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AVIAN RESPONSE TO CONTROLLED FIRE AT BARBERSPAN

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Abstract

Grasslands cover about a quarter of the Earth and are often characterised by wetlands (McAllister, 2000). A large diversity of animal life is found there. In South Africa, there are 21 species of grassland birds, of which 12 species are endemic (Anon, 2000). About 20% of South Africa's threatened land mammals are found in grasslands (Anon, 2000; Anon, 2003b; McAllister, 2000). In South Africa the grassland region is of great economic importance, since it is ideal for farming (Le Roux, 2002).

Whether controlled or not, fire has an effect on the environment. Destruction of vegetation can affect animals, as there is little place to hide or perch on (MacArthur, 1958; Kozlowski & Ahlgren, 1974). Birds that feed on seeds may also be affected until vegetation produces seed again (Kozlowski & Ahlgren, 1974). Fire is such a part of the environment that it is regarded as a natural factor. Fire is thought to play an important role in plant communities (Tainton & Mentis, 1984). According to evidence, early humans modified the natural fire regime to suit their own purposes and by the eighteenth century veldt burning occurred regularly to stimulate new growth in plants to improve grazing and hunting (Edwards, 1984).

Birds adapted to their environment and became one of the planet's most successful creatures with many examples of their adaptation to their environment. Through hunting, habitat destruction, pollution and introduction of exotic species, man threatens about 1000 bird species globally (Davies, 2003). Distribution may be related to environmental change, making the birds, in many instances, a good indicator of environmental change (Morrison, 1986). Mills (2004) explained that changes in the savannah could be predicted based on the alteration of habitat. Species that feed on the ground may be attracted to a fire whereas those that prefer the cover of vegetation would stay in the control sites (Mills, 2004). According to Parr and Chown (2003), most of the research on birds and fire in South Africa has been done at species level and only the responses of a few species to fire have been studied.

Barberspan is a bird sanctuary in the North-West Province of South Africa. It is situated in an area of seasonally filled pans, which makes this perennial pan very important to waterfowl and conservation (Beyer & Duggan, 1997; De Beer, 2001). Barberspan was declared a Ramsar site in 1975 according to the Ramsar Convention of 1971 (Dini, 1999).

I decided on using controlled burns at Barberspan to achieve the aims of this study. A point count method (Bibby, Burgess, Hill & Mustoe, 2000) was used at each of the three burns. Counts were taken on a regular basis or as predetermined by the observer for two years at Burn 1 and one year for Burns 2 and 3. Birds that were seen or heard were counted, as not all birds may be visible to the observer (Bibby, *et al.*, 2000). Birds hiding in the grass were identified according to their calls. Birds that flew over were ignored. If the birds perched in the grass, on the ground, or utilised the site in some other way, they were counted. The computer programmes Excel 2000, Primer 5 and MapViewer 5 were used to analyse and present the data.

The densities increased after the fire and started to decrease at the end of the year. The number of species increased after the fire and returned to pre-fire levels at the end of the year. The species that normally used the habitat (fire-sensitive), left after the fire, and other species (fire-colonizers) colonized the area. Some of the original species remained in the area after the fire (site-tenacious). The species that had left after the fire, started to return at the end of the year. There was little change in the diversity, as measured by the Shannon index. The densities of the birds, the species composition and number of species changed, but this was not reflected in the Shannon index. Therefore, the Shannon index is not be a good measure to quantify the effect of fire on birds, at least in cases such as at Barberspan. The biomass increased after the fire, because larger birds were attracted to the fire. Smaller species were also attracted to the Burn Sites, but in much larger numbers than the Control Sites. The size of the burned areas had an effect on the birds. More birds per hectare were attracted to the larger fires (Burns 1 and 3), when compared with the smaller fire at Burn 2. The guilds showed that the birds were probably attracted to the fire because of the availability of food rather than habitat or breeding opportunities.

Therefore, optimal foraging probably played a significant role in explaining the differences found between larger and smaller fires. Some of the larger birds only took the opportunity to feed on the prey killed immediately after the fire, and left after a day or two. The island effect was also seen in the Burned Sites. The burned areas could be considered as "islands" in the "sea" of grassland. The larger islands had a higher density in birds, greater species richness and more total avian biomass. The fires probably had an effect over an area larger than the burned areas itself. There were no apparent increases in density or species richness in the Control Sites after the fire, and therefore the birds that left had to move out further. The number of birds and number of species in the Control Sites did not decrease at the same rate as the increases seen at the Burn Sites, showing that the birds probably were attracted from a larger area than that immediately surrounding the burned areas.

Opsomming

Graslande bedek ongeveer 'n kwart van die Aarde en word dikwels gekenmerk deur vleilande (McAllister, 2000). 'n Hoë diversiteit van dierelewe word hier gevind. Suid-Afrika het 21 spesies grasland voëls, waarvan 12 endemies is (Anon, 2000). Omtrent 20% van Suid-Afrika se bedreigde soogdiere word in graslande gevind (Anon, 2000; Anon, 2003b; McAllister, 2000). Suid-Afrika se graslandstreek is van ekonomiese belang omdat dit ideaal is vir landbou (Le Roux, 2002).

Vuur, beheer of onbeheer, het 'n effek op die omgewing. Vernietiging van plantegroei deur vuur affekteer die diere omdat skuiling en sitplek vernietig word (MacArthur, 1958; Kozlowski & Ahlgren, 1974). Voëls wat van sade leef, mag geaffekteer word totdat die plantegroei weer saad produseer (Kozlowski & Ahlgren, 1974). Vuur is so 'n geïntegreerde deel van die omgewing dat dit as 'n natuurlike komponent van die ekostelsel gesien word. Vuur speel 'n belangrike rol in plantgemeenskappe (Tainton & Mentis, 1984). Die mens het die natuurlike vuur regime verander om sy eie doelwitte te bereik en reeds teen die agtiende eeu is veldbrande gereeld gebruik om nuwe plantegroei te stimuleer en sodoende die veld en ook jagtoestande te verbeter (Edwards, 1984).

Voëls het aangepas by hulle omgewing en het een van die planeet se suksesvolste kreature geword. Deur middel van jag, habitatvernietiging, besoedeling en die inbring van uitheemse spesies, bedreig die mens omtrent 1000 voëlspesies globaal (Davies, 2003). Verspreiding van voëls mag gekoppel wees aan omgewingsveranderinge, wat die voëls 'n goeie indikator maak vir omgewingstoestande (Morrison, 1986). Mills (2004) het verduidelik dat verandering in die savanna voorspel kan word, gebaseer op verandering van die habitat. Spesies wat op die grond voed mag deur vuur aangetrek word, maar spesies wat van die bedekking van plantegroei hou, sal in die kontrole-gebiede bly (Mills, 2004). Volgens Parr and Chown (2003), is meeste navorsing op voëls en vuur op spesie-vlak gedoen in Suid-Afrika en die reaksie van slegs 'n paar spesies tot vuur is bestudeer.

Barberspan is 'n voëlreservaat in die Noordwes-Provinsie van Suid-Afrika. Dit kom in 'n gebied van seisoen-gevulde panne voor, wat hierdie standhoudende pan baie belangrik maak vir die voëlgemeenskappe en vir bewaring (Beyer & Duggan, 1997; De Beer, 2001). Barberspan is as Ramsar-gebied verklaar in 1975 volgens die Ramsar-Konvensie van 1971 (Dini, 1999).

Ek het besluit om beheerde brande by Barberspan te gebruik om aan die doelwitte van hierdie studie te voldoen. 'n Punttelling-metode (Bibby, Burgess, Hill & Mustoe, 2000) is gebruik by elk van die drie brande. Tellings is op 'n gereelde basis, of soos vooraf bepaal deur die

waarnemer, gedoen en het vir twee jaar plaasgevind by Brand 1 en vir 1 jaar by Brand 2 en Brand 3. Die voëls wat gesien of gehoor is, is getel omdat nie al die voëls sigbaar was nie (Bibby, *et al.*, 2000). Voëls wat in die gras weggekruip het, is volgens hulle geluide geïdentifiseer. Voëls wat net oorgevlieg het, is geïgnoreer. As die voëls in die gras of op die grond gesit het, of die gebied op een of ander manier gebruik het, is hulle getel. Die rekenaarprogramme Excel 2000, Primer 5 en MapViewer 5 is gebruik om die data te analiseer.

Die getal voëls het toegeneem na die vuur en weer begin afneem aan die einde van die jaar. Die getal spesies het toegeneem na die vuur en weer na voor-vuur vlakke teruggekeer teen die einde van die jaar. Die spesies wat gewoonlik in die gebied voorkom (vuur-sensitief), het na die vuur vertrek, en ander spesies (vuur-koloniste) het die gebied gekolonialiseer. Sommige van die oorspronklike spesies het in die gebied gebly na die vuur (standvastig). Die spesies wat vertrek het, het aan die einde van die jaar begin terugkeer. Daar was min verandering in die diversiteit, soos gemeet met die Shannon indeks. Die getal voëls, getal spesies en spesiesamestelling het verander, maar dit is nie in die Shannon indeks weerspieël nie. Dus is die Shannon indeks nie 'n goeie metode om die effek van vuur op voëls te kwantifiseer nie (gevalle soos Barberspan). Die biomassa het toegeneem na die vuur, omdat groter voëls na die vuur gelok is. Kleiner spesies is ook na die vuur gelok, maar in veel groter getalle as by die Kontrole Gebiede. Die grootte van die vuur het ook 'n effek op voëls. Meer voëls per hektaar word na groter vure (Brande 1 en 3) gelok, in vergelyking met die kleiner Brand 2. Die gildes het getoon dat die voëls waarskynlik as gevolg van voedsel na die brande gelok word, eerder as gevolg van habitat en broeigeleenthede.

Dus, optimale vergaar speel waarskynlik ook 'n kenmerkende rol in die verduideliking van die verskille wat gevind is tussen die groter en kleiner brande. Sommige van die groter voëls het net die geleentheid gebruik om op prooi te voed wat in die vuur doodgebrand het, en het weer na 'n dag of twee vertrek. Die eiland effek is ook in die gebrande gebiede gesien. Die gebrande gebiede kan as "eilande" in 'n "see" van grasland gesien word. Die groter eilande het hoër digthede voëls, groter spesierykheid en groter totale biomassa gehad. Die brande het waarskynlik 'n effek oor 'n groter gebied gehad as die gebrande gebiede self. Daar was geen waarneembare toenames in digthede of spesierykheid in die kontrole gebiede na die vuur nie, en dus moes die voëls wat vertrek het, na ander gebiede beweeg het. Die getal voëls en getal spesies in die Kontrole Gebiede het nie teen dieselfde koers afgeneem as wat dit in die Brand Gebiede toegeneem het nie, wat wys dat die voëls waarskynlik van 'n groter area as dié rondom die brand gelok is.

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Chapter 1: Introduction

"... we met ... natives engaged in burning the bush, which they do in sections every year. The dexterity with which they manage so proverbially a dangerous agent as fire is indeed astonishing ... I can conceive no finer subject for a picture than a party of the swarthy beings engaged in kindling, moderating and directing the destructive element, which under their care seems almost to change its nature, acquiring, as it were, complete docility, instead of the ungovernable fury we are accustomed to ascribe to it ... " Stokes (1846) in "The voyage of H.M.S. Beagle" *gave this description of aborigines intentionally firing the country near Albany, western Australia. (Quoted by Kozlowski & Ahlgren, 1974)*

1.1 General introduction

In contrast to sporadic and unpredictable natural disasters, humans exert tremendous and sustained pressure on the amount of habitat available to wildlife (Morrison, 1986). Human actions are changing the diversity of life on the planet, some of these changes irreversible. These actions have transformed most of the planet's ecosystems. More land was converted into agriculture in the last 30 years than ever before. Water that is being stored is more than the water flowing in the river systems of the planet at any given time. So far, 20% of known coral reef has been destroyed in the last few decades. All these impacts and biodiversity changes have taken place mainly in developing countries (Millennium Assessment, 2005).

In some places, ecosystem conversion has begun to slow, but this is because there is not much more habitat left for conversion. These conversions have sent a number of animal groups into a decline. Studies around the world show the population decline of butterflies, birds, mammals, amphibians, fish and corals. Some of the exceptions include species that are protected in the planet's nature reserves and those that tend to adapt to human habitats. In the past few hundred years, humans have caused more species extinctions than in global history. There are many well-documented extinctions of several species in the last hundred years of human history. The extinction rates may well be higher if lesser cases were included (Millennium Assessment, 2005).

The distribution of species has also become more homogenous in some places. Species are transported from their indigenous habitat to other parts of the world in trade. Because of this, there are high rates of introduction and invasion in some regions, endangering and threatening the local species with extinction. According to the IUCN (International Union of the Conservation of Nature) criteria for threats of extinction, 10% to 50% of higher taxonomic groups (for example birds, mammals and amphibians) are currently threatened (Millennium Assessment, 2005).

Because of the plant and animal population decline globally, genetic diversity has also been declining. This decline in genetic diversity mostly takes place in human domesticated species used for agriculture. Farmers homogenise their crops and farm animals for better production. The decline in genetic diversity lowers the animals' and plants' resilience to diseases or ecological changes. The loss of genetic diversity also results in reduced fitness and adaptive potential and it limits the recovery of species whose populations have declined to low levels (Millennium Assessment, 2005).

Whereas natural processes of succession will often return a devastated area to a state resembling its former condition, human activities often help to keep an area at its new, unnatural state. Human-induced disturbance may range from great changes in the physical landscape, to rather subtle manipulations (Morrison, 1986).

The impact of a single action can change the ecology of an area from months to years to even decades, and sometimes it is irreversible. "Good" change (storms or other natural disasters) is necessary, but "bad" change (removal of plants or overgrazing) can cause desertification or destruction, leaving an area poor and uninhabitable. Nature itself has an impact and brings change. Storms, volcanoes, tornadoes and floods are a few examples of the changes nature brings unto itself (Morrison, 1986). The natural fauna and flora in the area dies, but are soon replaced by new species or existing species from neighbouring areas. The new species are formed by the environmental change and/or its conditions through natural selection.

Fire is also a force of nature's change, but since humans have "discovered" fire and how to make and control it, they have begun to use it to their advantage to change nature, for better hunting and farming, but not always for the better of the natural environment (Stewart, 1963). Controlled fire can be a good thing, bringing new grass and other plants and thus good food for the animals, but a controlled fire can easily turn into a destructive force, destroying rather than producing growth (Stoddard, 1963). An uncontrolled fire can seriously affect the fauna and flora in an area and often also destroys man's own hard work such as buildings and crops (Kozlowski & Ahlgren, 1974).

