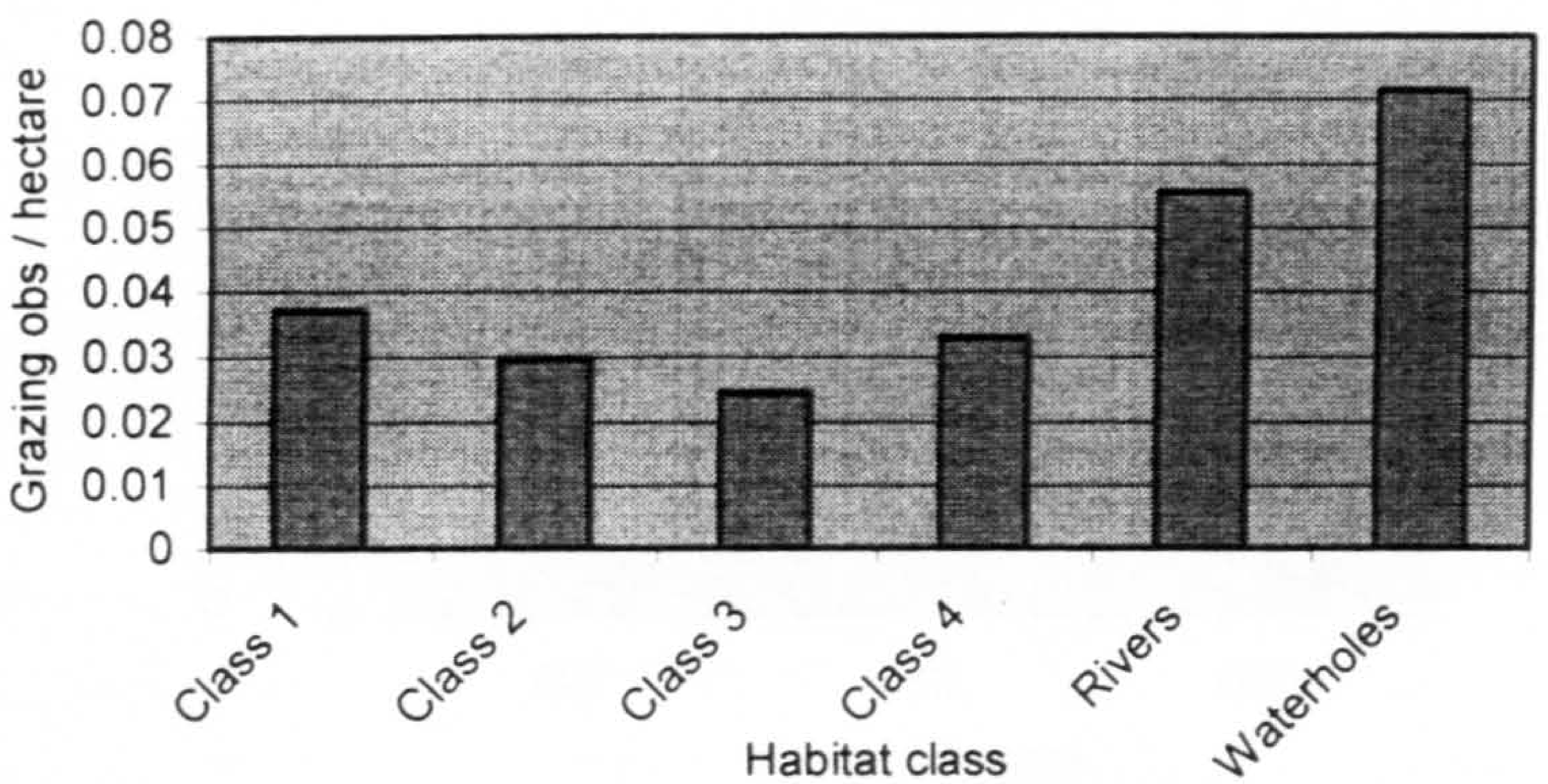
(a) Area Covered by Each Class



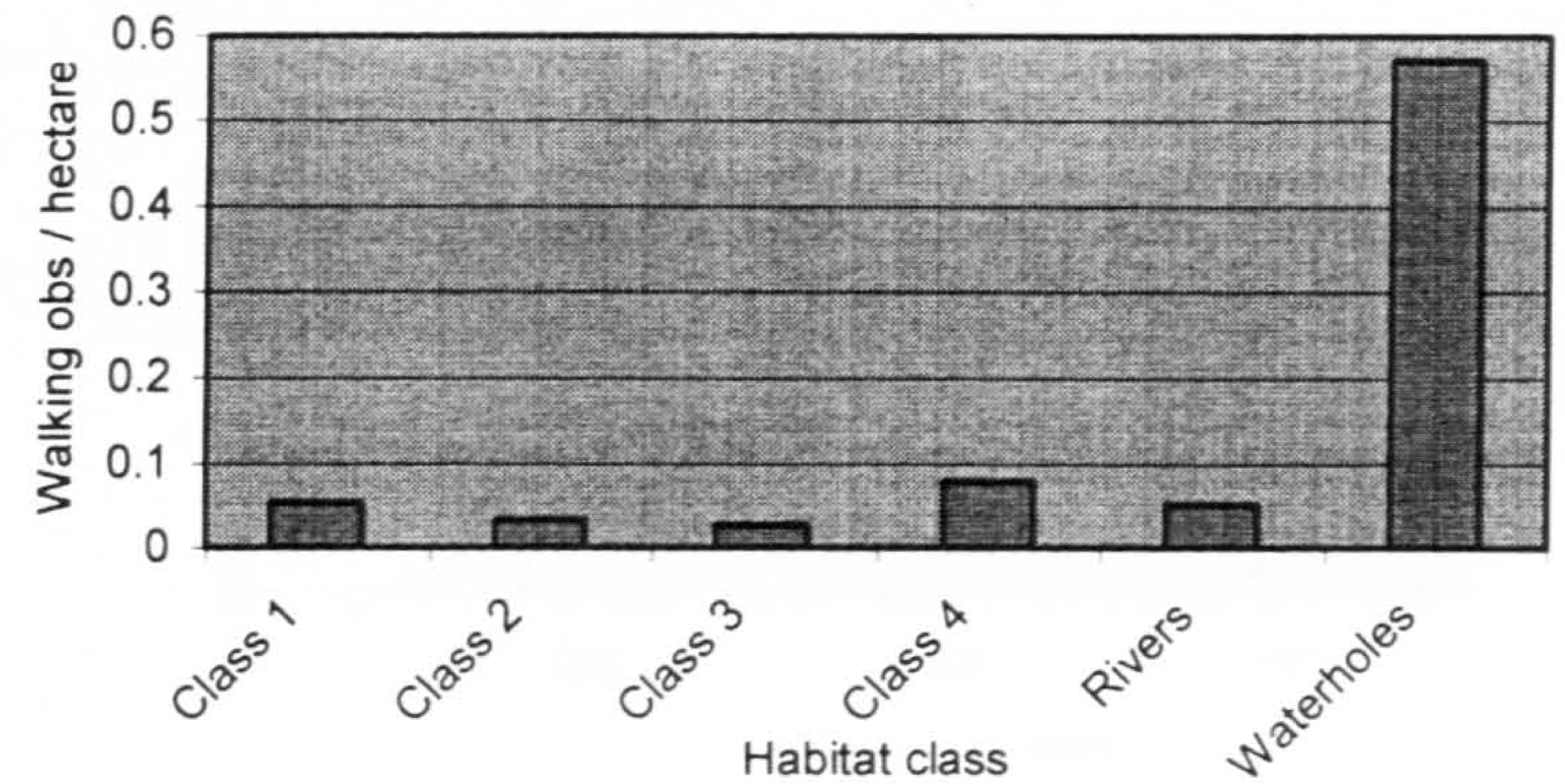
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

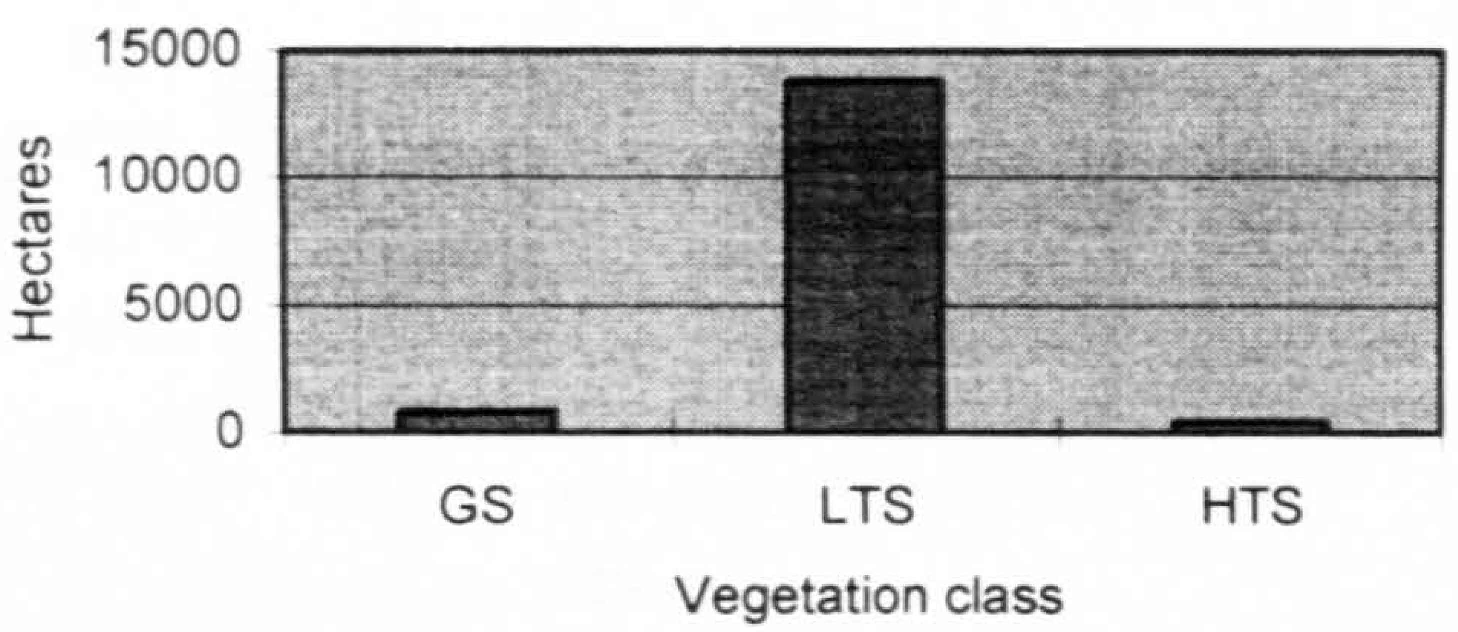


(d) Grazing Observations per Hectare in Each Class

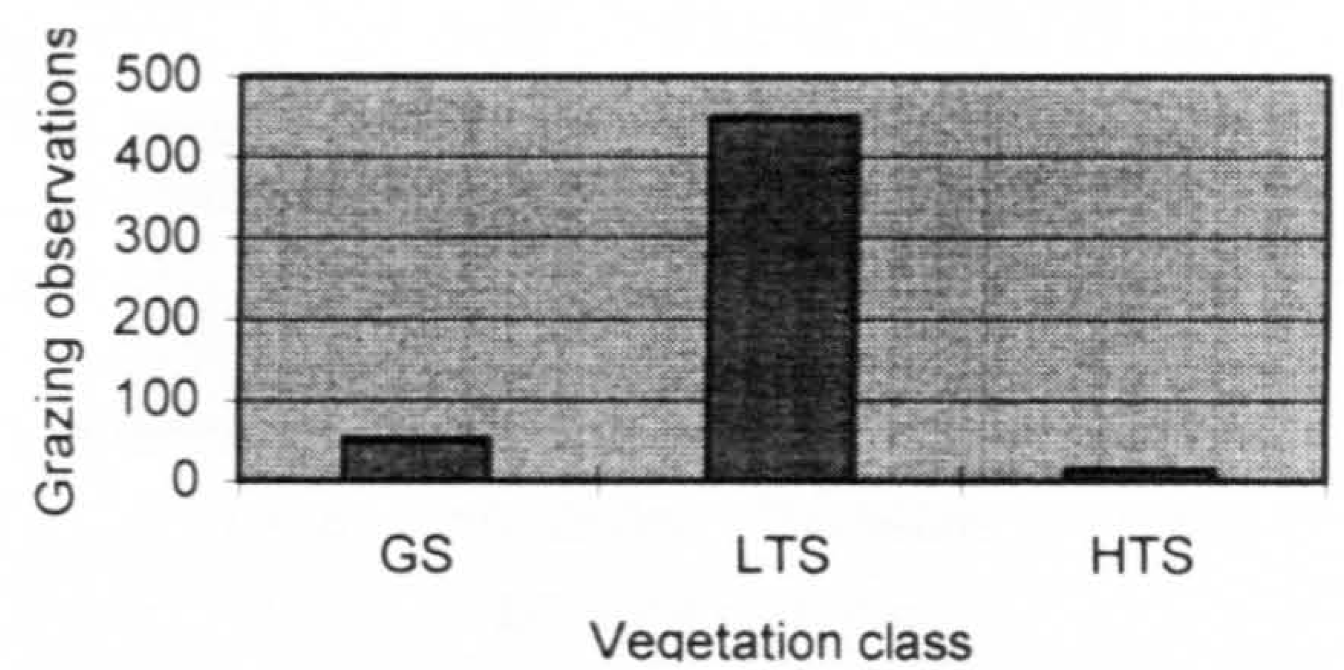


(e) Walking Observations per Hectare in Each Class

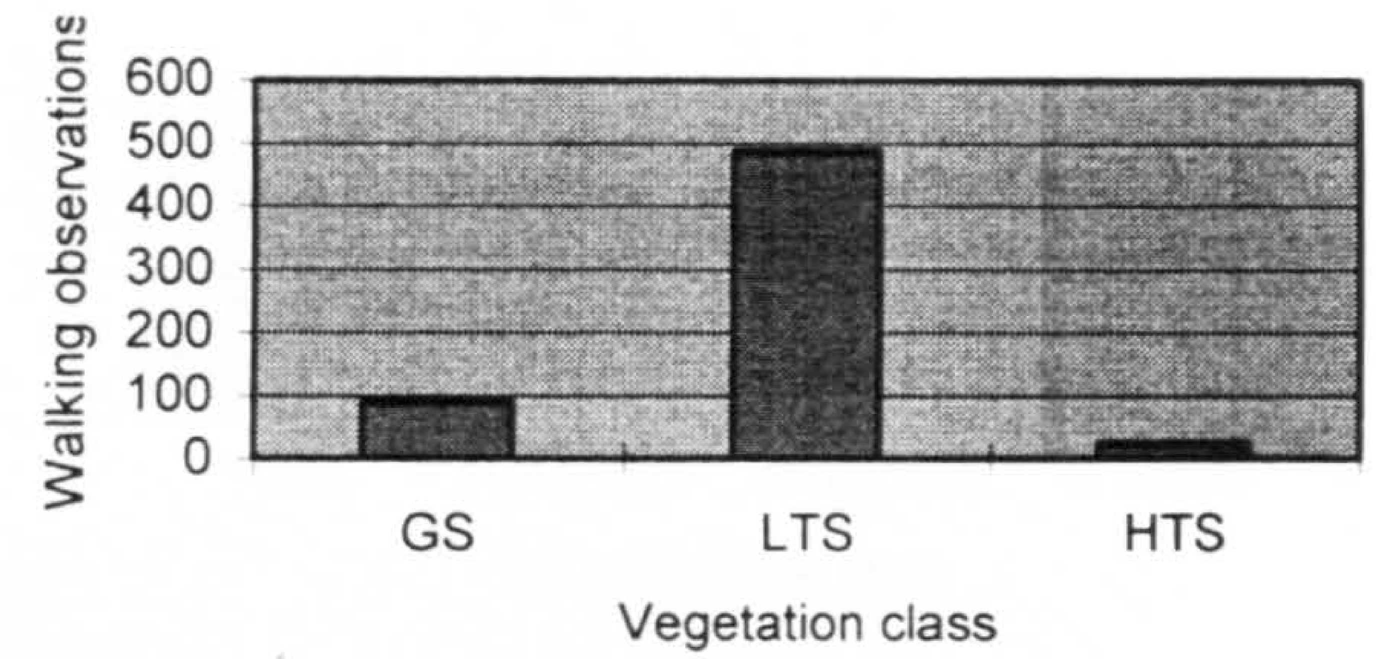
Fig. 18 Analysis of Utilisation of Detailed Four-Class Habitat Classification



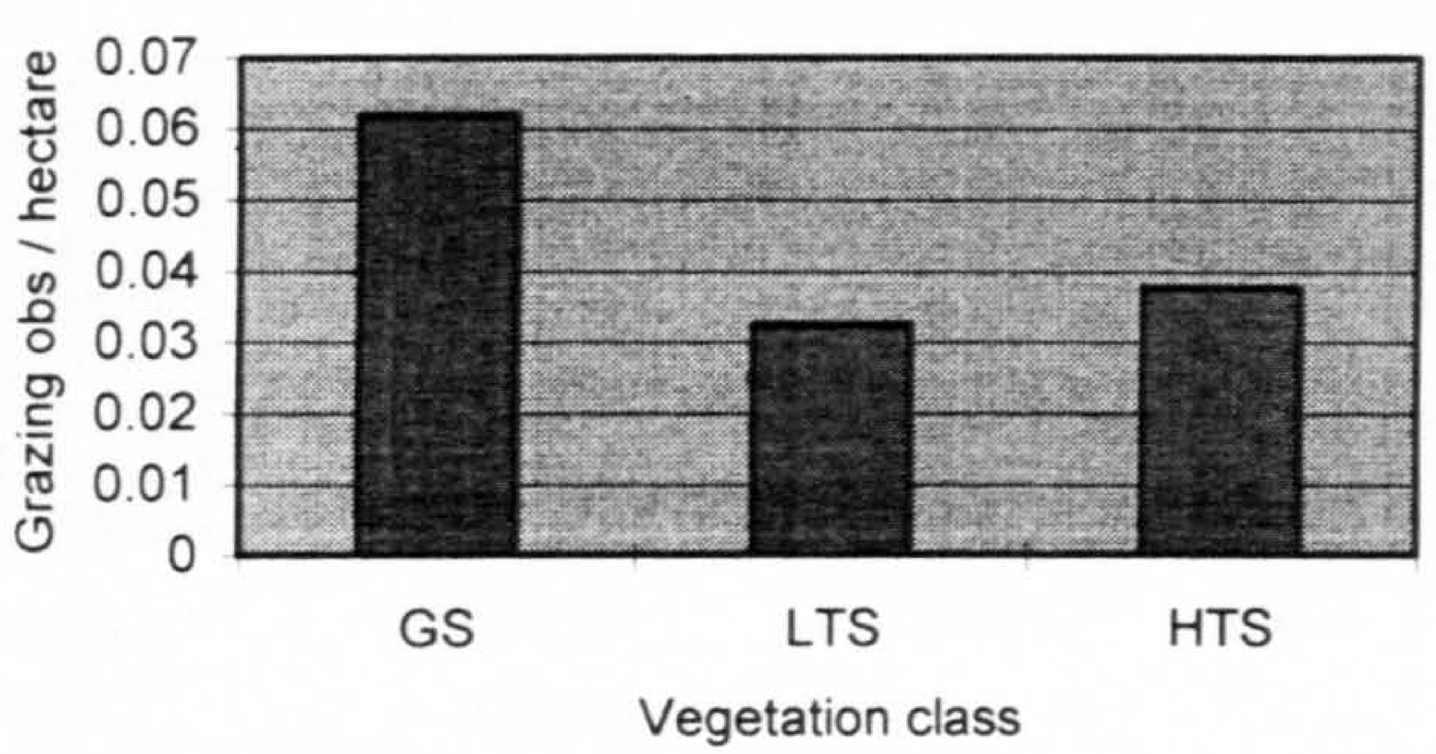
(a) Area Covered by Each Class



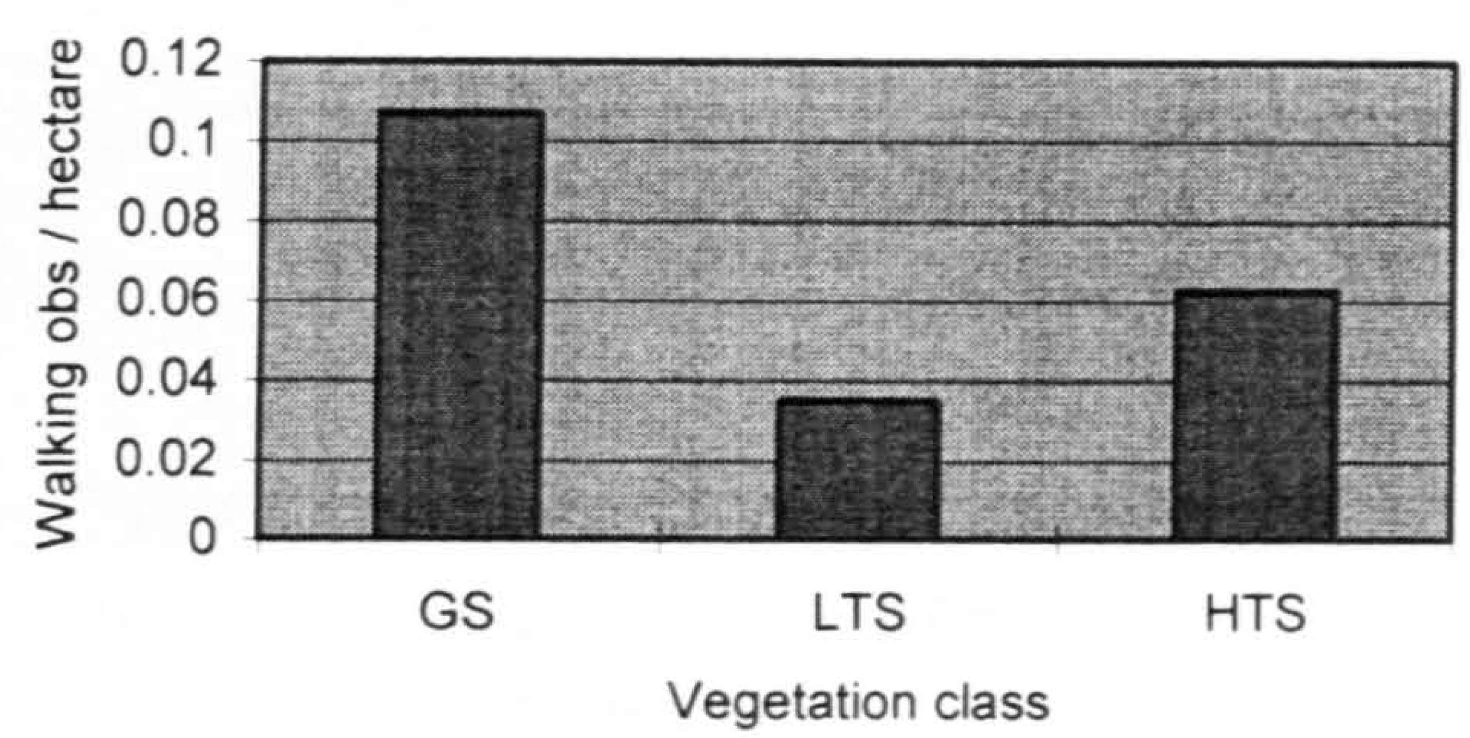
b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

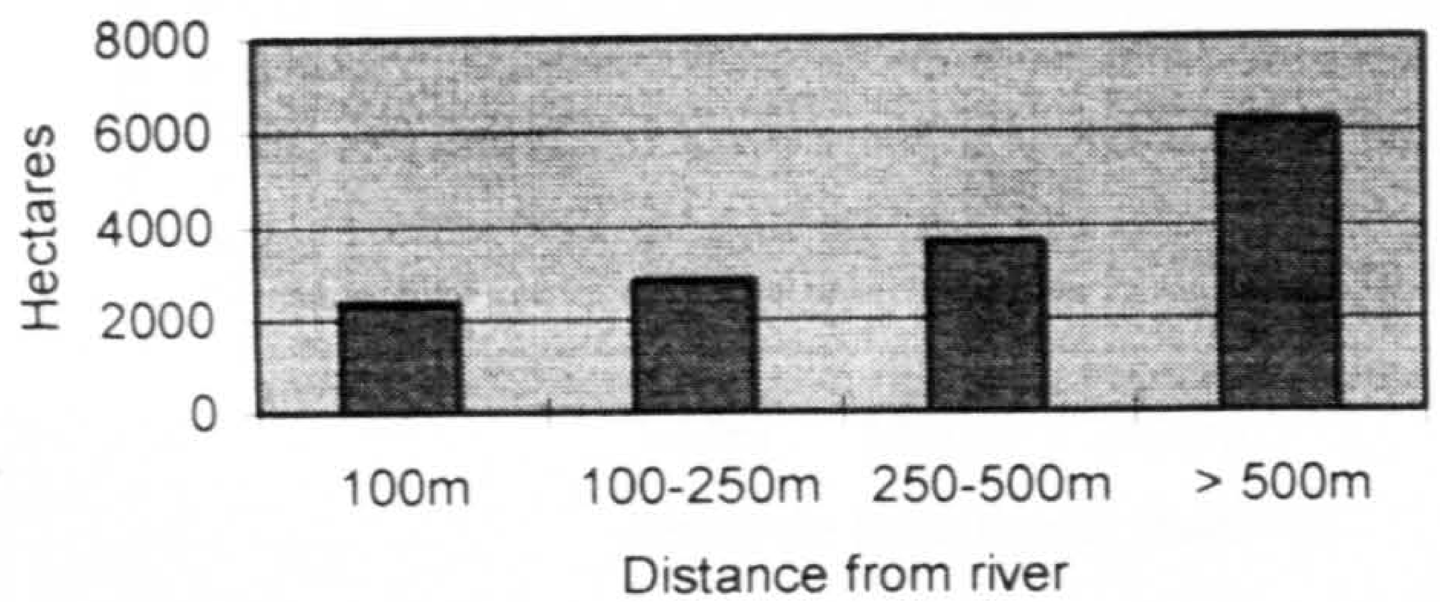


(d) Grazing Observations per Hectare in Each Class

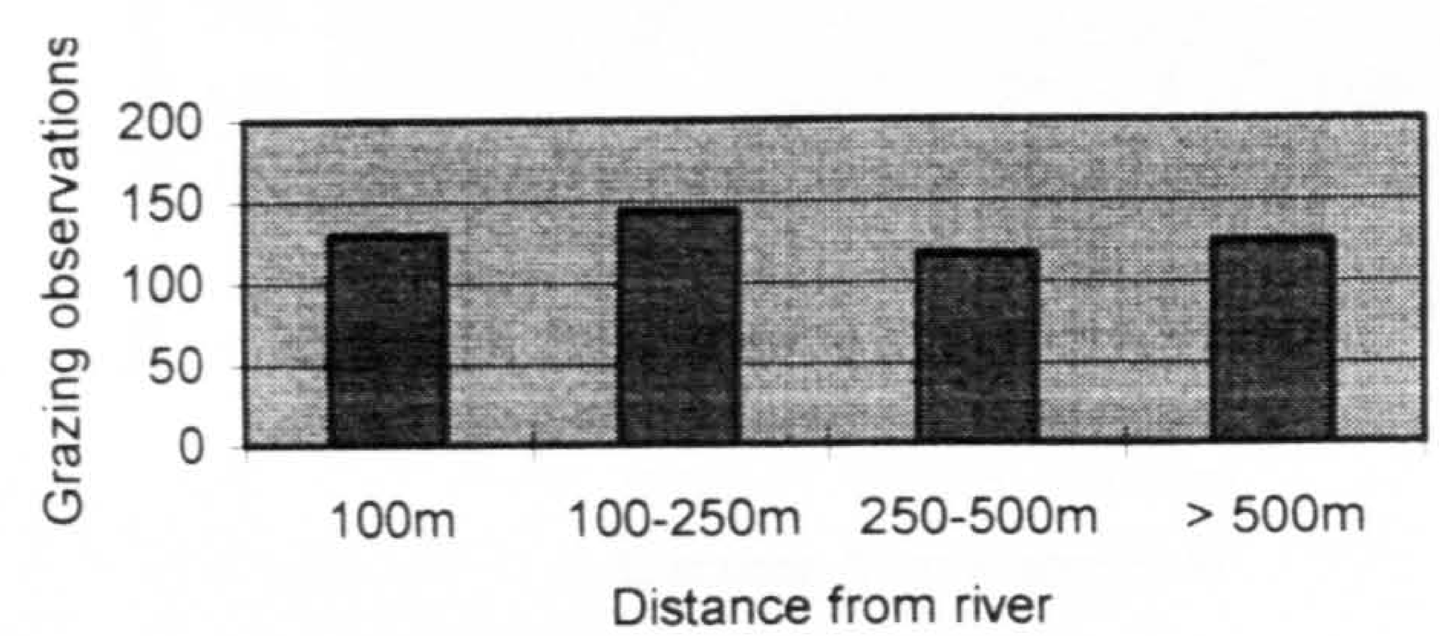


(e) Walking Observations per Hectare in Each Class

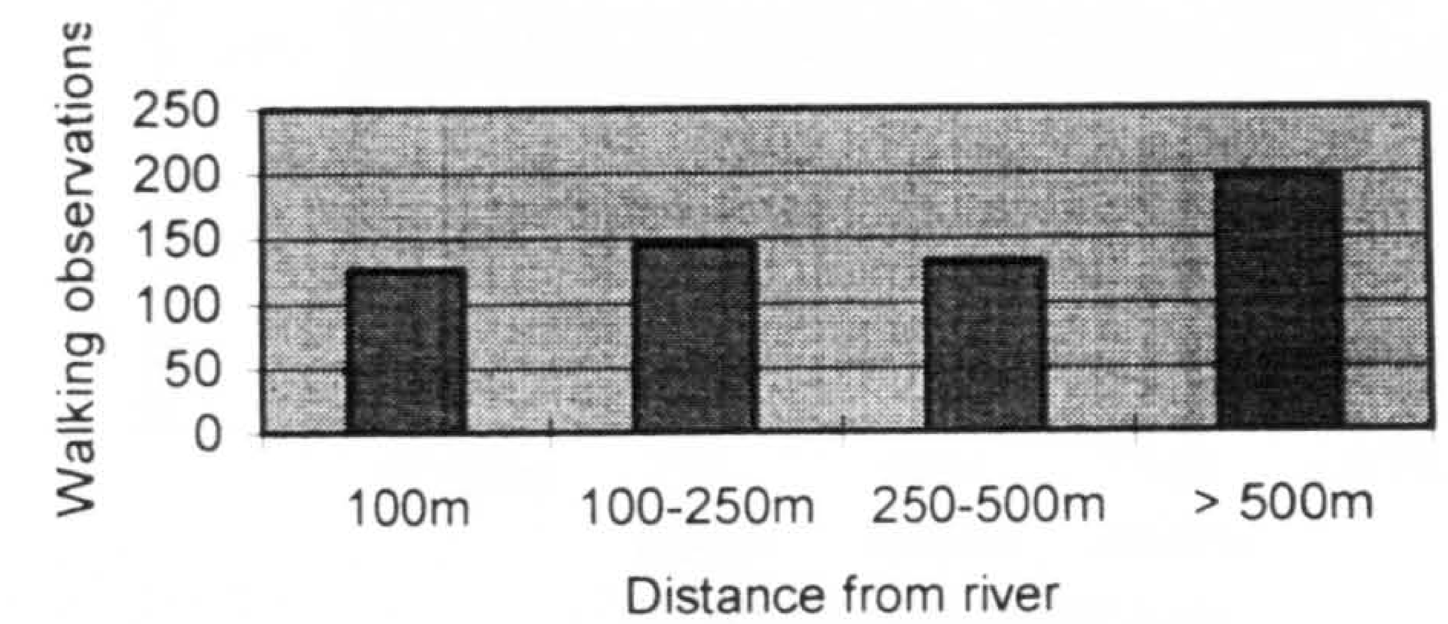
Fig. 19 Analysis of Utilisation of Vegetation Type Classes



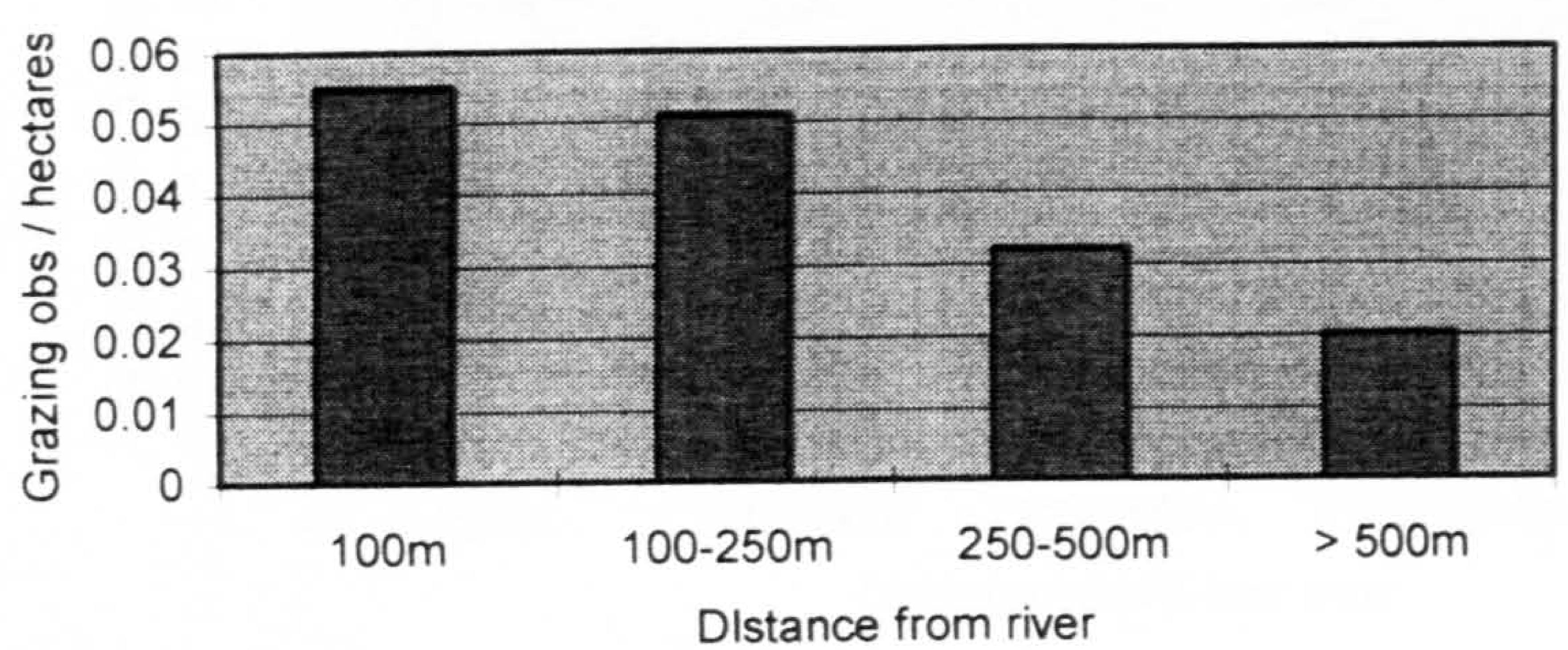
(a) Area Covered by Each Class



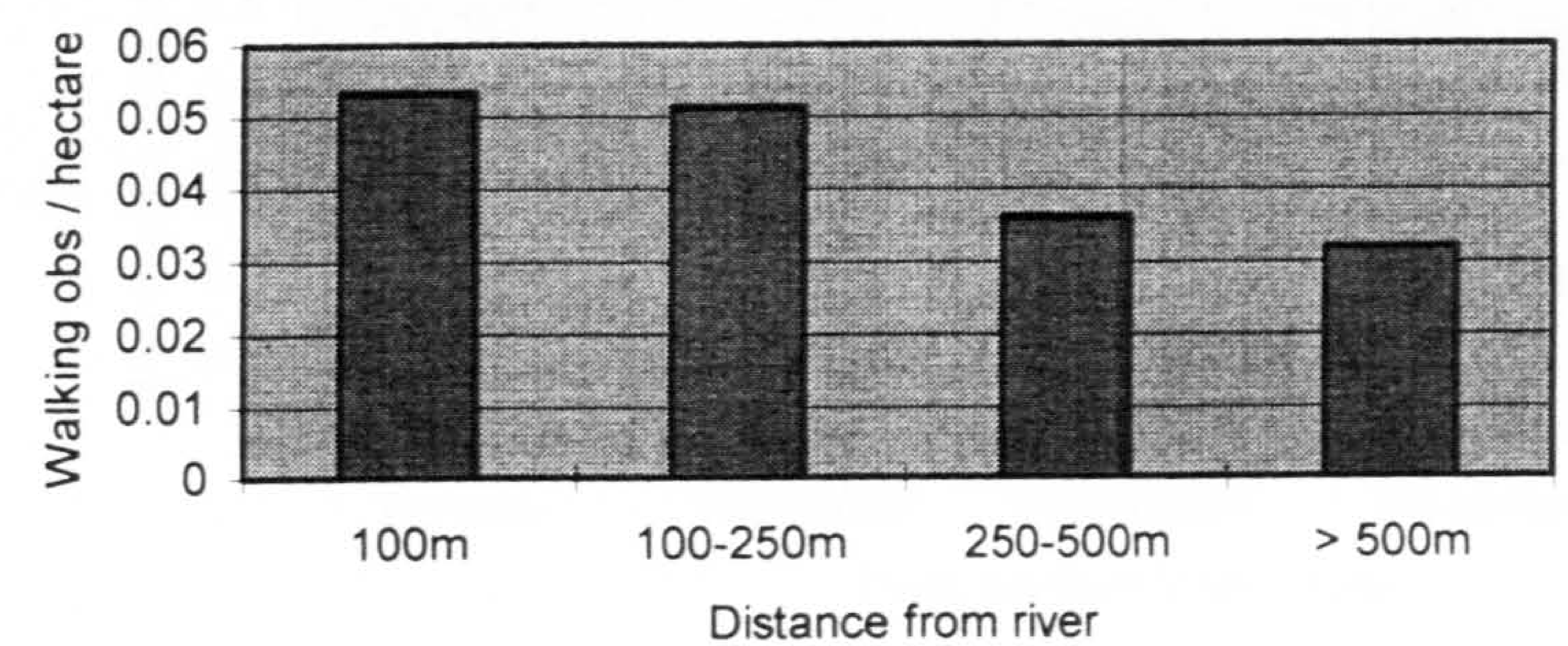
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

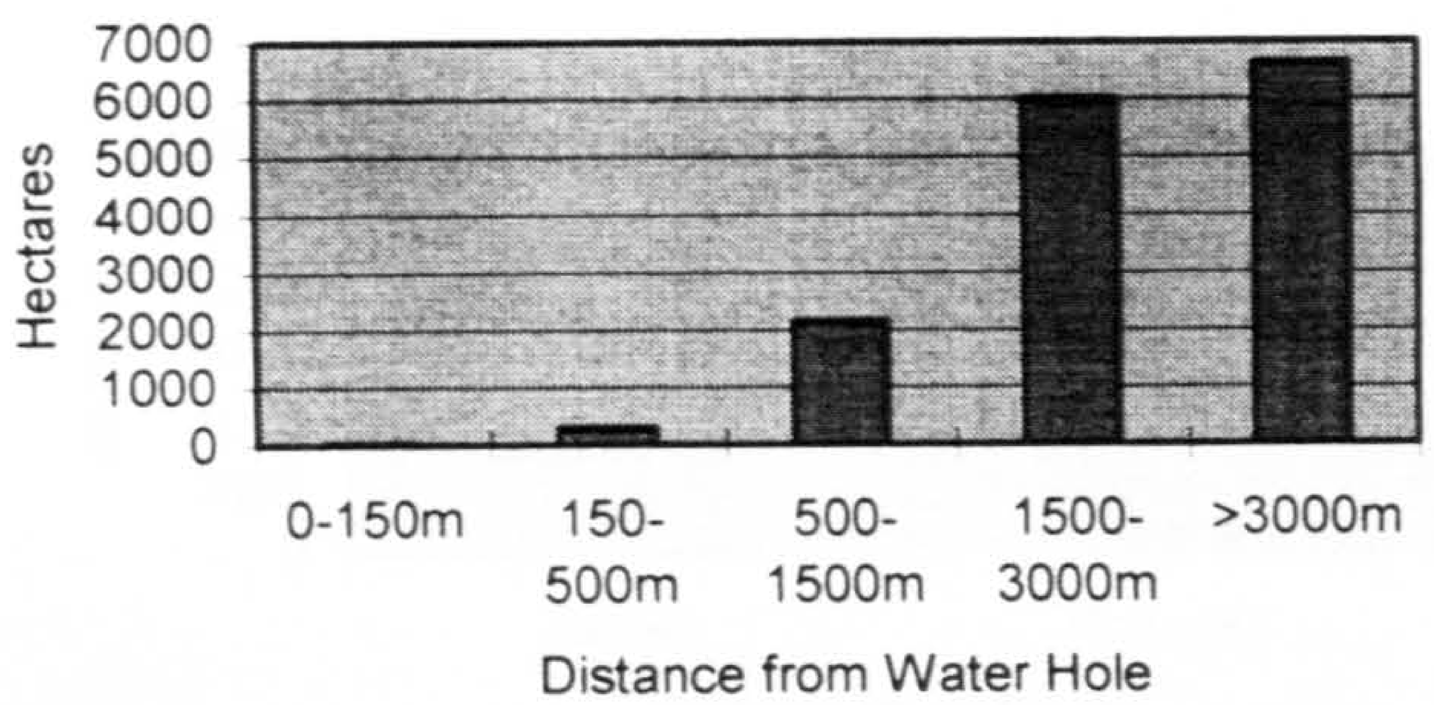


(d) Grazing Observations per Hectare in Each Class

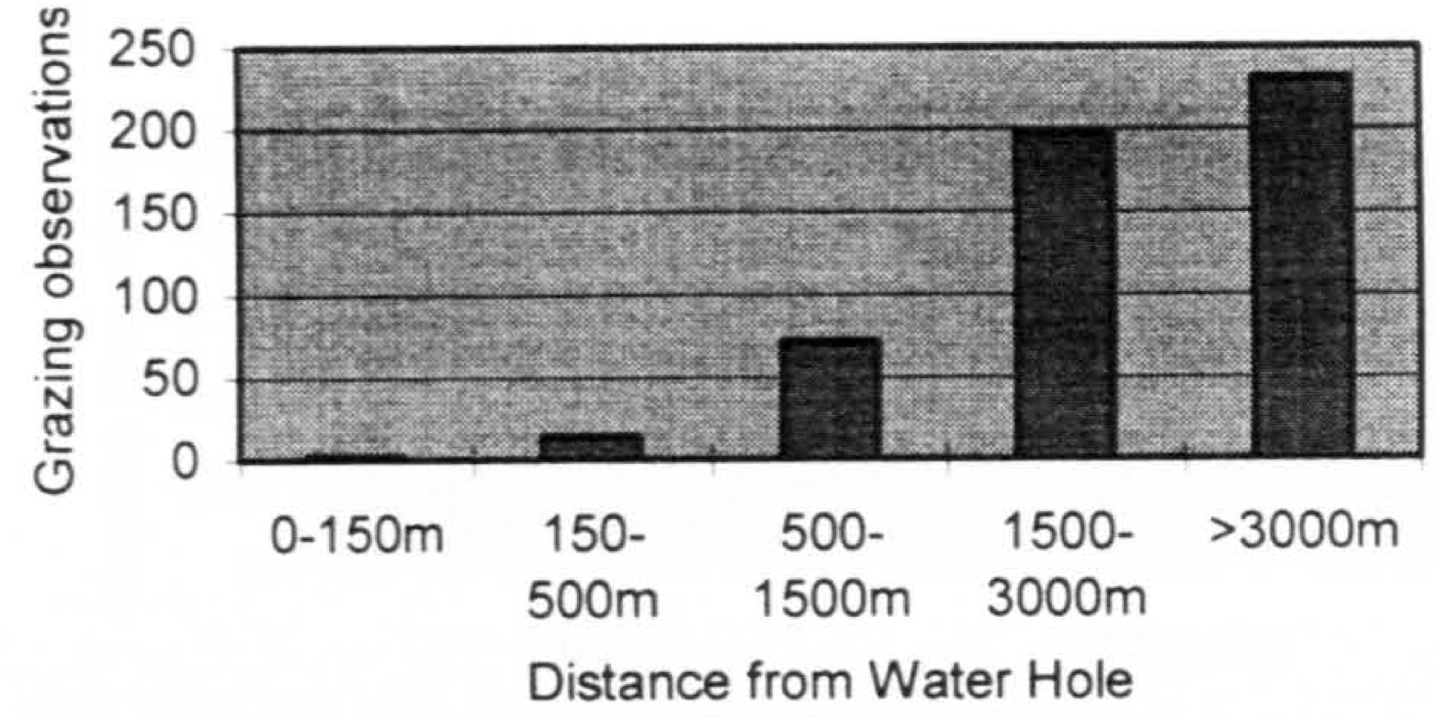


(e) Walking Observations per Hectare in Each Class

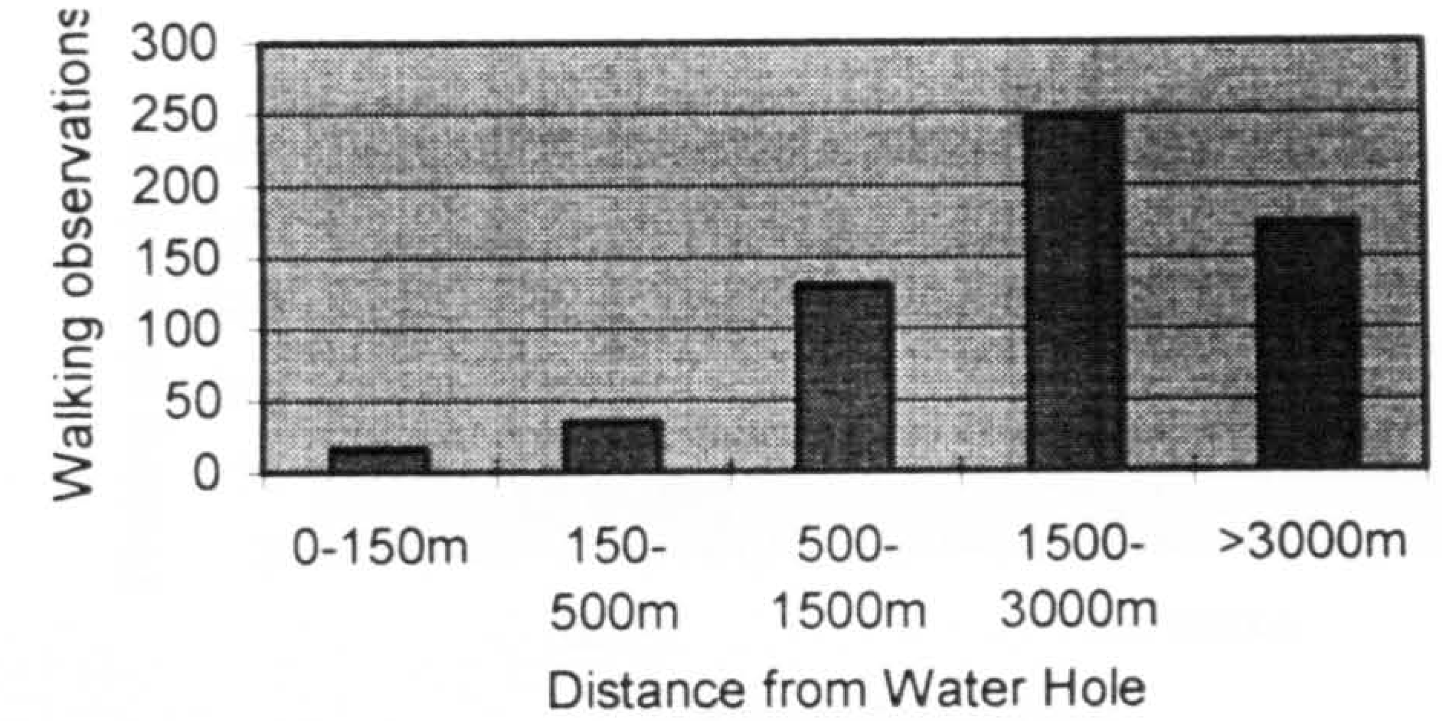
Fig. 20 Analysis of Utilisation of Distances from Rivers



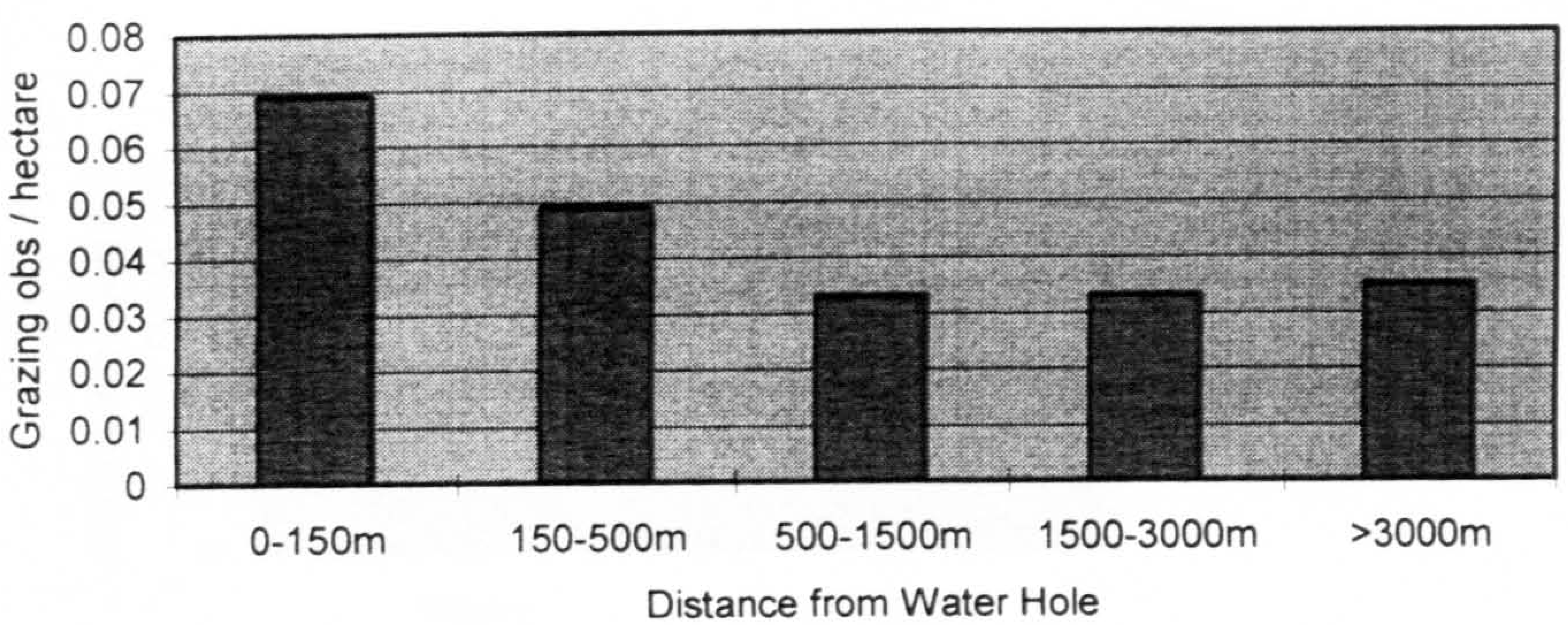
(a) Area Covered by Each Class



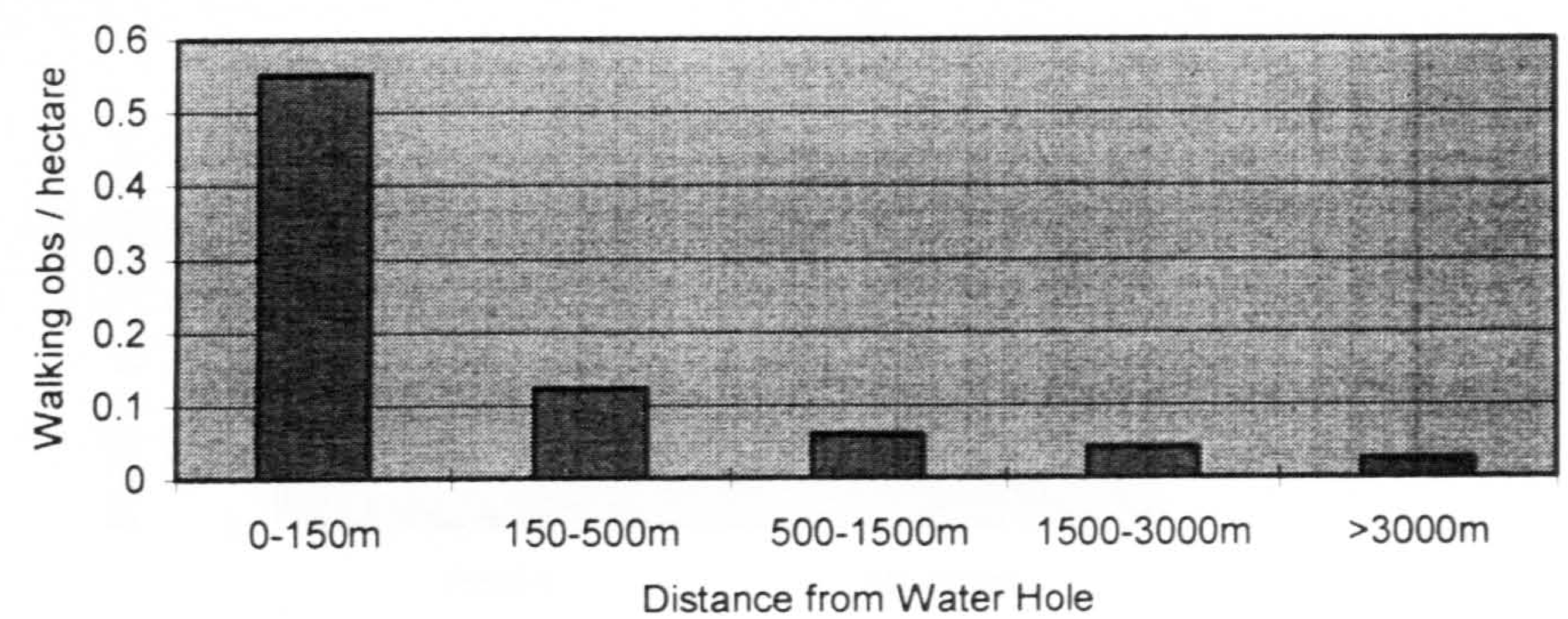
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

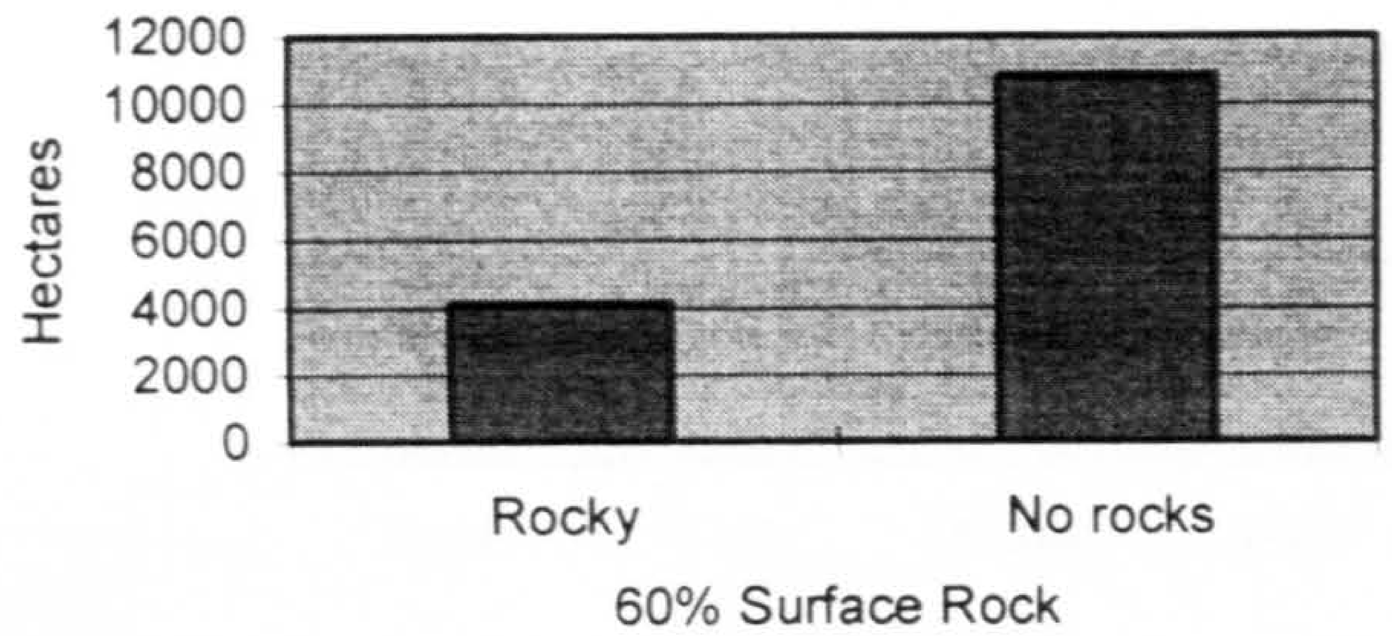


(d) Grazing Observations per Hectare in Each Class

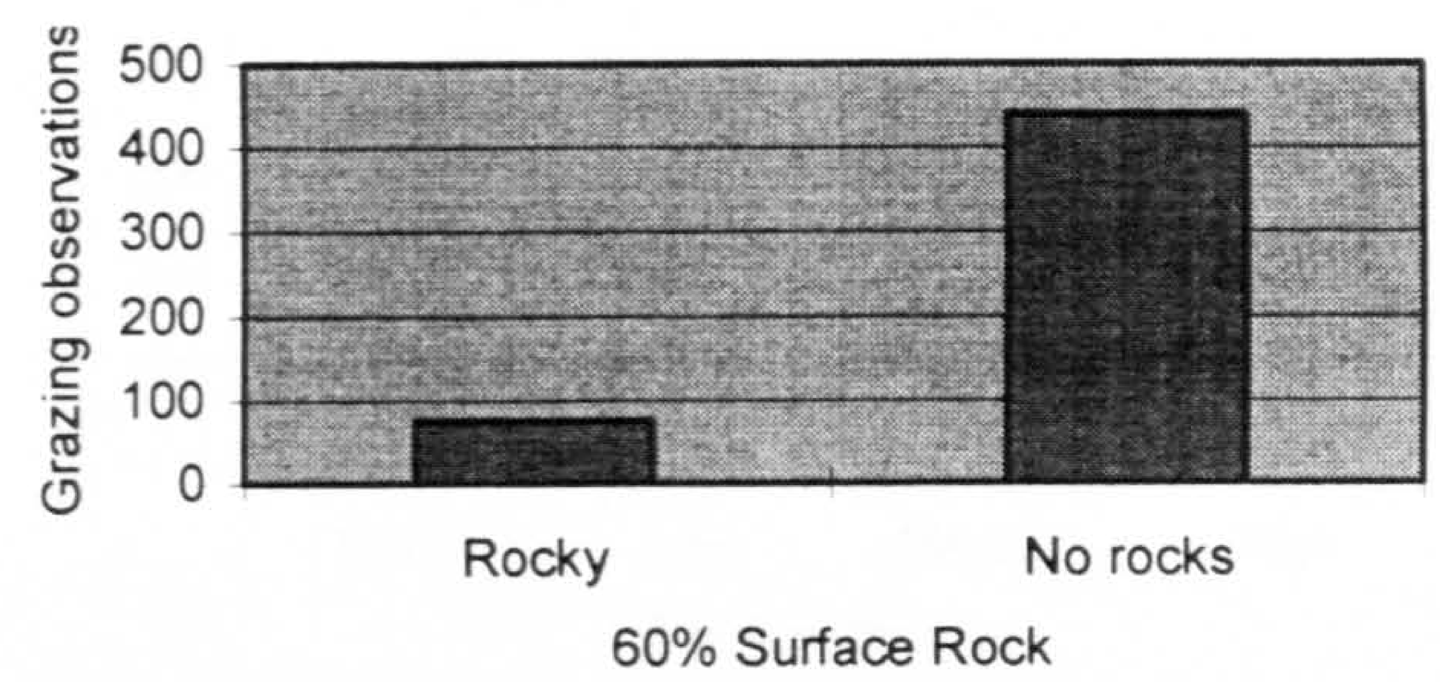


(e) Walking Observations per Hectare in Each Class

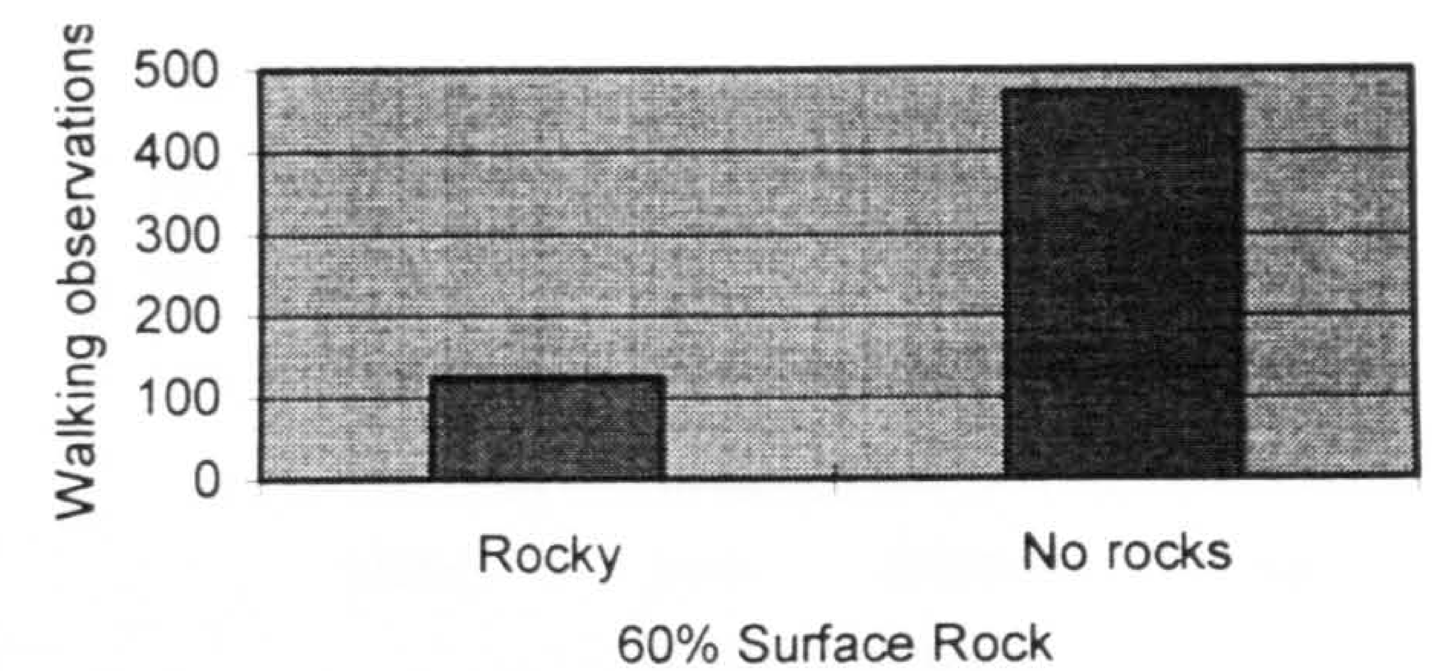
Fig. 21 Analysis of Utilisation of Distances from Water Holes



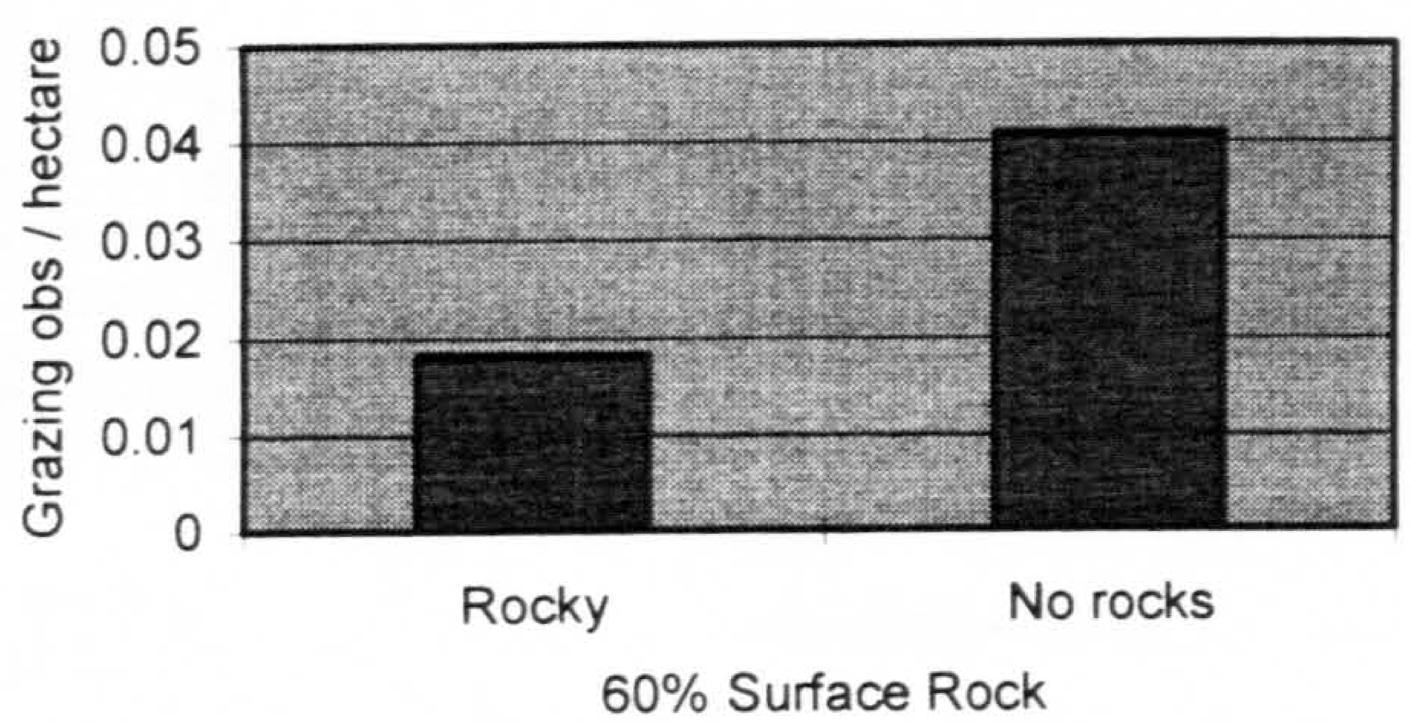
(a) Area Covered by Each Class



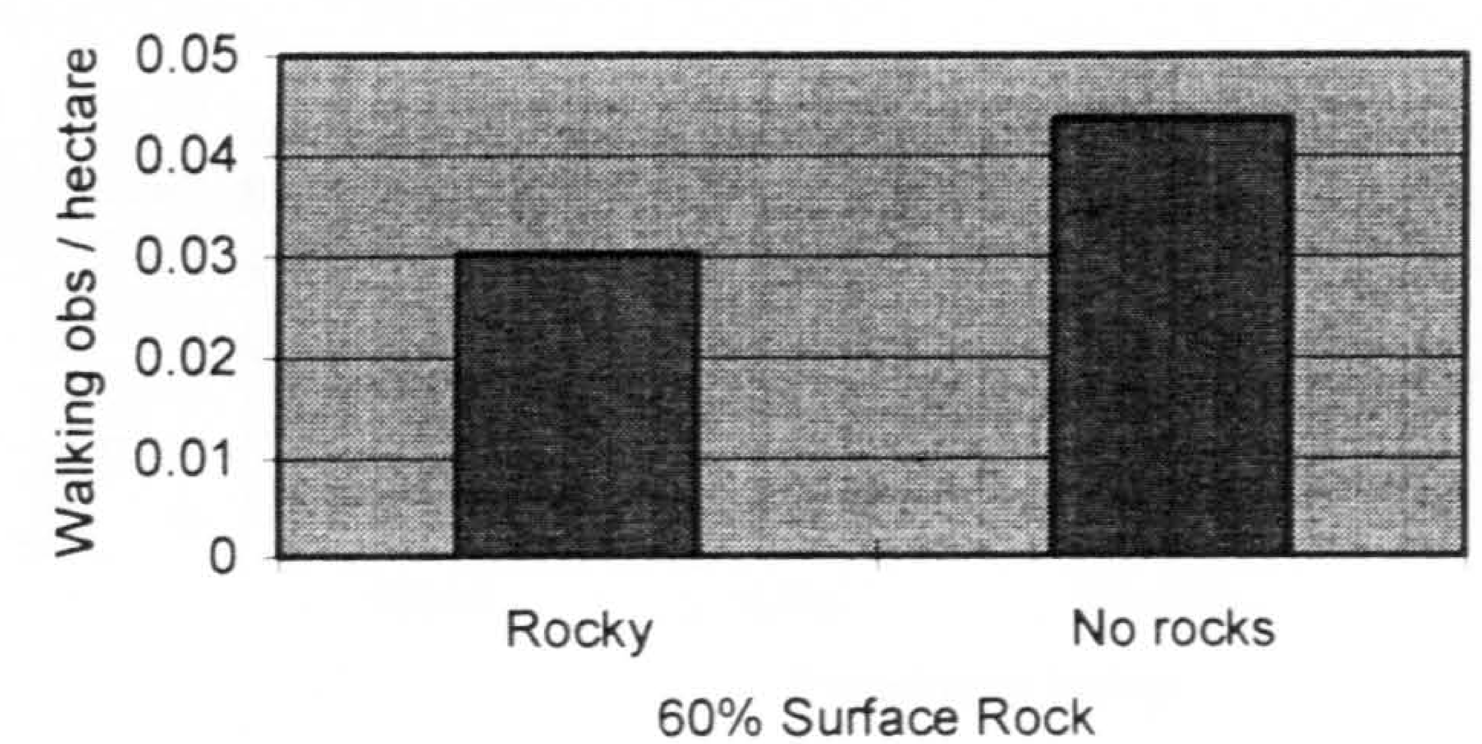
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