Controlled fire can be used to encourage better growth in plants, especially those adapted to fire to germinate seed. This means getting rid of moribund vegetation which can drain nutrients from the ground and result in poor soil conditions and habitat, and better growth means better food for animals. Fire creates open spaces where new seeds can germinate and thereby improve the food quality for animals (Tainton, 1999 and Tainton & Mentis, 1984).

Fire also has an influence on bird life. It destroys cover, thus grassland birds hiding in grass cover must look elsewhere for it. On the other hand, it creates open spaces for other birds and attracts new species to an area that has been burned. Burnt areas can also provide food for a short period of time as well as nesting grounds for birds, which camouflage their dark-coloured eggs in the ashes and soot. Fire also influences breeding birds that need plants to camouflage their eggs. A badly timed fire will destroy nests that are already in use (Apps & Du Toit, 2000).

Prescribed fire is not a "magic bullet" that alone will erase past failures or make up for future poor management. However, combined with other sound management practises, prescribed fire can yield many benefits. In grasslands, prescribed fire can increase grass nutritive quality, palatability, availability and yield. Fire reduces hazardous fuels, suppresses unwanted plants, and improves wildlife habitat. If the soil moisture is adequate, grass yields can increase. Baring and darkening the soil surface allow it to warm more quickly and this can stimulate earlier growth while competing weeds are suppressed (Stubbendieck, Masters, Ortmann & Beran, 1998).

1.2 Overview of literature

1.2.1 Grassland and savannah

1.2.1.1 Savannah

A savannah is essentially grassland with trees or shrubs. The word savannah stems from an American Indian term for the plains (Woodward, 1996). There are different types of savannah all over the world. Africa has savannahs dotted with acacia trees, of which the Serengeti Plains in Tanzania are probably the best known. Others are mostly found in Botswana, Kenya, Namibia, South Africa, Zimbabwe and Madagascar (Col, 2000b; Anon, 2003a and Woodward, 1996). Savannahs cover about 46% of the region in southern Africa and are the largest ecoregion in South Africa (Le Roux, 2002). The rainfall in southern African savannahs ranges between 235mm and 1000mm (Anon, 2003a; Le Roux, 2002; Col, 2000b and Woodward, 1996).

South America has two names for savannah. In Venezuela and Colombia, they are known as llanos. They are mainly situated in the Orinoco basin and are flooded every year. Plants and animals have adapted to long periods of standing water. Brazil has the cerrado that has several plants and animals, which cannot be found anywhere else. The cerrado's plant diversity is second only to the tropical rainforests. Belize and Honduras in Central America have pine savannahs that occur on sandy soils (Anon, 2003a; Woodward, 1996). Northern Australia has eucalyptus savannah, which harbours many species of kangaroo, but not much animal diversity. Other savannahs are found in India and the Myanmar-Thailand region of Southeast Asia (Woodward, 1996).

The savannah's plants are adapted to long periods of drought and some species are even fire-adapted. Plants have long roots to reach the water table and have developed methods to keep herbivores at bay. Savannahs support more than 5700 plant species in South Africa, second only to the fynbos ecoregion in the Western Cape. Animals in the savannah consist of many types of ungulates, herbivores and carnivores. They are adapted to long migrations and droughts (Le Roux, 2002).

The savannah's open spaces and trees are used by birds of prey that need a clear view of their prey and a perch to rest on. The open spaces are also used by browsers and grazers, which can coexist in one area because of different food preferences. Few of the mammals are restricted to the savannah. Termites are abundant in most savannahs and their termitarias can be easily spotted. The termitaria provide shelter for other animals and the termites themselves are food for anteaters, aardvarks and pangolins (Anon, 2003a; Woodward, 1996).

1.2.1.2 Grassland

Grasslands consist of rolling terrains of grass, flowers and herbs. Forest development is prevented by fire and drought, but since the grass grows from the bottom instead of the top, they survive fires easily. Grasslands cover about a quarter of the Earth and are often characterised by wetlands. Grasslands used to cover 50% of Africa about 3 million years ago, but because of a climate change, woody plants invaded and changed the grasslands to savannahs. Grasslands are now found only in South Africa (McAllister, 2000). There are two types of grasslands: tropical and temperate. Tropical grasslands are normally hot throughout the year and have wet seasons with torrential rain. Temperate grasslands have hot summers and cold winters (Col, 2000a).

Like savannahs, grasslands have different names over the world. In South America, Argentina has the pampas and Uruguay and Brazil have campos. In North America, grasslands are called prairies and in Eurasia, Mongolia and parts of the former Soviet Union, they are called steppe. Grassland and veldt are found in Africa and Madagascar, whereas in Australia and New Zealand they are called rangelands (Col, 2000a).

Grasses reduce runoff in the rainy season and thus control erosion (McAllister, 2000). Grasslands have a large diversity of plant life, including wildflowers and geophytic species (Le Roux, 2002). A large diversity of animal life is found there. The prairie in North America contains more than 80 species of mammals and 300 species of birds. In South Africa, there are 21 species of grassland birds, of which 12 species are endemic (Anon, 2000). In fact, the grasslands found in Mpumalanga, Free State and KwaZulu-Natal have been declared an Endemic Bird Area (EBA) in urgent need of conservation because of Rudd's Lark, *Heteromirafra ruddi*, Botha's Lark, *Spizocorys fringillaris* and Yellow-breasted Pipit, *Anthus chloris*, which are all considered threatened on a global scale (Statterfield, Crosby, Long & Wege, 1998).

Other grassland animals are mammals, reptiles, amphibia and insects. About 20% of South Africa's threatened land mammals are found in grasslands. Since there are few hiding places in grasslands, some animals have adapted speed in order to survive. They are also colour-adapted to create better camouflage for hiding and/or hunting (Anon, 2003b; Anon, 2000 and McAllister, 2000).

In South Africa the grassland region is of great economic importance, since it is ideal for farming. Gold and coal mining industries are also found in the area. Large portions of grassland have been transformed by invasion of woody species due to overgrazing and the development of forestry. Grasslands have become one of the most threatened biomes in South Africa and only 2% is formally conserved (Le Roux, 2002).

1.2.2 Fire

1.2.2.1 History of fire

When it comes to the argument when humans "discovered" and started to use fire, anthropologists differ in their estimates. Some believe that humans started to use fire more than 500 000 years ago (Stewart, 1963), while others believe differently. In the context of this study, it doesn't really matter when humans discovered fire - what matters is when they started using it to control the environment. Stewart (1963) suggested that man was responsible for the fire subclimax vegetation types that covered about a quarter of the earth, while Komarek (1967) disagrees. He argued that lightning over long periods created the vegetation mosaics that had existed before man.

At the time humans discovered fire, they were not interested in controlling the vegetation, merely to provide fire for warmth, cooking, hunting and encouraging the growth of berries and seeds for food. Sometimes it was even used in warfare (Kozlowski & Ahlgren, 1974). In North America, fire was one of the principle forces that affected the vegetation of the Great Plains. They were set by the American Indians and lightning, but that was before European settlement. It was first believed that lightning was the primary source of fire, but that would have limited the amount of fires. More recent information indicates that the Indians used fire in all seasons for hunting, warfare, signalling and to reduce insect numbers around their villages. Other fires resulted from campfires that were left unattended and some fires were even set simply for the entertainment thereof. The Indians were also using fire, as land managers do today, to attract animals to fresh vegetation growth (Stubbendieck *et al.*, 1998; Stoddard, 1963).

Periodic drought and seasonal dryness, combined with constant winds, caused fires to burn extensively, which in turn suppressed the woody vegetation that would have developed. When the settlers came to North America, they also imported the concept of property. They believed that fire was bad for their property and should thus not be used as a management tool. The only exception was the Kansas Flint Hills, where fire was used to increase steer weight since the 1880s, due to improved grass quality and yield. Fire as a management tool was not critically examined until the 1960s, when it was reintroduced in the south-eastern and north-western United States to encourage forest regeneration. Since then, interest has increased in fire as a management tool because other methods, such as herbicides and cutting, could be risky, expensive and even dangerous. (Stubbendieck *et al.*, 1998).

Fire was also used by people in other parts of the world. The Aborigines of Australia developed a "fire-stick" regime after they had seen the lightning-induced fires in northern Australia about 50 000 years ago. The objectives were to attract kangaroos and wallabies to the new growth of grasses and flushing and trapping small game. This type of management produced a diverse mosaic of burned and unburned vegetation and helped to keep lightning fires burning less fiercely. The arrival of European settlers changed the natural regimes and the result was a reversion to higher intensity fires in tropical savannahs (Woinarski, 1988).

1.2.2.2 Fire used in religion

Fire is not only an agent being used to control and manage the environment, it is also a symbol for man in his religious life and social ceremonies. In the Old Testament of the Bible, there are many references to the relationship between man and God in the form of offerings (Maertens, 1964). In social ceremonies, fire has little meaning for the Zulu people in South Africa, but it has considerable importance for the Pedi (Bryant, 1949). The Pedi belief uses fire in weddings and political control. The men also meet around the fire to discuss the political affairs of their groups (Monnig, 1978).

The Thonga of southern Mozambique have certain taboos about fire, like the maintenance of a deceased tribesman's fire after the mourning period. They also believe that when you light a new fire, it cancels out severe misfortune (Junod, 1966). The Bemba of Zambia build and light a sacred hearth before establishing a new village (Richards, 1939), and the !Kung of Nyae Nyae in the Namib believe that all fire is the property of the head of the village and that his fire, which may not go out, is essential for welfare (Marshall, 1976).

1.2.2.3 Fire behaviour

To control fire, though, one must know how fire behaves. Primary variables of fire are the amount of fuels (dead plant material) present, weather conditions before and during the fire and objectives of the fire. Vegetation can be classified by volatility. Plants with high amounts of fats, oils and waxes (highly flammable) are high volatility fuels, while plants with fewer such compounds are low volatility fuels. High volatility fuels can produce firebrands and flaming debris that is easily carried by wind, but these fuels can be used safely with the proper care. Low volatility fuels can be burned safely within a wider range of conditions. If more fuel is present than is needed, fires can be burned under a wider range of conditions. If fuel is adequate, but the weather is not, postponing the fire is a better consideration (Stubbendieck *et al.* 1998).

Vegetation fires can be classified in two ways: wildfire and prescribed fire. Wildfires are unplanned and originate from lightning, human negligence or malice. They mostly take place in very dry seasons such as winter, when the soil is dry and plants have low moisture content, and sometimes leave undesired effects behind. On the other hand, prescribed fires are planned and executed at a specified time and place, as part of a management plan. Weather and environmental conditions are such that a safe, controllable fire is ensured. Reasons for burning can be to remove unpalatable vegetation, stimulate new growth, control or destroy insects and diseases, keep undesirable vegetation types out, aid in distribution of animals in a habitat, remove accumulated fuels, stimulate seed production or germination, and to establish fire breaks to protect an area from wildfires (Kozlowski & Ahlgren, 1974).

1.2.2.4 Fire and conservation

Parks are managed to conserve parts of the environment, and fire has a role in this. At first, fire was seen as an unavoidable evil, and later it was seen as something, which should be avoided at all costs. Currently fire is seen as a tool to help in maintaining diversity (see Brawn, Robinson & Thompson, 2001 and Botkin, 1990). The management regimes in parks have changed over the years. First, only large herbivores were valued, and then concern was extended to include predators, veldt and finally the whole ecosystem. Parks have progressed through four phases of burning policy to reach the fifth and current phase (Mentis & Bailey, 1990).

The first phase was pre-proclamation, where fire occurred only at times, caused by lighting or locals inhabitants (Manry & Knight, 1986). The second phase was post-proclamation, where fire was seen as an unavoidable evil. The third phase was used to improve the means of controlling fire. Vegetation (which had not been burned by natural fires) was burned annually during autumn and firebreaks were used to control the fire. Thereafter it was felt that the natural balance was sure to be upset by this frequent burning and fires were permitted only every five years and only after good spring rain (Brynard, 1964). Accidental fires were to be avoided.

The fourth phase (1954 to mid-1970s) saw the Kruger National Park compartmentalised. The same compartments were burned at the same time every few years. This phase is still a reigning one for some conservation areas in South Africa, while the fifth phase has already been incorporated in several other parks. According to the current phase, if fire is applied in a uniform way, the system will simplify. Thus, the property of savannahs will be reduced. Park managers should not regard fire parameters as scalars (single value representing, for example, a mean) each with a single optimal value, but as vectors (a set or series of figures or values representing, for example, a frequency distribution). The Kruger National Park, Mkuzi Game Reserve and other parks have introduced this variation to a greater or lesser degree (Mentis & Bailey, 1990).

1.2.2.5 Effects of fire

Whether controlled or not, fire has an effect on the environment. Fire can control local climates for a short period of time. Without rain, moisture levels may drop and it becomes dry on the burned area. The temperature can also be higher on the burned area than it would normally be, since the black earth absorbs the heat from the sun more easily (Kozlowski & Ahlgren, 1974). Destruction of vegetation can also affect animals, as there is little place to hide or perch on. With the cover of vegetation, competition can be avoided, as each species seeks a particular resource for shelter and food. Take them away in a fire and competition between two species, which have to share the same resources that are left after the fire, occur and may persist until one of them withdraws (Kozlowski & Ahlgren, 1974 and MacArthur, 1958).

The same goes for predation. Take away the cover of vegetation after a fire and suddenly both predator and prey are visible to each other. It is difficult for the prey to avoid its predator and it is difficult for the predator to sneak up on the prey (Bryant, 1971). On the other hand, it can be advantageous to both sides. Prey can see a predator coming and some predators function better in open environment and thus the hunt is made easier for them (Kozlowski & Ahlgren, 1974 and MacArthur, 1958).

One of the advantages after a fire is the reduction of parasites (internal and external) and disease (Brynard, 1964). Animals are adapted to certain kinds of food (for example, grass, seeds or leaves) and their abundance may depend on the supply of their preference of food. Mammals are more affected than birds, as they tend to feed from a certain height. Some prefer the tops of the grass, others the middle and after a fire both of these are gone and food for them is scarce. Birds that feed on seeds may also be affected until vegetation produces seed again (Kozlowski & Ahlgren, 1974).

It is easy for big mammals and birds to flee before a fire (Apps & Du Toit, 2000; Booysen & Tainton, 1984). Small mammals, such as mice and squirrels, and reptiles, such as snakes and lizards, have to hide, as they are not fast enough to flee. They choose rocks, water, or their burrows under the ground, since the heat of most fires don't reach very far underground (Apps & Du Toit, 2000). The only loss is therefore food resources, cover and nesting sites (Mentis & Bigalke, 1979). The wind, carrying smoke from the fire, acts as an early warning system to animals and they can get away in time. The only mortalities occur when animals are trapped by rocky outcrops, rivers, ravines or fences blocking their escape routes (Apps & Du Toit, 2000).