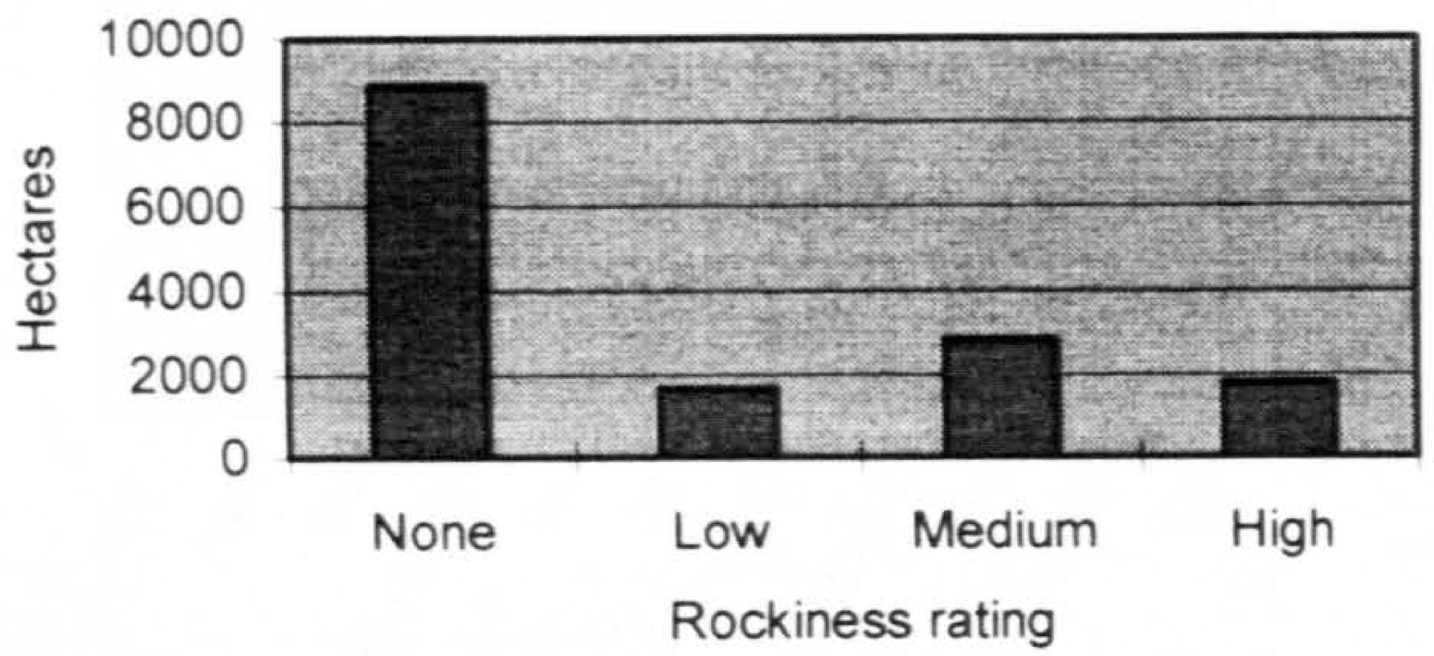


(d) Grazing Observations per Hectare in Each Class

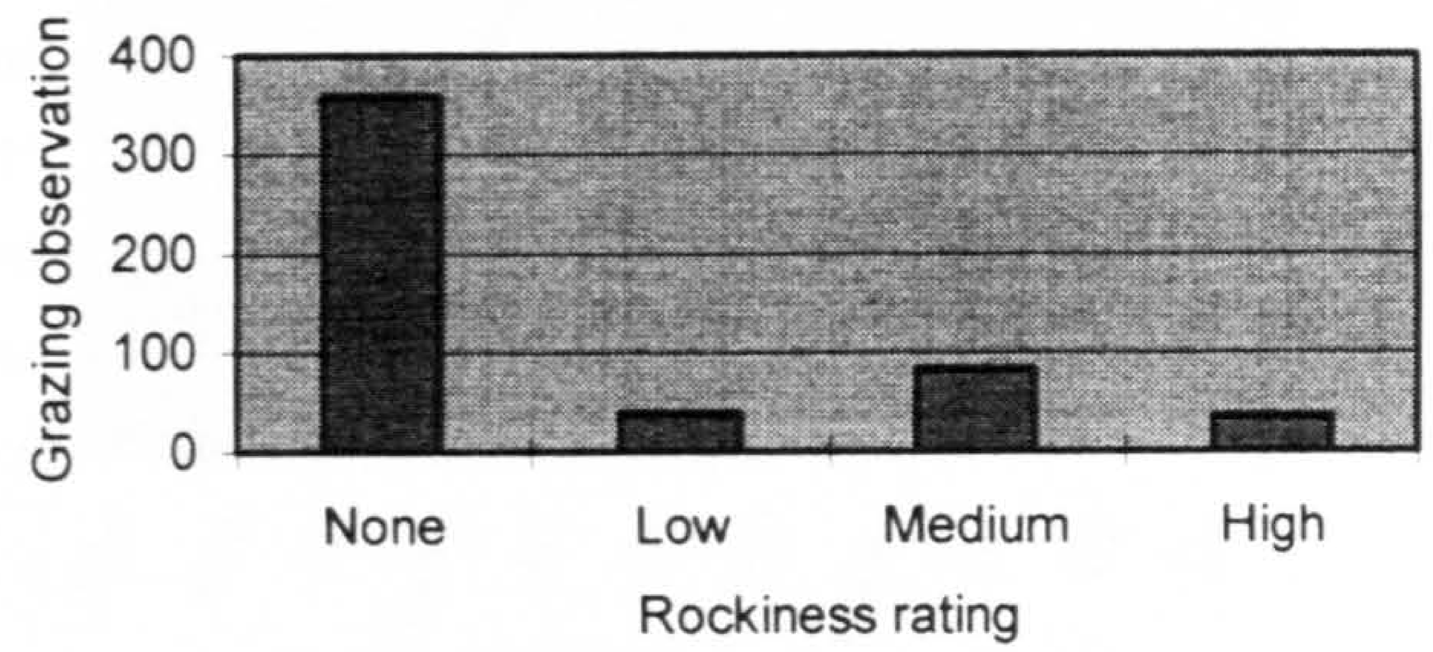


(e) Walking Observations per Hectare in Each Class

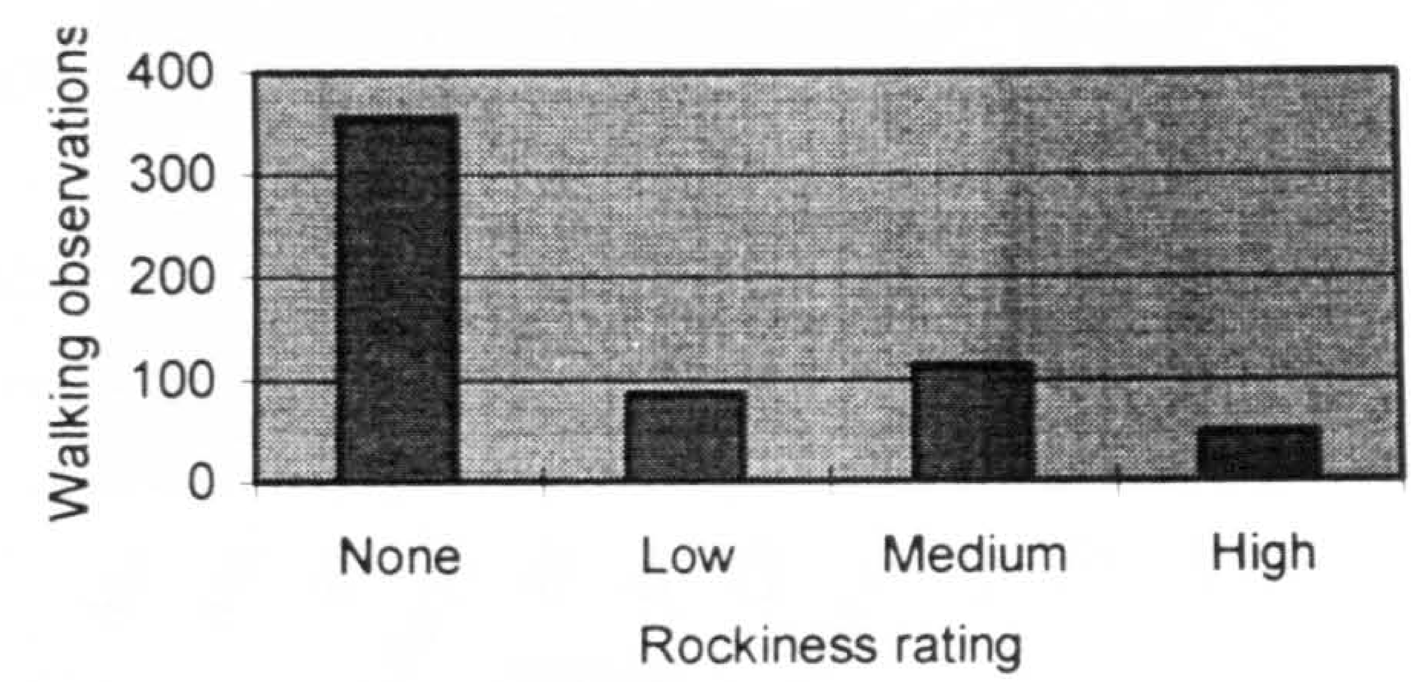
Fig. 22 Analysis of Utilisation of Rocky Areas



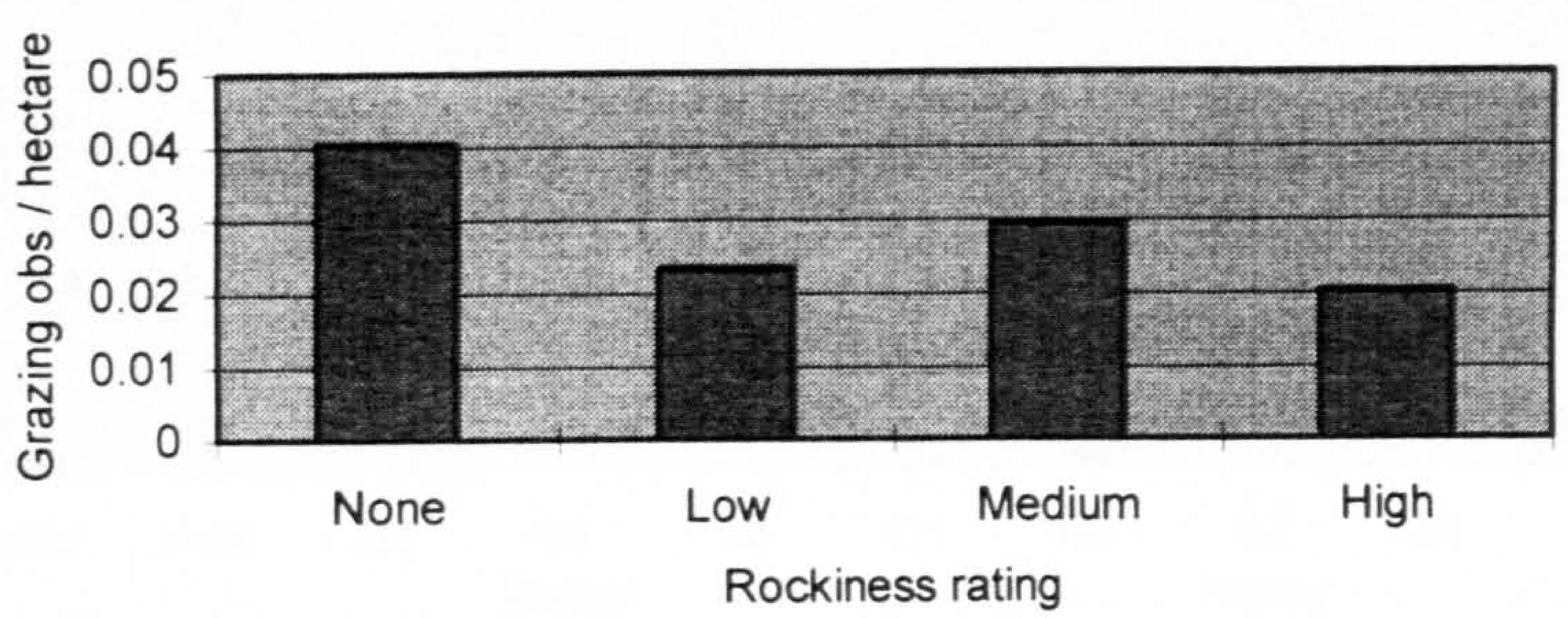
(a) Area Covered by Each Class



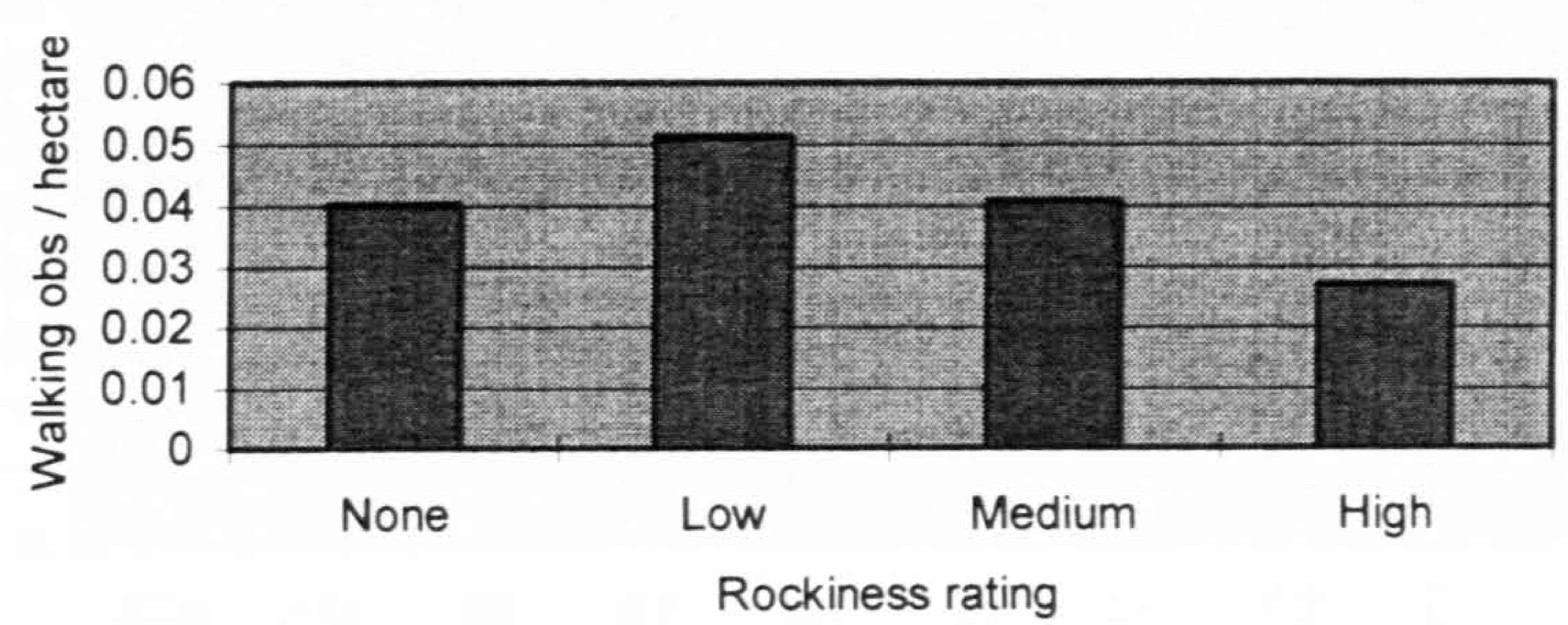
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

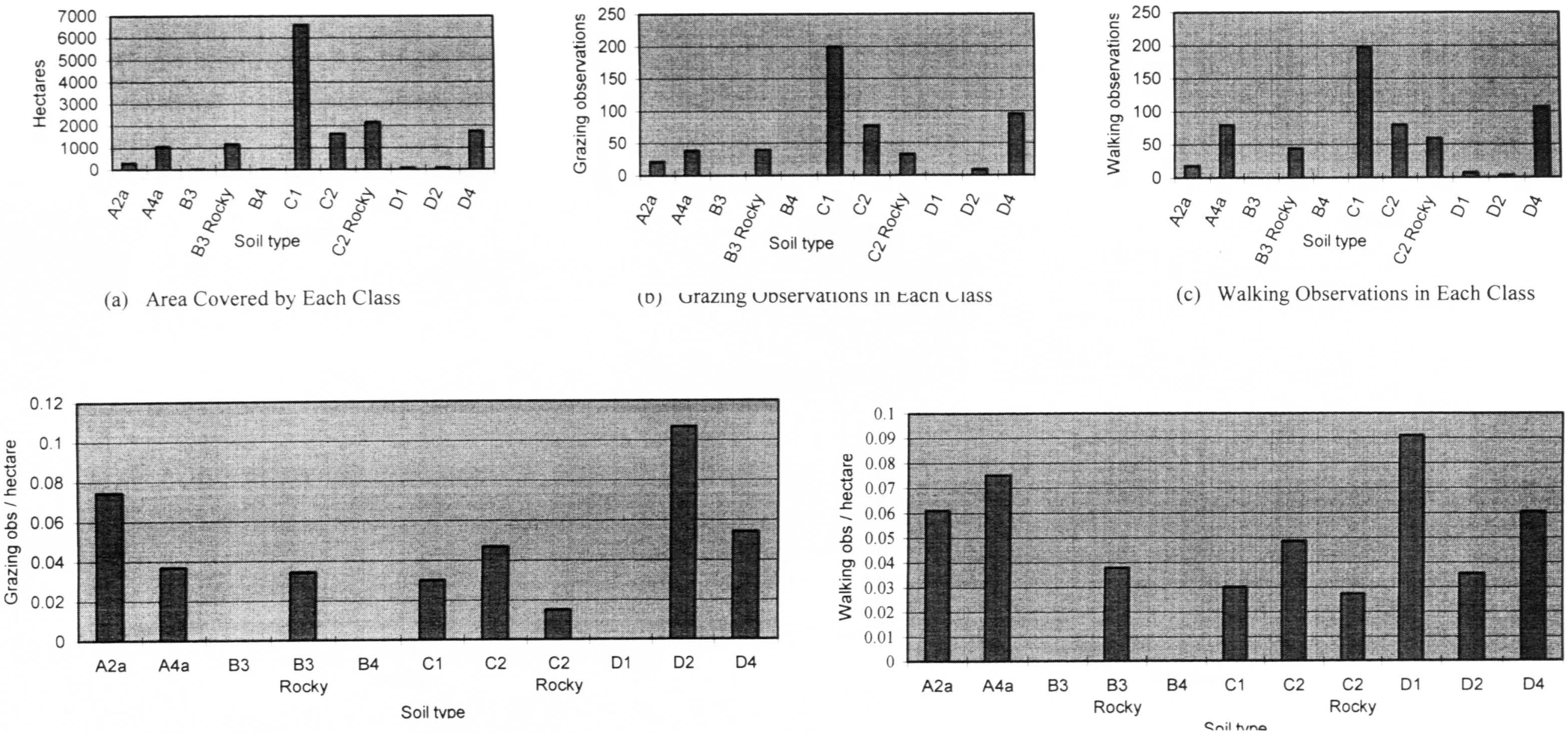


(d) Grazing Observations per Hectare in Each Class



(e) Walking Observations per Hectare in Each Class

Fig. 23 Analysis of Utilisation of Rockiness Ratings



(a) Area Covered by Each Class

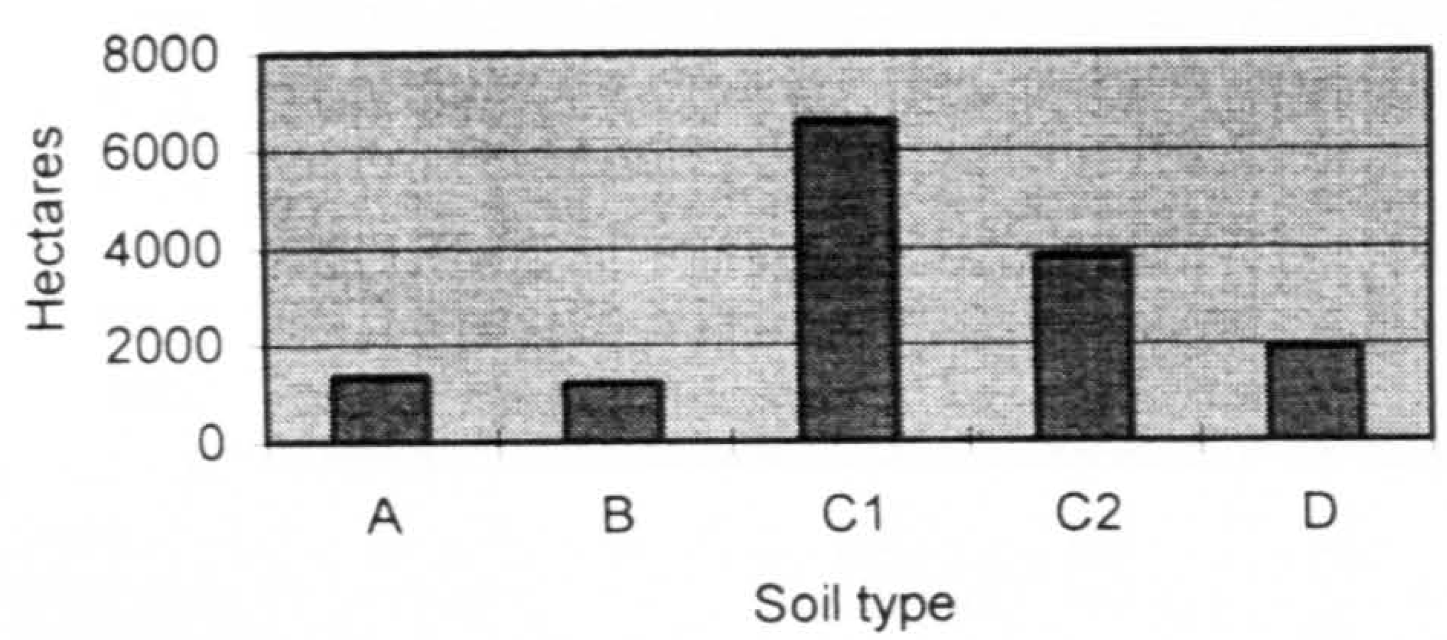
(b) Grazing Observations in Each Class

(c) Walking Observations in Each Class

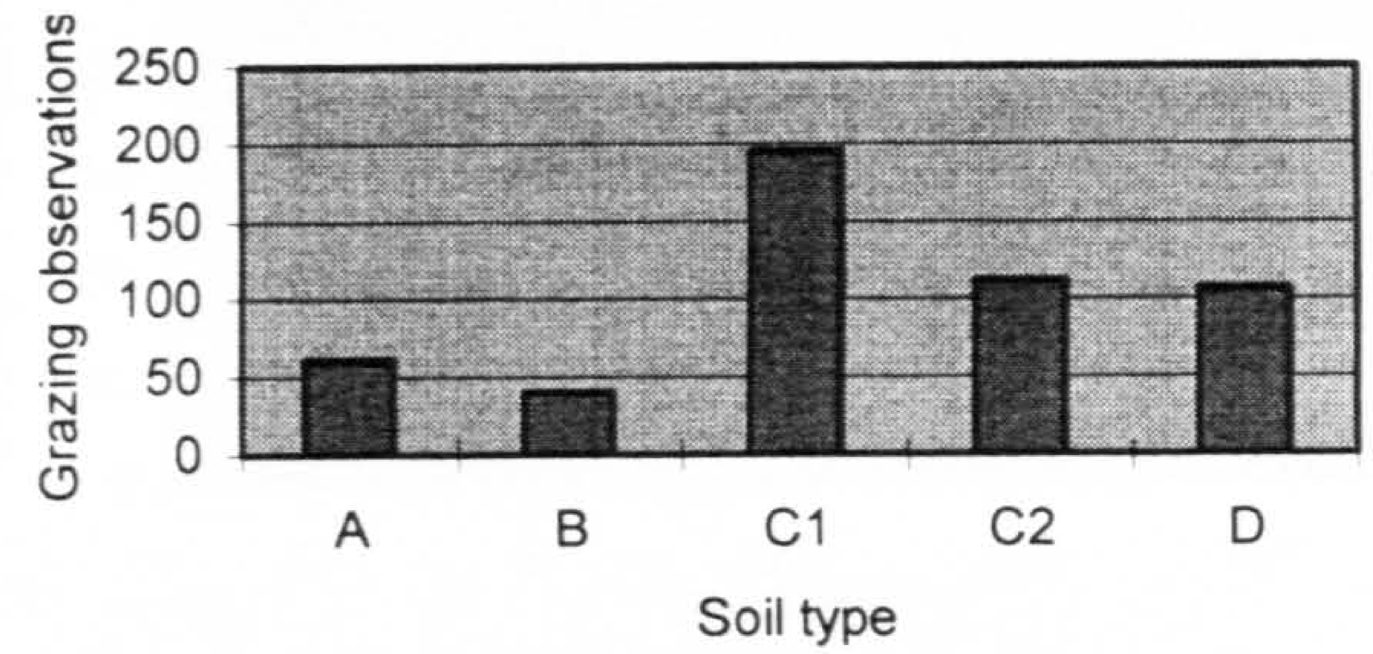
(d) Grazing Observations per Hectare in Each Class

(e) Walking Observations per Hectare in Each Class

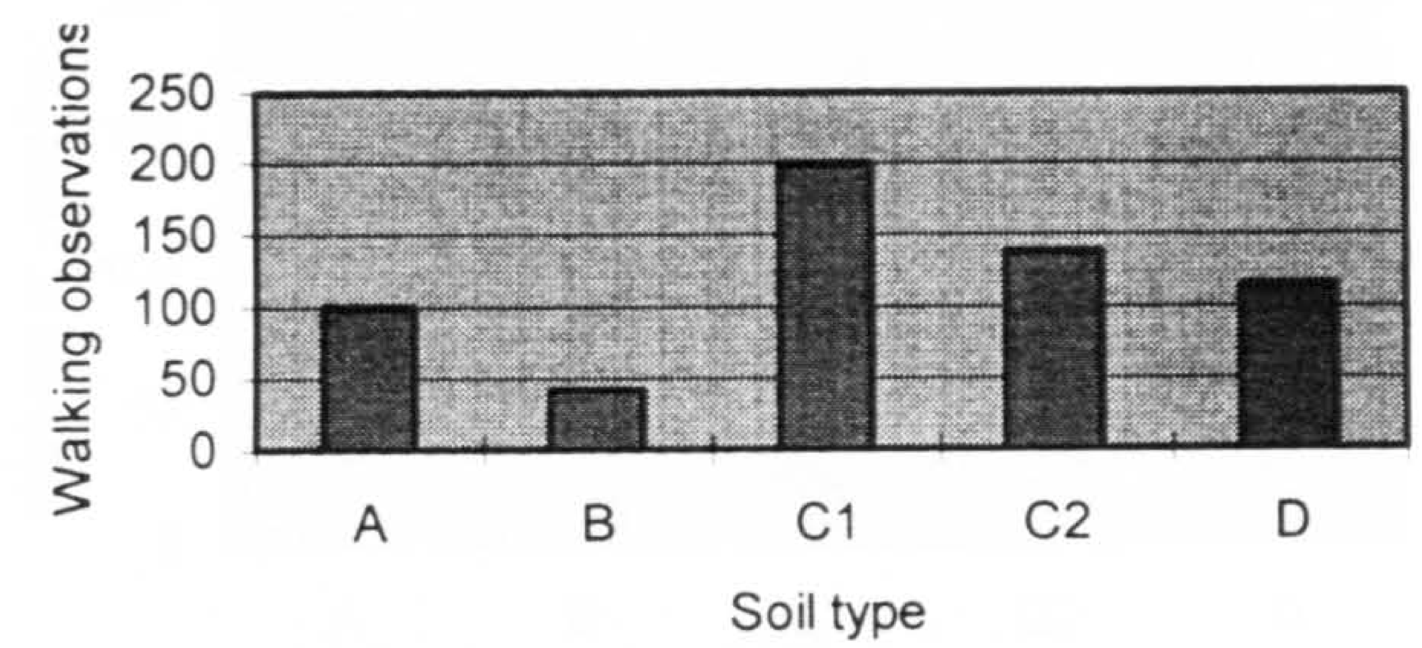
Fig. 24 Analysis of Utilisation of Eleven-Class Soil Types



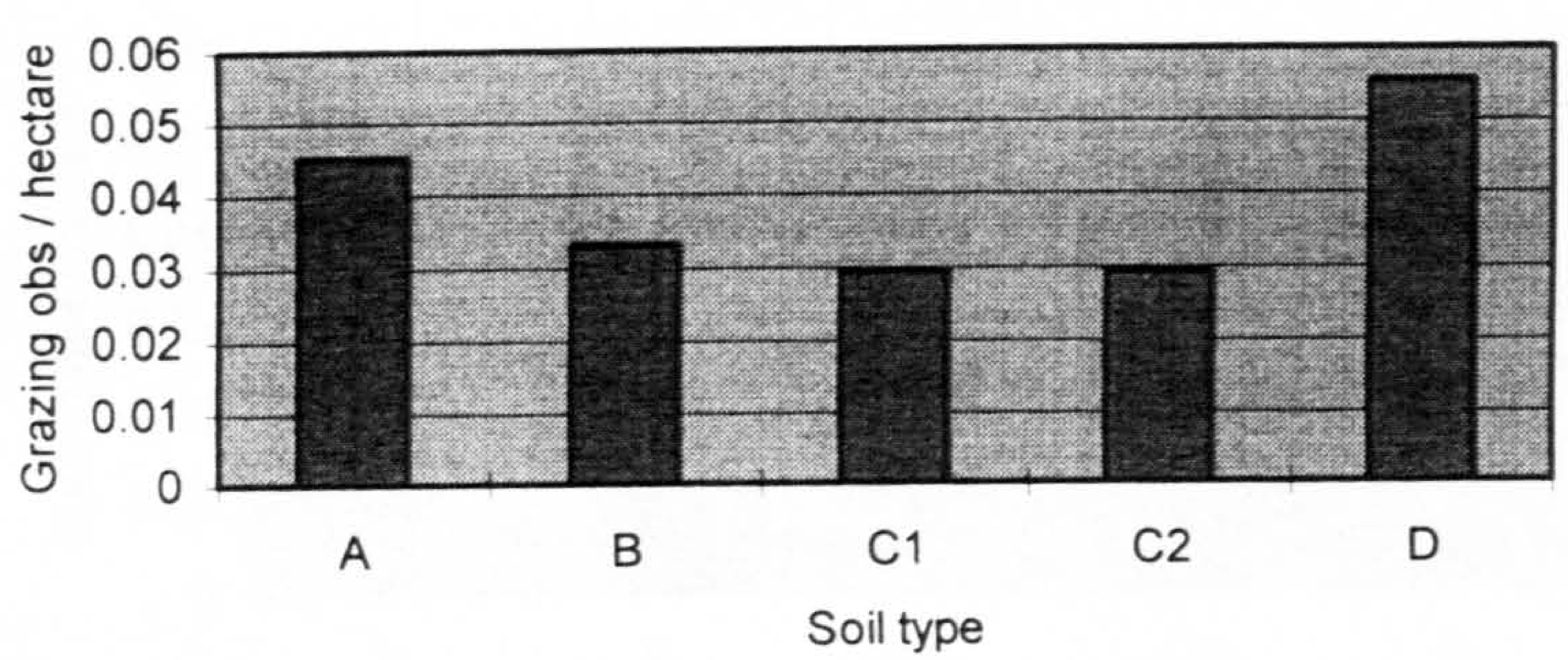
(a) Area Covered by Each Class



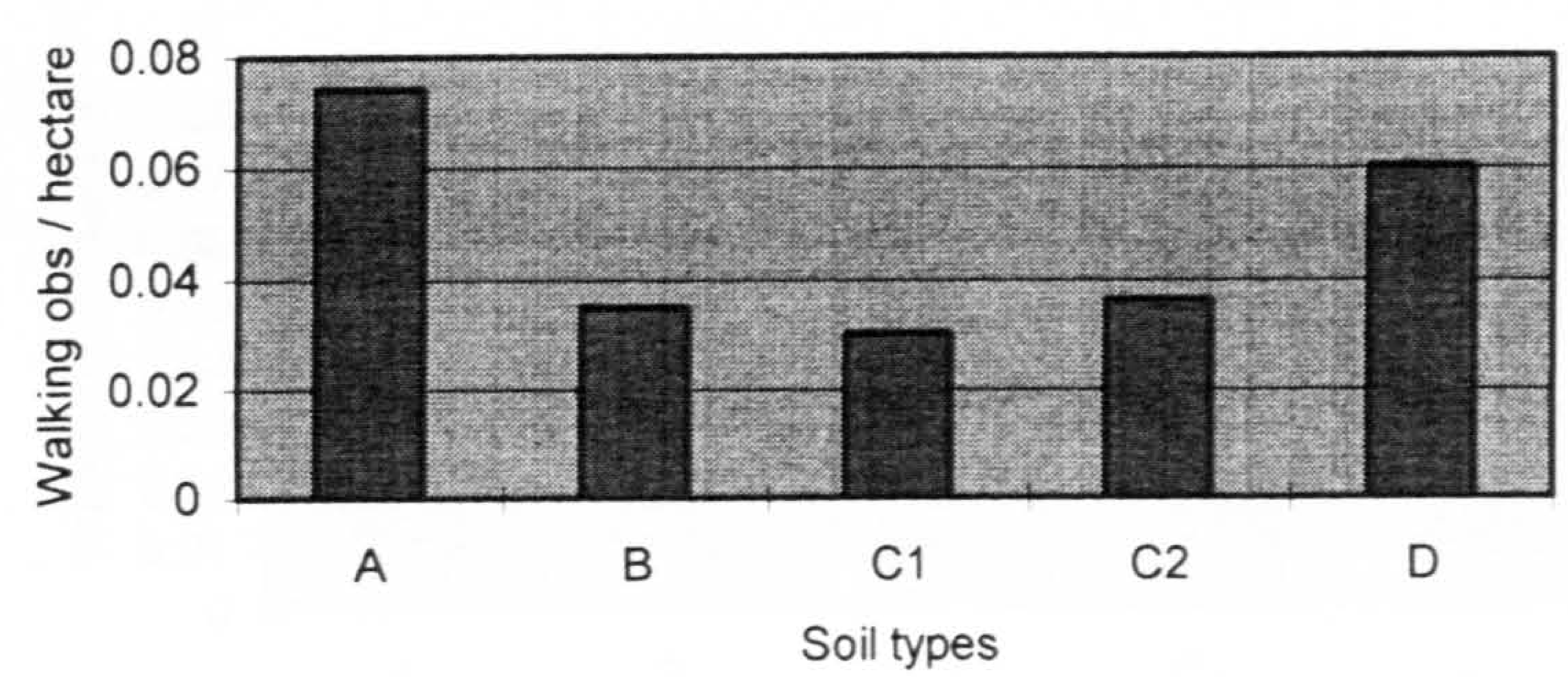
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