1.2.3 Grassland and fire

Fire is such a part of the environment that it is regarded as a natural factor. Reports of Portuguese explorers state that they called the interior of South Africa "Terra dos fumos" – the land of smoke and fire (Thompson, 1936 and Kanthack, 1907). Fire is also thought to play an important role in plant communities (Tainton & Mentis, 1984). Grassland, savannah and fynbos owe their nature to fire. In spite of all this, management (except in conservation areas) tend to have a negative attitude to fire, probably because the first researchers on fire effects were foresters, who were against its use and also in view of fire's destructive effects on grassland if used unwisely. According to evidence, early humans modified the natural fire regime to suit their own purposes and by the eighteenth century veldt burning occurred regularly to stimulate new growth in plants to improve grazing and hunting (Edwards, 1984). Since man had "discovered" fire, he had to learn how it behaves and how to use it properly (Tainton, 1999).

When plants burn, three phases can be recognised: a pre-heating phase, where the temperature in vegetation ahead of the fire is raised to burning temperatures, flaming combustion, which results from the lighting of the gasses set free during the pre-heating phase and glowing combustion, where the remaining charcoal is consumed, leaving a residual ash behind. The phases overlap and occur at the same time during the fire. The amount of energy released during the flaming and glowing phases differs according to fuel type (Tainton, 1999).

According to literature (Luke & McArthur, 1978), fire can be divided into three categories: crown fires that burn in the canopies of trees, surface fires that burn in the surface fuels such as grass, shrubs, seedlings, leaves, twigs and barks, and ground fires that burn below the surface of the ground in deep layers of organic materials. Head- or backfires, as are found in grasslands and savannah, behave differently with respect to rates of speed, fire intensity, flame height and temperature, thus they have different effects on the plant life. Head-fires travel faster than backfires and their rate of spread is also more variable, thus being more influenced by environmental conditions (Trollope, 1978).

The rate of spread of a fire also determines its intensity. Flames of head-fires also reach greater heights and are more variable than those of backfires. Backfires are hotter at ground level than head-fires and the temperatures of both are higher at grass canopy level, but head-fires become hotter at a meter above grass canopy level (Trollope, 1987).

Grassland areas, which are prone to fire, support many organisms that are adapted to fire (Mentis & Bigalke, 1979). Africa is prone to lightning storms and during the dry period, lightning-induced fires burn plant fuels that have accumulated during the wet season. Fire can be regarded as a central component in the management of grasslands. The grassland biome is characterised by wet summers and dry winters. After the first frost has killed the aboveground parts of plants, they dry out and become flammable. The fires are head-fires, burning intensely and spreading rapidly (Tainton, 1999).

1.2.4 Birds

Ancient birds have taken over the skies after the dinosaurs went extinct to give us today's diversity of more than 9 000 different species (Davies, 2003). They could go where many other creatures couldn't, in search of food and habitat. Birds adapted to their environment and became one of the planet's most successful creatures with many examples of their adaptation to their environment. The Golden Finch, *Carduelis carduelis*, for example, feeds on speargrass. It can reach the seeds on the ground only after fire has cleared the undergrowth. The Temminck's Courser, *Cursorius temminckii*, in Africa seeks grassland that has been completely destroyed by fire for nesting sites. The benefits of these kinds of terrain are that predators are easily seen and that insects, a food source, are abundant after fire (Davies, 2003).

Humans are the biggest threat to birds, having the habit to control, and thus manipulate, the environment. Through hunting, habitat destruction, pollution and introduction of exotic species, man threatens about 1000 bird species globally (Davies, 2003).

Many research studies have been done on birds. From some of the results it has been determined that species in southern Africa change their habitat so often that it is not always safe to presume that a forest bird in the south will be one in the north. Also, because abnormal conditions, such as cold in the tropics and a wet season in the arid southwest, produce oddities such that the normal pattern of distribution may become clouded (Liversidge, 1962).

Distribution may also be related to environmental change, making the birds, in many instances, a good indicator of environmental change. If factors determining distribution of animals are known, response can be predicted and environmental quality can be monitored. While plants have been used as indicators of physical condition in plant ecology, animals, especially birds, have traditionally played a more restricted role as indicators of environmental contamination. Populations are subjected to various natural disasters, such as earthquakes, floods, droughts and volcanic eruptions. Birds are not needed in these instances to indicate that a disaster has taken place, but not all disasters are apparent. Humans can also cause disasters. Some of these disasters are not always visible until a few years have passed and therefore changes in populations must be monitored. Humans exert pressure on the habitat of wildlife, and while an area may return to something like its previous state after a natural disaster (for example Mount St Helens), it does not always do so after human-inflicted disasters (for example Chernobyl). It remains in its new, unnatural state, changed either significantly or subtly. Even with subtle changes, bird populations cannot stay healthy with insufficient habitat quality, which does not always refer to the quantity of habitat as well. A big piece of land that is not managed correctly may have poor quality even though there is a big quantity. On the other hand, a smaller quantity may have good quality because of good management practises (Morrison, 1986).

1.2.5 Birds and fire

Prescribed fire is used all over the world for conservation and management purposes, as seen in section 1.2.2. The question invariably arises as to the reaction of the birds to these disturbances. At Matagorda Island in Texas, wrens were more abundant on the control plots, while sparrows chose the burned plots. This happened after a period of six to 10 months post-burn. A year and a half later, wren abundance had increased on burned plots, but they still chose the control plots, while sparrows still preferred the burned plots. Thus, in conclusion, burning impacted wren abundance negatively while affecting the sparrows positively (Van't Hul, Lutz & Mathews, 1997).

Most of the grassland birds at the Lostwood National Wildlife Refuge (North Dakota in North America) were positively related to an index of amount of burning and were absent from unburned areas. Since fire has been restored as a dynamic process at the Refuge, abundances of endemic passerines have increased. Some species responded negatively, although they were not completely absent from the burnt area (Madden, Hansen & Murphy, 1999).

Managers need to understand how fires affect grassland birds as some species may only spend six months or less on wintering grounds. Doves may have been attracted by foraging habitat, created after a burn in mesquite grassland, while sparrows will seek out patches with little cover and high seed density (Grzybowski, 1983). Van't Hul *et al.* (1997) stated that sparrows preferred burned areas in the first breeding season after the fire on a Texas barrier island. Sparrows and wrens may be more susceptible to fires than other wintering birds because they prefer dense cover and have small home ranges in winter (Reynolds & Krausman, 1998).

A diversity of bird groups use habitats that are caused by natural ecological disturbances. As these habitats have been lost to agriculture and development, resulting in the suppression of those disturbances, many species, having adapted to these previously natural habitats, have been declining.

Avian abundance decreased after a spring burn on a Kansas Conservation Reserve Program. This program was established to curb excess crop production and to improve soil and water resources. The program called for the establishment of permanent vegetation cover on highly erodible cropland. This program was generally believed to benefit the grassland birds in the Great Plains. As vegetation was nearly absent, birds went elsewhere to find cover and to breed, though no significant difference was found between nesting success by birds in both burned and unburned fields. It was found that burning less frequently rather than annually could reduce the adverse effects (Robel, Hughes, Hull, Kemp & Klute, 1998).

In a Mediterranean shrubland, birds were never completely absent from the burned area after a fire. The minimal abundance was only observed later and not immediately after the fire. When compared with the control, the burn shows that more than 50% of the species are site-tenacious or philopatric to some degree, some species disappear almost completely and some are post-fire colonisers. Decreases may be because of food depletion or a lack of cover (Pons & Prodon, 1996).

Mills (2004) explained that changes in birds in the savannah due to fire could be predicted based on the alteration of habitat. Species that feed on the ground may be attracted to a fire, whereas those that prefer the cover of vegetation would stay in the unburned sites. Species feeding on grass seed were also less common on the burn sites and insectivorous birds showed no difference. None of the species were entirely absent from the burn sites.

Changes in communities are minor and may be short-lived, as habitat structure recovers quickly.

Davis *et al.* (2000) stated that restoration of many plant communities involves the reintroduction of fire. Their results showed that a savannah could be thus restored, and concomitantly restored many of the bird species' populations (Davis, Peterson, Reich, Crozier, Query, Mitchell, Huntington & Bazakas, 2000).

It is important to predict and understand community responses to fire when managing biodiversity. Most of the past studies have been concentrated on the effects of fire on vegetation (For example see Pyne, 1997 and Daubenmire, 1968), although conservation organisations now have their goal on biodiversity conservation as a whole. It is therefore essential to have knowledge of the effects of fire on groups other than plants for management purposes (Parr & Chown, 2003). According to Parr and Chown (2003), most of the research on birds and fire in South Africa has been done at species level and only the responses of a few species to fire have been studied. The focus has been on two species of Francolin (*Francolinus levaillantii* and *F. africanus*) (e.g. Mentis & Bigalke, 1979), the Fork-tailed Drongo, *Dicrurus adsimilis* (Paintin, 1965) and other species such as Helmeted Guineafowl (*Numida meleagris*), oxpeckers, larks, ibises and several species of raptor (Parr & Chown, 2003).

Effects of fire on animals can be assessed in several different ways (Parr & Chown, 2003). Experiments should have a sound design, as poorly designed experiments are unlikely to produce the correct results necessary for testing hypotheses. Most of the studies on birds were observational and mostly on feeding habits during a fire. Not many burning experiments have been set up as fire experiments. Experiments usually depend on firebreaks instead of a fire planned as part of the experiment. Mostly, experiments are done on accidental fire or do not mention if the fire was planned. Very few experiments include fire that is deliberately set for the experiment, and only about half of these are long-term. Therefore, most of the experiments in Southern Africa should be viewed as observational, suggesting mechanisms but not testing them (Parr & Chown, 2003).

Fire can have consequences on biodiversity over a range of scales, thus making it essential to mention the scale of a burn in the experiment. Many investigators fail to mention scale in their results. For example, how much of the area was burned and from what portion was data collected? Incorrect scaling can lead to misleading results in data (Parr & Chown, 2003).

Many studies also fail to mention spatial replication. It is often not mentioned if studies took place over more than one year, or whether there was any kind of replication at all. Many studies include pseudo-replication, where several sampling grids are chosen in an area. This may be complicated as no information on spacing between grids is mentioned.

Most studies would be better understood with a complete description of methods used (Parr & Chown, 2003).

Replication in studies is not always possible, especially when it involves fire. Fire ecology is not always replicable, but cannot be excluded from study simply because of replication problems as it has an important influence on the environment. These problems can be overcome with alternative approaches, for example documenting the fire history of an area. Repeating an experiment may also help to increase the robustness of the results, although this will not help poorly designed experiments (Parr & Chown, 2003).

Because reaction to a fire may differ, short-term results may not always reflect the long-term results. Some changes may be too subtle for a short-term study. It is thus essential to report the duration of the experiment (Parr & Chown, 2003). Improving our understanding of the effects of fire on fauna should be viewed as a challenge and an opportunity. There is much scope for future work. The results will help to improve the conservation of animals in protected areas that constitute an ever-growing proportion of habitat available to many species (Parr & Chown, 2003).

1.3 Aims and objectives

Using Parr and Chown (2003) as guidance, the aim of this project was:

- To determine the effects of prescribed and accidental grassland fires on the terrestrial birds of the Barberspan Nature Reserve.

  To achieve this aim, the following objectives were identified:

  - To investigate the effects of fire on bird numbers
  - To investigate the effects of fire on bird species
  - To investigate the effects of fire on bird diversity using Shannon Index
  - To investigate the effects of fire on avian biomass
  - To investigate the effects of the surface area of the burn on birds

- I will also develop recommendations on:
  - Further research and,
  - Future burning at Barberspan.

The study design to achieve the aim and objectives will be introduced in Chapter 2.

Chapter 2: Materials and Methods

"...Almost 500 years ago a civilization... said to dwarf the wonders of Egypt, Greece and Rome laid down its arms and entered a non-martial and non-material period... much of the environment that once supported immense cities and armies was abandoned to a few scattered villagers who, with the aid of the agency of fire, have since maintained... one of the last great refuges for herbivorous mammals in all of southeast Asia..." Wharton (1966) wrote of Cambodia. (Quoted by Kozlowski & Ahlgren, 1974)

2.1 Methodology

Based on the information and aims in Chapter 1, the following design was developed and executed:

Planning

- Obtained literature relevant to study
- Conducted review based on literature (Chapter 1.2)
- Formulated objective and aims of study (Chapter 1.3)

Identification of study area and selection of sites

- Selection of study area – Barberspan (Chapter 2.2)
- Obtained map of study area (Chapter 2.2)
- Sites identified (Chapter 2.4)
- Planning of burns (Chapter 2.4)

Data collection

- Execution of burns (Chapter 2.4)
- Data collected by means of point counts (Chapter 2.4)
- Number of species and abundance of each species recorded (Chapter 2.4)
- Weather conditions and time of day recorded (Chapter 2.4)

Data analyses

- Data analysed using Primer 5 and Excel 2000 (Chapter 3)
- Data analysed according to abundance of species and individuals overall and in guilds. Diversity and biomass analysed (Chapter 3)

Discussion and conclusion

- Interpretation and discussion of results (Chapter 4.2)
- Develop conclusions (Chapter 4.4)
- Develop further suggestions and comments (Chapter 4.5)

2.2 Description of the study area

2.2.1 History of Barberspan

Barberspan lies in the North-West Province of South Africa (Fig. 2.2.1), between the towns of Delareyville and Sannieshof. The previous Transvaal Provincial Administration started buying property at the northern end of the pan in 1952. The reason for this was to start a bird sanctuary and this end of the pan had the greatest concentration of bird life. In May 1955, the first ornithologist, Captain E. L. Shewell, was appointed and research, primarily ringing, was started. Dr. T. Farkas succeeded him in June 1958 and resigned in June 1966. Mr Peter Milstein started in January 1968, but although transferred in late 1966, he could not go because of other commitments. At this stage, negotiations to buy another 439 ha on the southern side of the pan had been finalised (Milstein, 1975).