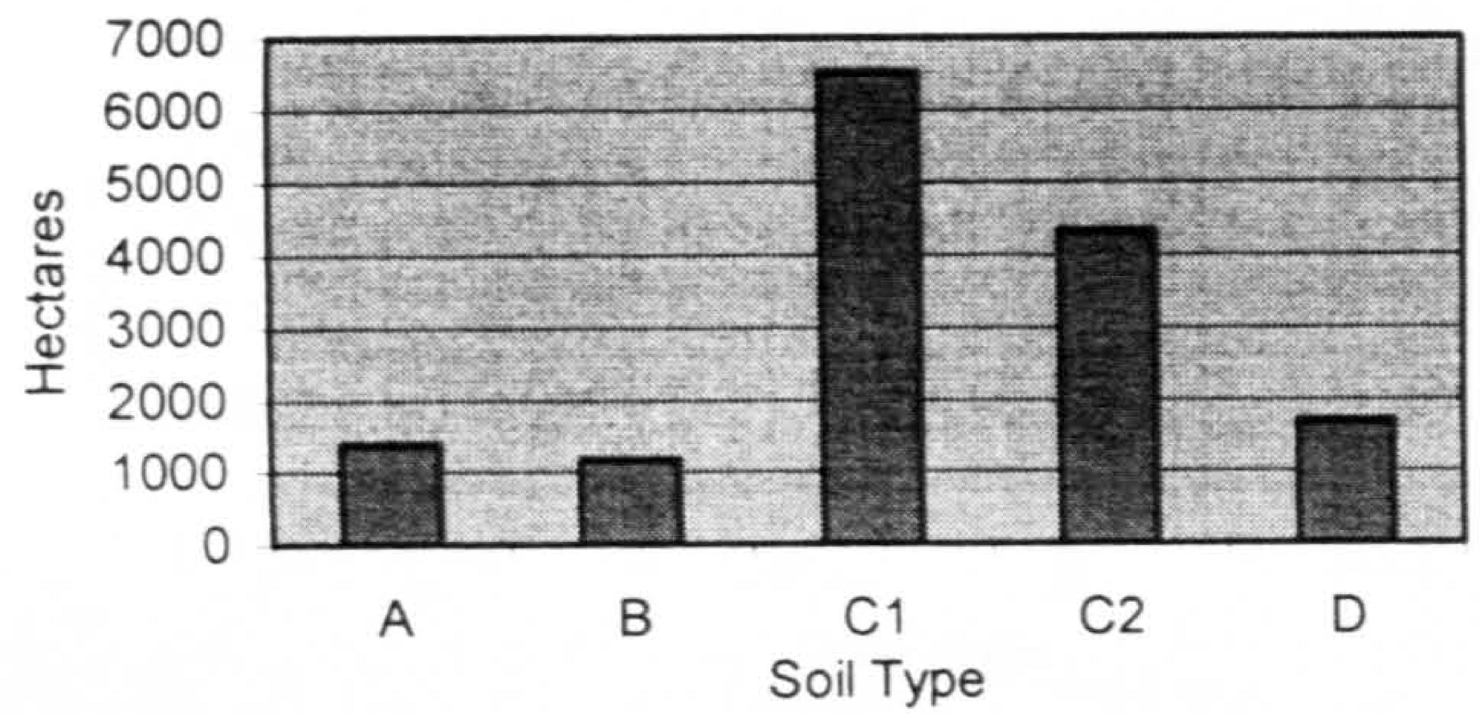


(d) Grazing Observations per Hectare in Each Class

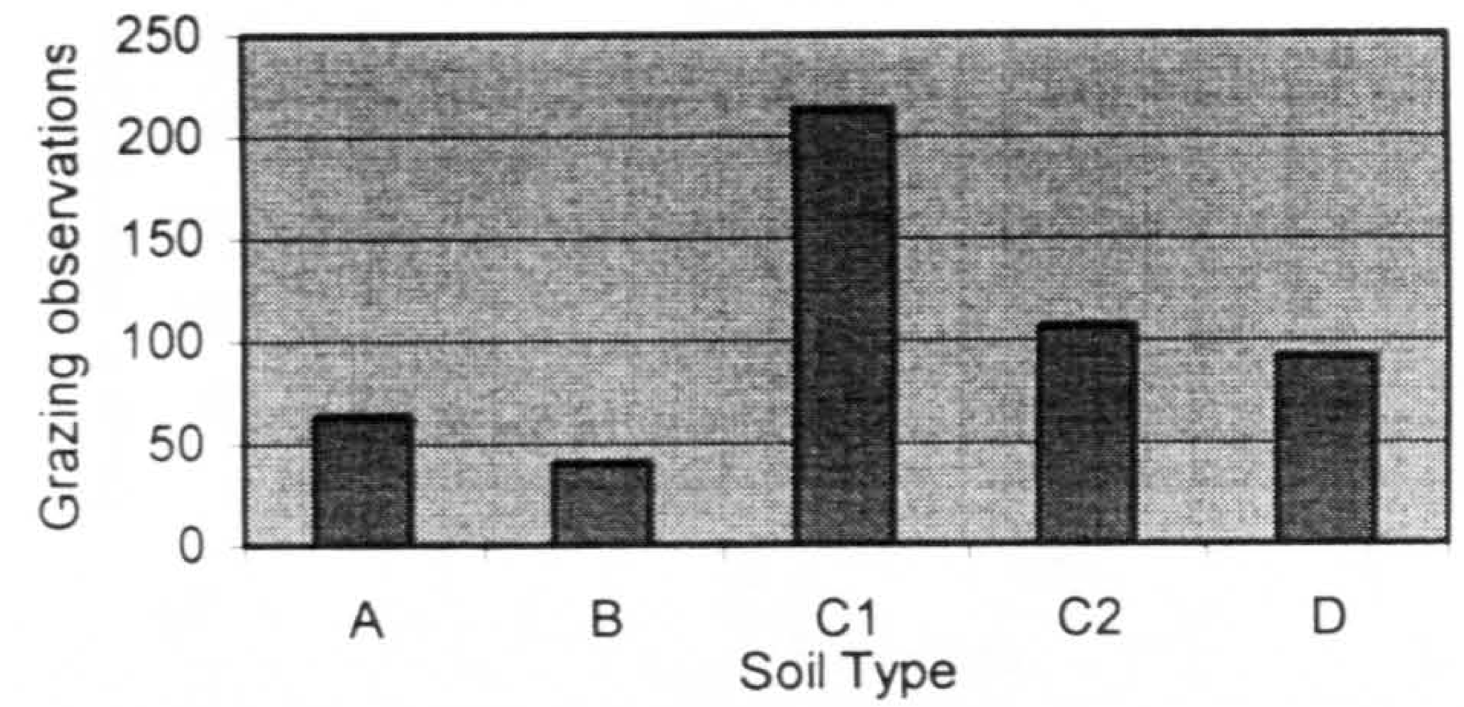


(e) Walking Observations per Hectare in Each Class

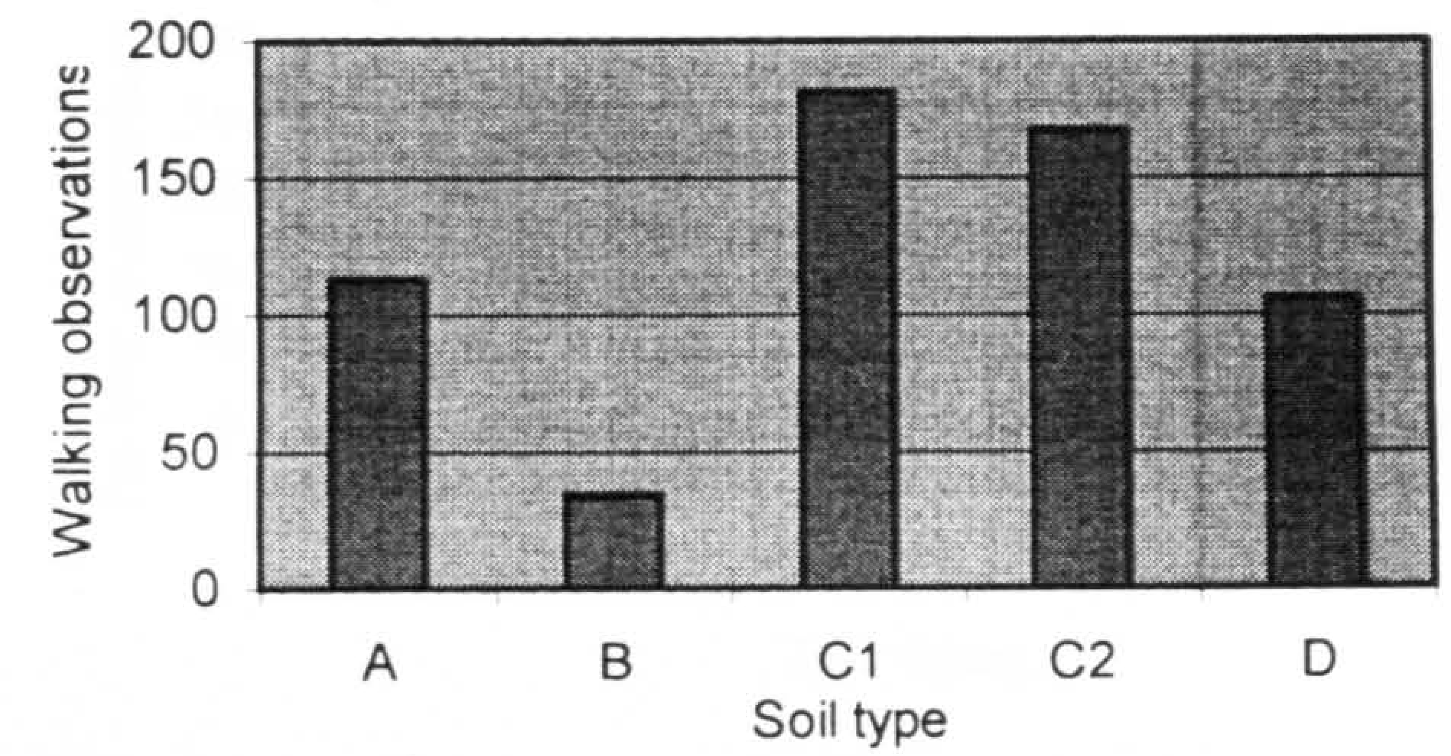
Fig. 25 Analysis of Utilisation of Five-Class Soil Types



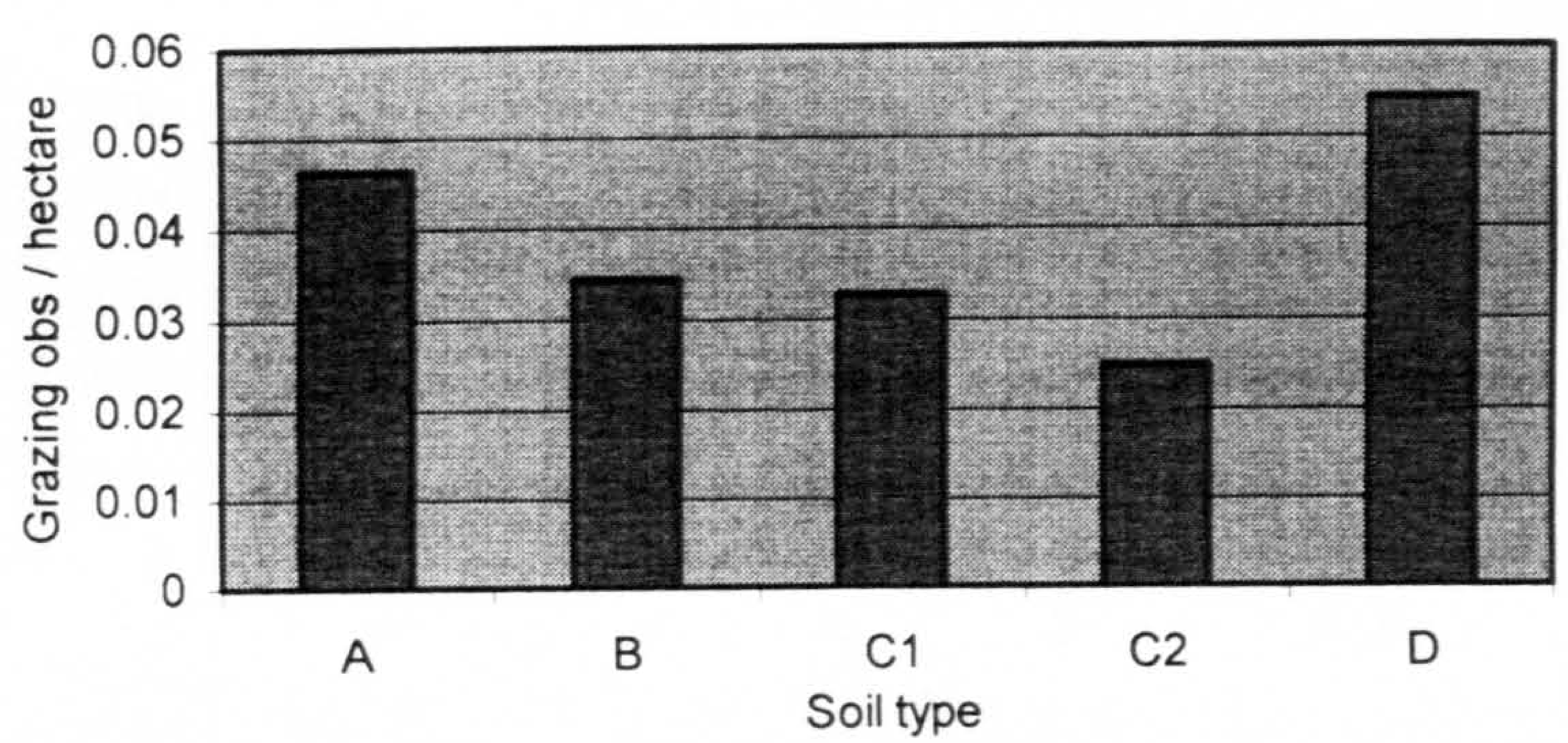
(a) Area Covered by Each Class



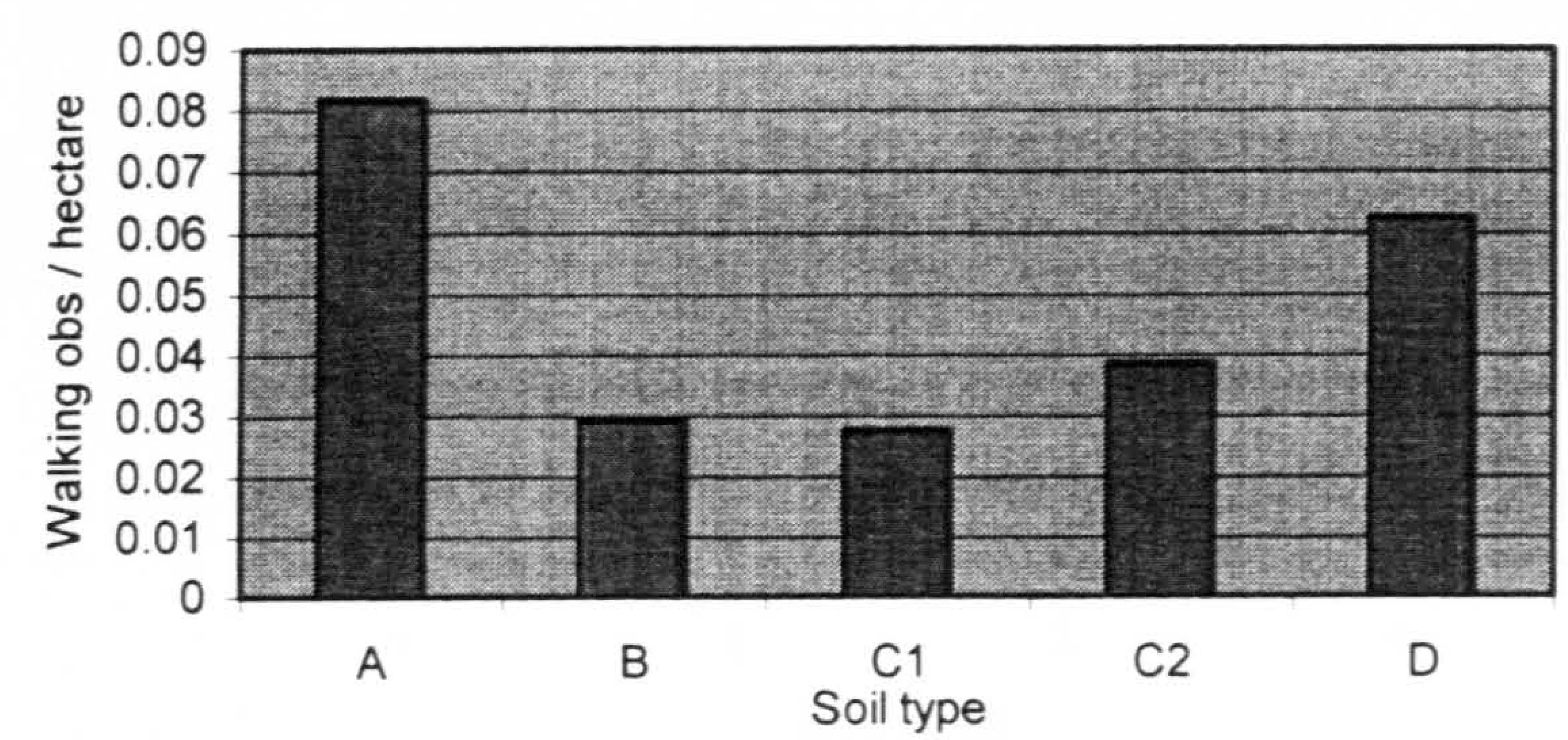
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

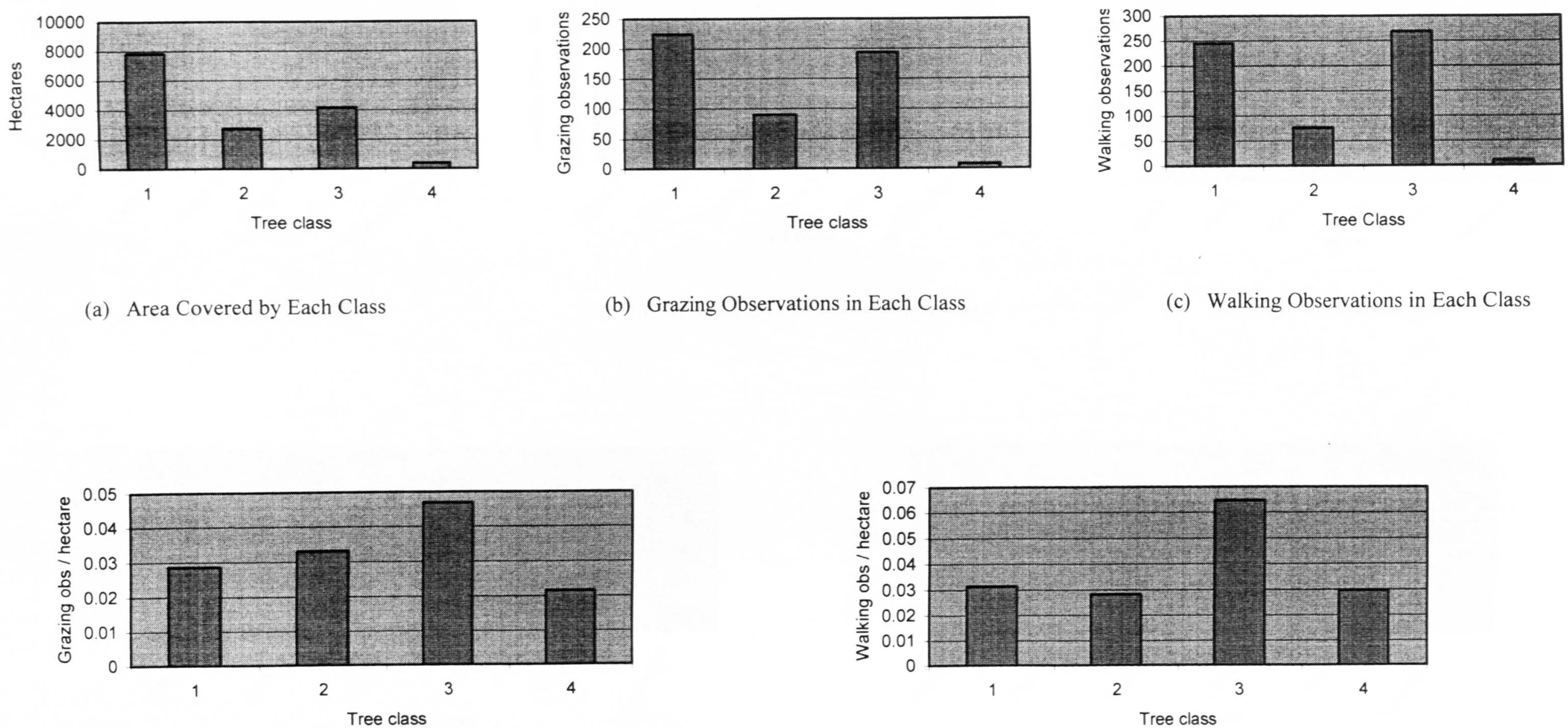


(d) Grazing Observations per Hectare in Each Class



(e) Walking Observations per Hectare in Each Class

Fig. 26 Analysis of Utilisation of Five-Class Assign Proximity Soil Types



(a) Area Covered by Each Class

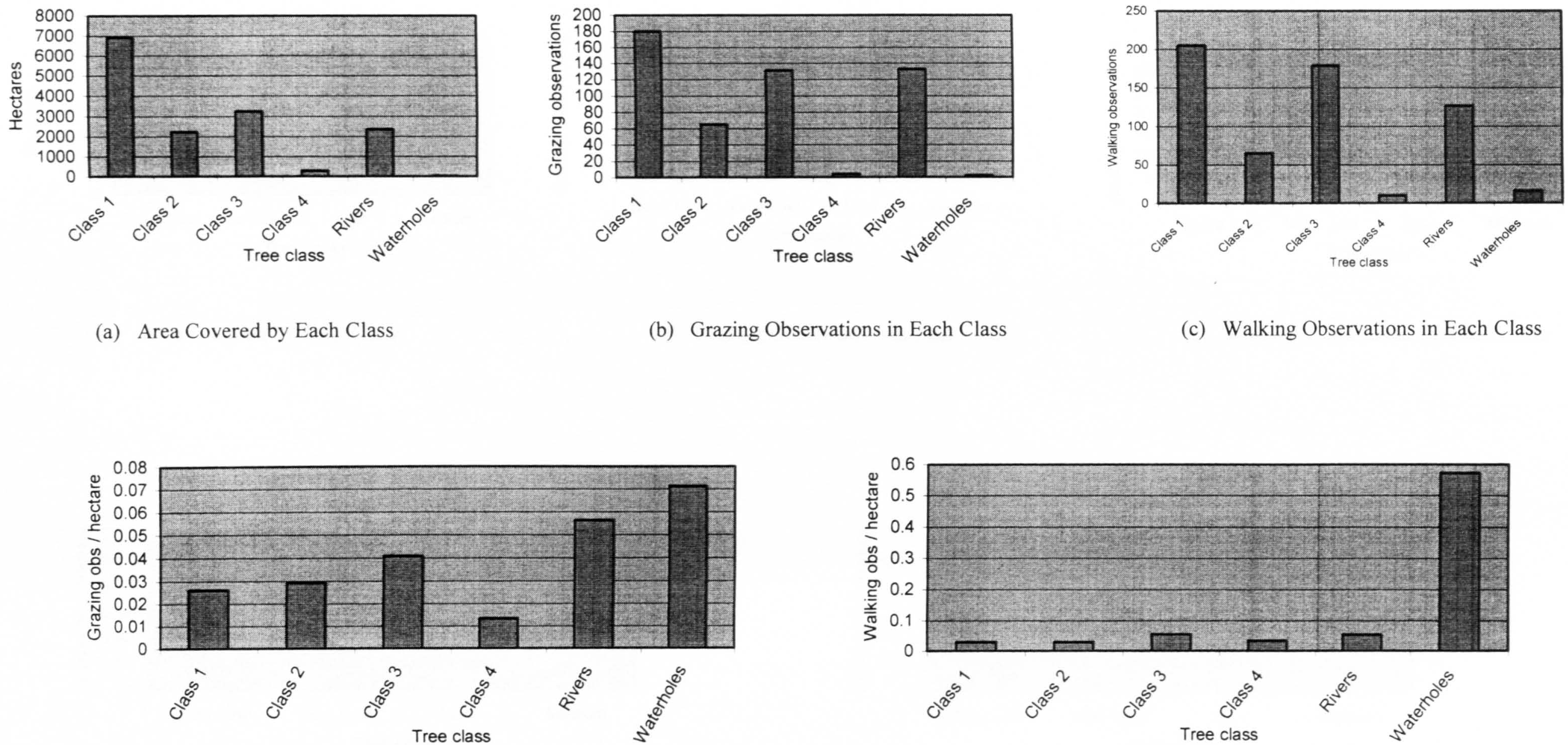
(b) Grazing Observations in Each Class

(c) Walking Observations in Each Class

(d) Grazing Observations per Hectare in Each Class

(e) Walking Observations per Hectare in Each Class

Fig. 27 Analysis of Utilisation of Four-Class Tree Classification



(a) Area Covered by Each Class

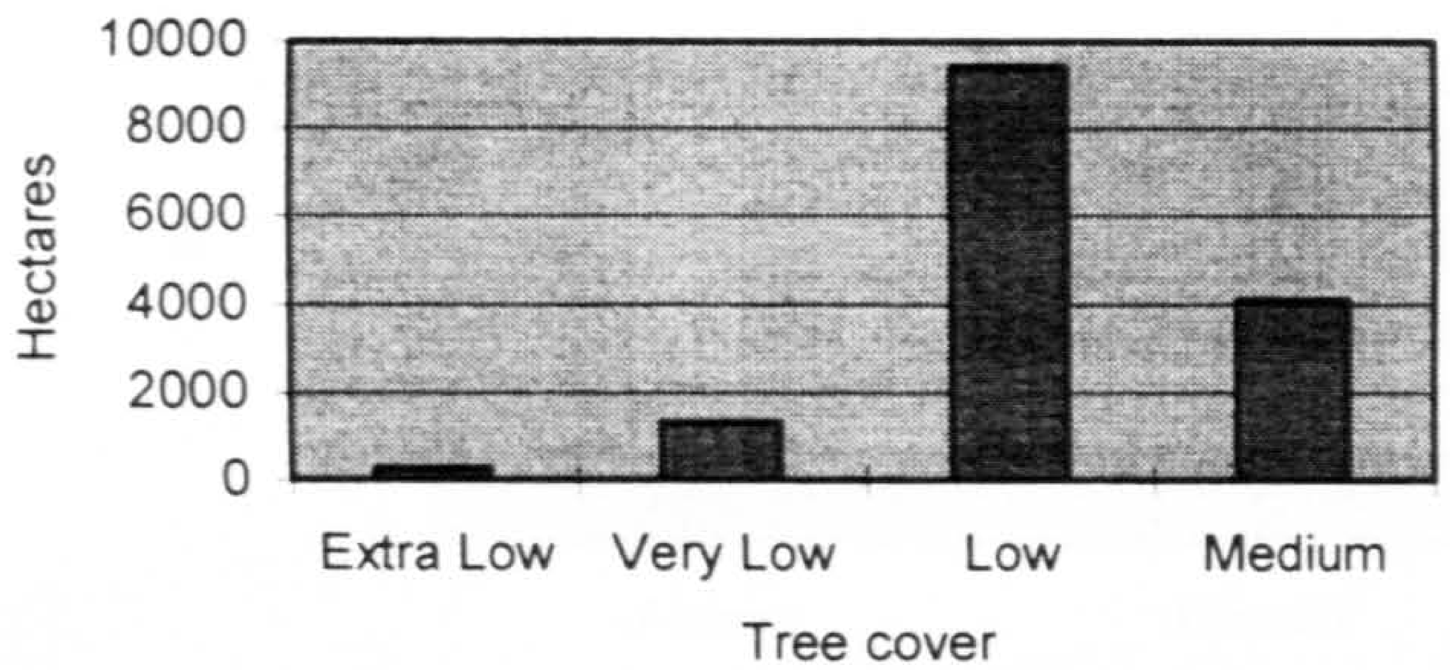
(b) Grazing Observations in Each Class

(c) Walking Observations in Each Class

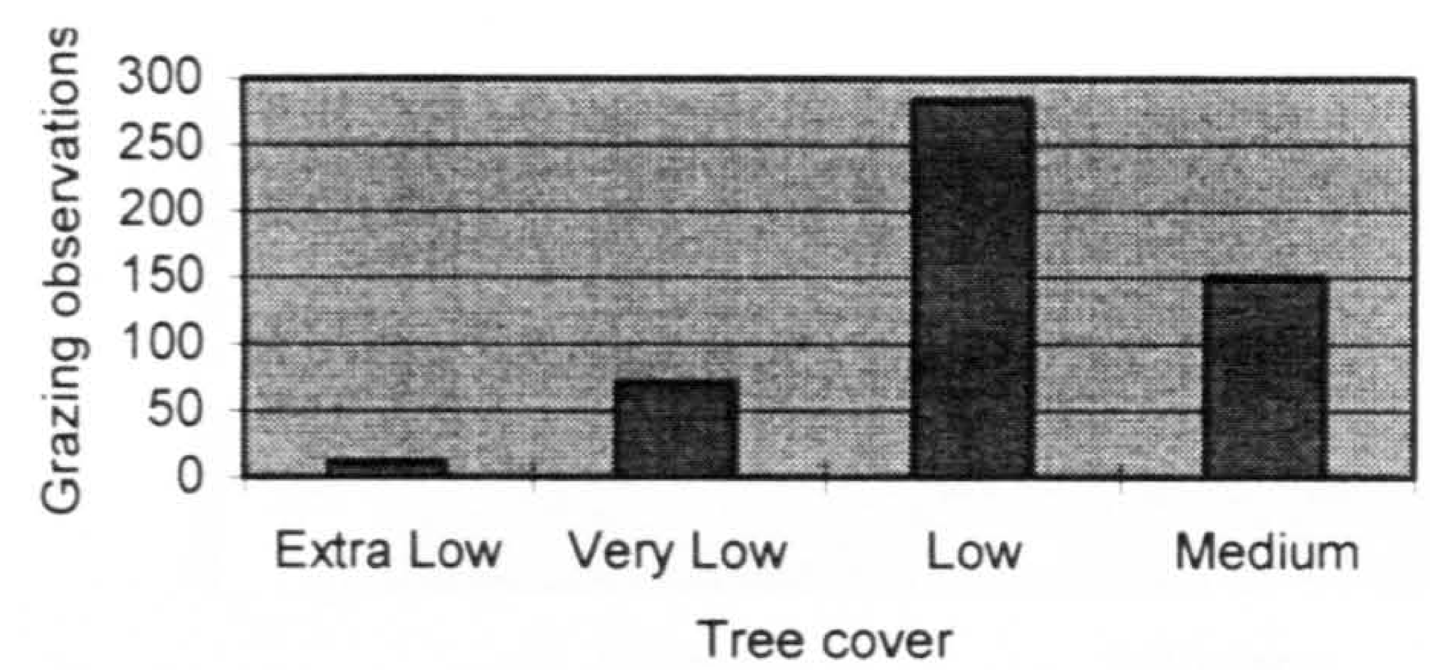
(d) Grazing Observations per Hectare in Each Class

(e) Walking Observations per Hectare in Each Class

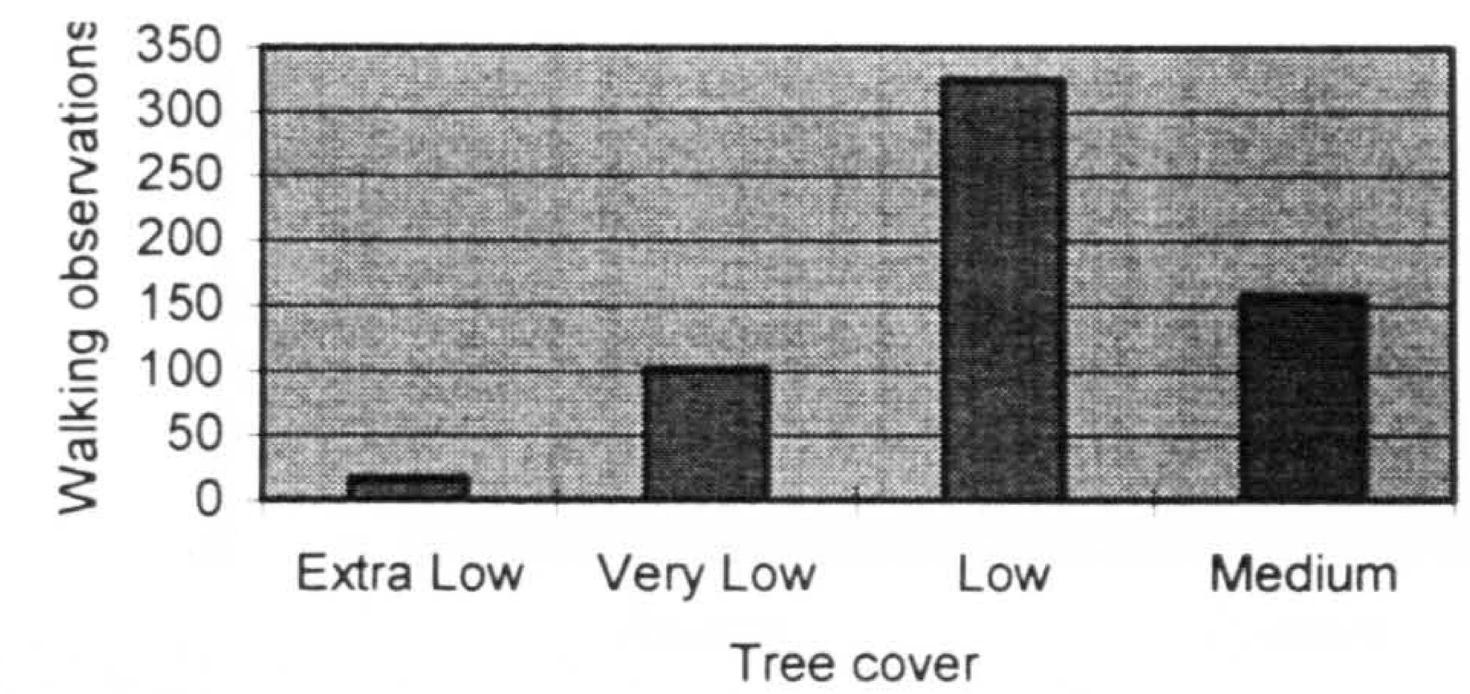
Fig. 28 Analysis of Utilisation of Detailed Four-Class Tree Classification