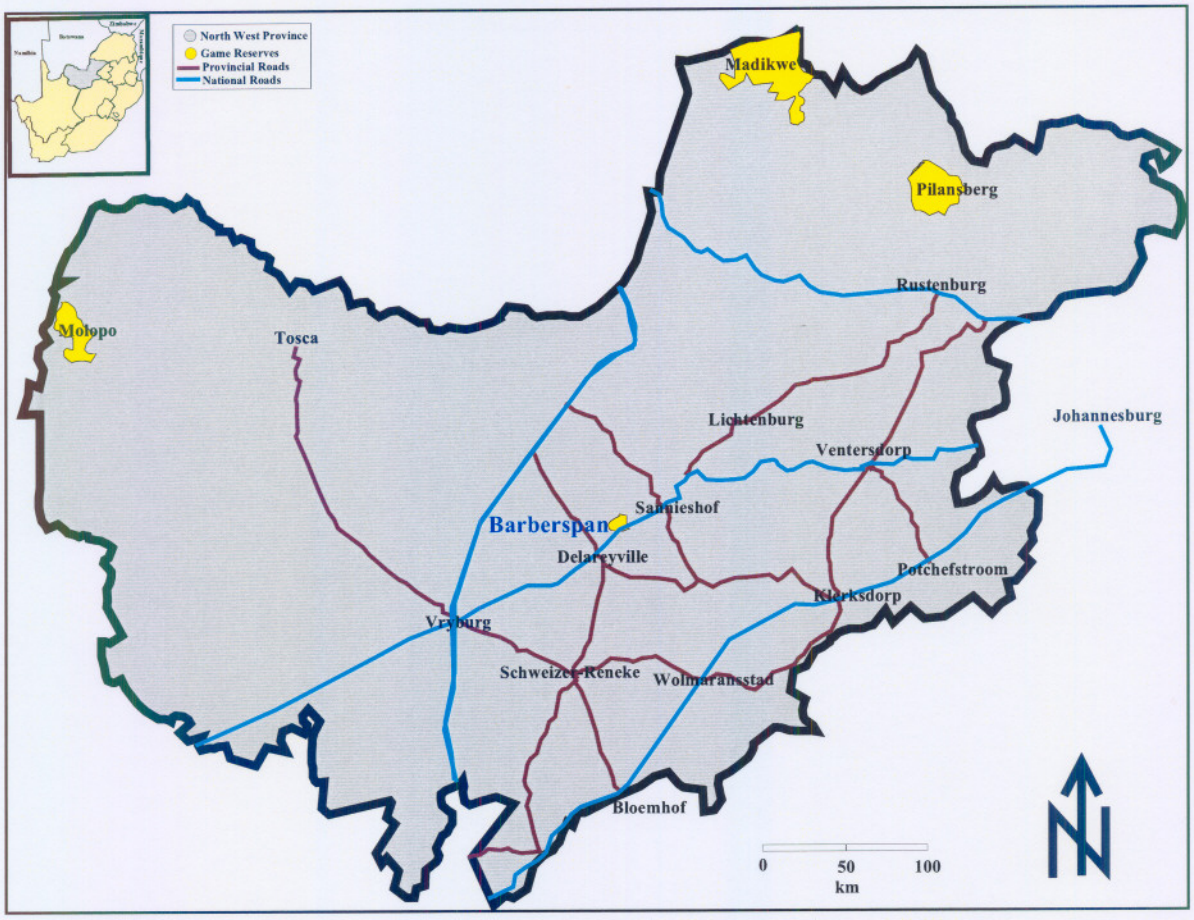

Fig. 2.2.1 A map of the North-West Province in South Africa, indicating some of the major Provincial nature reserves, as well as Barberspan, in yellow.

There has been a certain amount of confusion about the origin of Barberspan's name, mainly because of the occurrence of the barbel fish (*Clarias gariepinus*) or "baber" in Afrikaans. In truth, the name of the pan did not originate from the fish, but from an Englishman named Frederick Hugh Barber (Polderman, 1945), the man after whom Barberton was also named. He had hunted along the Harts River, which nowadays feeds Barberspan, in 1875, before white people settled in the area. The station was known as Barberspan since the completion of the railway line in 1911, according to the South African Railways' records (Milstein, 1975).

The farm received its name later, on 21 December 1915, when the part belonging to Wessel Johannes Lemmer became known as Barberspan 309 (IO6A). On 10 June 1888, President Paul Kruger ceded the original farm, Groenfontein, to Cornelius Jansen Lemmer. Jacobus Frederick Daniel Oosthuizen owned it from 2 October 1888. On 7 March 1889 he sold a half-share each to Wessel Johannes Lemmer and Jan Christian Smuts (Milstein, 1975). A small graveyard of the Lemmer and Oosthuizen family still exists at Barberspan.

Barberspan, lying next to the flood plain of the Harts River, did not receive water from the fossil course, except in peak floods, because of a limestone obstruction, and would frequently dry up. The Harts River went past the pan and Schweizer-Reneke to the Vaal River. In 1918, however, General J. C. Smuts sent about 60 mine labourers to Mr. M. S. Basson, his second cousin and farm manager, to divert the Harts River into the fossil course. They constructed a stonewall, still visible today, to block the course and also removed 50 meters of a surface limestone obstruction from the fossil course. The first flood thereafter bypassed the sluice, which was intended to control the water, and the fossil course into Barberspan was enlarged (Bothma, 1945 and Milstein, 1975). Since then (as far as could be established), Barberspan has never been dry again. According to Polderman (1945), the last dry-up occasion was in 1913. The Harts River now only flows past Schweizer-Reneke in peak floods (Milstein, 1975).

2.2.2 Description of Barberspan

Barberspan (26°35'S; 25°35'E) is a bird sanctuary in the North-West Province of South Africa (Fig. 2.2.1 and 3.1.1). It is situated in an area of seasonally filled pans, which makes this perennial pan very important to waterfowl and conservation. It is continually fed by the Harts River and is connected to the adjacent Leeupan by a shallow channel, which may dry up at times. In the dry season the birds go to Barberspan for sanctuary or as a stopover on their migration routes. The Reserve measures 3000 ha, while the water body itself is 2000 ha (Fig. 2.2.2 and 2.2.3). Herds of springbuck had trampled the bottom of the pan in dry seasons, enlarging the area that was already eroded by the fierce winds that blow annually at Barberspan. The depth now varies between 5 m and 9.5 m (Beyer & Duggan, 1997 and De Beer, 2001).

Barberspan is a paradise for birdwatchers as there has been more than 350 species recorded in the reserve including waders, herons, ducks and other waterfowl, larks, pipits, bee-eaters, chats, owls, birds of prey and many more (Fig 2.2.4 and 2.2.5). The bird population varies greatly between seasons. Migratory birds, such as waders and swallows, leave in winter, but return in the summer months (Beyer & Duggan, 1997 and De Beer, 2001).

Animals

Other animals that can be seen in the reserve are ground squirrel (*Xerus inauris)*, black-backed jackal (*Canis mesomelas)*, porcupine (*Hystrix africaeaustralis*), bats, cape hare (*Lepus capensis*), suricate (*Suricata suricatta*), yellow mongoose (*Cynictus penicillata*), slender mongoose (*Galerella sanguinea*), steenbok (*Raphicerus campestris*), common duiker (*Sylvicapra grimmia*), bat-eared fox (*Otocyon megalotis*), rinkhals (*Hemachatus haemachatus*) and other snakes. There are also 11 fish and nine amphibian species present. The south-eastern side of the pan has been allocated for angling and there is a campsite (Beyer & Duggan, 1997; Dini, 1999; North West Parks & Tourism Board, 2002). See

Appendix A for birds that were seen at Barberspan when research on water birds was still done.

Plants

The soil at Barberspan is shallow and calcareous. It has sandy patches in some areas and consists of Mispah and Katspruit sand types. The area around Barberspan is mainly open grassland with mixed clumps of trees, which consist of sweet thorn (*Acacia karoo*), camel thorn (*Acacia erioloba*), the occasional white stinkwood (*Celtis africana*) and karee (*Rhus lancea*) (Fig 2.2.6 and 2.2.7). The area is flat and farmers raise cattle and maize. With the long-term withdrawal of larger herbivores, the vegetation has reached a sub-climax stage, which may also have an influence on the bird species (Milstein, 1975; De Beer, 2001; Dini, 1999).

Trees and shrubs have been planted since 1955 to attract bush bird species. Farkas (1966) stated that the trees planted near the staff houses and laboratory, were mainly exotic species. Some indigenous trees were also planted in the past. Recently, large-scale planting of trees has been restricted to indigenous species. Other plant-species that occur are aquatic, which include *Potamogeton pectinatus*, Juncaceae (rushes) and Cyperaceae (sedges). There are smaller forbs around the shore of the pan. The rushes and sedges lead into the veldt, which consists of *Themeda triandra, Eragrostis, Aristida, Setaria, Cynodon dactylon, Rhus pyroides, Rhus ciliata, Tachonanthus camphorates, Zizphus mucronata* and *Grewia flava* (Milstein, 1975; De Beer, 2001; Dini, 1999).

Climate

The reserve has prevailing northerly winds, causing regular dust storms, which usually originate from the surrounding farmlands. The area receives summer rainfall, with an annual average of 557 mm. The average temperatures range between 9°C (minimum) to 27°C (maximum). These temperatures may fluctuate higher or lower (Milstein, 1975 and Dini, 1999).

Fig. 2.2.2 A view of the pan from the causeway.

Fig. 2.2.3 A view of the pan from the bridge by late afternoon.

Fig. 2.2.4 A Long-tailed Widowbird taking a rest .

Fig. 2.2.5 A Marsh Owl. These birds are common near the pan.

Fig. 2.2.6 A few Cattle Egret resting in the Acacia trees.

Fig. 2.2.7 A path that leads from the mouth of the pan to the Acacia trees.

Fig. 2.2.8 The old jetty at Goose point.

Fig. 2.2.9 The causeway between the gate and the office.

Barberspan as a RAMSAR site

Barberspan was declared a Ramsar site in 1975 according to the Ramsar Convention of 1971. Various reasons have been given for its inclusion. It is an example of a specific type of wetland, i.e. a grass pan, which is rare or unusual in the biogeographical area. It maintains a large number of threatened plants and/or animals. It is of special value for the maintenance of the ecological diversity of the region. It is of special value as habitat to plants and animals in a critical part of their life cycles. It also maintains large numbers of individuals of specific groups of water birds, which indicate the value, productivity and diversity of the wetland (Dini, 1999).

There are research facilities at Barberspan, but these are now seldom used. The reserve was very important as a bird ringing station. Ringing helps in studying the migration patterns of birds. Aquatic bird species were the focus of the research conducted here. Threats to the reserve are mainly from the surrounding farmlands, which use agricultural chemicals such as fertilisers and pesticides, alluvial diamond mining and hunting, while littering is also a problem. Illegal fishing and motor boating beyond the limits also occur on occasion. However, with continued proper management and support, Barberspan will play a role in the observation of birds and tolerances to environmental changes can be monitored (Milstein, 1975 and Dini, 1999).

2.3 Materials

The following materials have been used in the field research of the study.

- Binoculars
- Sasol Birds of Southern Africa, 3rd edition (Sinclair, Hockey & Tarboton, 2002) identification book for identifying birds in the field. The bird names I used were also according to this source.
- Roberts' Birds of Southern Africa, 6th Edition identification book for biomass, habitat and habits.
- Thermometer
- Kestrel Meter for wind-speed recording
- Watch to record time of day
- Map and GPS to mark count sites
- Recording forms for information.
- Camera and film

2.4 Methods

I decided on using controlled burns at Barberspan to achieve the objectives and aim of this study. A point count method (Bibby, Burgess, Hill & Mustoe, 2000) was used at each of the three burns. With this method, an area, for example Burn 1, was chosen on advice from an ecologist from North-West Parks Board, regarding grassland homogeneity. A few points are chosen, either laid out systematically (Burn 2) or chosen according to circumstances dictated by the size and shape of the burned site (Burns 1 and 3), for both Control and Burn sites. A fixed radius, not overlapping with others, was used. When a point was located on the edge of a burned site as at Burns 1 and 3, a semi-circle was used. Counts were taken on a regular basis or as predetermined by the observer for two years at Burn 1 and one year for Burns 2 and 3.

Birds that were seen or heard were counted, as not all birds may be visible to the observer (Bibby *et al.*, 2000). Care was taken to reduce the possibility of double counting, by mentally noting and tracking birds as they move. It is acknowledged that using birdcalls is likely to introduce some bias, as birdcall activity varies during the day, as well as with season.

I arranged and coordinated with the Park Warden, Mr. Sampie van der Merwe, about the selection of the sites to be burned and used as control, the personnel available to help with the burning of the site and the time of the burn.

Before I started with data collection, I spent considerable time at the reserve to get acquainted with the birds. Bird ringing and support for other avian related projects allowed me to obtain a good knowledge of the diversity present in the reserve. I also spent some time with other birders to sharpen my identification skills, especially on birdcalls.

It must be noted that the detectability of the birds would be different between an open area that has just been burned and an area that has already recovered, or has not been burned, such as the Control sites. However, since it is nearly impossible to correct for visibility and detectability, especially since the bird species composition changed quite appreciably before and after the fires, the data will not be corrected regarding detectability in any way, as further bias would then be introduced. The counts should therefore be seen as relative, rather than absolute, with the aim of identifying trends and differences.

I did transform the data to achieve densities of birds per 20 ha, so that the findings from the different burns can be compared, and to transform the 20-minute counts used at Burn 1, to conform with the 10-minute counts used at Burns 2 and 3, as described in section 2.5. It should also be noted that the presence of the observer would also affect the birds. Since my presence was a requirement in both Control and Burn sites, this factor was deemed constant, and was therefore not corrected. One could argue that birds in unburned or recently regrown sites will react differently than in burned sites, due to variable vegetation cover, and that it would affect their behaviour, especially because of the presence of a human observer. The time I spent observing birds before and during the counts, however, has given me reasonable confidence that the differences observed were mainly due to the effects of the burn and much less ascribable to the presence of an observer, or a change in detectability. Therefore, the following assumptions were made during the counts (Bibby *et al.*, 2000):

- Birds do not approach the observer and neither do they flee.
- Birds are not 100% observable from the observer's point of view.
- Birds do not move from their place before observation.
- Birds act independently.
- Birds are identified fully and correctly.

The definitions of terms used in the study are as follows:

- Burn 1 – This is the entire area that was included in the study. This includes the Burn and Control Sites. For example Burn 1.
- Site – This is the area that was used either for the Control or the Burn. The Points lie within this area. For example Burn Site at Burn 1.
- Point – This term includes the point from which the point count was done, as well as the circular or semi-circular area with a defined radius from the point. For example Point B1 at Burn 1.

The methods used for each burn will be discussed separately. The methods that were the same for each of the three burns were as follows: Binoculars and the Sasol guide (Sinclair, Hockey & Tarboton, 2002) were used to identify birds that could be seen in a 250-meter radius for Burns 1 and 3, and a 120m-radius for Burn 2. The surface area of each point at Burns 1 and 3 was 193250 m^2 or 19.625 ha. The surface area of each point at Burn 2 was 45216 m^2 or 4.522 ha. The radii of each of the points did not overlap. Burn 2's radii also did not touch the sides of the block. No counts were done at wind speeds in excess of 10 km/h.