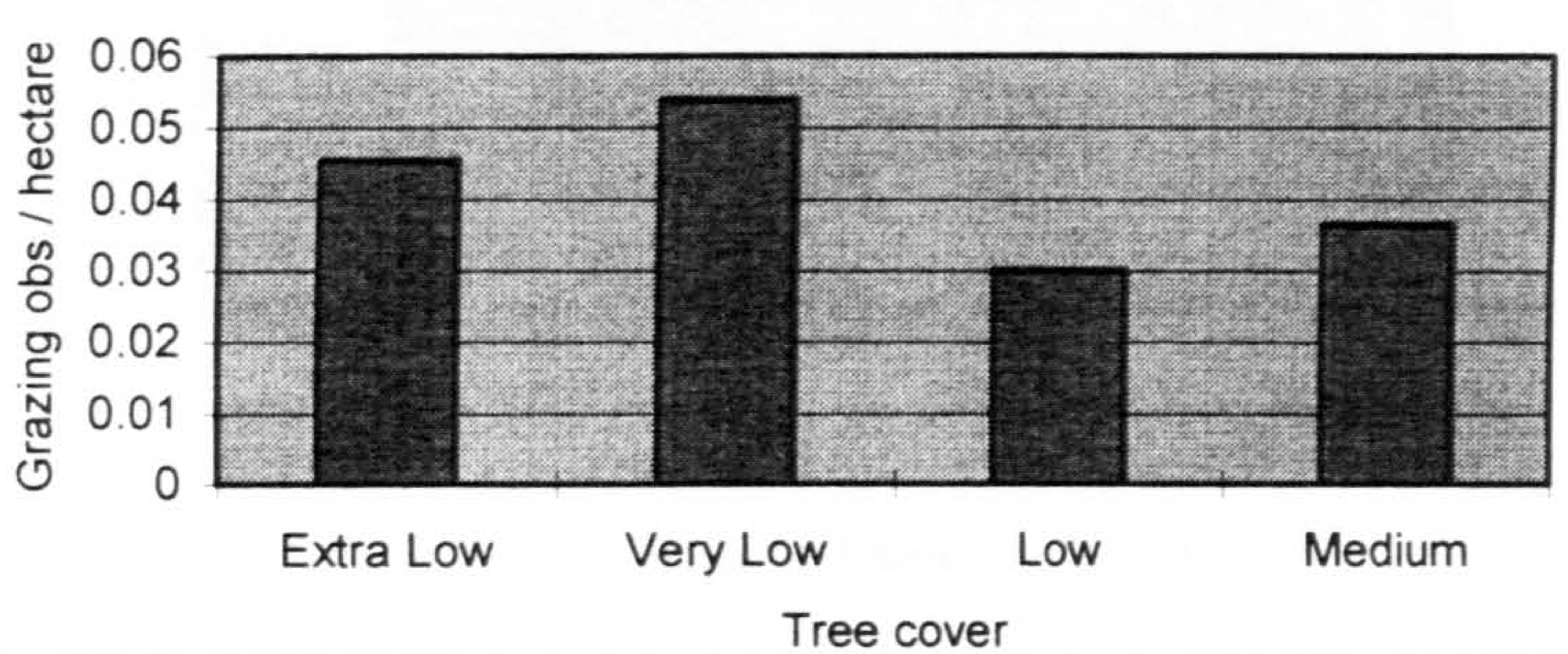
(a) Area Covered by Each Class



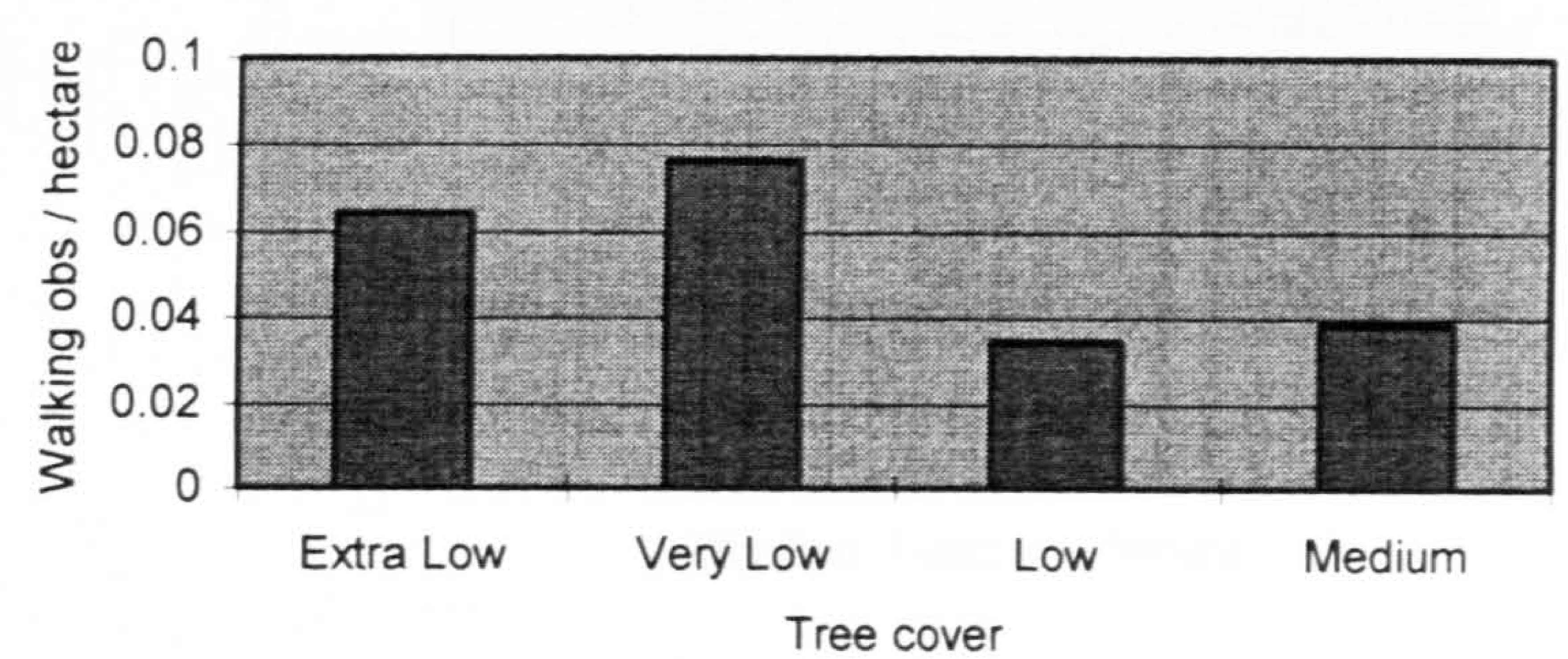
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

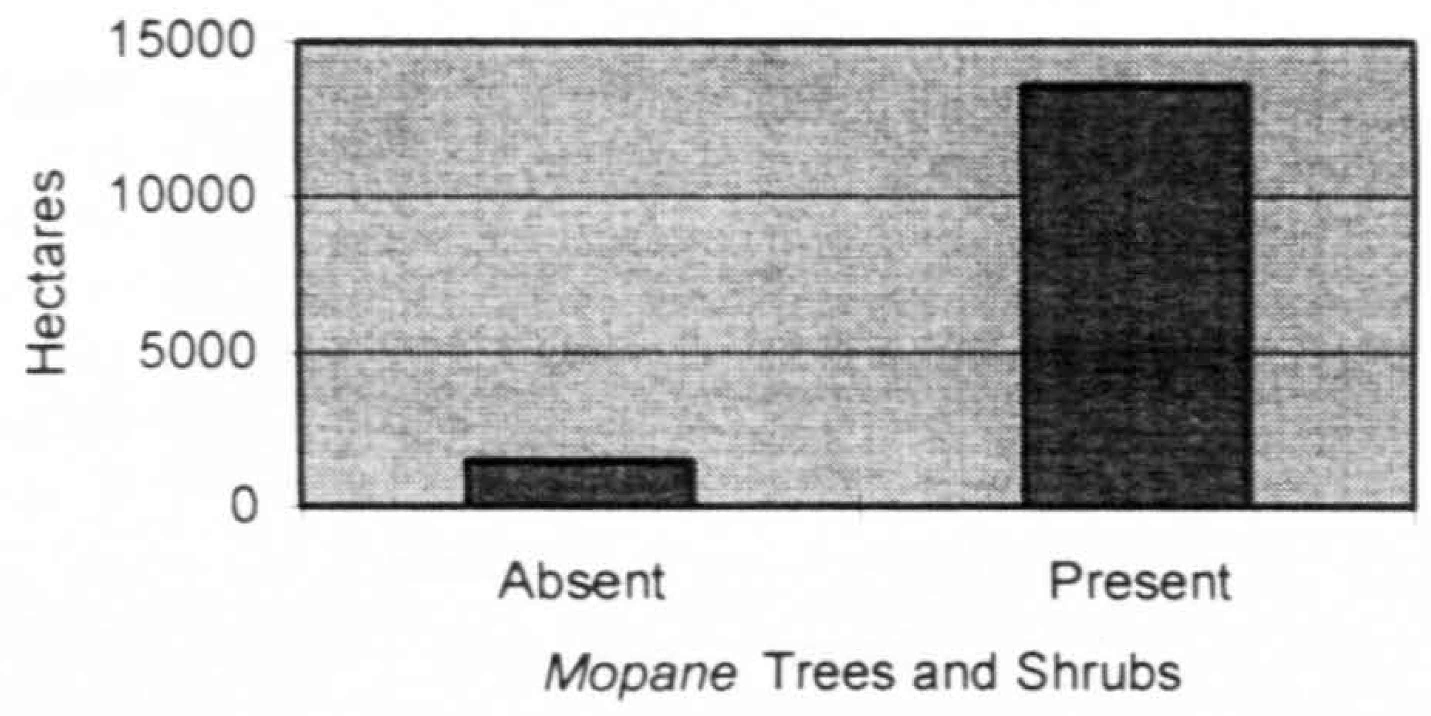


(d) Grazing Observations per Hectare in Each Class

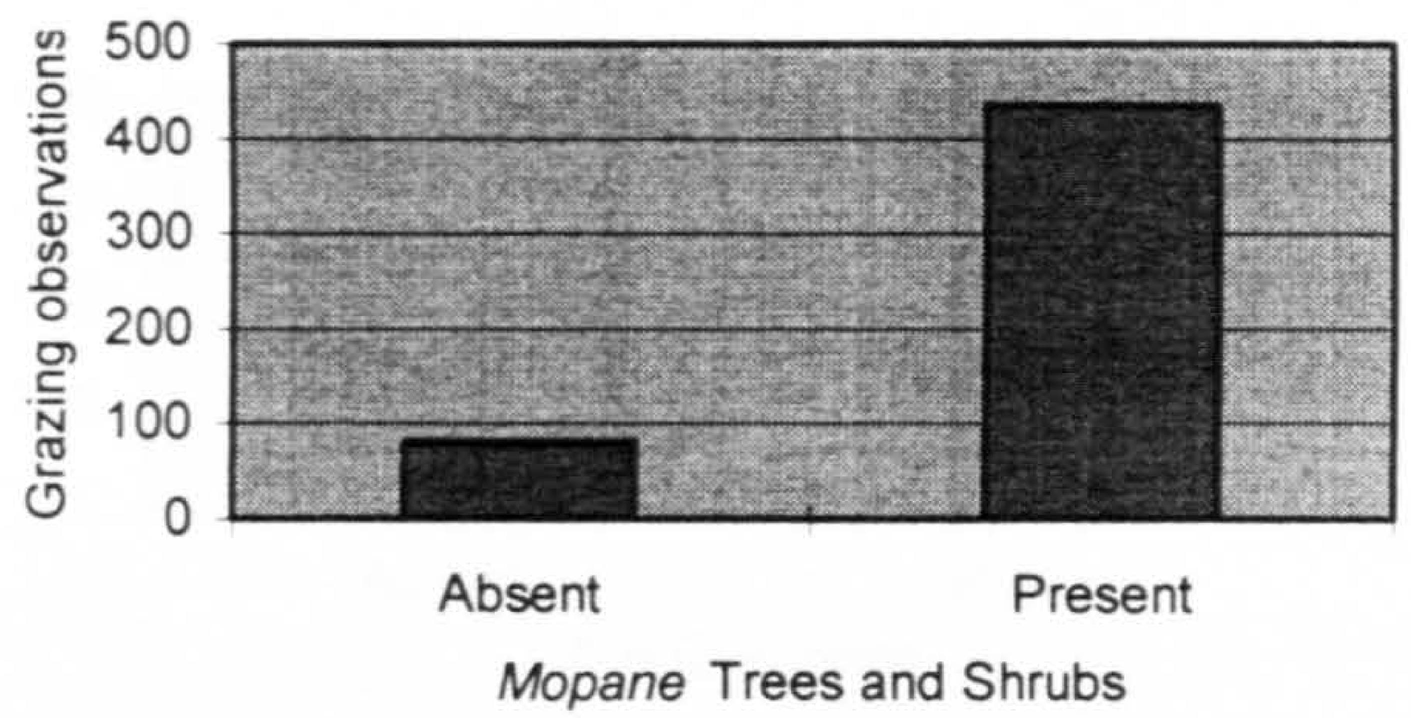


(e) Walking Observations per Hectare in Each Class

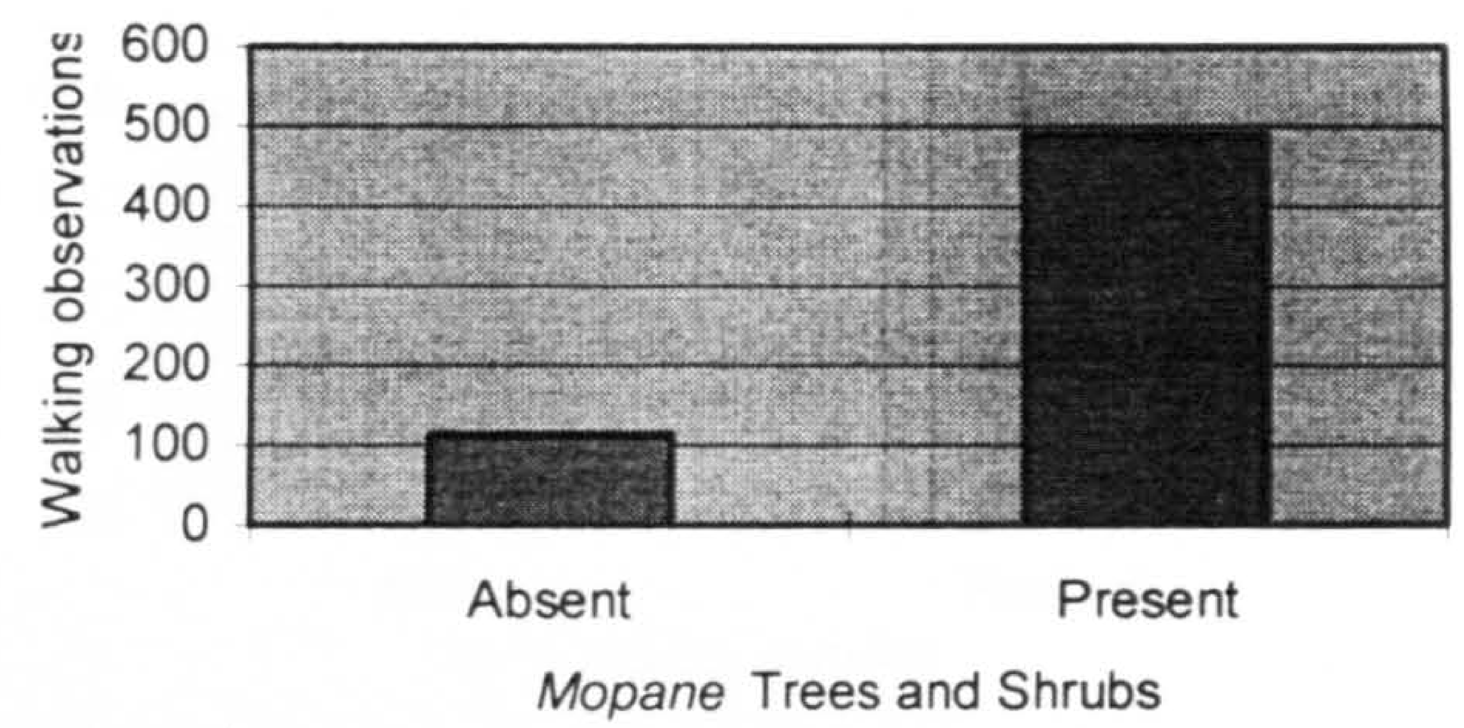
Fig. 29 Analysis of Utilisation of Tree Cover Classes



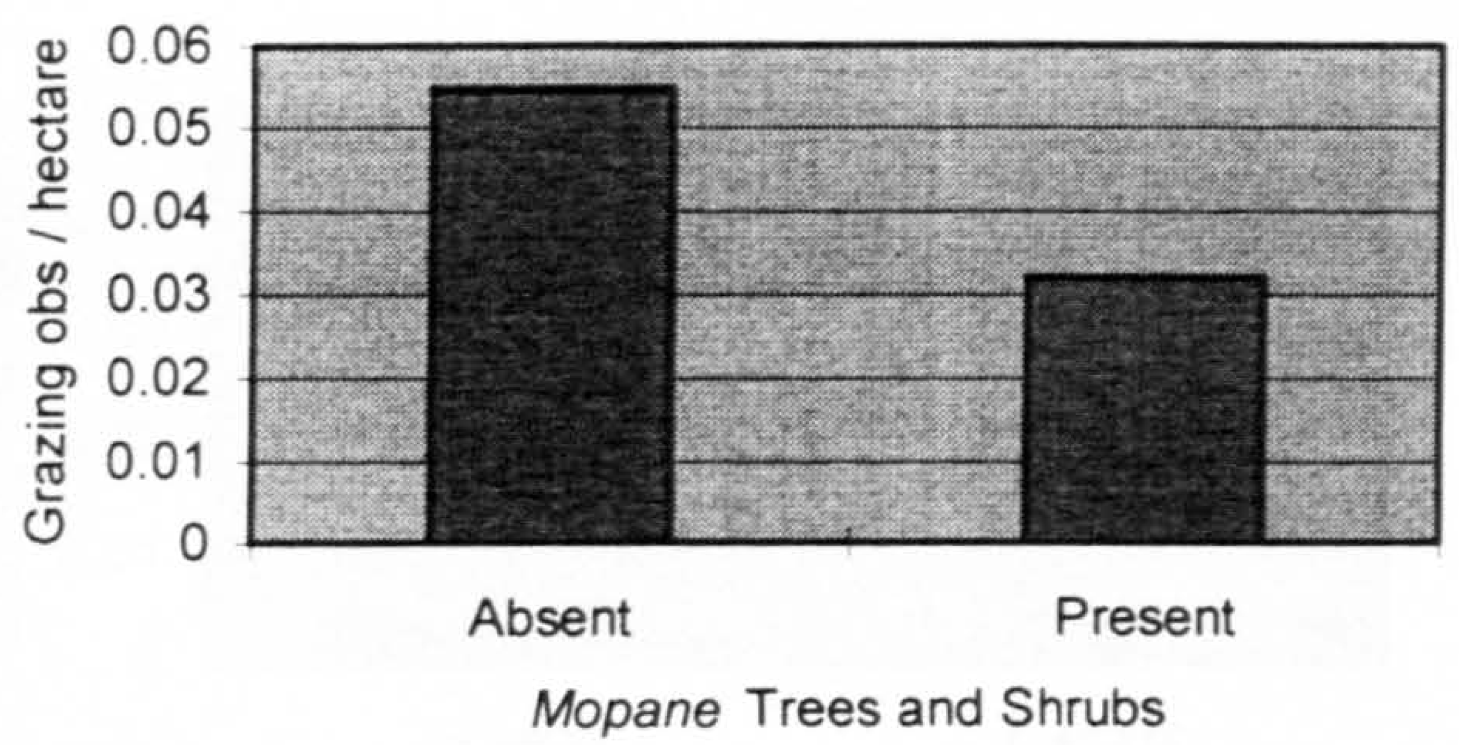
(a) Area Covered by Each Class



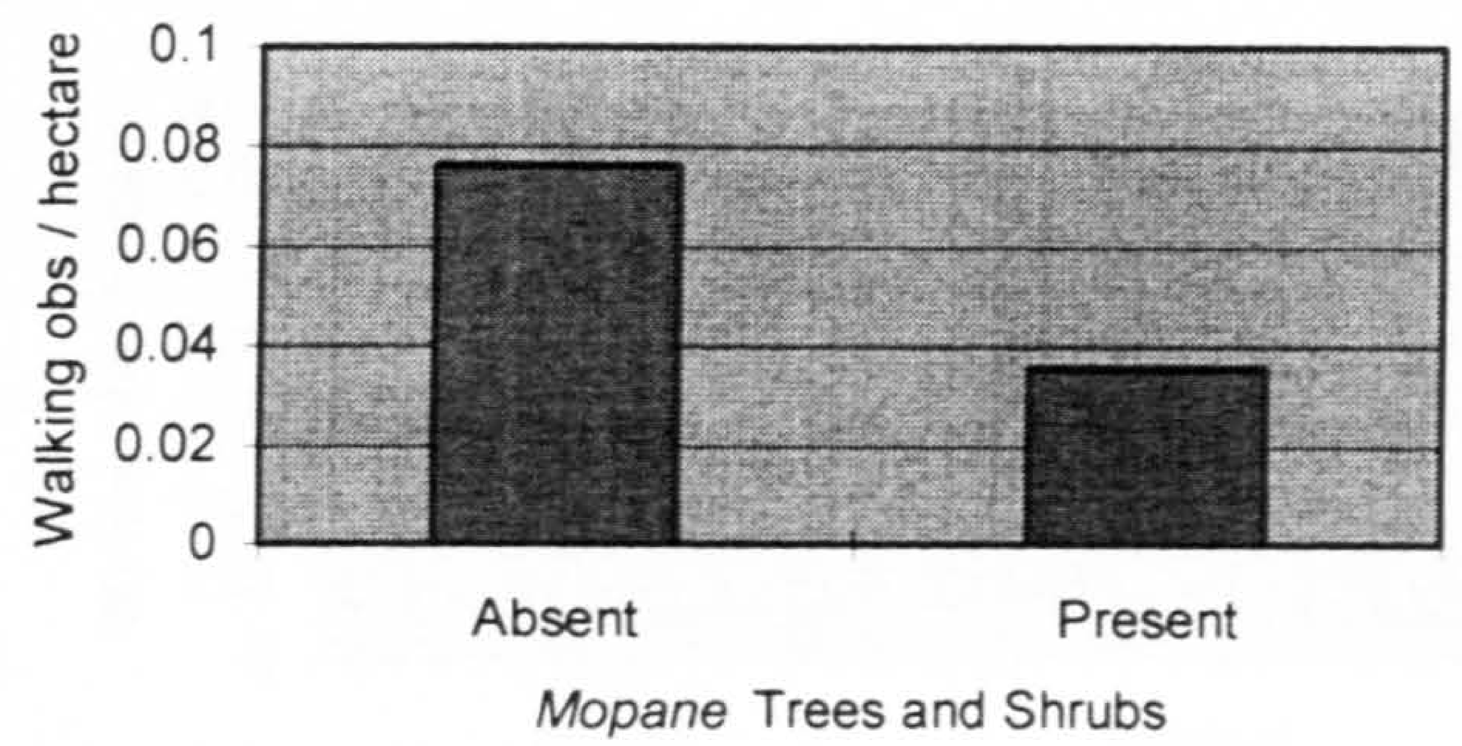
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

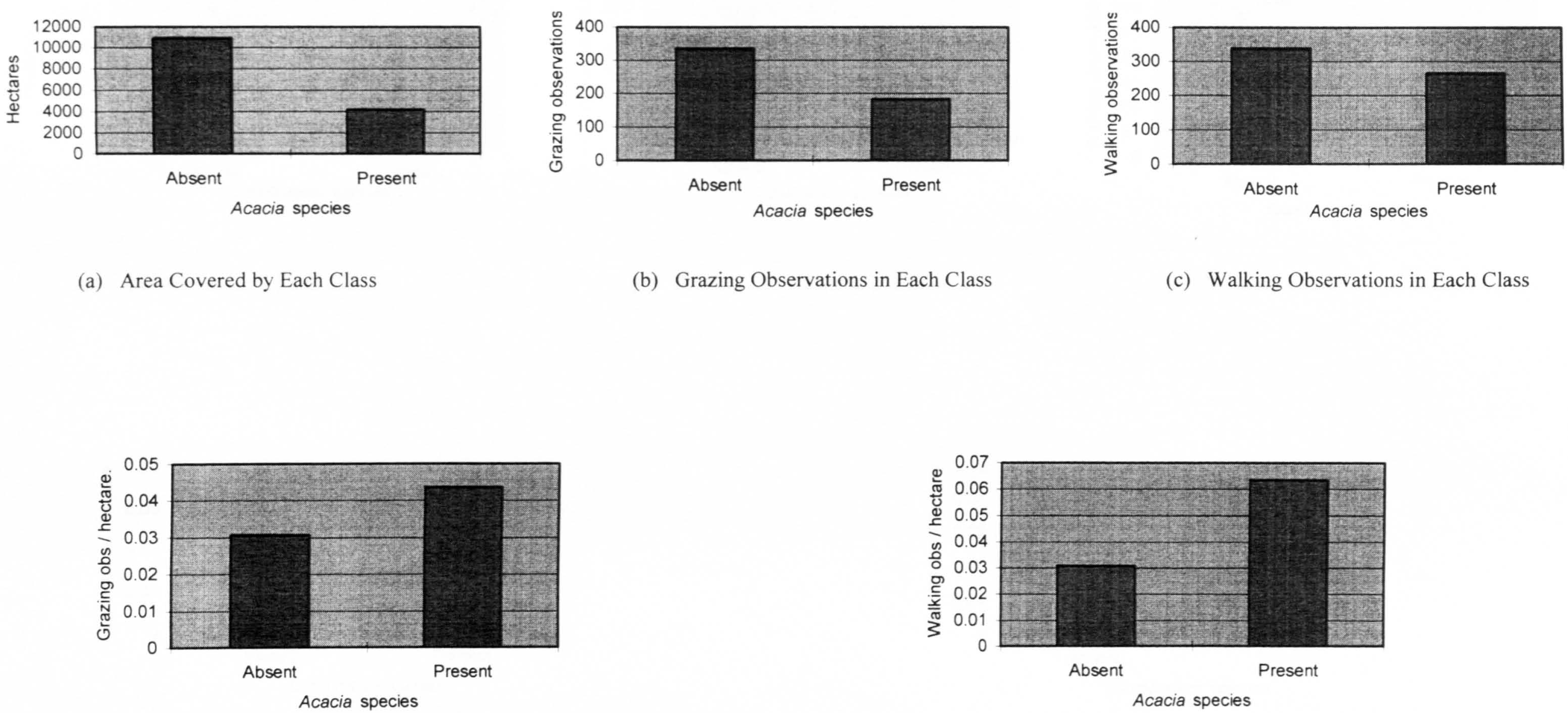


(d) Grazing Observations per Hectare in Each Class



(e) Walking Observations per Hectare in Each Class

Fig. 30 Analysis of Utilisation of Areas with *Mopane* Trees and Shrubs



(a) Area Covered by Each Class

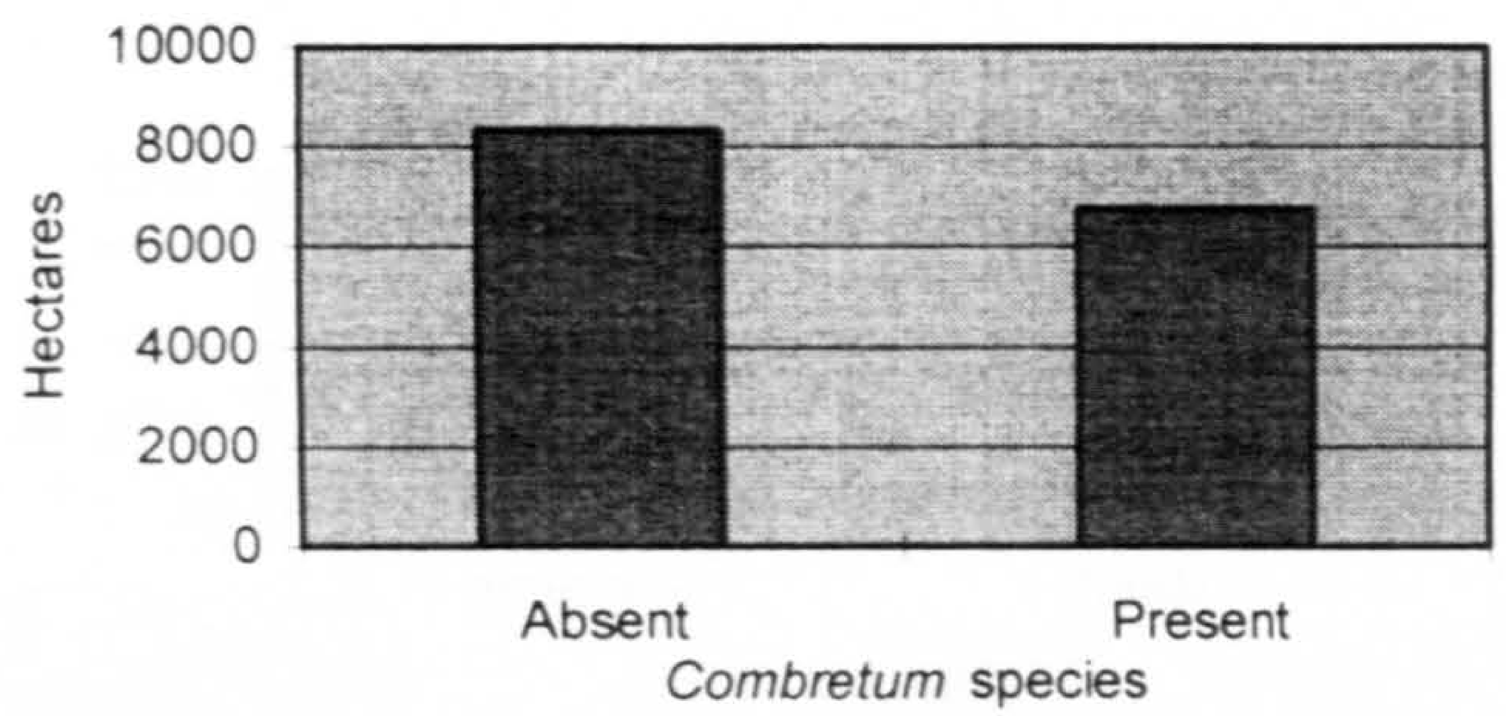
(b) Grazing Observations in Each Class

(c) Walking Observations in Each Class

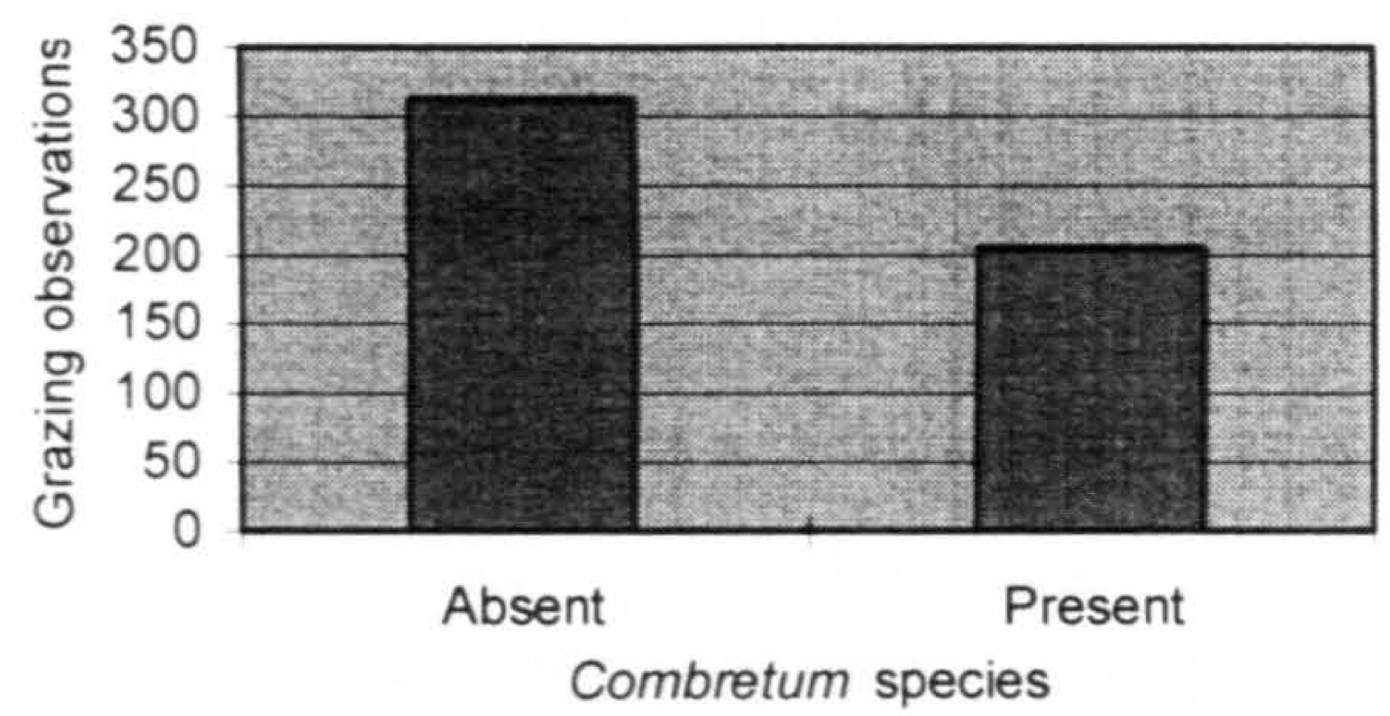
(d) Grazing Observations per Hectare in Each Class