Birds hiding in the grass were identified according to their calls. Birds that flew over were ignored. Birds perched on high bushes or trees were not counted, as they were deemed using the tree, rather then the terrestrial burned or unburned site. If they perched in the grass, on the ground, or utilised the site in some other way, they were counted. Ostriches were ignored, as they could not leave the reserve. Rainy days and/or windy days (causing dust storms) were not used for counting, as bird activity was very low and would introduce a bias in the recording and data. No counts were done at wind speeds in excess of 10 km/h. A GPS and map were used to identify and relocate the counting points on subsequent visits.

2.4.1 Burn 1

At Burn 1 (Fig. 3.1.1), between the mouth of the pan and Godwit Bay, it was envisaged to burn only 25 ha, with an adjacent 25 ha set aside as control. Four observation points to count birds were selected in each of the Burn and Control Sites. Counts were done every month, for three days per month, until the burn. Thereafter it was repeated every two weeks as far as possible. At every point, five minutes were given for the birds to settle and these were used to fill in the date, time and weather particulars on the form as well as to take a quick look around the site or take photographs. Each point count lasted 20 minutes, but was reduced to 10 minutes in the second year, as two additional burn counts were done at the same time. See section 2.5 for data conversion methods between the two count timings.

On the day of the burn (11 July 2003) the wind blew mildly and the pre-burn was started before noon (Fig. 2.4.1.1). The reserve personnel wore protective gear and machinery and tools were inspected. A clear path to water was planned. The fire was started and as it spread, any jumping flames were immediately doused with water. Beaters following behind also put out any smouldering grass. The order of the men controlling the fire was first the fire starter in front, followed closely by three water trucks. Three persons with water guns on foot, and two beaters followed them.

At the first corner of the burn block, the wind suddenly changed and became stronger. The fire jumped across the pre-burn, but was contained (Fig. 2.4.1.2). However, the second big jump could not be controlled. The fire tore through most of the Control Site going in the direction of the pan, where it burned itself out. The fire was left uncontrolled, to allow fire fighters to concentrate on preventing the reeds from spreading the fire along the shore of the pan to the public road next to the reserve. Fighting the fire lasted until the evening. About twenty grey herons were already present at the burn sites. About 175 ha were eventually burned as opposed to the planned 25 ha.

New points were selected after the fire in both the Burn Site and a new Control Site, adjacent to the burned site as shown in the map in Chapter 3.1 (Fig. 3.1.1). As B2 was in the acacia bush, it was not considered suitable for the study and was left out, therefore leaving B1, B3 and B4 (Fig. 3.1.1). There were in all, two points in the Control Site and three points in the Burn Site. Vegetation-regrowth (Fig. 2.4.1.4) started late in August 2003. The first rain fell in mid-September. The counts were conducted for three consecutive days, twice a month (until 27 November 2003). In the second year after the fire, counts were also conducted twice a month until 11 November 2004. With each count, each point was counted twice over the three-day period.

2.4.2 Burn 2

Burn 2, between the office and Peter's Pan (Fig. 3.1.1), was divided into two equally-sized blocks of 500 meters by 500 meters with a 100 meter gap in between, which had been mowed beforehand to help prevent the spread of possible wild fires. The size of the burn was decided upon after consideration of the events and data at Burn 1. This size was deemed small enough to be able to control any jumps of the fire, if wind would increase in strength. Four points were marked with droppers in both the Burn and Control Sites. The size of the burn (25 ha), however, constrained the radii of the individual counting points.

The burn was started after 13:00 on the day of the burn (30 June 2004). Since it had rained the previous day, the grass did not burn in the morning and the burn had to be postponed to noon when the grass had dried sufficiently to burn. Standard protective gear was used. There were two fire starters, four vehicles with water and one person on foot, with a water gun. The wind was strong, between 10 km/h and 22.1 km/h. The fire was started in a corner of the burn block (Fig. 2.4.2.1) and lit along the side of the block, against the wind. It was allowed to burn into the block, but was checked whenever it jumped out of the block. The block was burned around the sides and then the fire was allowed to burn the inside of the block completely.

About 25 ha were burned. The wind was more help than hindrance, but everything was done by evening, leaving enough time for a count and photographs of the burn sites (Fig. 2.4.2.2). After the burn, morning, midday and evening counts were done, to determine the difference time of day would have on bird activity. Counts were done every week for a month after the fire and at least twice a month (for two days) thereafter. Counts lasted until 11 November 2004.

2.4.3 Burn 3

I was not present when Burn 3 took place on 4 July 2004 and had to rely on reports from the Park Warden (Sampie van der Merwe, pers. comm.). A wild fire started outside the reserve, next to the public road. It burned for a few meters before entering the reserve close to Godwit Bay, and ran for about 3.5 km along the side of the pan before the fire fighters arrived to control and douse it at Botany Bay (Fig. 3.1.1). The burned site was 500 m at its widest. About 450 ha were burned. Counts started 6 July 2004. There were six points in the Burn Site and three points in the adjacent Control Site. The number of Control points was constrained due to the particular shape of the burned site. Counts lasted until 11 November 2004.

Fig. 2.4.1.1 The first strip being burned.

Fig. 2.4.1.2 Before the fire jumped. The wind is already quite strong.

Fig. 2.4.1.3 Point B3 in the Burn Site after the fire.

Fig. 2.4.1.4 Point B3 in the Burn Site after the first rain.

Fig. 2.4.1.5 The grass is being lit by dragging a can with burning paraffin across the veldt.

Fig. 2.4.1.6 After the last flames have been doused.

Fig. 2.4.1.7 Burn point W4 three days after the rain.

Fig. 2.4.1.8 Burn point W4 after the first fire.

2.5 Data conversion

As was noted above, the time available for counting each point was reduced from 20 minutes in the first year to 10 minutes in the second year. This had to be done to accommodate the morning counts at Burn 1, as well as the morning, noon and afternoon counts at Burns 2 and 3, on the same day. Clearly, the data could not be compared between the different timings (10 and 20 minutes) and therefore had to be adjusted. Halving the 20-minute data would be entirely wrong, as most birds were sighted in the first couple of minutes of each count. I decided to use the cumulative rate of counts to convert the 20-minute counts to 10-minute counts. For additional information, specially planned and conducted counts in both Burn and Control Sites were done to attain a wide range of final 20-minute counts, with which to achieve the conversion to 10 minutes.

Each of the four counts lasted for four hours in the mornings. Five 20-minute-counts were taken each hour, by starting a new 20-minute count every 10 minutes, thereby obtaining 10 and 20 minute counts. The 20-minute counts thus overlapped. This data was then used to draw a regression of 10-minute counts against 20-minute counts (Fig. 2.5.1). The 20-minute counts in Burn Sites were converted to 10-minute counts by reading the corresponding 10-minute count of the regression line. Therefore, 84 birds counted over 20 minutes would be converted to 45 birds in 10 minutes. A similar graph was used for converting the numbers in the Control Sites.

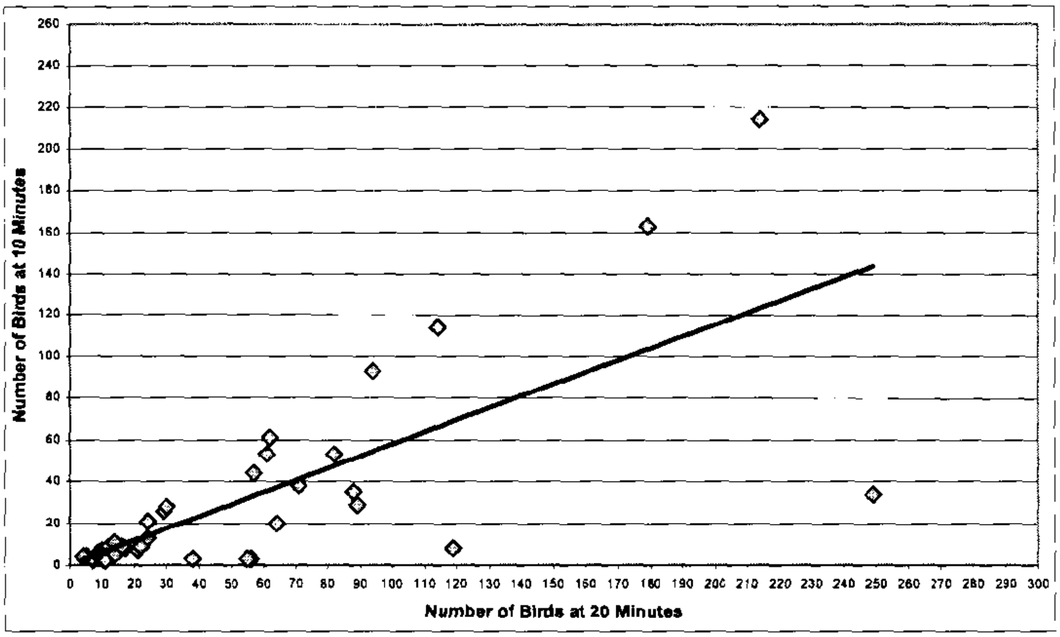

Fig. 2.5.1 Graph showing the regression between 10 and 20 minute counts, used to convert the 20-minute data to 10-minute data for Burn 1. A similar graph was used for unburned areas.

This method took care of the number of birds, but not the species richness. Since the data for the original 20-minute counts were noted sequentially (the species and numbers were written in order as they were seen), the original data sheets were used, and the numbers cumulated until 45, as in the example above. Any subsequent numbers or additional species were then eliminated, and 10-minute counts were thus derived.

All counts were then calculated to 20-hectare mean densities to allow comparisons between sites. Densities were derived by calculating the percentage difference between the areas of the radii, and 20 hectares, and then adding the difference to the number of birds for each point. The means for each Control and Burn Site was then calculated. However, for Burns 1 and 3, the difference between the counted site (19.625 ha per point) and the converted site (20 ha per point) was very small. Also, 18.089 ha or 72% of the total area for Burn 2 (25 ha) was counted, providing very useful and comparable data.

2.6 Allocation of birds to different guilds

Three groups of guilds were chosen for this study (Table 2.6.1). Bird species were allocated into three breeding guilds: "Grass", "Ground" or " Other". Most of the species chose to breed on the grass or on open ground, including burned ground. The species that did not fit into these two groups were too few to place them into separate groups and I therefore added them to the third group called "Other". This includes birds that breed in buildings, trees, bushes and wetlands.

The same species were also allocated into two food preference guilds: "Predator" or "Omnivore". This guild was also chosen, because a fire changes food availability in the burned site. Those species that were not included in the food guild were exclusively herbivores. Since there were so few of these herbivorous birds, this guild was not used in further guild analysis.

The groups in the habitat-feeding guild (where they would be predominantly feeding) are Aerial and Terrestrial. The Aerial group catches their food predominantly in the air. The Terrestrial group feeds mainly on the ground. The species were allocated into the guilds according to their habits in Roberts (Maclean, 1993).

Table 2.6.1 Allocation of each species (Hawthorne, 1998) into its most appropriate Breeding, Food type or Habitat preference Guilds.

Species	**Biomass$^{\#}$(g)**	**Guilds**						
		Breeding			**Feeding**		**Habitat**	
		Grass	**Ground**	**Other**	**Predator**	**Omnivore**	**Terrestrial**	**Aerial**
*African Hoopoe *Upupa Africana*	56.06			x	x		x	
African Palm-swift *Cypsiurus parvus*	13.86			x	x			x
African Pipit *Anthus leucophrys*	24.65		x		x		x	
African Quailfinch *Ortygospiza atricollis*	11	x				x	x	
African Stonechat *Saxicola torquata*	14.95	x			x		x	
Ant-eating Chat *Myrmecocichla formicivora*	47.26		x			x	x	
*Barn Swallow *Hirundo rustica*	18			x	x			x
Black-chested Prinia *Prinia flavicans*	9.31	x			x		x	
Black-headed Heron *Ardea melanocephala*	1117			x	x		x	
Black-shouldered Kite *Elanus caeruleus*	254			x	x		x	
Blacksmith Lapwing *Vanellus crassirostris*	164.7		x		x		x	
*Black-throated Canary *Serinus atrogularis*	11.12			x		x	x	
Cape Longclaw *Macronyx capensis*	40.53	x			x		x	
Cape Sparrow *Passer melanurus*	28.26			x		x	x	
Capped Wheatear *Oenanthe pileata*	28.2		x		x		x	
Cattle Egret *Bubulcus ibis*	357.7			x	x		x	
Chestnut-backed Sparrowlark *Eremopterix leucotis*	19.58		x			x	x	
*Common Fiscal *Lanius collaris*	41.4			x	x		x	
*Common House-martin *Delichon urbica*	18.8			x	x			x
*Common Ringed Plover *Charadrius hiaticula*	44.65			x	x		x	
Crowned Lapwing *Vanellus coronatus*	171.7		x		x		x	

Desert Cisticola *Cisticola aridulus*	8.95	x			x		x	
Eastern Clapper Lark *Mirafra fasciolata*	30.77	x				x	x	
Egyptian Goose *Alopochen aegyptiacus*	2110			x			x	
*Goliath Heron *Ardea goliath*	4328			x	x		x	
*Greater Kestrel *Falco rupicoloides*	260.3			x	x		x	
Greater Striped Swallow *Hirundo cucullata*	27			x	x			x
*Grey Heron *Ardea cinerea*	1480			x	x		x	
*Grey-backed Sparrowlark *Eremopterix verticalis*	16.87		x			x	x	
Helmeted Guineafowl *Numida meleagris*	1409	x				x	x	
*Kittlitz's Plover *Charadrius pecuarius*	36.98		x		x		x	
*Laughing Dove *Streptopelia senegalensis*	98.79			x		x	x	
*Lesser Kestrel *Falco naumanni*	130.8			x	x		x	
Levaillant's Cisticola *Cisticola tinniens*	12.63	x			x		x	
Little Swift *Apus affinis*	29.03			x	x			x
Long-tailed Widowbird *Euplectes progne*	36.1	x				x	x	
Marsh Owl *Asio capensis*	304.5	x			x		x	
*Namaqua Sandgrouse *Pterocles namaqua*	174.1		x				x	
Northern Black Korhaan *Eupodotis afraoides*	695.8		x			x	x	
*Pearl-breasted Swallow *Hirundo dimidiata*	12.3			x	x			x
Pied Crow *Corvus albus*	541.1			x		x	x	
Red-billed Quelea *Quelea quelea*	20.02			x		x	x	
*Red-breasted Swallow *Hirundo semirufa*	30.96			x	x			x
Red-capped Lark *Calandrella cinerea*	26.06		x			x	x	
*Red-headed Finch *Amadina erythrocephala*	23.17			x		x	x	
*Secretarybird *Sagittarius serpentarius*	3872			x	x		x	
South African Cliff-swallow *Hirundo spilodera*	20.38			x	x			x
*Southern Grey-headed Sparrow *Passer diffuses*	23.77			x		x	x	

*Southern Pale Chanting Goshawk *Melierax canorus*	793.6			x	x		x	
*Southern Red Bishop *Euplectes orix*	20.73			x		x	x	
*Speckled Pigeon *Columba guinea*	331.2			x			x	
Spike-heeled Lark *Chersomanes albofasciata*	26.13		x		x		x	
Spotted Thick-knee *Burhinus capensis*	479.6		x			x	x	
Spur-winged Goose *Plectropterus gambensis*	6225		x				x	
Swainsons's Spurfowl *Pternistes swainsonii*	596		x			x	x	
*Three-banded Plover *Charadrius tricollaris*	34.46		x		x		x	
*Wattled Starling *Creatophora cinerea*	71.83			x		x	x	
*White Stork *Ciconia ciconia*	3214			x	x		x	
*White-browed Sparrow-weaver *Plocepasser mahali*	47.7			x		x	x	
*White-throated Swallow *Hirundo albigularis*	22.8			x	x			x
*White-winged Widowbird *Euplectes albonotatus*	19.64	x				x	x	
Wing-snapping Cisticola *Cisticola ayresii*	6.7	x			x		x	
*Yellow Canary *Serinus flaviventris*	16.98			x		x	x	
Zitting Cisticola *Cisticola juncidis*	9.8	x			x		x	

According to Maclean (1993)

* Species that were rarely seen

2.7 Statistics

The following computer programmes were used to analyse and present the data: Excel 2000, Primer 5 and MapViewer 5. An introduction to each follows to explain what they can do:

Excel 2000 is a spreadsheet programme that does calculations, tables and graphs. It was mainly used for calculations and graphs. The number of birds, number of species, guilds and biomass were calculated in Excel and graphs constructed. Calculations for Student T-tests and Standard Deviations (SD) were also done in Excel.