(e) Walking Observations per Hectare in Each Class

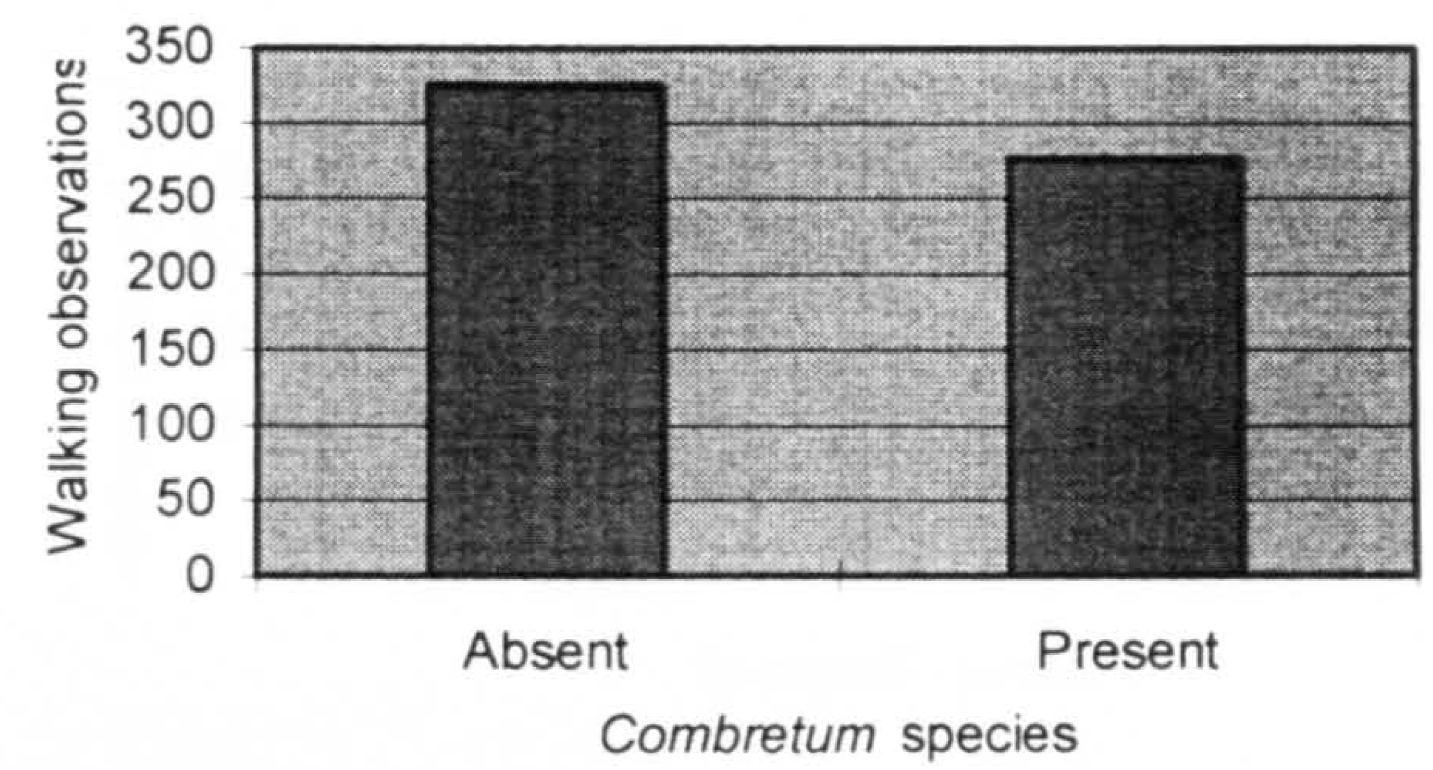
Fig. 31 Analysis of Utilisation of Areas with *Acacia* Species



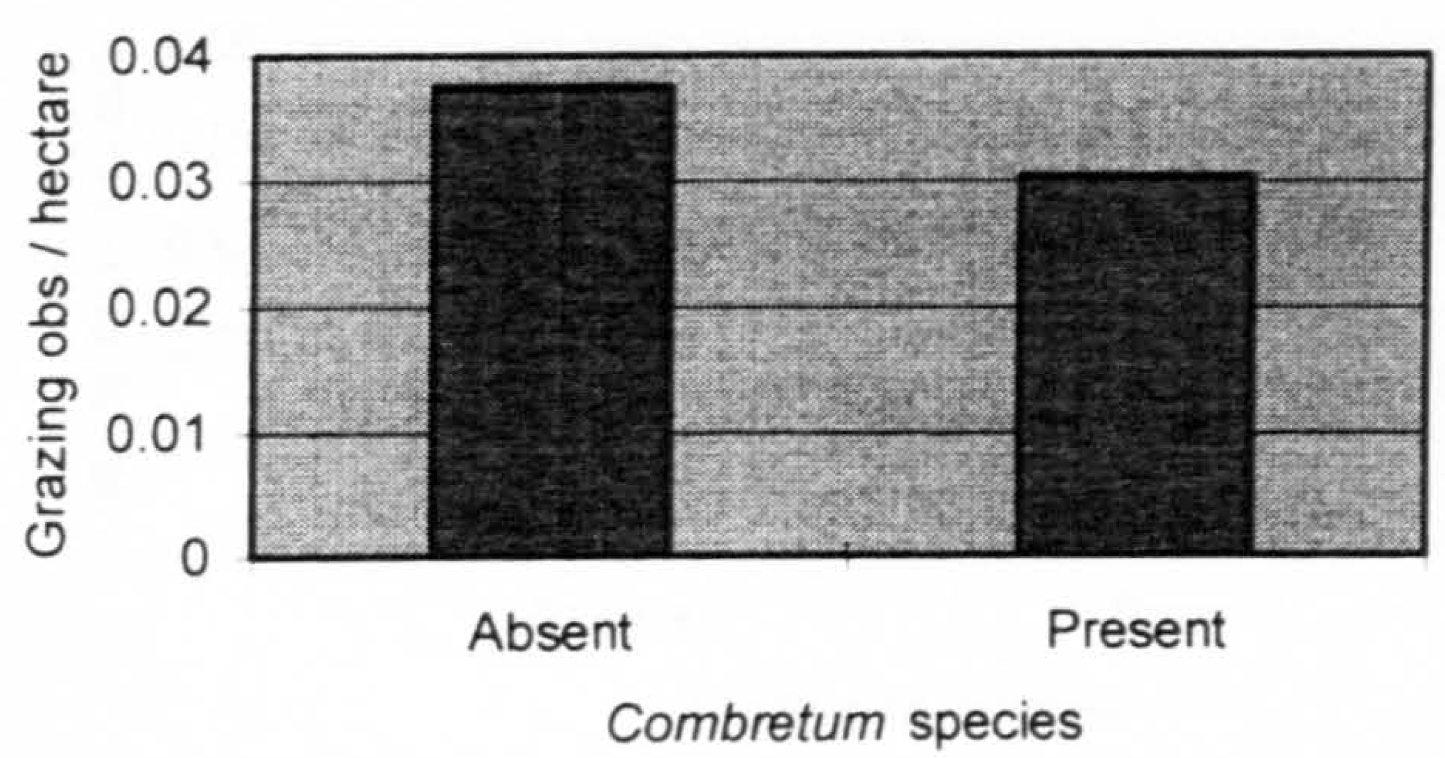
(a) Area Covered by Each Class



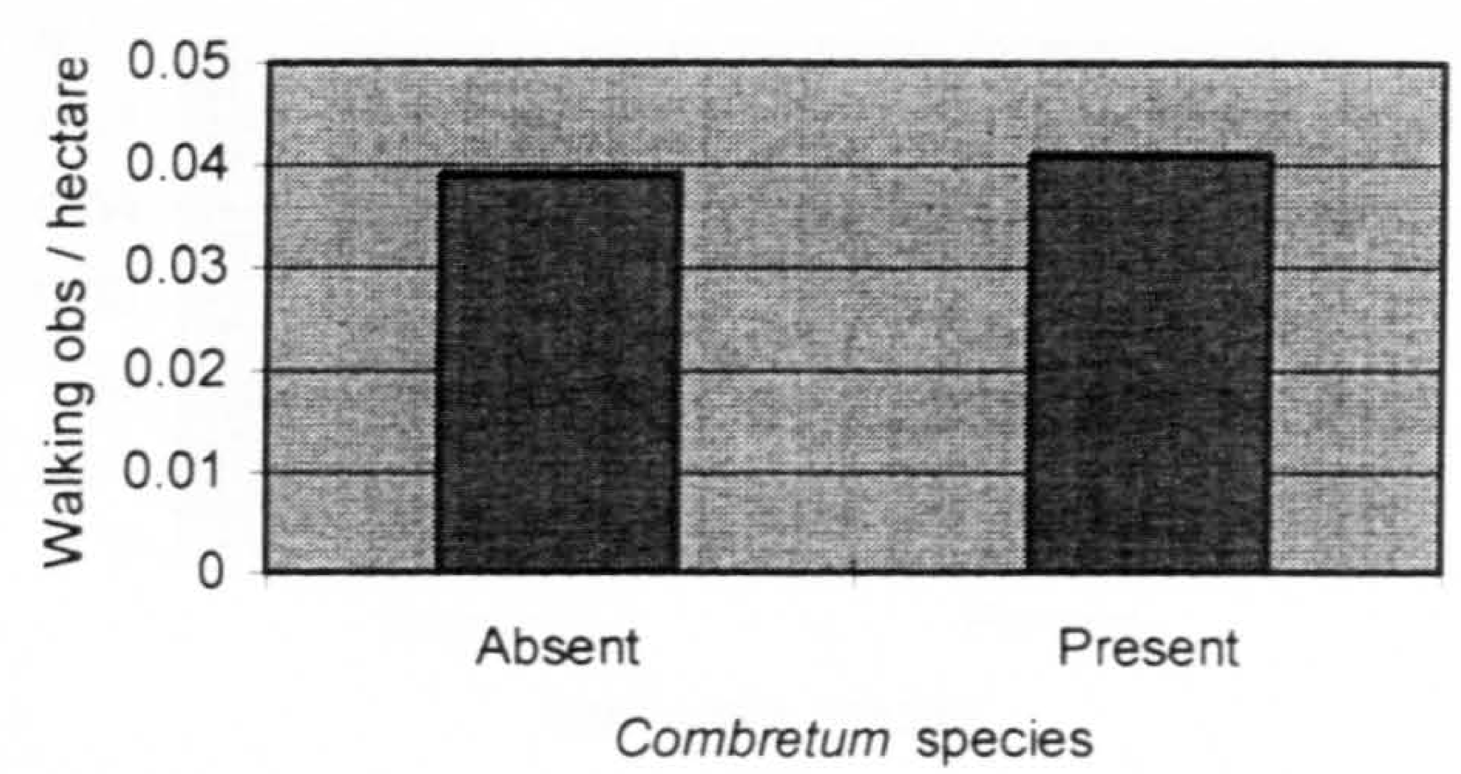
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class

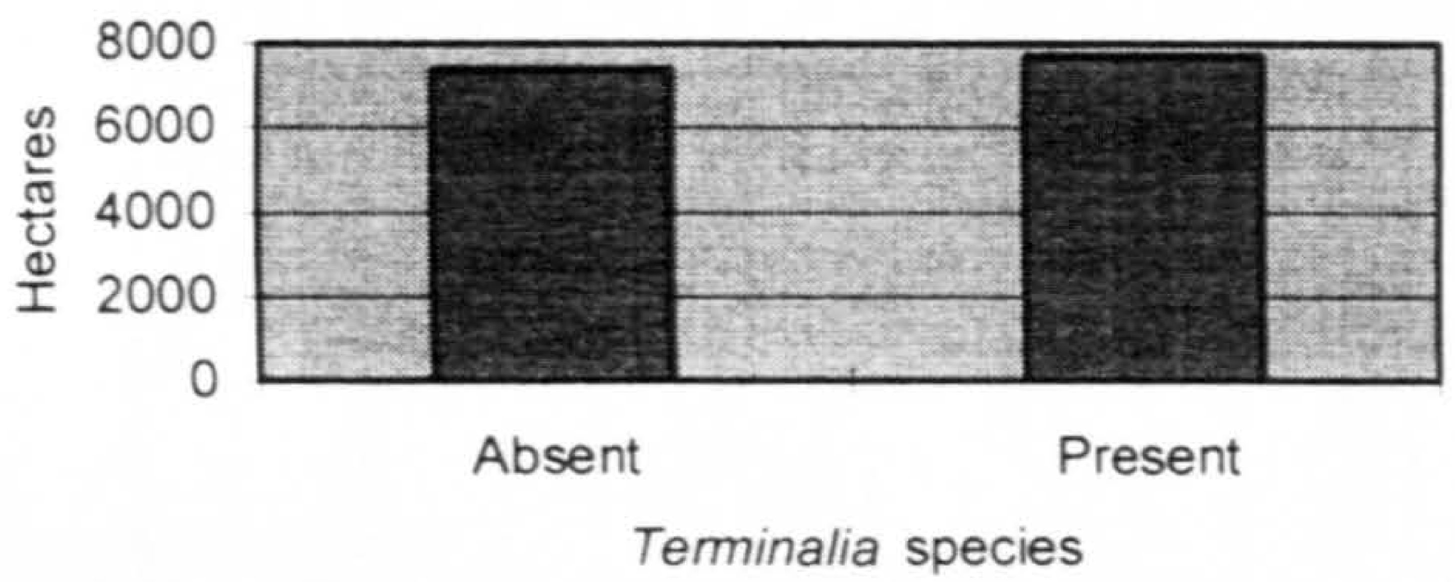


(d) Grazing Observations per Hectare in Each Class

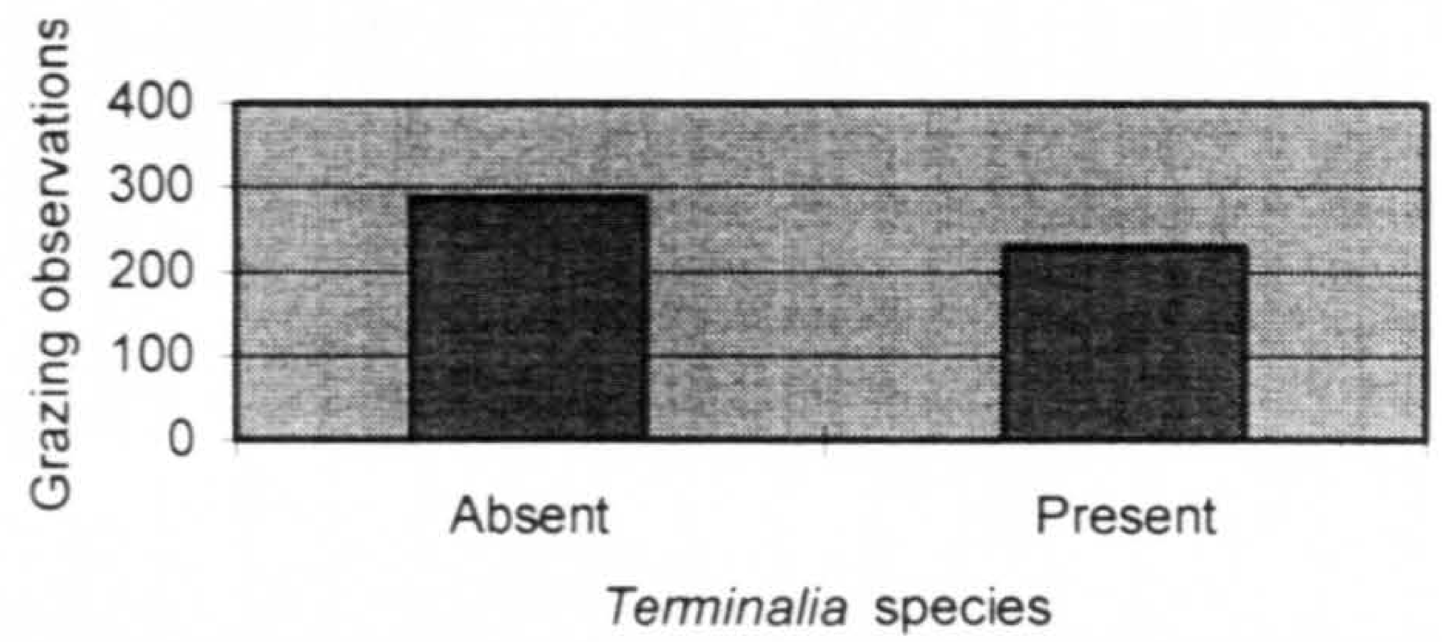


(e) Walking Observations per Hectare in Each Class

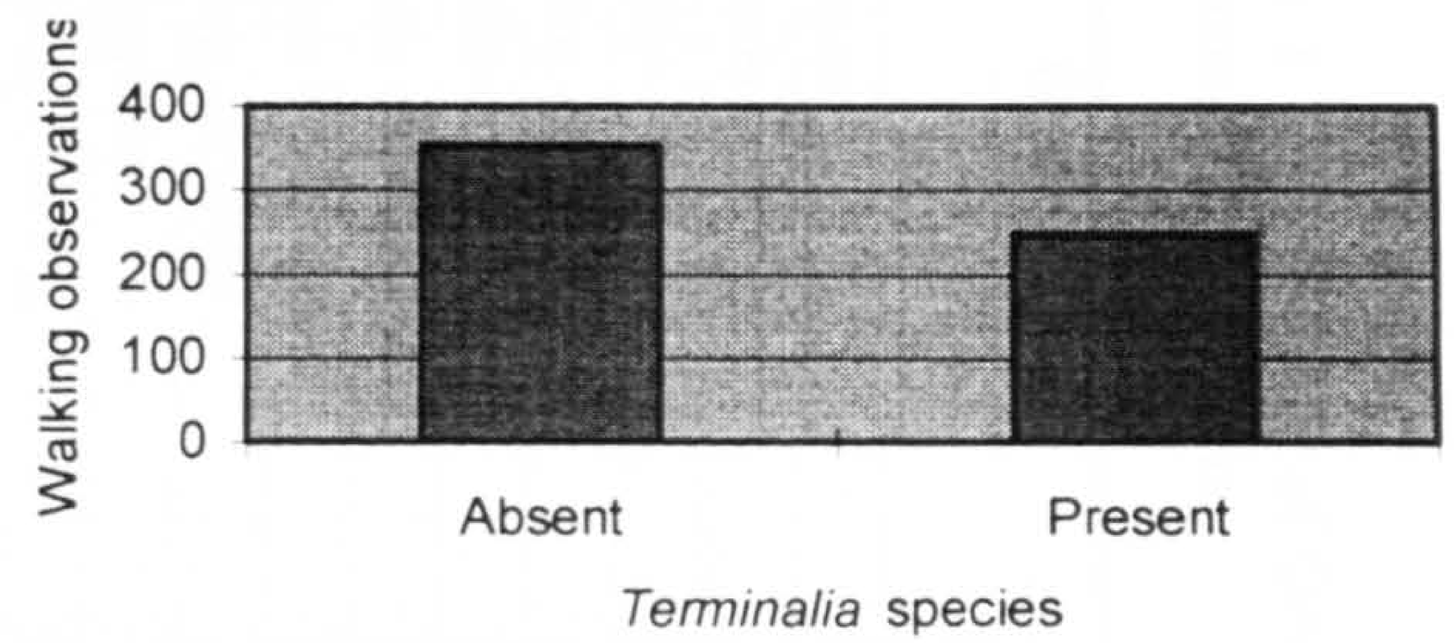
Fig. 32 Analysis of Utilisation of Areas with *Combretum* Species



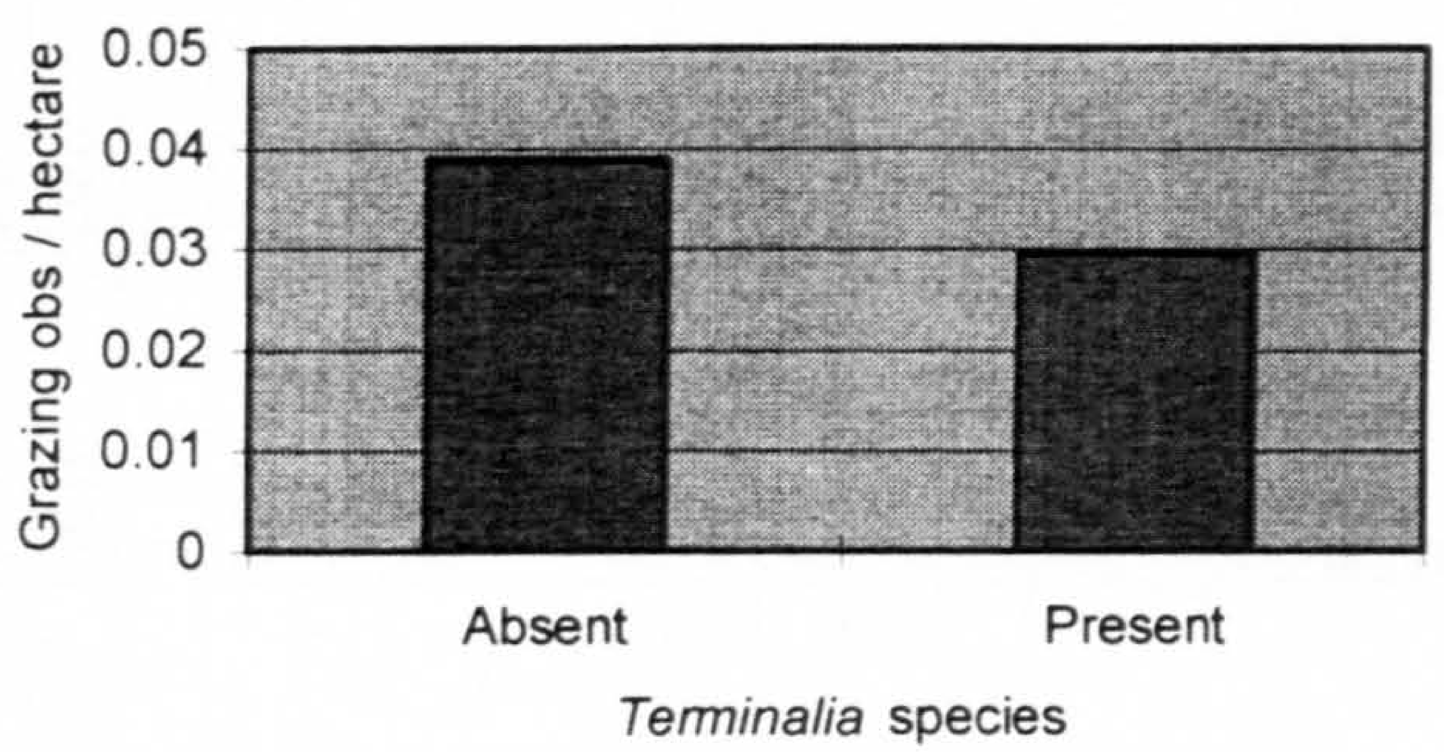
(a) Area Covered by Each Class



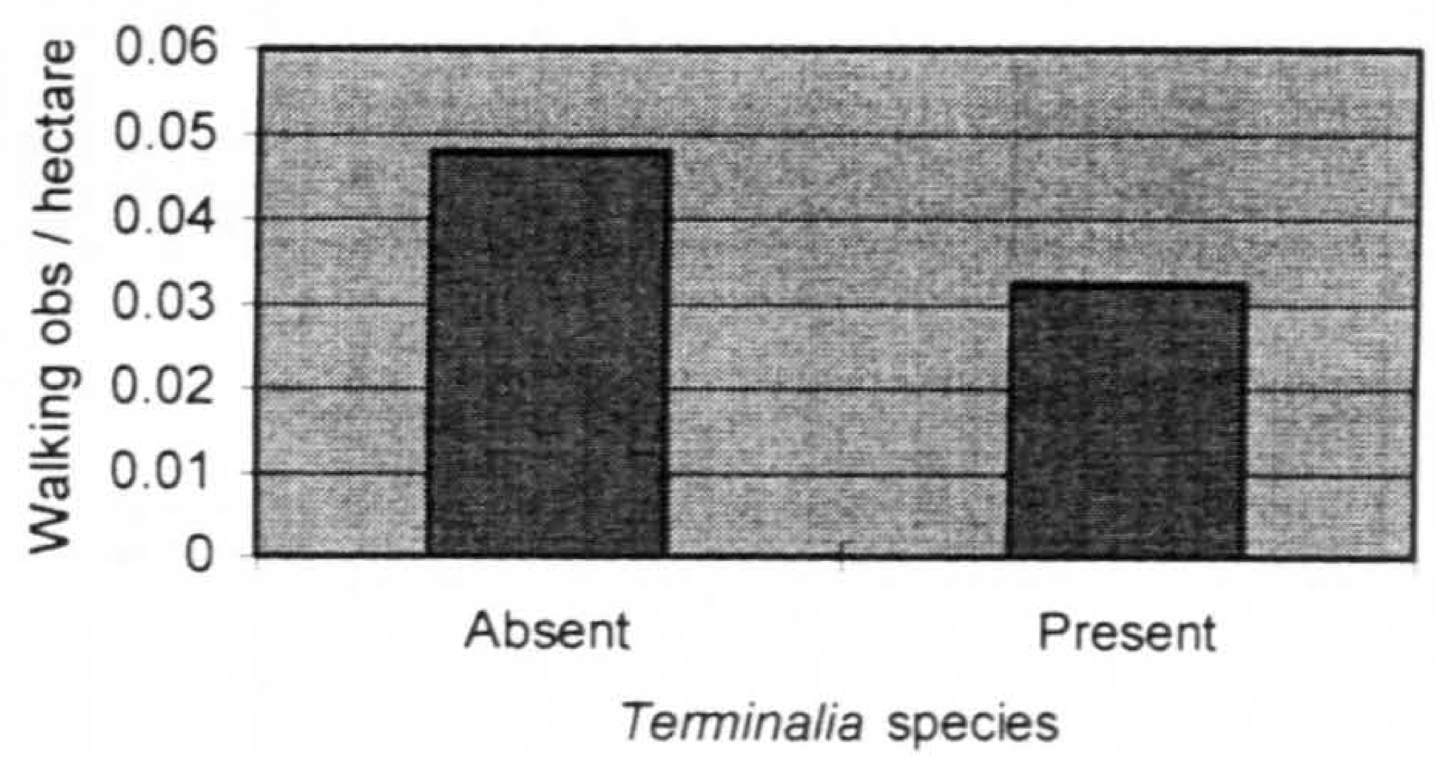
(b) Grazing Observations in Each Class



(c) Walking Observations in Each Class



(d) Grazing Observations per Hectare in Each Class



(e) Walking Observations per Hectare in Each Class

Fig. 33 Analysis of Utilisation of Areas with *Terminalia* Species

Table 1 Percentage of Grass Species (Calculated from Biomass) With Respect to Activity and the Herbaceous Layer Survey

Grass Species	Rhino Activity					Herbaceous Layer Survey
	Grazing	Gr/Wa	Wa/Gr	Walking	Other	
Anthephora pubescens	0.05	0	0	0.21	0	0.17
Anthephora schinzii	1.27	0	2.4	0.56	0	3.53
Annuals	7.05	0	8.85	5.68	0.95	0.00
Aristida adscensionis	0.72	3.44	1.05	3.37	9.76	5.69
Aristida congesta	0	0	0	0	0	0.01
Aristida meridionalis	0.3	0	0.1	0.17	0	0.56
Aristida rhinochloa	0.02	0	0	0.31	0	0.38
Aristida stipitata	0	0	0	0	0	0.02
Bare ground	0	0	0	0	0	1.26
Cenchrus ciliaris	4.74	1.15	2	2.16	0	0.36
Chloris virgata	0	0	0	0.04	0	0.02
Cynodon dactylon	0.18	0	0.5	0	0	0.00
Cyprus	0.49	0	1.35	0.63	0	0.02
Danthoniopsis dinteri	0	0	0	0	0	0.26
Enneapogon cenchroides	0.65	0	1.05	1.5	0.71	1.67
Enneapogon desvauxii	0.67	0	0.95	0.4	0	0.33
Eragrostis annulata	0.74	0	0.85	0.9	0	0.26
Eragrostis echinochloidea	1.78	0	1.5	0.98	0	0.06
Eragrostis lehmenniana	0.18	0	0.9	0.33	0	0.06
Eragrostis nindensis	6.49	7.16	7.8	5.66	6.43	13.88
Eragrostis porosa	4.07	6.88	5.35	6.37	2.86	3.29
Eragrostis rigidior	0.07	0	0	0	0	0.12
Eragrostis rotifer	0.99	1.43	0.2	0.65	0.71	1.81
Eragrostis superba	0.6	0	0.6	0.75	0	0.14
Eragrostis trichophora	0.14	0	0	0	0	0.00
Flowers	0.16	0	0	0.19	0	0.00
Forb annual	0.16	0.57	0.15	0.1	0	0.00
Fingerhuthia africana	0	0	0	0	0	0.06
Heteropogon contortus	0.09	0	0.5	0	0	0.01
Melinus repens	0.02	0	0	0	0.24	1.05
Michrocloa caffra	1.76	4.87	3.4	1.71	9.05	2.96
Monolytrum luederitzianum	0	0	0	0.21	0	0.01
Panicum coloratum	0.09	0	0	0	0	0.17
Panicum maximum	0.23	0	0	0.02	0	0.01
Pogonarthria fleckii	0.02	0	0.05	0.13	0	0.39
Schmidtia kalahariensis	42.39	43.55	29.86	27.65	27.62	30.99
Stipagrostis hirtigluma	0.23	0	0	0.44	0	0.19
Stipagrostis hochstetteriana	3.47	0	2.5	1.81	0	0.94
Stipagrostis namaquensis	0	0	0	0	0	0.01
Stipagrostis uniplumis	17.31	28.08	26.41	35.81	40.24	26.62
Tricholaena monachne	0.25	0	0.5	0.54	0	0.09
Triraphis ramosissima	0	0	0	0	0	0.95
Grazed beyond identification	1.98	2.87	0.65	0.58	0	1.08
Urochloa brachyura	0.62	0	0.5	0.13	1.43	0.58
Number Observations	439	36	200	520	42	25700

Table 2 Key to ANOVA Groups used in Herbaceous Species Analysis

ANOVA Class	Activity	Season
1	Grazing	January to April
2	Grazing/Walking	January to April
3	Walking/Grazing	January to April
4	Walking	January to April
5	Other	January to April
6	Grazing	May to August
7	Grazing/Walking	May to August
8	Walking/Grazing	May to August
9	Walking	May to August
10	Other	May to August
11	Grazing	September to December
12	Grazing/Walking	September to December
13	Walking/Grazing	September to December
14	Walking	September to December
15	Other	September to December

Table 3 ANOVA Analysis of *Schmidtia kalahariensis*

BIOMAS
by ACTIVITY
SEASON

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	14779.388	6	2463.231	13.779	.00
ACTIVITY	9244.169	4	2311.042	12.928	.000
SEASON	2936.713	2	1468.357	8.214	.000
2-Way Interactions	2436.709	8	304.589	1.704	.093
ACTIVITY SEASON	2436.709	8	304.589	1.704	.093
Explained	31252.704	14	2232.336	12.487	.00
Residual	210231.497	1176	178.768		
Total	241484.202	1190	202.928		

1191 cases were processed.
0 cases (.0 pct) were missing.

----- O N E W A Y -----

Variable BIOMAS
By Variable GROUP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	14	31252.7044	2232.3360	12.4873	.0000
Within Groups	1176	210231.4971	178.7683		
Total	1190	241484.2015			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	175	15.4342	20.5724	1.5551	12.3649	TO	18.5035
Grp 2	17	22.1297	14.8874	3.6107	14.4753	TO	29.7842
Grp 3	69	10.1760	16.0998	1.9382	6.3084	TO	14.0436
Grp 4	120	7.3140	12.5596	1.1465	5.0438	TO	9.5843
Grp 5	6	13.3845	19.5375	7.9761	-7.1185	TO	33.8875
Grp 6	218	14.8379	14.8566	1.0062	12.8547	TO	16.8211
Grp 7	13	5.4827	7.3837	2.0479	1.0208	TO	9.9446
Grp 8	93	7.9817	11.0455	1.1454	5.7069	TO	10.2565
Grp 9	316	3.6076	7.1726	.4035	2.8137	TO	4.4015
Grp10	28	6.3393	13.1511	2.4853	1.2398	TO	11.4388
Grp11	23	9.7663	17.9864	3.7504	1.9884	TO	17.5442
Grp12	4	12.2228	14.8348	7.4174	-11.3824	TO	35.8279
Grp13	29	4.8221	8.1794	1.5189	1.7108	TO	7.9334
Grp14	74	3.2981	7.7969	.9064	1.4918	TO	5.1045
Grp15	6	.0000	.0000	.0000	.0000	TO	.0000
Total	1191	9.0348	14.2453	.4128	8.2250	TO	9.8447

GROUP	MINIMUM	MAXIMUM
Grp 1	.0000	62.8319
Grp 2	.0000	43.9823
Grp 3	.0000	62.8319
Grp 4	.0000	62.8319
Grp 5	.0000	50.2655
Grp 6	.0000	62.8319
Grp 7	.0000	26.7035
Grp 8	.0000	33.3794
Grp 9	.0000	33.3794
Grp10	.0000	62.8319
Grp11	.0000	62.8319
Grp12	.0000	30.0415
Grp13	.0000	26.7035
Grp14	.0000	33.3794
Grp15	.0000	.0000
TOTAL	.0000	62.8319

```
Levene Test for Homogeneity of Variances

    Statistic    df1    df2      2-tail Sig.
     32.4826     14     1176        .000

- - - - -  O N E W A Y  - - - - -


      Variable  BIOMAS
   By Variable  GROUP

Multiple Range Tests:  Tukey-HSD test with significance level .050

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 9.4543 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 4.80

   (*) Indicates significant differences which are shown in the lower triangle

                          G G G G G G G G G G G G G G G
                          r r r r r r r r r r r r r r r
                          p p p p p p p p p p p p p p p
                          1 1   1   1     1   1
                          5 4 9 3 7 0 4 8 1 3 2 5 6 1 2
    Mean      GROUP

     .0000    Grp15
    3.2981    Grp14
    3.6076    Grp 9
    4.8221    Grp13
    5.4827    Grp 7
    6.3393    Grp10
    7.3140    Grp 4
    7.9817    Grp 8
    9.7663    Grp11
   10.1760    Grp 3           *
   12.2228    Grp12
   13.3845    Grp 5
   14.8379    Grp 6         * * *     * *
   15.4342    Grp 1         * * *     * *
   22.1297    Grp 2       * * * *   * * *
```

```
                    - - - - -  O N E W A Y  - - - - -

      Variable  BIOMAS
   By Variable  GROUP

Multiple Range Tests:  Scheffe test with significance level .05

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 9.4543 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 6.90

   (*) Indicates significant differences which are shown in the lower triangle

                          G G G G G G G G G G G G G G G
                          r r r r r r r r r r r r r r r
                          p p p p p p p p p p p p p p p
                          1 1   1   1     1   1
                          5 4 9 3 7 0 4 8 1 3 2 5 6 1 2
    Mean      GROUP

     .0000    Grp15
    3.2981    Grp14
    3.6076    Grp 9
    4.8221    Grp13
    5.4827    Grp 7
    6.3393    Grp10
    7.3140    Grp 4
    7.9817    Grp 8
    9.7663    Grp11
   10.1760    Grp 3
   12.2228    Grp12
   13.3845    Grp 5
   14.8379    Grp 6         * *       *
   15.4342    Grp 1         * *       *
   22.1297    Grp 2         * *
```

Table 4 ANOVA Analysis of *Stipagrostis uniplumis*

```
            BIOMASS
       by   ACTIVITY
            SEASON
```

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	1293.537	6	215.590	1.023	.408
ACTIVITY	1051.543	4	262.886	1.248	.289
SEASON	462.163	2	231.082	1.097	.334
2-Way Interactions	1566.932	8	195.867	.930	.491
ACTIVITY SEASON	1566.932	8	195.867	.930	.491
Explained	5859.576	14	418.541	1.987	.016
Residual	247715.599	1176	210.643		
Total	253575.175	1190	213.088		

1191 cases were processed.
0 cases (.0 pct) were missing.