Primer 5 was used to calculate the Shannon diversity. This was then inserted into Excel, as Primer could not construct the desired graphs. Primer stands for Plymouth Routines In Multivariate Ecological Research and consists of a range of univariate, graphical and multivariate routines for analysing abundance of species or sample matrices that arise in biological monitoring of environmental impact and community ecology. The methods concentrate on straightforward analyses and make few assumptions about the form of the data, which makes the methods widely applicable (Primer 5 Help Files). MapViewer 5 was used to draw some of the maps used in this study.

Although more advanced statistics are available, it was decided not to do this, since the three Burn and Control Sites were different in size, location and distance from water. Therefore, the major effort of data analysis was on constructing and inspecting time-based graphs to determine the effects of fire on birds.

Chapter 3: Results

"The historic records from around the world leave no room to doubt that primitive hunting and gathering peoples, as well as ancient farmers and herders, for a number of reasons, frequently and intentionally set fire to almost all the vegetation around them which could burn." (Stewart, 1963)

This chapter deals with the tables and graphs showing the results of the data, with a description of each. The discussion of the results will follow in Chapter 4. This chapter has been divided into the following sections: Section 3.1 deals with the Burn and Control Sites at Barberspan, and Section 3.2 has the summary results. Section 3.2.1 will present data on species, and Section 3.2.2 will present the data over time on species and densities. In Section 3.2.3 I will present changes in the avian diversity, Section 3.2.4 will investigate the effect of size of the burn, and Section 3.2.5 will deal with the effects of the total biomass of birds. Section 3.2.6 will present the breeding guild analysis; Section 3.2.7 presents the data on the feeding guilds, and Section 3.2.8 on habitat feeding guilds.

3.1 Burn and Control Sites within Barberspan

The entire study was carried out in the Barberspan Nature Reserve. Fig. 3.1.1 is a map of Barberspan and the Reserve. The dotted lines show the roads in the reserve. The white areas show the Control Sites of the three burns. The grey areas show the location and extent of the three burns. The block in Burn 1 is the site where the planned burn would have been before the fire jumped and became uncontrollable. The green spots are trees. At Godwit Bay, these are mostly *Acacia* trees, and at Botany Bay and near the office they are mainly *Eucalyptus*.

The arrows on the map show the direction to the closest towns. The brown line shows the boundaries of the reserve. The dark green spot is Peter's Pan. Since this pan is only filled when Barberspan is flooded, it was coloured green rather than blue, as the counts took place during relatively low water levels.

The dotted blue line at Botany Bay shows where the water pushes into the trees when Barberspan floods, but this area was also dry during the study. Swallows and bee-eaters can be seen here in the summer months. The area between Botany Bay and Godwit Bay harbours many water birds such as waders and geese in the summer months.

Fig. 3.1.1 A map of Barberspan. Scale is approximate and in km.

3.2 Summary results

The weather conditions over the two years of observations were as follows: Mean summer temperatures ranged between 10°C (mornings) and 30°C (middays), with the highest temperature, taken at midday, at 41°C in 2004. Mean winter temperatures ranged between -4°C (mornings) and 20°C (middays), with the lowest temperature, taken just before sunrise in 2003, at -14°C. Wind speed was measured between 3 and 26.8 km/h. Wind speed was only measured in 2004.

Red-capped Larks and Crowned Lapwings were successful with nest building and breeding in the burn sites. I saw nests on Burns 1 and 3, and possible breeding behaviour on Burn 2. I also observed nests of a Red-capped Lark and Crowned Lapwing on Burn 1 and observed development from egg to chicks. Breeding activity was not used in subsequent analyses.

For most of the graphs with a time axis in Chapter 3, there is an arrow present, showing the time of the burn. Although Burn 2 took place on the 30th of June, the data was calculated as a July-burn. There are also asterisks in the monthly graphs, showing a significant difference for the Student T-test. Burn 3 had no pre-fire data for either Burn or Control Sites, and this was assumed and calculated from the mean of the post-fire data in the Control Site of Burn 3. This value should therefore be treated with caution during interpretation. The midday and evening surveys for Burns 2 and 3 were only started after the fire, and the pre-fire data was calculated in the same way to compensate. Burn 1 (2003) had no midday and evening surveys. The bars in the monthly graphs represent the standard deviation. Please note that on some pages the X and Y-axis scales might differ between the graphs.

Table 3.2.1 shows the number of each species that were seen in the Control and the Burn Sites of each of the three burns. The scientific name of each species (Sinclair, Hockey & Tarboton, 2002) is also provided.

The birds that are marked with an asterisk were rarely seen during the time of the study, some of them only once. It is mostly because these birds spend their resting time in places other than the grass or ground, and was therefore ignored. If they flew to the ground to eat, they were counted. Some species, such as the Pearl-breasted Swallow, were a rare find at Barberspan.

Table 3.2.1 Numbers of each species seen over the recording period on each of the three Control and Burn Sites.

Species**	Burn 1: Control (10 min counts)	Burn 1: Burn (10 min counts)	Burn 2: Control	Burn 2: Burn	Burn 3: Control	Burn 3: Burn
*African Hoopoe *Upupa africana*	0	0	0	0	0	2
African Palm-swift *Cypsiurus parvus*	32	140	0	0	0	0
African Pipit *Anthus leucophrys*	37	470	0	43	0	139
African Quailfinch *Ortygospiza atricollis*	11	0	20	12	34	12
African Stonechat *Saxicola torquata*	30	13	1	1	1	4
Ant-eating Chat *Myrmecocichla formicivora*	46	102	27	43	11	68
*#Barn Swallow *Hirundo rustica*	3	40	0	0	0	0
Black-chested Prinia *Prinia flavicans*	12	45	13	1	6	3
Black-headed Heron *Ardea melanocephala*	0	50	0	19	0	12
Black-shouldered Kite *Elanus caeruleus*	6	8	2	0	1	0
Blacksmith Lapwing *Vanellus crassirostris*	0	399	0	58	0	115
*Black-throated Canary *Serinus atrogularis*	0	0	0	0	0	1
Cape Longclaw *Macronyx capensis*	88	90	38	54	3	28
Cape Sparrow *Passer melanurus*	0	77	0	0	0	14
Capped Wheatear *Oenanthe pileata*	0	60	0	0	0	21
Cattle Egret *Bubulcus ibis*	0	78	0	95	0	0
Chestnut-backed Sparrowlark *Eremopterix leucotis*	18	9	0	3	0	5
*Common Fiscal *Lanius collaris*	0	0	0	0	0	4
*#Common House-martin *Delichon urbica*	5	0	0	0	0	0
*#Common Ringed Plover *Charadrius hiaticula*	0	16	0	0	0	0
Crowned Lapwing *Vanellus coronatus*	0	1270	5	198	0	438
Desert Cisticola *Cisticola aridulus*	30	7	1	2	0	2
Eastern Clapper Lark *Mirafra fasciolata*	0	1	0	0	0	0

Egyptian Goose *Alopochen aegyptiacus*	0	17	2	0	0	16
*Goliath Heron *Ardea goliath*	0	1	0	0	0	2
*Greater Kestrel *Falco rupicoloides*	0	0	0	1	0	0
#Greater Striped Swallow *Hirundo cucullata*	2	0	0	1	0	0
*Grey Heron *Ardea cinerea*	0	7	0	0	0	0
*Grey-backed Sparrowlark *Eremopterix verticalis*	2	20	0	0	0	0
Helmeted Guineafowl *Numida meleagris*	848	2520	136	429	296	2943
*Kittlitz's Plover *Charadrius pecuarius*	0	90	0	0	0	0
*Laughing Dove *Streptopelia senegalensis*	0	0	0	3	0	1
*#Lesser Kestrel *Falco naumanni*	0	0	0	0	0	1
Levaillant's Cisticola *Cisticola tinniens*	48	50	0	0	0	0
Little Swift *Apus affinis*	136	450	0	0	6	0
Long-tailed Widowbird *Euplectes progne*	886	25	24	21	44	5
Marsh Owl *Asio capensis*	1	9	0	1	0	0
*Namaqua Sandgrouse *Pterocles namaqua*	9	2	0	0	0	0
Northern Black Korhaan *Eupodotis afraoides*	19	6	3	5	11	11
*Pearl-breasted Swallow *Hirundo dimidiata*	0	5	0	0	0	0
Pied Crow *Corvus albus*	10	25	4	7	0	3
Red-billed Quelea *Quelea quelea*	0	1250	0	55	0	811
*#Red-breasted Swallow *Hirundo semirufa*	0	0	0	0	0	2
Red-capped Lark *Calandrella cinerea*	5	120	0	9	0	5
*Red-headed Finch *Amadina erythrocephala*	0	0	0	0	0	1
*Secretarybird *Sagittarius serpentarius*	0	1	0	0	0	0
#South African Cliff-swallow *Hirundo spilodera*	255	1809	0	0	48	145
*Southern Grey-headed Sparrow *Passer diffuses*	0	10	0	0	0	0
*Southern Pale Chanting Goshawk *Melierax canorus*	0	0	0	1	0	0
*Southern Red Bishop *Euplectes orix*	0	0	0	0	0	111

*Speckled Pigeon *Columba guinea*	0	5	0	2	0	0
Spike-heeled Lark *Chersomanes albofasciata*	15	20	0	1	2	1
Spotted Thick-knee *Burhinus capensis*	2	3	0	1	0	3
Spur-winged Goose *Plectropterus gambensis*	0	1	0	0	1	0
Swainsons's Spurfowl *Pternistes swainsonii*	50	89	29	1	0	9
*Three-banded Plover *Charadrius tricollaris*	0	4	0	0	0	0
*Wattled Starling *Creatophora cinerea*	0	0	0	0	0	1
*#White Stork *Ciconia ciconia*	0	0	0	0	0	3
*White-browed Sparrow-weaver *Plocepasser mahali*	0	1	0	0	0	2
*#White-throated Swallow *Hirundo albigularis*	0	1	0	0	0	0
*White-winged Widowbird *Euplectes albonotatus*	1	2	0	0	0	0
Wing-snapping Cisticola *Cisticola ayresii*	3	1	2	0	2	3
*Yellow Canary *Serinus flaviventris*	0	0	0	0	0	1
Zitting Cisticola *Cisticola juncidis*	72	56	29	29	8	2

Summer visitor

* Species that were rarely seen

** Species names according to Sinclair, Hockey and Tarboton, 2002.

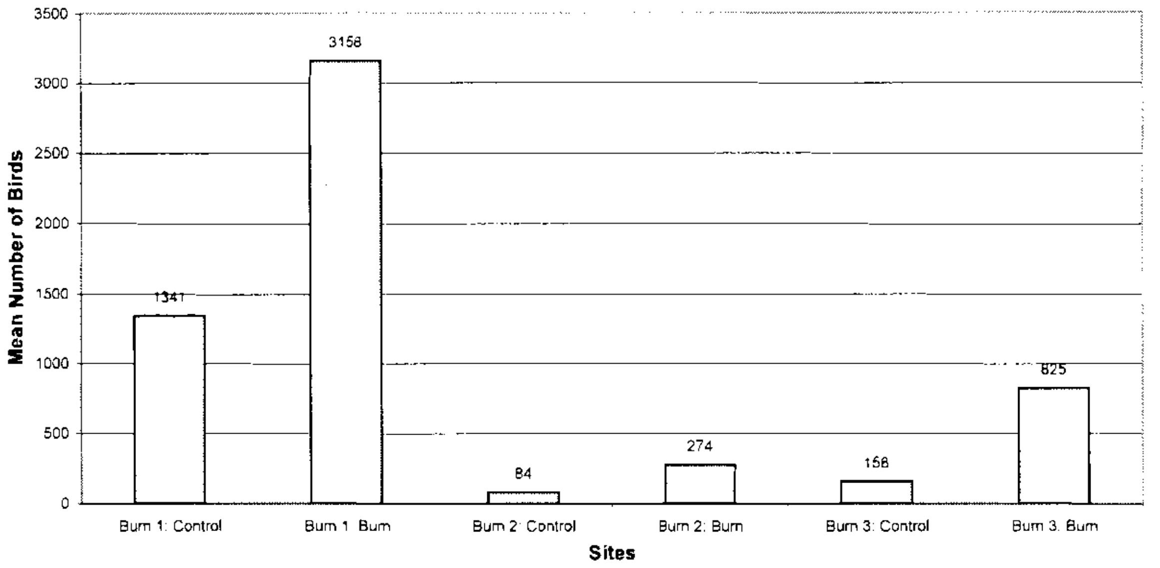

Fig. 3.2.1 The mean number of birds per point at each of the three Burn and Control Sites from March/April to November of their respective years, recorded both before and after the fire.

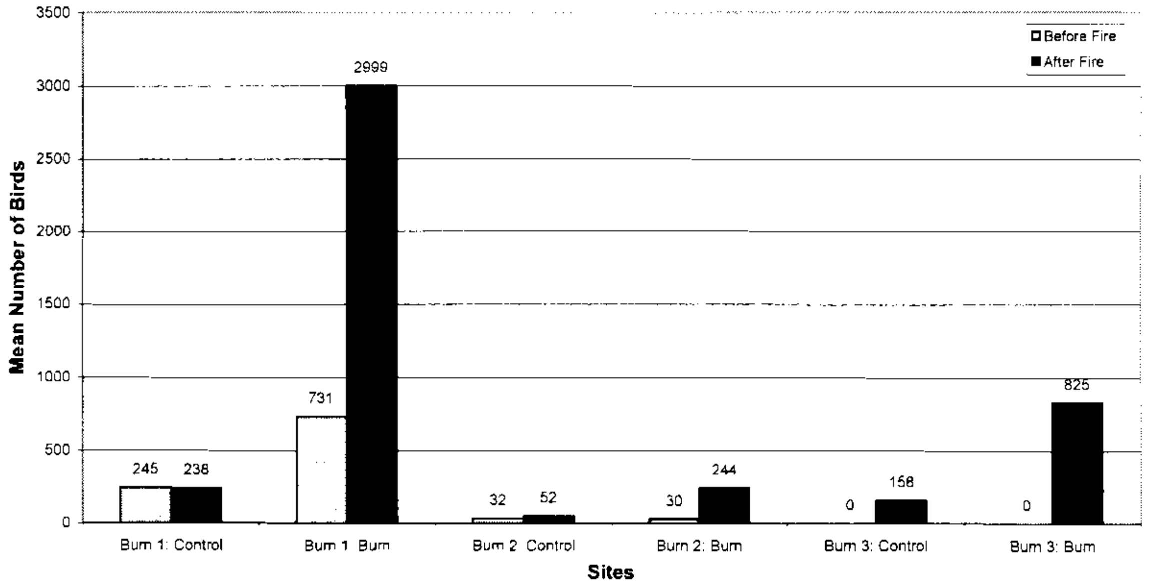

Fig. 3.2.2 The mean number of birds per point recorded before and after the fire at each of the three Burn and Control Sites.

3.2.1 Effect of fire on bird species

In Fig. 3.2.1 and Fig. 3.2.2 the mean number of birds was acquired by calculating the mean of each site. This was done by adding the total number of birds of the site and dividing them by the number of Points for that Site. The whole year's numbers were used. These numbers were not converted to 20 ha densities, and represent the raw data before the conversions. Although Burn 1 (Fig. 3.2.1) was the second largest burn, its numbers were the largest of the three burns, leaving Burn 3 with the second largest numbers.

In Fig. 3.2.2, Burn 1 had the largest numbers again, before and after the fire. These numbers were calculated in the same manner as those of Fig. 3.2.1, but the pre-fire and post-fire data were separated. Since Burn 3 was a wildfire and had no pre-fire data, the numbers were zero before the fire. These numbers were also the raw data and not converted to 20 ha densities. As explained before, Burn 3 had no surveys done before the fire, thus giving it the same numbers as in Fig. 3.2.1.

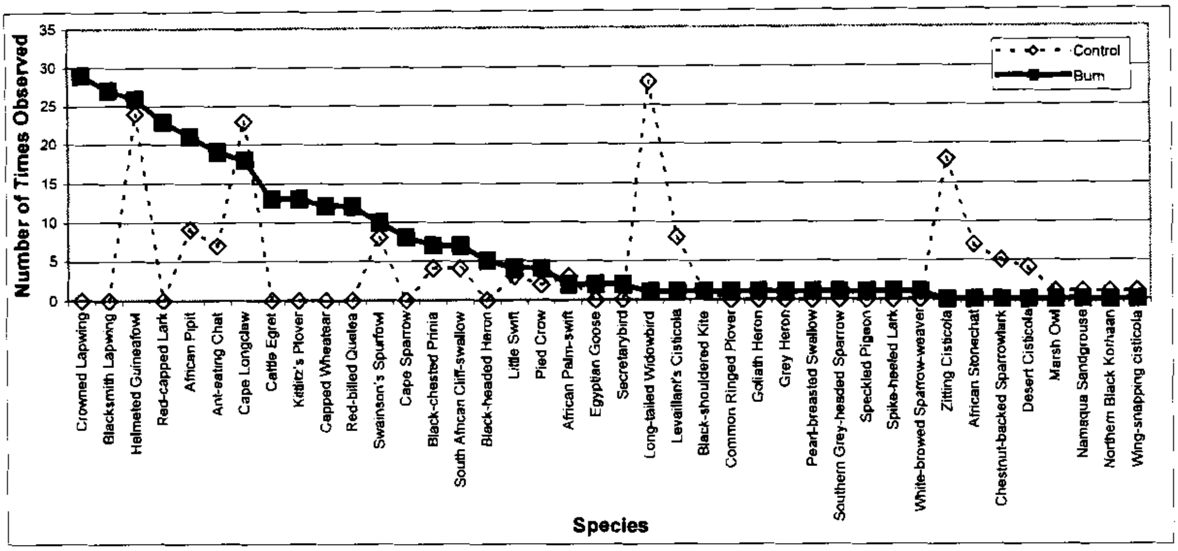

Fig. 3.2.3 The number of times a species was seen for the first 3 months after the fire at Burn 1, from July 2003 to September 2003, normalised on the species from the Burn Site.

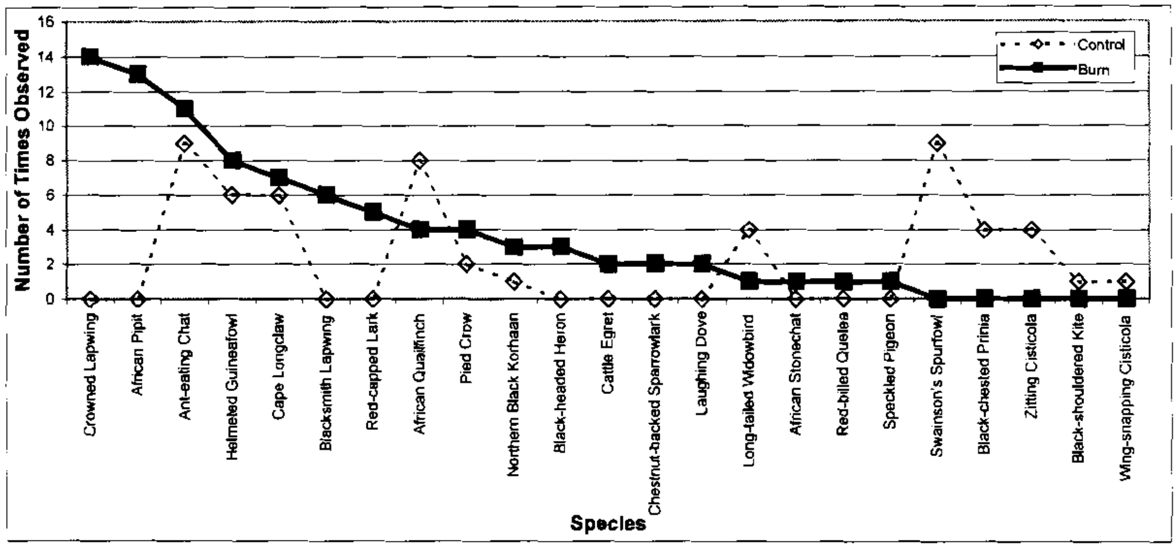

Fig. 3.2.4 The number of times a species was seen for the first 3 months after the fire at Burn 2, from July 2004 to September 2004, normalised on the species from the Burn Site.

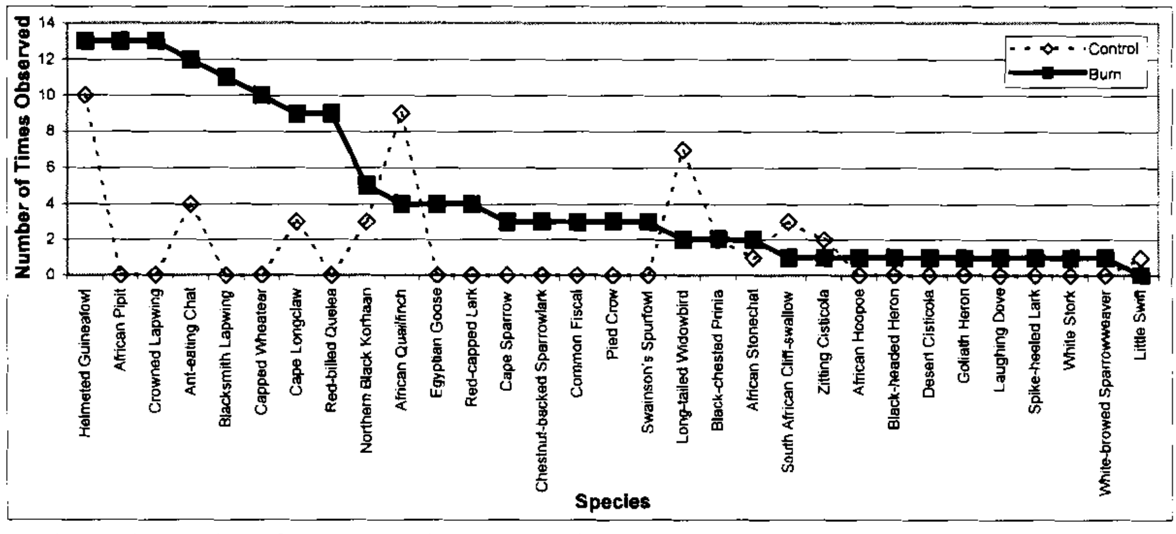

Fig. 3.2.5 The number of times a species was seen for the first 3 months after the fire at Burn 3, from July 2004 to September 2004, normalised on the species from the Burn Site.

In Fig. 3.2.3 to 3.2.5 the number of times a species was seen is shown as from directly after the fire until September of the same year for each burn. In these graphs most of the species had larger numbers in the Burn Sites than in the Control Sites. But some of the species had larger numbers in the Control Sites. The graphs show the Burn Sites' species from highest to lowest.

The species that were seen only in the Burn Sites of the three burns, were as follows: Crowned Lapwing (*Vanellus coronatus*), Blacksmith Lapwing (*Vanellus crassirostris*), Red-capped Lark (*Calandrella cinerea*), Cattle Egret (*Bubulcus ibis*), Kittlitz's Plover (*Charadrius pecuarius*), Capped Wheatear (*Oenanthe pileata*), Red-billed Quelea (*Quelea quelea*), Cape Sparrow (*Passer melanurus*), Black-headed Heron (*Ardea melanocephala*), Secretarybird (*Sagittarius serpentarius*), Common Ringed Plover (*Charadrius hiaticula*), Goliath Heron (*Ardea goliath*), Grey Heron (*Ardea cinerea*), Pearl-breasted Swallow (*Hirundo dimidiata*), Southern Grey-headed Sparrow (*Passer diffuses*), Speckled Pigeon (*Columba guinea*), Spike-heeled Lark (*Chersomanes albofasciata*), White-browed Sparrow-weaver (*Plocepasser mahali*), Laughing Dove (*Streptopelia senegalensis*), Common Fiscal (*Lanius collaris*), African Hoopoe (*Upupa africana*) and White Stork (*Ciconia ciconia*). No species were seen exclusively in the Control Sites.

Species that were seen mostly in the Burn Sites were as follows: Helmeted Guineafowl (*Numida meleagris*), African Stonechat (*Saxicola torquata*), African Pipit (*Anthus leucophrys*), Ant-eating Chat (*Myrmecocichla formicivora*), Cape Longclaw (*Macronyx capensis*), Swainson's Spurfowl (*Pternistes swainsonii*), Pied Crow (*Corvus albus*), Egyptian Goose (*Alopochen aegyptiacus*), Chestnut-backed Sparrowlark (*Eremopterix leucotis*) and Northern Black Korhaan (*Eupodotis afraoides*).

Species that were seen mostly in the Control Sites were as follows: Little Swift (*Apus affinis*), African Palm-swift (*Cypsiurus parvus*), Long-tailed Widowbird (*Euplectes progne*), Levaillant's Cisticola (*Cisticola tinniens*), Black-shouldered Kite (*Elanus caeruleus*), Zitting Cisticola (*Cisticola juncidis*), Marsh Owl (*Asio capensis*), Namaqua Sandgrouse (*Pterocles namaqua*), Wing-snapping Cisticola (*Cisticola ayresii*) and African Quailfinch (*Ortygospiza atricollis*).

The Desert Cisticola was seen in the Control Site of Burn 1 and the Burn Site of Burn 3. The South African Cliff-swallow (*Hirundo spilodera*) was mostly seen in the Burn Site of Burn 1 and the Control Site of Burn 3. The Black-chested Prinia (*Prinia flavicans*) was mostly seen in the Burn Site of Burn 1, the Control Site of Burn 2 and in equal amounts in both the Burn and Control Sites of Burn 3. This observation indicates that the detectability of birds was very good in both Burn and Control Sites, as other, similarly small birds did show distinctive differences.

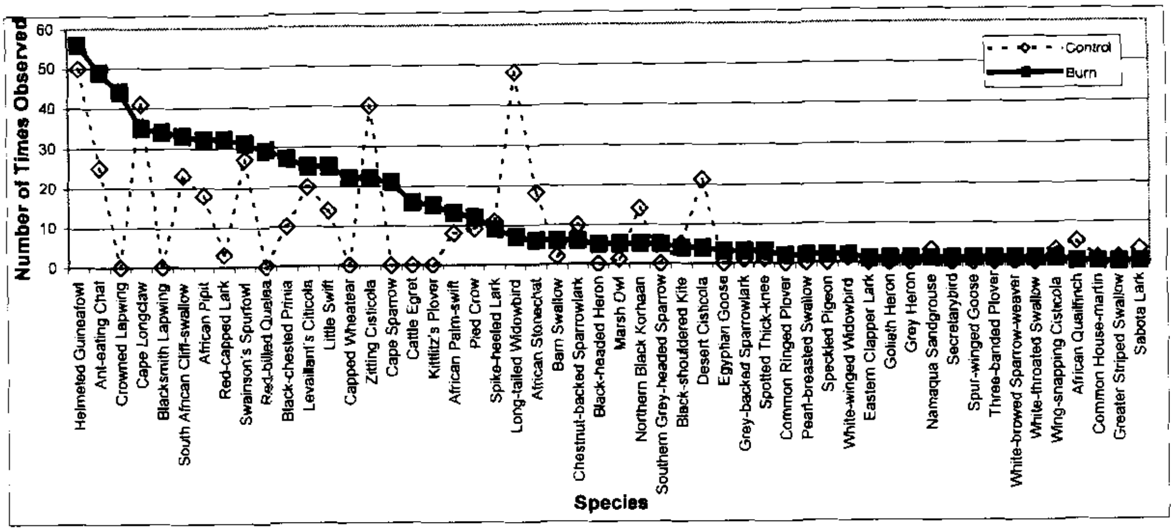

Fig. 3.2.6 The number of times a species was seen after the fire at Burn 1, from July to November.