----- O N E W A Y -----

Variable BIOMASS
By Variable GROUP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	14	5859.5760	418.5411	1.9870	.0159
Within Groups	1176	247715.5992	210.6425		
Total	1190	253575.1752			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	175	6.7937	14.2053	1.0738	4.6743	TO	8.9131
Grp 2	17	14.1372	21.0981	5.1170	3.2895	TO	24.9848
Grp 3	69	5.3128	11.3464	1.3659	2.5871	TO	8.0385
Grp 4	120	7.3271	12.8913	1.1768	4.9969	TO	9.6573
Grp 5	6	11.7155	20.5144	8.3750	-9.8127	TO	33.2437
Grp 6	218	6.6948	12.2350	.8287	5.0616	TO	8.3280
Grp 7	13	12.1586	21.6955	6.0173	-.9519	TO	25.2691
Grp 8	93	11.8580	18.8028	1.9498	7.9856	TO	15.7304
Grp 9	316	9.3421	14.6076	.8217	7.7253	TO	10.9589
Grp10	28	7.8435	12.5224	2.3665	2.9878	TO	12.6991
Grp11	23	10.6370	15.6375	3.2606	3.8749	TO	17.3992
Grp12	4	18.5059	17.8375	8.9187	-9.8771	TO	46.8890
Grp13	29	11.1445	15.9466	2.9612	5.0787	TO	17.2103
Grp14	74	12.1458	15.7631	1.8324	8.4938	TO	15.7978
Grp15	6	10.8319	15.1484	6.1843	-5.0651	TO	26.7290
Total	1191	8.6004	14.5975	.4230	7.7705	TO	9.4303

GROUP	MINIMUM	MAXIMUM
Grp 1	.0000	83.2522
Grp 2	.0000	62.8319
Grp 3	.0000	52.0326
Grp 4	.0000	50.2655
Grp 5	.0000	50.2655
Grp 6	.0000	62.8319
Grp 7	.0000	56.5487
Grp 8	.0000	104.0653
Grp 9	.0000	62.8319
Grp10	.0000	33.3794
Grp11	.0000	50.2655
Grp12	3.3379	43.9823
Grp13	.0000	62.8319
Grp14	.0000	62.8319
Grp15	.0000	33.3794
TOTAL	.0000	104.0653

```
Levene Test for Homogeneity of Variances

    Statistic     df1     df2       2-tail Sig.
      4.2571      14      1176         .000

                    - - - - -  O N E W A Y  - - - - -

      Variable  BIOMASS
   By Variable  GROUP

Multiple Range Tests:  Tukey-HSD test with significance level .050

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 10.2626 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 4.80

- No two groups are significantly different at the  .050 level

                    - - - - -  O N E W A Y  - - - - -

      Variable  BIOMASS
   By Variable  GROUP

Multiple Range Tests:  Scheffe test with significance level .05

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 10.2626 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 6.90

- No two groups are significantly different at the  .050 level
```

Table 5 ANOVA Analysis of *Eragrostis nindensis*

BIOMASS
by ACTIVITY
SEASON

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	476.161	6	79.360	2.348	.029
ACTIVITY	267.669	4	66.917	1.980	.095
SEASON	237.161	2	118.580	3.509	.030
2-Way Interactions	492.154	8	61.519	1.820	.069
ACTIVITY SEASON	492.154	8	61.519	1.820	.069
Explained	1287.015	14	91.930	2.720	.001
Residual	39745.264	1176	33.797		
Total	41032.279	1190	34.481		

1191 cases were processed.
0 cases (.0 pct) were missing.

----- O N E W A Y -----

Variable BIOMASS
By Variable GROUP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	14	1287.0150	91.9296	2.7201	.0006
Within Groups	1176	39745.2637	33.7970		
Total	1190	41032.2787			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	175	2.6406	7.2350	.5469	1.5612	TO	3.7201
Grp 2	17	.0000	.0000	.0000	.0000	TO	.0000
Grp 3	69	2.4501	8.1018	.9753	.5038	TO	4.3964
Grp 4	120	2.6638	7.4056	.6760	1.3252	TO	4.0024
Grp 5	6	2.2253	5.4508	2.2253	-3.4949	TO	7.9455
Grp 6	218	1.2551	5.0610	.3428	.5795	TO	1.9307
Grp 7	13	1.7671	5.5467	1.5384	-1.5847	TO	5.1190
Grp 8	93	1.1950	4.1363	.4289	.3431	TO	2.0468
Grp 9	316	.6601	2.7710	.1559	.3534	TO	.9668
Grp10	28	1.4200	4.4175	.8348	-.2929	TO	3.1330
Grp11	23	5.0795	14.3891	3.0003	-1.1428	TO	11.3018
Grp12	4	9.1793	10.6866	5.3433	-7.8252	TO	26.1839
Grp13	29	2.4916	6.6874	1.2418	-.0522	TO	5.0354
Grp14	74	1.7592	6.3049	.7329	.2985	TO	3.2199
Grp15	6	.0000	.0000	.0000	.0000	TO	.0000
Total	1191	1.6593	5.8720	.1702	1.3255	TO	1.9931

GROUP	MINIMUM	MAXIMUM
Grp 1	.0000	37.6991
Grp 2	.0000	.0000
Grp 3	.0000	43.9823
Grp 4	.0000	33.3794
Grp 5	.0000	13.3518
Grp 6	.0000	33.3794
Grp 7	.0000	20.0277
Grp 8	.0000	26.7035
Grp 9	.0000	26.7035
Grp10	.0000	16.6897
Grp11	.0000	62.8319
Grp12	.0000	20.0277
Grp13	.0000	33.3794
Grp14	.0000	33.3794
Grp15	.0000	.0000
TOTAL	.0000	62.8319

```
Levene Test for Homogeneity of Variances

    Statistic    df1    df2        2-tail Sig.
      9.2537     14     1176         .000

- - - - -  O N E W A Y  - - - - -


      Variable  BIOMASS
   By Variable  GROUP

Multiple Range Tests:  Tukey-HSD test with significance level .050

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 4.1108 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 4.80

   (*) Indicates significant differences which are shown in the lower triangle

                            G G G G G G G G G G G G G G G
                            r r r r r r r r r r r r r r r
                            p p p p p p p p p p p p p p p
                              1       1 1       1     1 1
                            2 5 9 8 6 0 4 7 5 3 3 1 4 1 2
     Mean      GROUP

      .0000    Grp 2
      .0000    Grp15
      .6601    Grp 9
     1.1950    Grp 8
     1.2551    Grp 6
     1.4200    Grp10
     1.7592    Grp14
     1.7671    Grp 7
     2.2253    Grp 5
     2.4501    Grp 3
     2.4916    Grp13
     2.6406    Grp 1      *
     2.6638    Grp 4
     5.0795    Grp11      *
     9.1793    Grp12

                       - - - - -  O N E W A Y  - - - - -


      Variable  BIOMASS
   By Variable  GROUP

Multiple Range Tests:  Scheffe test with significance level .05

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 4.1108 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 6.90

- No two groups are significantly different at the  .050 level
```

Table 6 ANOVA Analysis of *Eragrostis porosa*

* * * A N A L Y S I S   O F   V A R I A N C E * * *

BIOMASS
by ACTIVITY
SEASON

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	496.029	6	82.671	2.927	.008
ACTIVITY	20.281	4	5.070	.180	.949
SEASON	433.512	2	216.756	7.674	.000
2-Way Interactions	166.863	8	20.858	.738	.658
ACTIVITY SEASON	166.863	8	20.858	.738	.658
Explained	1569.573	14	112.112	3.969	.000
Residual	33216.925	1176	28.246		
Total	34786.498	1190	29.232		

1191 cases were processed.
0 cases (.0 pct) were missing.

\- - - - - O N E W A Y - - - - -

Variable BIOMASS
By Variable GROUP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	14	1569.5730	112.1124	3.9692	.0000
Within Groups	1176	33216.9247	28.2457		
Total	1190	34786.4976			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
15.5862	14	1176	.000

```
                    - - - - -  O N E W A Y  - - - - -


      Variable  BIOMASS
   By Variable  GROUP

Multiple Range Tests:  Tukey-HSD test with significance level .050

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 3.7580 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 4.80

   (*) Indicates significant differences which are shown in the lower triangle

                          G G G G G G G G G G G G G G G
                          r r r r r r r r r r r r r r r
                          p p p p p p p p p p p p p p p
                          1 1 1 1 1     1
                          1 2 5 3 4 9 7 0 6 8 1 5 2 4 3
     Mean      GROUP

      .0000    Grp11
      .0000    Grp12
      .0000    Grp15
      .0054    Grp13
      .3967    Grp14
      .4971    Grp 9
      .5286    Grp 7
      .8345    Grp10
     1.0619    Grp 6
     1.1602    Grp 8
     2.2979    Grp 1                *
     2.7816    Grp 5
     3.3495    Grp 2
     3.5097    Grp 4              * *     *
     3.5428    Grp 3              * *
```

```
                    - - - - -  O N E W A Y  - - - - -


      Variable  BIOMASS
   By Variable  GROUP

Multiple Range Tests:  Scheffe test with significance level .05

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 3.7580 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 6.90

   (*) Indicates significant differences which are shown in the lower triangle

                          G G G G G G G G G G G G G G G
                          r r r r r r r r r r r r r r r
                          p p p p p p p p p p p p p p p
                          1 1 1 1 1     1
                          1 2 5 3 4 9 7 0 6 8 1 5 2 4 3
     Mean      GROUP

      .0000    Grp11
      .0000    Grp12
      .0000    Grp15
      .0054    Grp13
      .3967    Grp14
      .4971    Grp 9
      .5286    Grp 7
      .8345    Grp10
     1.0619    Grp 6
     1.1602    Grp 8
     2.2979    Grp 1
     2.7816    Grp 5
     3.3495    Grp 2
     3.5097    Grp 4                *
     3.5428    Grp 3
```

Table 7 ANOVA Analysis of Annual Species

```
            BIOMASS
       by   ACTIVITY
            SEASON
```

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	2402.147	6	400.358	7.003	.000
ACTIVITY	306.224	4	76.556	1.339	.253
SEASON	1862.781	2	931.390	16.292	.000
2-Way Interactions	869.227	8	108.653	1.901	.056
ACTIVITY SEASON	869.227	8	108.653	1.901	.056
Explained	12719.381	14	908.527	15.892	.00
Residual	67232.020	1176	57.170		
Total	79951.401	1190	67.186		

1191 cases were processed.
0 cases (.0 pct) were missing.

- - - - - O N E W A Y - - - - -

```
     Variable   BIOMASS
  By Variable   GROUP
```

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	14	12719.3809	908.5272	15.8917	.0000
Within Groups	1176	67232.0199	57.1701		
Total	1190	79951.4008			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	175	7.0456	14.3759	1.0867	4.9007	TO	9.1904
Grp 2	17	.0000	.0000	.0000	.0000	TO	.0000
Grp 3	69	9.2455	15.3774	1.8512	5.5514	TO	12.9396
Grp 4	120	5.3538	11.2204	1.0243	3.3256	TO	7.3820
Grp 5	6	4.1888	6.4892	2.6492	-2.6212	TO	10.9987
Grp 6	218	.0000	.0000	.0000	.0000	TO	.0000
Grp 7	13	.0000	.0000	.0000	.0000	TO	.0000
Grp 8	93	.0000	.0000	.0000	.0000	TO	.0000
Grp 9	316	.0000	.0000	.0000	.0000	TO	.0000
Grp10	28	.0000	.0000	.0000	.0000	TO	.0000
Grp11	23	.0000	.0000	.0000	.0000	TO	.0000
Grp12	4	.0000	.0000	.0000	.0000	TO	.0000
Grp13	29	.0000	.0000	.0000	.0000	TO	.0000
Grp14	74	.0000	.0000	.0000	.0000	TO	.0000
Grp15	6	.0000	.0000	.0000	.0000	TO	.0000
Total	1191	2.1314	8.1967	.2375	1.6654	TO	2.5974

GROUP	MINIMUM	MAXIMUM
Grp 1	.0000	62.8319
Grp 2	.0000	.0000
Grp 3	.0000	50.2655
Grp 4	.0000	33.3794
Grp 5	.0000	12.5664
Grp 6	.0000	.0000
Grp 7	.0000	.0000
Grp 8	.0000	.0000
Grp 9	.0000	.0000
Grp10	.0000	.0000
Grp11	.0000	.0000
Grp12	.0000	.0000
Grp13	.0000	.0000
Grp14	.0000	.0000
Grp15	.0000	.0000
TOTAL	.0000	62.8319

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
84.8594	14	1176	.000

----- O N E W A Y -----

Variable BIOMASS
By Variable GROUP

Multiple Range Tests: Tukey-HSD test with significance level .050

The difference between two means is significant if
MEAN(J)-MEAN(I) >= 5.3465 * RANGE * SQRT(1/N(I) + 1/N(J))
with the following value(s) for RANGE: 4.80

(*) Indicates significant differences which are shown in the lower triangle

Mean	GROUP	Grp 2	Grp 6	Grp 7	Grp 8	Grp 9	Grp 10	Grp 11	Grp 12	Grp 13	Grp 14	Grp 15	Grp 5	Grp 4	Grp 1	Grp 3
.0000	Grp 2															
.0000	Grp 6															
.0000	Grp 7															
.0000	Grp 8															
.0000	Grp 9															
.0000	Grp10															
.0000	Grp11															
.0000	Grp12															
.0000	Grp13															
.0000	Grp14															
.0000	Grp15															
4.1888	Grp 5															
5.3538	Grp 4		*		*	*				*	*					
7.0456	Grp 1	*	*		*	*	*	*		*	*					
9.2455	Grp 3	*	*	*	*	*	*	*		*	*			*		

----- O N E W A Y -----

Variable BIOMASS
By Variable GROUP

Multiple Range Tests: Scheffe test with significance level .05

The difference between two means is significant if
MEAN(J)-MEAN(I) >= 5.3465 * RANGE * SQRT(1/N(I) + 1/N(J))
with the following value(s) for RANGE: 6.90

(*) Indicates significant differences which are shown in the lower triangle

Mean	GROUP	Grp 2	Grp 6	Grp 7	Grp 8	Grp 9	Grp 10	Grp 11	Grp 12	Grp 13	Grp 14	Grp 15	Grp 5	Grp 4	Grp 1	Grp 3
.0000	Grp 2															
.0000	Grp 6															
.0000	Grp 7															
.0000	Grp 8															
.0000	Grp 9															
.0000	Grp10															
.0000	Grp11															
.0000	Grp12															
.0000	Grp13															
.0000	Grp14															
.0000	Grp15															
4.1888	Grp 5															
5.3538	Grp 4		*		*	*										
7.0456	Grp 1		*		*	*					*					
9.2455	Grp 3		*		*	*	*	*		*	*					

Table 8 ANOVA Analysis of *Aristida adscensionis*

BIOMASS
by ACTIVITY
SEASON

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	35.435	6	5.906	.917	.481
ACTIVITY	30.703	4	7.676	1.192	.312
SEASON	3.699	2	1.850	.287	.750
2-Way Interactions	104.017	8	13.002	2.020	.041
ACTIVITY SEASON	104.017	8	13.002	2.020	.041
Explained	211.845	14	15.132	2.351	.003
Residual	7570.475	1176	6.437		
Total	7782.321	1190	6.540		

1191 cases were processed.
0 cases (.0 pct) were missing.

- - - - - O N E W A Y - - - - -

Variable BIOMASS
By Variable GROUP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	14	211.8453	15.1318	2.3506	.0033
Within Groups	1176	7570.4754	6.4375		
Total	1190	7782.3207			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	175	.2177	1.7771	.1343	-.0475	TO	.4828
Grp 2	17	2.8066	9.3126	2.2586	-1.9814	TO	7.5947
Grp 3	69	.6488	3.1212	.3757	-.1010	TO	1.3986
Grp 4	120	.2782	2.1888	.1998	-.1175	TO	.6738
Grp 5	6	.0000	.0000	.0000	.0000	TO	.0000
Grp 6	218	.2472	1.7153	.1162	.0183	TO	.4762
Grp 7	13	.1133	.4084	.1133	-.1335	TO	.3601
Grp 8	93	.0992	.7166	.0743	-.0483	TO	.2468
Grp 9	316	.5260	2.3895	.1344	.2615	TO	.7905
Grp10	28	1.9705	6.4086	1.2111	-.5145	TO	4.4555
Grp11	23	.0000	.0000	.0000	.0000	TO	.0000
Grp12	4	.0000	.0000	.0000	.0000	TO	.0000
Grp13	29	.5755	3.0992	.5755	-.6034	TO	1.7544
Grp14	74	.6241	2.6195	.3045	.0172	TO	1.2310
Grp15	6	1.2763	2.6742	1.0918	-1.5301	TO	4.0827
Total	1191	.4370	2.5573	.0741	.2916	TO	.5824

GROUP	MINIMUM	MAXIMUM
Grp 1	.0000	18.8496
Grp 2	.0000	37.6991
Grp 3	.0000	18.8496
Grp 4	.0000	20.0277
Grp 5	.0000	.0000
Grp 6	.0000	20.8131
Grp 7	.0000	1.4726
Grp 8	.0000	6.2832
Grp 9	.0000	23.3656
Grp10	.0000	33.3794
Grp11	.0000	.0000
Grp12	.0000	.0000
Grp13	.0000	16.6897
Grp14	.0000	16.6897
Grp15	.0000	6.6759
TOTAL	.0000	37.6991

```
Levene Test for Homogeneity of Variances

    Statistic     df1    df2       2-tail Sig.
      8.0496      14     1176        .000
```

```
                     - - - - -  O N E W A Y  - - - - -


      Variable  BIOMASS
   By Variable  GROUP

Multiple Range Tests:  Tukey-HSD test with significance level .050

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 1.7941 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 4.80

   (*) Indicates significant differences which are shown in the lower triangle

                         G G G G G G G G G G G G G G G
                         r r r r r r r r r r r r r r r
                         p p p p p p p p p p p p p p p
                           1 1               1 1   1 1
                         5 1 2 8 7 1 6 4 9 3 4 3 5 0 2
     Mean      GROUP

      .0000    Grp 5
      .0000    Grp11
      .0000    Grp12
      .0992    Grp 8
      .1133    Grp 7
      .2177    Grp 1
      .2472    Grp 6
      .2782    Grp 4
      .5260    Grp 9
      .5755    Grp13
      .6241    Grp14
      .6488    Grp 3
     1.2763    Grp15
     1.9705    Grp10       *   *
     2.8066    Grp 2     *   *   * * * *
```

```
                     - - - - -  O N E W A Y  - - - - -


      Variable  BIOMASS
   By Variable  GROUP

Multiple Range Tests:  Scheffe test with significance level .05

The difference between two means is significant if
  MEAN(J)-MEAN(I)  >= 1.7941 * RANGE * SQRT(1/N(I) + 1/N(J))
  with the following value(s) for RANGE: 6.90

- No two groups are significantly different at the  .050 level
```

Table 9 ANOVA Analysis of *Cenchrus ciliaris*

```
            BIOMASS
        by  ACTIVITY
            SEASON
```

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	505.222	6	84.204	1.134	.340
ACTIVITY	489.494	4	122.373	1.648	.160
SEASON	30.515	2	15.257	.205	.814
2-Way Interactions	183.350	8	22.919	.309	.963
ACTIVITY SEASON	183.350	8	22.919	.309	.963
Explained	1173.325	14	83.809	1.129	.327
Residual	87312.648	1176	74.245		
Total	88485.974	1190	74.358		

1191 cases were processed.
0 cases (.0 pct) were missing.

- - - - - O N E W A Y - - - - -

```
   Variable  BIOMASS
By Variable  GROUP
```

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	14	1173.3255	83.8090	1.1288	.3271
Within Groups	1176	87312.6482	74.2454		
Total	1190	88485.9737			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	175	2.6546	10.3651	.7835	1.1082	TO	4.2011
Grp 2	17	.0000	.0000	.0000	.0000	TO	.0000
Grp 3	69	.0000	.0000	.0000	.0000	TO	.0000
Grp 4	120	.6480	4.6105	.4209	-.1854	TO	1.4813
Grp 5	6	.0000	.0000	.0000	.0000	TO	.0000
Grp 6	218	2.6498	10.8014	.7316	1.2079	TO	4.0917
Grp 7	13	.1510	.5446	.1510	-.1780	TO	.4801
Grp 8	93	2.4153	15.2366	1.5800	-.7226	TO	5.5533
Grp 9	316	1.2769	7.2650	.4087	.4728	TO	2.0810
Grp10	28	.0000	.0000	.0000	.0000	TO	.0000
Grp11	23	2.5269	8.4023	1.7520	-1.1065	TO	6.1604
Grp12	4	.0000	.0000	.0000	.0000	TO	.0000
Grp13	29	1.1510	6.1984	1.1510	-1.2067	TO	3.5088
Grp14	74	.1698	1.4608	.1698	-.1686	TO	.5083
Grp15	6	.0000	.0000	.0000	.0000	TO	.0000
Total	1191	1.5568	8.6231	.2499	1.0666	TO	2.0470

GROUP	MINIMUM	MAXIMUM
Grp 1	.0000	62.4392
Grp 2	.0000	.0000
Grp 3	.0000	.0000
Grp 4	.0000	37.6991
Grp 5	.0000	.0000
Grp 6	.0000	72.8457
Grp 7	.0000	1.9635
Grp 8	.0000	104.0653
Grp 9	.0000	62.8319
Grp10	.0000	.0000
Grp11	.0000	31.4159
Grp12	.0000	.0000
Grp13	.0000	33.3794
Grp14	.0000	12.5664
Grp15	.0000	.0000
TOTAL	.0000	104.0653

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
4.6691	14	1176	.000

----- O N E W A Y -----

Variable BIOMASS
By Variable GROUP

Multiple Range Tests: Tukey-HSD test with significance level .050

The difference between two means is significant if
MEAN(J)-MEAN(I) >= 6.0928 * RANGE * SQRT(1/N(I) + 1/N(J))
with the following value(s) for RANGE: 4.80

- No two groups are significantly different at the .050 level

----- O N E W A Y -----

Variable BIOMASS
By Variable GROUP

Multiple Range Tests: Scheffe test with significance level .05

The difference between two means is significant if
MEAN(J)-MEAN(I) >= 6.0928 * RANGE * SQRT(1/N(I) + 1/N(J))
with the following value(s) for RANGE: 6.90

- No two groups are significantly different at the .050 level

Appendix VIII

Information Booklet - White Rhinos as Game Ranch Animals in Namibia

Information Booklet

White Rhinos As Game Ranch Animals In Namibia

Information compiled by Vicky Myers

1997

This booklet has been produced to describe the current status the white rhino in Namibia and to provide guidance to owners of game farms considering the introduction of white rhinos. The first section describes the requirements of the species in relation to the natural habitat in Namibia. This is followed by a compilation of practical information and data from a conference on 'Rhinos as Game Ranch Animals', scientific research papers and information from various organisations.

The paper provides comprehensive information on many aspects of buying, owning and managing the species, but does not contain detailed information on drugs, capture or holding prior to transportation. This is because it has been assumed that the individuals or organisations carrying out these activities will be aware of how to carry them out competently and efficiently.

It should be noted that this information is specific to white rhinos and should not be applied to black rhinos which are different in many ways.

White Rhino Data

Weight :-	Males Females	2,000-2,300kg approx. 1,600kg
Shoulder height	Adult male	1.8m
Sexual maturity :-	Males Females	8 - 10 years 6 - 8 years
Oestrus cycle		27 - 44 days
Gestation period		16 - 18 months
Calving interval		2 - 4 years
Suckling period		12 - 18 months
Maximum age		40 years

* Data from Owen-Smith (1988).

Introduction Record

Since 1971, 103 white rhinos have been introduced to twelve properties in Namibia. In 1997, 69 animals remained on eight properties. This decline in numbers was mainly due to the over-utilisation and mismanagement in the 1970's and 1980's, with deaths attributable to hunting, poaching and drought. At present the situation is improving; in 1996-7 all introduced groups which contained reproductively viable individuals showed successful recruitment. White rhinos, if managed correctly, can be a profitable investment and easily sustainably utilised.

Purchasing Animals

Sales of live animals occasionally take place in Namibia. In 1995, white rhinos from Otjiwa Game Ranch fetched an average of N$50,000 a head (A. Bonthuyes, personal communication).

Prices at the Natal Game Auction (NGA) have fluctuated dramatically over the last few years as illustrated in the following table (updated in 1998):

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
NGA Price - (Rand)	50,172	43,800	26,450	27,400	32,767	48,063	43,700	82,051	116,311

If buying from NGA, transportation costs of approximately N$9 per km should be allowed for. Rhinos may be moved in single crates or transported in a compartmentalised crate accommodating up to six animals.

In addition to South African export documentation, it is necessary to have an import permit which is issued by Ministry of Environment and Tourism (MET). The Veterinary Services Division of the Ministry of Agriculture, Water and Rural Development should also be contacted and will specify requirements concerning communicable diseases including foot and mouth disease, tuberculosis, ectoparasites and other veterinary matters.

Biological and Physical Requirements

Food White rhinos are a bulk grazer and the extent to which the typical habitat in Namibia provides sufficient grazing for the species is limited. Areas receiving more than 400mm average annual rainfall, where the veld is in good condition; can expect to maintain animals with minimal requirement for supplementary feed, except in drought years when it may be necessary. Areas receiving less than 400mm average annual rainfall will not necessarily have to feed. However in the event of a grass shortage due to drought or overgrazing, supplementary feeding may be necessary.

Veld assessments prior to the introduction of animals can be carried out by the MET or by an independent environmental consultant. Taking a long term view, if supplementary feed is considered likely to be necessary to maintain the condition of the animals, the cost of this must be taken into account before introduction.

The cost of supplementary feed depends upon the grass species purchased, current availability and demand, and the quantity required to meet the needs of the animals. Various grasses are available from South Africa including *Lucerne*, teff and monkey nut hay. If a normal size rhino is being entirely supplement fed, it will be necessary to provide 3/4 to 1 bale of hay a day, possibly more for a big bull.

Under extremely dry conditions it may be necessary to add molasses or some other energy concentrate to dry feed material to assist the rhinos digestion (Bothma 1989).

After introduction, the state of the veld on the farm should be monitored as an indicator of whether it is necessary to commence supplementary feeding, since this will deteriorate before the rhinos lose condition. Rhino condition should remain good throughout the year and if any deterioration is noticed, feeding should commence immediately.

Water Observations of white rhinos in Namibia have indicated an approximate drinking frequency of once every 1-2 days during the dry season. During the rainy period, rhino movement decreases as they remain in areas with good grazing and they drink from temporary water sources.

Immediately after release it is preferable to ensure that a source of water is readily available.

If possible, a permanent mud wallow should be provided as white rhinos are partial to wallowing to cool down and control external parasites. In the absence of a wallow, rhinos have been noticed to frequently roll in dust. They also enjoy lying in water to keep cool over the hottest part of the day.

Shade During the middle of the day, sometimes from late morning and extending into early evening, rhinos take a long rest. This is often in the shade of a tree and possibly on a gentle hill slope, where there may be a breeze.

Salt lick Rhinos have been noticed to use a salt and bonemeal lick in sour veld areas, consequently its provision may be advisable in areas where mineral deficiencies may be expected.

Anthrax The white rhino is susceptible to Anthrax, a disease which results in death with external bleeding. Introductions to areas where Anthrax is known to be endemic should be carefully considered. Annual inoculations can be administered by a qualified vet via drop out darts.

Monitoring and protection from poaching Good animal management demands that the animals are regularly monitored. Monitoring is increasingly important for white rhinos as the owner is entirely responsible for the animals protection from poachers. One or more employees should preferably be responsible for monitoring the animals, with all sightings being recorded and the disappearance of any animal investigated as soon as noticed. Costs associated with this protection may include wages, accommodation, rations, transport (vehicle, horse, motorbike) and possibly firearms.

Fence Good fencing is important to keep animals within an area, particularly after release and when the animals have not been boma trained. Electric fencing is preferable.

Additional considerations may include unexpected management expenses, veterinary fees, insurance and boma accommodation.

Time of Release

Ideally, rhino should be released at the end of the rainy season so that the animals can find water and food easily. It is advisable to release only one animal at a time (except cow/calf combination) to avoid fighting.

Preferred Population Structure

The size and structure of the founder population is important when establishing new groups. It is recommended that a minimum of six animals, with an ideal of eight (three bulls and five cows) is released during one introduction programme. Natal Parks Board provide founder populations of six prime animals, generally two bulls and four cows.

The sex ratio under natural conditions is one bull to one cow. On game ranches with larger groups fewer males can be introduced to reduce the possibility of fighting between bulls. However with smaller groups at least two sexually mature bulls should be introduced to allow a replacement if the one bull dies. There is some evidence from captive white rhinos in zoos which indicates that cows do not come into oestrus if there is only one bull with her (Lindemann 1982), however this is not always the case in free-ranging populations. This factor may be considered if a white rhino population is not breeding successfully.

Larger populations are preferable as they are less vulnerable to over-exploitation and habitat degradation. Small populations are more at risk from random variations in birth and death rates, which may result in the population becoming extinct. In the long term this is also preferred for genetic considerations.

Monitoring

Monitoring is necessary in order to:

- Check veld and animal condition to enable decisions on supplementary feeding.
- Identify individual animals, territories and home ranges to provide awareness of any competition between individuals which may results in fights and deaths.
- Observe possible anthrax carcasses of any species.
- Provide early warning of any poaching threat including checking the fence for signs of intrusion.

Animals should be regularly located, particularly during the first few weeks after release. This is easily undertaken by tracking spoor either from water holes or from where it is observed to cross roads. Patrols may be carried out by vehicle or on foot. Horseback patrols are also practised in certain areas and have been found to be a highly efficient and economical method of monitoring. It is also possible to use radio telemetry to locate individuals by placing transmitters in a horn or collar. Other ideas (expensive) include transponders or microchips in the foot of the animal, which may be detected by an antenna loop around water holes attached to a data logger.

Identification of individuals is possible through distinctive patterns of hairs on ears, lip patterns, tail description, scars, ear notches, horn profile, spoor measurements and crease patterns on the feet.

Prevention of Poaching

Poaching for the horn is the major threat to the rhino population in Africa. Although trade in rhino products is now illegal world-wide, demand for horn products still exists in the Middle East and Asia. Both casual and professional poachers still operate although the numbers seem to have declined slightly in recent years. Recent poaching activity is illustrated by the following statistics:

	1990	1991	1992	1993	1994	1995
Rhino cases	19	21	20	26	18	15
Number of horns confiscated	63	42	37	42	28	27
Number of accused in relation to rhino offences	48	35	36	63	31	25

* Information provided by the Protected Resources Unit, NamPol (approximate figures).

Advice on protection and investigations into poaching are conducted by the Protected Resources Unit (PRU) branch of Namibia Police. The PRU was previously known as the Diamond and Gold Branch. The Unit is responsible for investigating all cases of poaching of endangered species, primarily for precious items such as rhino horn. The PRU have compiled an advice leaflet for the ownership of rhinos, outlining monitoring techniques, security measures for protection, information concerning poaching and general management responsibilities. This includes monitoring by game guards or anti-poaching units, checking that all employees have a clear criminal record before recruiting and advice on how to approach a poacher and the scene of a poaching event.

De-horning seems to deter some poachers although in other countries de-horned animals have still been killed. If carried out correctly, it does not appear to have any detrimental effect on the animal. The deterrent effect of de-horning has a limited life span because the horn re-grows, consequently the process should ideally be repeated at least every two years. The need to periodically assemble a team of competent personnel for capture and de-horning makes the process particularly expensive.

Trophy Hunting

Trophy hunting has the potential to provide useful income to offset purchase and management costs. Hunters will currently (1996) pay N$ 60-70,000 for a complete package to bag a white rhino bull (A. Bonthuyes, Otjiwa Game Ranch, personal communication). Older subordinate bulls may possibly be used for trophy hunting purposes without any detriment to a population of adequate size and structure. Female white rhinos should only be hunted if they have not reproduced for the last two or more seasons, or if there are obviously too many sub-adults growing in the population. Hunting other animals in a small population may disrupt breeding and lead to a decline in numbers from other causes.

A hunting permit is required and is issued by MET subject to certain conditions regarding the status of the animal on the farm. An export permit must also be obtained to export the trophy. Difficulties with trophies are mainly from the hunters own country. Europe is currently tightening up on all animal product imports unless adequate proof is provided that the farm is operating in a sustainable fashion and benefiting the conservation of the species.

Ecohunting, where the hunter pays to temporarily immobilise the animal, is another possible source of revenue and should perhaps be promoted more vigorously in future. However a qualified vet must be present in addition to a professional hunter, which results in a relatively costly operation.

CONTACTS (1997)

Ministry of Environment and Tourism.

Permits: Mr. D. Morsbach, Ministry of Environment and Tourism Head Office, LTA Building, Private Bag 13306, Windhoek. Tel: 061 263131. Fax: 061 263195.

Rhino Co-Ordinator: Dr. H. O. Reuter, Ministry of Environment and Tourism, Schubert House, Private Bag 13306, Windhoek. Tel: 061 237552.

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Tel: 061 3029111. Fax: 061 221962.
Contact: Dr. Theo Van Der Merwe or Dr. Schmidt.

Save the Rhino, PO Box 22691, Namibia. Tel 061 232194. Contact: Mrs Blythe Loutit.

African Rhino Owners Association, PO Box 381, Bedfordview, 2008, SA.
Tel: 011 453 7648. Fax: 011 453 7649.
Same address and contact for the **Rhino and Elephant Foundation.**

Namibia Professional Hunters Association. Tel: 061 234455.

Environmental Consultant; Allan Cilliers. Tel: 061 220124.

Natal Parks Board, PO Box 662, Pietermaritzburg, 3200, SA.
Tel: 27 331 471961. Fax: 27 331 471037.

Historic Distribution of White Rhinos

Maps depicting the historical distribution of the white rhino in Namibia vary. The obvious discrepancy between these distributions covers the area of Etosha National Park, which may (Player *et al.* 1960; Penny 1987) or may not (Huntley 1967; Owen-Smith 1973; Pienaar 1994) Fig. 1 have been included.

Owen-Smith (1973) described the distribution of the species in the western region of its range as follows.

'In the west, it was first encountered by Galton and Anderson during their journey westwards from Walvis Bay in 1851 about 100km west of Ghanzi in western Botswana (Galton 1889). Anderson (1861) mentions eating rhinoceros hump on a subsequent expedition in the vicinity of Omuramba Omatoko to the south-east of Etosha Pan. According to Castell-Ruedenhausen (1966), the white rhinoceros occurred in South West Africa as far south as Rehoboth and Swartrand in 1836 (reported in Huntley 1966). Horns of the species have been found in sands of the Omaruru and lower Ugab Rivers, and from near Usakos (Zukowsky 1924), and the local Nama Hottentots have a name for it (Shortridge 1934). It formerly occurred on both sides of the Okavango River, extending northwards a short way into the south-eastern Angola at Lujana (Schultz and Hammer, 1877 quoted in Huntley 1966).... Repeated suggestions that the species still survives in the Kaokoveld region of South-West Africa (e.g. Barnard 1952) are without foundation (G. Owen-Smith 1971).'

Occasional observations in the Kunene (Damaraland) region could also never be substantiated (Shortridge 1934; Bigalke 1958; Owen-Smith 1970). Consequently the validity of any assumptions regarding historical distribution may be questioned.

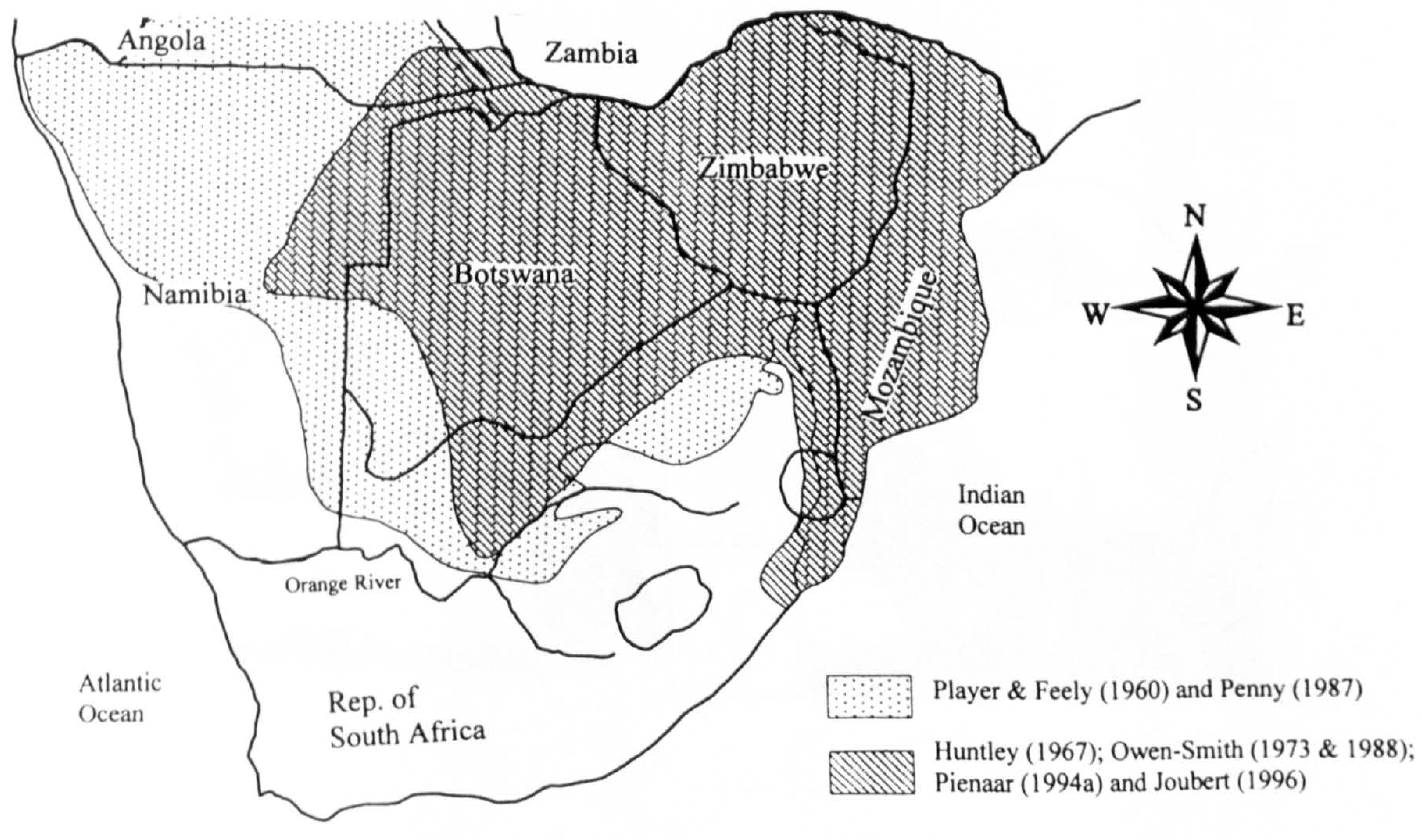

Fig. 1 Historic Distributions of White Rhinos in Southern Africa.

Ageing White Rhinos

(Hillman-Smith *et al.* 1986)

In live animals it is possible to estimate the age of an animal by the size, appearance and horn development of an animal. A more accurate estimate of age can be made by assessing stages of tooth eruption and wear from cranial material.

Horn lengths	Anterior horn	Posterior horn
6 months	1/4 ear length	discernible
1 year	1/2 ear length	bump
2 years	3/4 - 1 ear length	knob
3 years	1 ear length or over	1/4 ear length

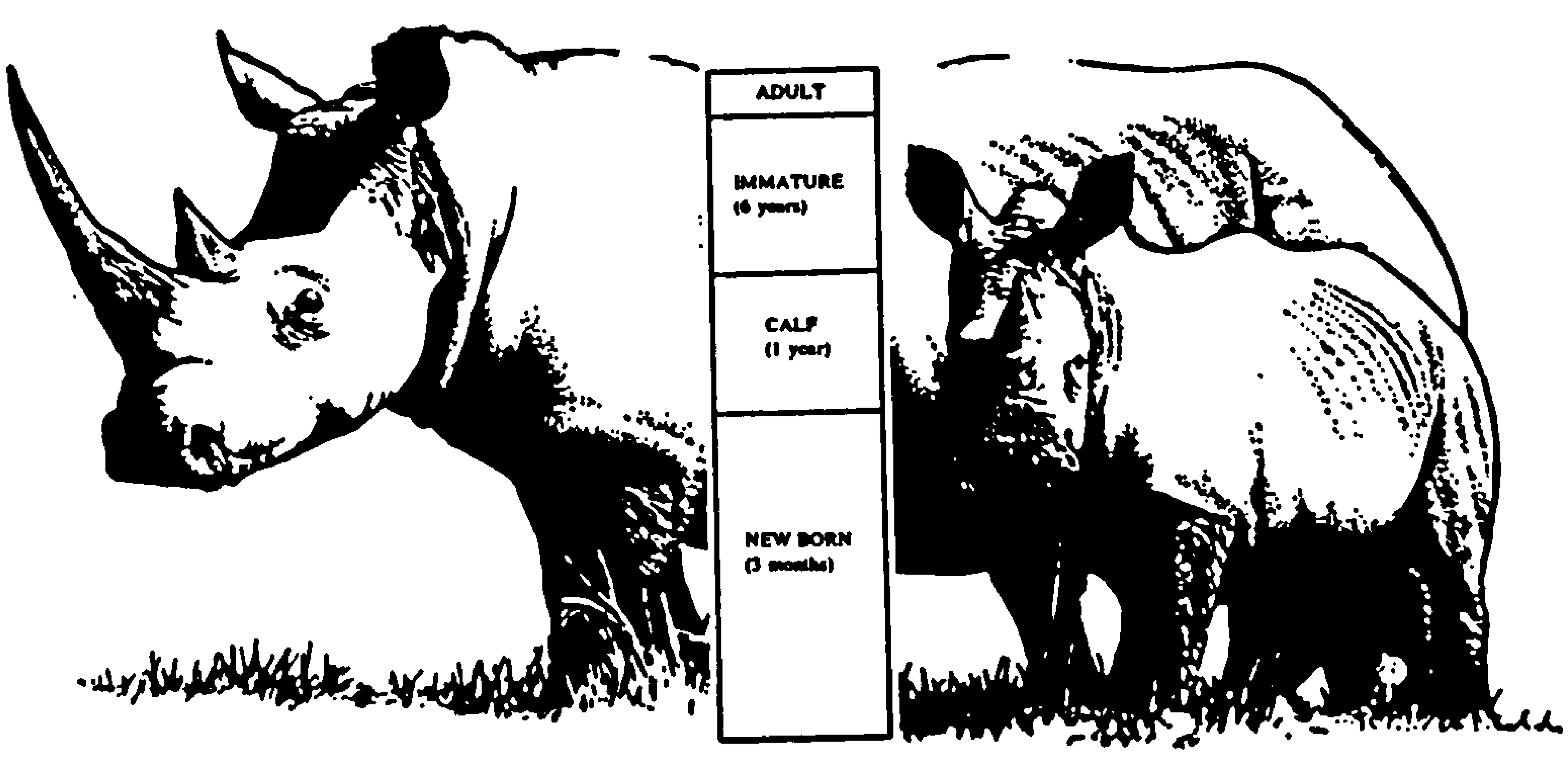

Fig. 2 Calf height in relation to adult. (NGA leaflet on ageing the White Rhino)

Transportation and Boma Management of Rhinos

(Rogers 1994)

General

Ensure that adequately robust crates are used, and that facilities at the receiving end are suitable for accommodating rhinos.
Ensure that the rhinos do not lie down in the crate for at least the first six hours.
All white rhinos are crated and transported individually - even cows and calves.

Transportation to final destination

There are two approaches to the transportation of rhino:

- They can either be captured, loaded and transported directly to their destination; or
- They can first undergo an adaption period of at least six weeks in bomas before transportation to their final destination.

If the journey is going to be longer than 8-10 hours, it is preferable to first boma-train the animal. There are several advantages to the boma training period.

- It is advisable to keep the rhinos in a boma at the receiving end for a few days before release. The idea behind this is to let the animal settle down and adapt to its new surroundings. It is therefore preferable to have a boma-trained animal that one knows is eating and will eat in the boma at the receiving end. Rhinos released directly into the veld (especially if they are not boma trained) usually scatter, breaking fences and ending up on neighbouring properties.

- The transportation is not that stressful to the animal, as it is used to being confined. The animal is therefore calmer when being off-loaded.

- Animals that are caught and delivered directly, especially if the trip is longer than eight hours, are very likely to break their horns off in the crate.

Off-loading

The receiving pens should be prepared and food and water supplied before off-loading so that the animal may be left undisturbed once off-loaded.

Once the crate is lined up with the gate of the receiving boma, the door is simply opened and the animal allowed to walk out in its own time. If it refuses to move, a cloth may be waved slowly at the entrance to the boma to entice the animal out of its crate. If this fails, the animals hindquarters can be stroked with the extension handle of a stick or cattle prodder. Only if this fails should one consider using a cattle prodder itself, and then only sparingly.

It is important to keep unnecessary noise and movement to an absolute minimum during the off-loading process. Spectators should be kept as far away from the pens as possible while the animals are being off-loaded and they should not be allowed to approach the pens even after all the animals have been off-loaded.

Occasionally an animal will not get out of the crate, even resisting a cattle prodder. It is best to just leave the animal and go away for an hour or so, the animal will usually be out by the time you return. Be sure to leave someone reliable watching from a distance. If this does not work it may be necessary to tranquillise the animal and leave it to come out on its own.

When off-loading a cow and calf, they need to be released into separate pens, even if only for the first few minutes. An agitated cow may attack her calf.

Release

If the animals have been boma trained before transportation to their destination it is only necessary to keep them in the receiving bomas for a few days, ie. until they settle down. It is not necessary to reduce their daily lucerne/teff quota before release.

It is advisable to release only one animal at a time (except cow/calf combination) to avoid fighting. The best method is to open the gate at dawn and allow the animal to leave on its own. Disturbance must be kept to a minimum. The next pen is opened 24 hours later.

It may be necessary to provide a water source just outside the bomas if it is thought that the animals may take some time to find water in their new environment.

When white rhino are released into a foreign environment they tend to wander far and wide before settling. When introducing animals it may be a good idea to collect dung from the animals in the boma and place it at waterpoints and other exposed areas on the farm to help the animals settle down sooner (Pienaar 1994).

Accommodation

The white rhino:

- is big, strong, dangerous and unpredictable.
- is a gregarious animal and therefore likes to be with other animals of the same species.
- will calm down more quickly in captivity if the walls of the bomas allow it to see animals in the neighbouring bomas, and to see and get used to the activity around the bomas.

Precautions:

- Accommodation facilities should be of a very sturdy nature. A rhino will search for a weak point and will work at it until it gets out.
- A rhino should be put into a big boma initially to allow it to settle down.
- The boma should be in a quiet area away from roads and other potential sources of stress in order to minimise problems that may be encountered with adaptation to captivity.
- It is very important not to allow visitors until captive rhinos have settled down. The human element should be restricted to necessary personnel only.

Bomas

This description is for bomas to receive animals and to familiarise them with local conditions before their release. It is however also applicable to bomas necessary for an adaptation and training period before transportation. Bomas must be strong as captive rhinos will always attempt to break out of containment.

Siting

The siting of bomas is very important both from a drainage as well as from a climatic point of view:

- The boma should preferably be in the centre of the reserve to minimise contact with fences immediately after release.
- The site should be in an area with good quality natural food available in the immediate vicinity. This makes collection of feed during the boma period easier, and provides a suitable habitat when the animals are released.
- The boma must be close to a reliable water source for the provision of water during the boma training period. An adult rhino may drink up to 50 litres of water per day.
- The boma must be easily accessible to vehicles that will deliver the rhinos.
- Large trees are necessary for shade - alternatively, artificial shade must be provided.
- The substrate must be solid to prevent animals pushing over boma poles.
- The boma must be protected from cold winds.
- The boma must be away from busy roads, houses and other human disturbances.
- There must be minimum gravel and loose rock in the boma to prevent the development of foot problems.
- The area must be well protected against feld fires. Surround the boma site with good fire breaks. Although rhinos may not be injured by a fire, they may panic at the sight, sound or smell of a fire and are likely to injure themselves in the process.
- The slope of the land must be taken into account - it is preferable to have a net drainage of water from the front bomas, i.e., from the front to the back bomas.
- It is also desirable to have the bomas facing north-south, with the front bomas on the northern side. This ensures maximum shade in the summer and maximum sun in the winter.
- It is important that the bomas be situated where an animal can simply be released if it does not adapt to captivity.

Plan for receiving bomas

If the rhinos are being received for short-term accommodation prior to release, a system of pens should be used, with one spare pen being used to rotate animals for cleaning purposes. This may become necessary if the animals are kept for a prolonged period. The sizes of the pens should be increased (to at least 20m x 20m) if wild caught animals are introduced directly into these receiving pens. In such cases, it is obviously not necessary for the roof/shelter to extend the full length of the pens. Only one release gate is required if all the animals are boma trained (ie. eating) beforehand.

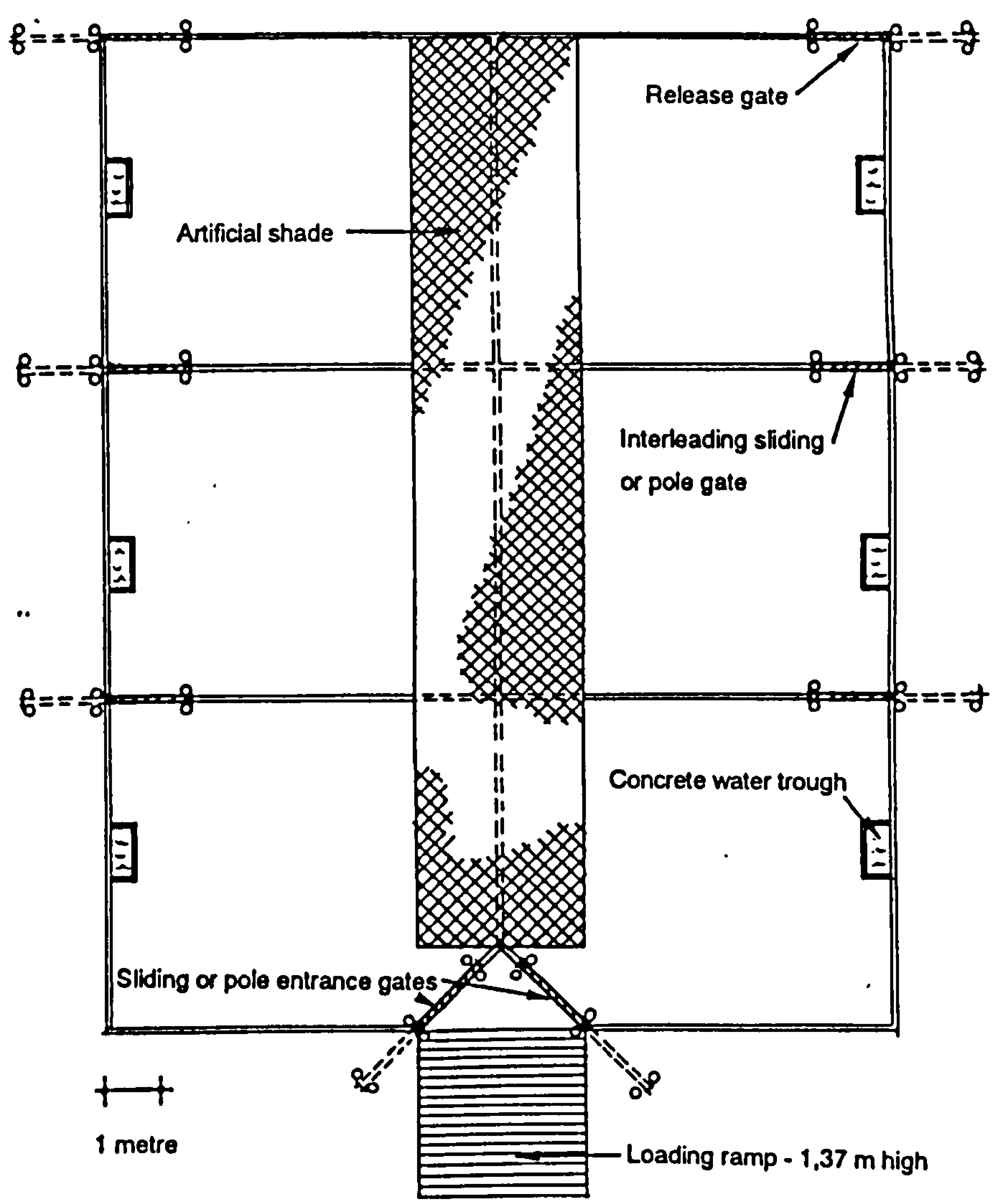

Fig. 3 Receiving Boma Complex for Rhinos. (A. A. McKenzie 1993.)

Walls

The boma walls must be sufficiently strong to contain a rhino at full charge. However, at the same time it is important that the animals should be able to see each other and be able to see outside. Captive rhinos calm down more quickly under these conditions.

Cable bomas are not recommended under any circumstances because:

- The animal may climb the cables and escape from the boma
- In attempting to climb the cables the animal may get its head or shoulders stuck in between the cables and suffer injury or death.

Problems with cable bomas can be avoided by embedding vertical poles in the soil. These poles should be tannalized and not creosoted, as creosote causes skin irritation which has been reported to cause gastric ulcers (rhinos tend to lick the poles).

Three meter poles of 130-150mm diameter are embedded 1m deep into soil or concrete every 1 - 1.5m (depending on the soil consistency). Two horizontal poles are affixed to the outside of the vertical ones. The lower horizontal pole is close to the ground, and the upper one about 300 mm from the top of the vertical poles. Three or four 2m poles of the same diameter are bolted to the horizontal poles in between the upright poles, with a gap of about 150mm between the poles. One can use either 12mm carriage bolts (the best) or, alternatively 12mm reinforcing rod with both ends bent over and knocked into the wood. It is very important to ensure that there are no sharp ends projecting into the boma. It is important that the vertical poles are bolted on the inside of the horizontal poles. If the vertical poles are on the outside, the force is transferred onto the bolts.

Gates

Simple gates can be constructed using double vertical posts through which horizontal wooden gum poles are inserted. These gates are relatively cheap to construct, but are difficult to operate. A rhino often rushes through the gate before all the poles have been removed, and may be tripped by or injured on the remaining poles. The rhino may also collide with partially withdrawn poles. This may result in injury to the unfortunate gate operator. Sliding gates consisting of metal frames and vertical metal poles are strongly recommended. These are easily operated from a catwalk above the pens.

Water Troughs

Water troughs should be about 1m x 0.5m in size. The sides should be elevated to not more than 300 mm above the ground. The elevated sides are to prevent sand from getting into the drinking water. The trough need only be about 400mm deep, and must have an outlet pipe to facilitate cleaning and draining. The corners of the trough should be rounded to avoid injures. The inside surface should be smooth and rounded to facilitate easy cleaning and minimize the build up of algae and bacteria. It is preferable to have the whole trough inside the boma. If the trough is half in and half out the boma, the rhino may get its horn stuck under the horizontal bar while drinking and either drown, break off its horn or escape.

Feeding Facilities

The feeding area should also be under a roof. A slightly (30mm) raised concrete slab, about 3m x 1.5m should be built under the roofed area on which to put the feed.

Shade and Shelter

The front half of the pens and all the crates should be totally under a roof. The back pens should also have an area under roof where the animal can shelter form sun and rain. The animals favour the corners furthest from any movement or action, ie. the corners where the bomas meet. It is therefore advisable to put the roofs in these corners.

It is difficult to shield the animals totally from the wind. Sections of the boma (e.g. corners) can be closed totally with poles. Plastic should not be used. It flaps in the wind and stresses the animals. The animals may not go near the plastic, or may rip pieces off it. In either case, the purpose of the shelter is defeated.

Off-loading Ramp

Depending upon the type of transport vehicle, the loading ramp may have to be dug into the ground. Raised ramps may also be used, but for off-loading of newly-caught animals that may be a bit groggy, dug in ramps leading directly onto the surface of the bomas are preferred. Animals should only be off-loaded into the large boma, not into the smaller front bomas.

How to care for white rhinos in captivity

The white rhino:

- is big, strong, dangerous and unpredictable.
- is a selective grazer, preferring short palatable grasses.
- is a gregarious animal and therefore likes to see and be with other animals of the same species.
- adapts with great difficulty to captivity, from a stress and nutritional point of view.
- tends to adapt better and quicker when young than adult animals.
- tends to adapt more slowly and less readily to captivity if alone - it is usually with these animals that one tends to run into problems.
- is unpredictable from a nutritional point of view - some simply will not eat in captivity for no apparent reason.
- will try to escape until it resigns itself to captivity and settles down . Almost all escape attempts occur at night. Nights 3,4 and 5 of captivity are most critical in this respect.

Precautions:

- It is essential to have a night guard who is in contact with the person in control of the bomas in case of an attempted escape by the rhino(s).
- The rhino must be put in a big pen initially to allow it to settle down.
- Antelope cubes should not be fed to rhinos as they contain cotton seed products. Cotton seed contains gossypol which is potentially toxic to monogastric animals such as rhino.
- Do not allow visitors until the rhino have settled down. The human element should be restricted to boma personnel only.
- Try, if possible, to capture and accommodate pairs of animals from the same herd. These animals will be more likely to adapt to captivity.

Boma Management

When catching animals to place in bomas one would obviously like animals that are going to adapt as soon as possible. This can be very important, bearing in mind the problems one has in getting white rhinos to adapt in captivity. There are three groups of animals that usually adapt fairly readily to captivity:

- A cow with a calf at foot;
- Animals that are running together in the wild; and
- Sub-adult animals, even if they are caught and put on their own.

Most problems are experienced with single, adult animals. The older they are, the more difficult they find it to adapt.

Water is given ad lib (bearing in mind that an adult drinks 40-50 litres daily) and the water trough is rinsed out, cleaned and refilled twice daily. The trough should be disinfected twice weekly with a chlorine compound (e.g. Bacterex^{TM}). Until the animal is eating properly, vitamin B-complex syrup is added to the water as an appetite stimulant at a dilution rate of 250ml per 50 litres of water. The vitamin B-complex is always added to the water in the evenings, as it is inactivated by sunlight.

It is very important to monitor defecation from the first day. Rhinos usually defecate on the first and second days, then stop for four to five days until they start eating again. If the animal only defecates on the first two days but not again, Epsom salts can be put in the water from day nine post-capture. Usually these are the animals that are refusing to eat, and it is found that if and when they start defecating they will start eating. Special care must be taken when administering Epsom salts (see below).

The animal should not be moved to the front pens until it is eating well. A spare back pen (for cleaning purposes) is not normally necessary because the animal can be moved forwards into the smaller front pens after 2-3 weeks. This is done by opening the gate between the front and back pens and letting the animal walk into the front pen at will for a day or two. The animal can then be fed in the front pen for a couple of days before closing it in the front pen. This does not present problems as the animal is well used to captivity by this stage. Once the animal has settled down in the front pen (3-4 days), the pen cleaning can be commenced on a daily basis.

Because rhinos are so bulky and heavy they are very prone to pressure sores, especially just above the front feet on the fetlock joints and on the hock joints. For this reason a layer of fine river sand should be removed and replaced on a weekly basis. The animal is kept in the front pen for at least 3-4 weeks before it is ready to be transported to its final destination (a total of at least six weeks of boma training).

Offloading

Ensure that the water trough is empty, as a sedated animal could drown in it. Water should only be given once the animal has fully recovered from the effect of the drugs.

When the animal is off-loaded at the bomas it is usually still very groggy and remains so for at least six hours. If it is very hot, the animal may be hosed down once off-loaded into the pen.

The animal often lies down after off-loading (white rhino only). This is acceptable as long as the animal does not lie down for longer than 20 minutes at a time (to avoid neuro-muscular damage to the hind legs). It is advisable to have a staff member equipped with a long-handled cattle prodder attending to the animal until it recovers. Sometimes the animal leans against the poles of the boma. Care must be taken to ensure the animal does not smother itself, especially if it is in a corner.

Crate Training

Once in the small pens, the animal is fed on a concrete slab for about four days. From then on the crate is opened and the feed is placed at the opening to the crate. The feed is gradually placed deeper and deeper into the crate until the animals whole body is inside the crate when feeding. This crate is similar to the one in which the animal will travel to its final destination, and this procedure is carried out to get the animal used to very confined spaces.

The rhino should be eating all its food out of the crate for at least 14 days before translocating it to its final destination.

Feeding

Because it is so difficult to get captive white rhinos to eat, highly palatable grasses must be given if possible. Freshly cut green grass is fed twice daily under the feeding roof on the concrete slab; old grass is removed after each feed. It may be found that the animal starts nibbling from day three or four, and only starts eating well from about day seven. *Eragrostis tef* can then be mixed with the natural grass and increased so that by day 12 the rhino is eating teff only. The vitamin B-complex supplement in the water can then be withdrawn. At this stage start mixing in lucerne up to a maximum of about 10% of the total hay diet: anything greater at this stage can lead to loose stools and even diarrhoea. The time taken to reach this stage will vary from one animal to the next.

It is essential to keep the best quality teff and lucerne available in order to get the animal to eat. This feed must be kept dry. The teff and lucerne must be checked for mould - this can lead to colic, diarrhoea or even death. Rodent control is essential - rats carry Salmonella, a bacteria that causes severe diarrhoea in rhino.

Rhinos should be fed twice daily throughout their period in captivity. Once eating well an adult should eat three-quarters to one bale of hay per day. Big bulls may eat up to 1½ bales. When the animal is eating well, horse cubes can be sprinkled on top of the feed, increasing gradually to about 2.5kg twice daily for adult animals.

Occasionally (10-20% of cases), an animal refuses to eat at all. A good rule of thumb is that if the animal has not taken food by day 10 it should be released by opening the gate. It is important that the bomas be situated where the animal can simply be released in this fashion. To have to dart an animal which has not eaten for 10 days, in order to load it again for translocation to a suitable release site is a very risky and stressful procedure. It must be emphasised, however, that 10 days is a rough guideline only. Some animals lose condition very rapidly and might have to be released after only six days, whereas others might last longer than 10 days (although this is very risky). Inclement weather, for example, can cause a perky animal that has not eaten for 10 days to succumb overnight. Experience has shown that it is always better to release the animal sooner rather than later.

Animals that are not in good condition when they reach the bomas will obviously have to be released sooner if they do not eat. An early visible guide to the condition of a rhino is the appearance of skin folds on the lower side of the abdomen, just in front of the hind legs, extending forward to the thorax. These folds are only visible in animals that are in poor condition. They start off short and shallow, just in front of the hind legs, later increasing in length and thickness as the animal's condition worsens.

If a rhino is refusing to eat and there are others in the boma that have been there for a while and are eating well, one can try mixing them. This often has the desired effect and the animal starts eating immediately. One must monitor the animals closely for a while after mixing them to make sure that the animals do not fight. This measure works particularly well where younger animals are involved: it is when older animals are mixed that fighting may occur.

Habitat Preference of White Rhino

(Pienaar 1994 & Owen-Smith 1973/88)

Once released, white rhinos can be expected to avoid areas if the low shrub (<2m) stratum is very thick or if the habitat consists of open plains with no shade. Similarly mountainous and rocky areas were not regarded as suitable habitat and consequently will be avoided.

White rhino are dependent upon regular access to surface water although they can go for 3 days without drinking. The existence of mud wallows will increase the appeal of an area for white rhino.

Social Organisation and Behaviour of White Rhinoceros

(Owen-Smith, 1973/88)

The social organisation and behaviour of the white rhinos varies with respect to the sex and density of animals. Studies in the high density area of the Umfolozi Game Reserve (Owen-Smith, 1973) varied to those in Kruger National Park (Pienaar, 1994).

Sociobiology

White rhino cows were usually accompanied by a single calf, while white rhinos bulls were most often solitary. Subadults tend to be associated in pairs, either of the same or opposite sex. Groups of three generally consisted of either a subadult attached to a cow-calf pair, or an adult male accompanying a cow plus calf. A few groups comprised three or more subadults and sometimes large groups were seen.

Reproduction

Young females underwent their first oestrus at about five years of age, but remained in sub-adult groups until the birth of their first calf at five to seven years of age. Thereafter they are usually accompanied only by their offspring and can be regarded as adult cows. There is evidence from captive white rhinos in zoos that cows do not come into oestrus if there is only one bull with her (Lindemann, 1982). Although this is not always the case this should be kept in mind if a white rhino population is not breeding successfully. Young males are regarded as adult once they became solitary between ten and twelve years of age and assume their territorial male or subordinate male behaviour patterns.

Dominant white rhino bulls investigated cows which they encountered within their territories, while cows responded with threatening snorts or roars. If a bull remained with a cow for more than a day, this was a sign that the cow was coming into oestrus. During the pre-oestrus consort period the bull followed behind the cow and her companions. However, if a cow approached a territory boundary, the bull moved in front to block her progress. A confrontation sometimes ensued, with roars form the cow and squeals from the bull. If a cow was able to evade the bull and cross into the next territory, the bull did not follow and she was joined by the neighbouring bull. The pre-oestrus consort period typically lasted 1-2 weeks.

The onset of oestrus was indicated by the commencement of repeated approaches by the bull, accompanied by a hic-throbbing sound. Eventually the cow would let the bull mount her. The gestation period in white rhino is about 16 months and the mean intercalving interval is 2.5 years.

Home Range

Territorial white rhino bulls occupied non-overlapping home ranges and left these territories only to proceed to and from water. Territorial bulls ejected their urine in powerful sprays, while subordinate bulls and cows urinated in a conventional stream. Territorial males scattered their dung after defecating, while subordinate males only made a few ineffectual kicking movements. Dominant bulls spend more time patrolling territories, and on social interactions.

Home ranges have been calculated for South African National Parks, however, these may not be directly compared to game farms in Namibia due to differences in habitat, rainfall and limits placed from the areas boundary. The size of home ranges depend on food availability, population composition and farm size.

Territoriality

Territorial males mark their territory by spray urination and dung scattering. When confronted by a territorial male a subordinate male gives a threat display. He lifts his head, roars and makes short rushes at the territorial males. Typical fighting wounds seen on an adult male other than obvious lacerations on the head include broken jaw bones, wounds between the hind legs, punctured abdomens, broken front legs and dislocated hind legs. These wounds are usually fatal.

Further Reading

The majority of the above information on managing black and white rhinos was taken from Proceedings of a Symposium on "Rhinos as Game Ranch Animals", which was held at Onderstepoort, SA on the 9 & 10 September 1994. Individuals interested in obtaining a copy of this information should contact the MET or the South African Veterinarian Association (Game Group), Onderstepoort, SA for advice.

Megaherbivores by Prof. N. Owen-Smith provides a superb and interesting insight to white rhinos and other large mammals in an easy to read book.

A complete and comprehensive account of how to capture and manage rhinos and other species is contained in the 'Capture and Care Manual', edited by A.A. McKenzie. This text provides a compilation of information from many leading people in this field.

References and Sources

With acknowledgements:

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