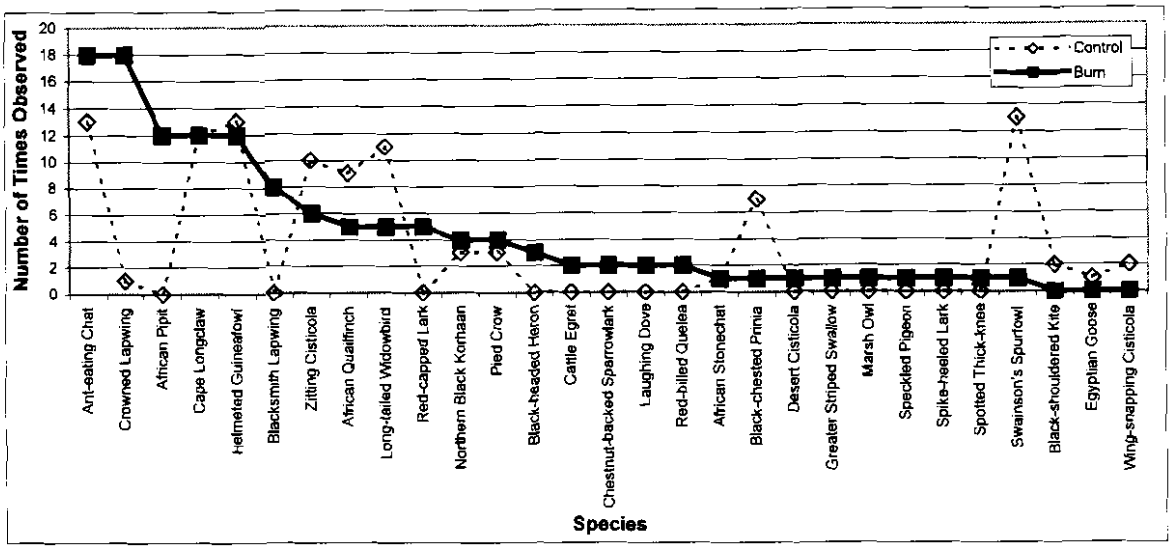

Fig. 3.2.7 The number of times a species was seen after the fire at Burn 2, from July to November.

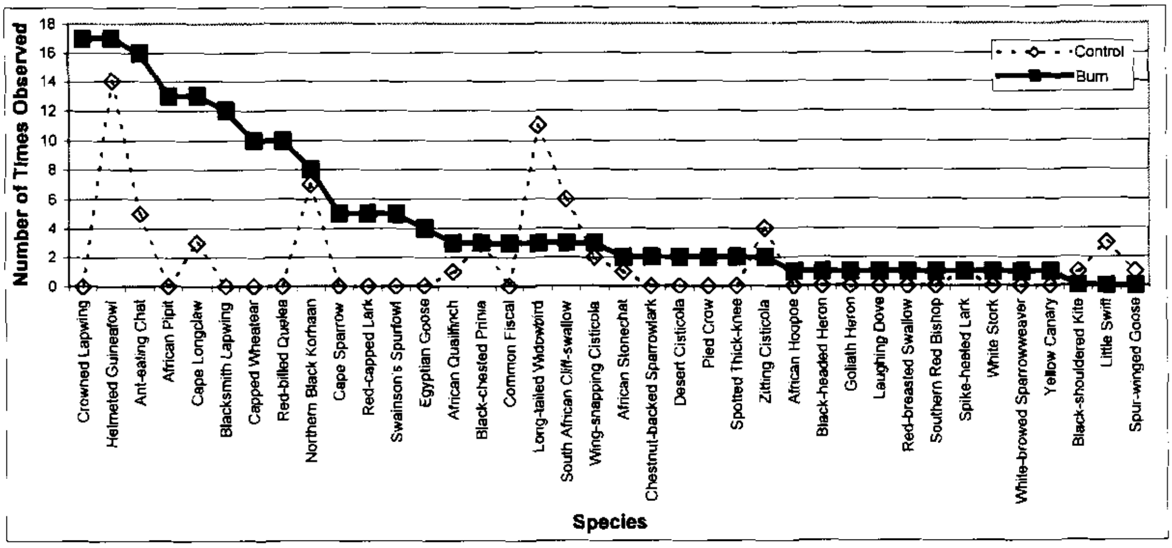

Fig. 3.2.8 The number of times a species was seen after the fire at Burn 3, from July to November.

In Fig. 3.2.6 to 3.2.8 the number of times a species was seen is shown as from directly after the fire until November of the same year for each burn. These graphs showed about the same results as Fig. 3.2.3 to Fig. 3.2.5. The three graphs (Fig. 3.2.6 to 3.2.8) showed differences from Fig. 3.2.3 to Fig. 3.2.5 as follows: The species that were seen mostly in the Burn Sites of the three burns were Crowned Lapwing (*Vanellus coronatus*), Levaillant's Cisticola (*Cisticola tinniens*), Marsh Owl (*Asio capensis*), Red-capped Lark (*Calandrella cinerea*) and African Palm-swift (*Cypsiurus parvus*). Species that were seen only in the Control Sites were Common House-martin (*Delichon urbica*) and Sabota Lark (*Mirafra sabota*). Species that were seen only in the Burn Site were about the same as in Fig. 3.2.3 to Fig. 3.2.5. Species that were seen mostly in the Control Site were about the same as in Fig. 3.2.3 to Fig. 3.2.5.

The African Stonechat (*Saxicola torquata*) was mostly seen in the Control Site of Burn 1, the Burn Site of Burn 3 and in equal amounts in the Burn and Control Sites of Burn 2. The South African Cliff-swallow (*Hirundo spilodera*) was mostly seen in the Burn Site of Burn 1 and the Control Site of Burn 3. The Black-chested Prinia (*Prinia flavicans*) was mostly seen in the Burn Site of Burn 1, the Control Site of Burn 2 and in equal amounts in both the Burn and Control Sites of Burn 3. The Cape Longclaw (*Macronyx capensis*) was mostly seen in the Control Site of Burn 1, the Burn Site of Burn 3 and in equal amounts in the Control and Burn Sites of Burn 2. The Spike-heeled Lark (*Chersomanes albofasciata*) was mostly seen in the Control Site of Burn 1, the Burn Site of Burn 2 and in equal amounts in the Burn and Control Sites of Burn 3. The Little Swift (*Apus affinis*) was mostly seen in the Burn Site of Burn 1 and the Control Site of Burn 3. The Greater Striped Swallow (*Hirundo cucullata*) was seen only in the Control Site of Burn 1 as well as the Burn Site of Burn 2.

Table 3.2.2 The reaction of species, found at all three of the burns and the percentage difference between Control and Burn Sites, from July to September. See text for details.

Species	Reaction of Species to Burn			Percentage Difference between the Control and Burn Sites			
	Burn1	**Burn2**	**Burn3**	**Burn1**	**Burn2**	**Burn3**	**Mean %**
African Pipit	+	+	+	61.9	100	100	**87.3**
Ant-eating Chat	+	+	+	68.9	18.2	66.7	**51.3**
Black-chested Prinia	+	-	0	42.9	-100	0	**-19**
Blacksmith Lapwing	+	+	+	100	100	100	**100**
Black-headed Heron	+	+	+	100	100	100	**100**
Cape Longclaw	-	+	+	-33.3	14.3	66.7	**15.9**
Cattle Egret*	+	+	*	100	100	*	**100**
Crowned Lapwing	+	+	+	100	100	100	**100**
Helmeted Guineafowl	+	+	+	7.7	25	23.1	**18.6**
Long-tailed Widowbird	-	-	-	-95.8	-75	-71.4	**-80.8**
Northern Black Korhaan	-	+	+	-100	66.7	40	**2.2**
Red-billed Quelea	+	+	+	100	100	100	**100**
Red-capped Lark	+	+	+	100	100	100	**100**
Swainson's Spurfowl	+	-	+	87.5	-100	100	**29.2**
Zitting Cisticola	-	-	-	-100	-100	-50	**-83.3**

* Only recorded at 2 sites

Table 3.2.3 The reaction of species, found at all three of the burns and the percentage difference between Control and Burn Sites, from July to November. See text for details.

Species	Reaction of Species to Burn			Percentage Difference between the Control and Burn Sites			
	Burn1	**Burn2**	**Burn3**	**Burn1**	**Burn2**	**Burn3**	**Mean %**
African Pipit	+	+	+	43.8	100	100	**81.3**
Ant-eating Chat	+	+	+	47.6	15.4	68.8	**43.9**
Black-chested Prinia	+	-	0	28.6	-100	0	**-23.8**
Black-smith Lapwing	+	+	+	100	100	100	**100**
Black-headed Heron	+	+	+	100	100	100	**100**
Cape Longclaw	-	+	+	-38.5	14.3	76.9	**17.6**
Cattle Egret*	+	+	*	100	100	*	**100**
Crowned Lapwing	+	+	+	100	94.4	100	**98.1**
Helmeted Guineafowl	+	+	+	5.1	27.3	17.6	**16.7**
Long-tailed Widowbird	-	-	-	-96.8	-83.3	-72.7	**-84.3**
Northern Black Korhaan	-	+	+	-88.9	66.7	12.5	**-3.2**
Red-billed Quelea	+	+	+	100	100	100	**100**
Red-capped Lark	+	+	+	93.8	100	100	**97.9**
Swainson's Spurfowl	+	-	+	12.9	-92.3	100	**6.9**
Zitting Cisticola	-	-	-	-88.9	-30	-50	**-56.3**

* Only recorded at 2 sites

Table 3.2.4 Colour codes that show the reaction of the species (Tables 3.2.2 and 3.2.3) to the fire.

▨	Positive for all three burns – post-fire colonizers
🟨	Positive for two burns – post-fire opportunists
🟩	Negative for all three burns – fire sensitive
⬜	Contains a neutral for one burn – site-tenacious

The results used to construct Fig. 3.2.3 to 3.2.8 were also used in tables for further interpretation regarding species that are site-tenacious, and others that are post-fire colonisers. In these tables (Tables 3.2.2 and 3.2.3) only the species that were seen at all three burns and that showed a clear reaction were used. The Cattle Egret was included in both tables, although it was not observed at Burn 3. I did this because I arrived two days after this accidental fire, and may well presume that these birds would have been present there, immediately after the fire. Table 3.2.4 gives the colour codes for these tables to show the groupings, which will be explained later in Chapter 4.

The first three columns show the effect of the fire on the individual species. A negative means that the species were mostly seen in the Control Site. A positive shows that the species were mostly seen in the Burn Site. A zero shows that the species were neutral and were seen in equal amounts in the Control and Burn Sites.

The second three columns show the percentage of the difference between the Burn Sites and the Control Sites (Fig. 3.2.3 to Fig. 3.2.8). The negative numbers show that the Control Site had more birds than the Burn Site, while the positive numbers show that the Burn Site had more birds. A 100% value means that the birds were only seen in the Burn Site.

The last column shows the mean of the percentages for all the Burns together. The positive numbers are the Burn Sites and the negative numbers are the Control Sites.

The colour codes in Table 3.2.4 were used to differentiate between the reactions of the birds. Grey showed that the African Pipit (*Anthus leucophrys*), Ant-eating Chat (*Myrmecocichla formicivora*), Black-smith Lapwing (*Vanellus crassirostris*), Black-headed Heron (*Ardea melanocephala*), Cattle Egret (*Bubulcus ibis*), Crowned Lapwing (*Vanellus coronatus*), Helmeted Guineafowl (*Numida meleagris*) and Red-capped Lark (*Calandrella cinerea*) had a positive reaction to the fire at all the burns and that the birds were seen mostly (and in some cases, only) in the Burn Site of all the burns. Yellow showed that the Cape Longclaw (*Macronyx capensis*), Northern Black Korhaan (*Eupodotis afraoides*) and Swainson's Spurfowl (*Pternistes swainsonii*) had a negative reaction to the fire at one of the burns. Green showed that the Long-tailed Widowbird (*Euplectes progne*) and Zitting Cisticola (*Cisticola juncidis*) showed a negative reaction to all the burns and were thus seen mostly in the Control Sites. White showed that the Black-chested Prinia (*Prinia flavicans*) was seen in equal amounts in the Burn and Control Sites of Burn 3 and thus had a neutral reaction to the fire.

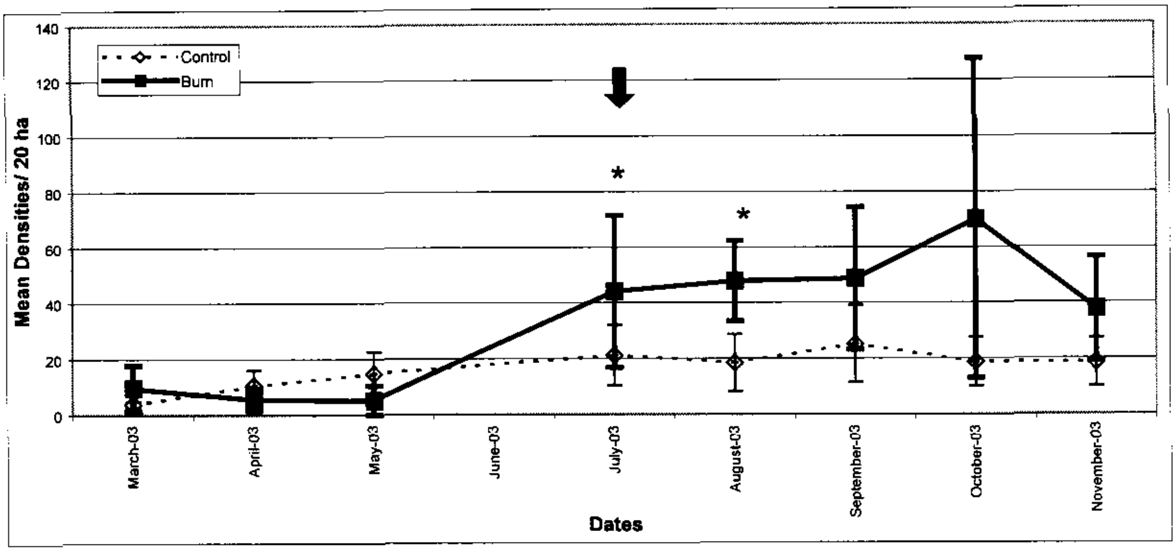

Fig. 3.2.9 The mean density recorded per month, in the mornings, on Burn 1.

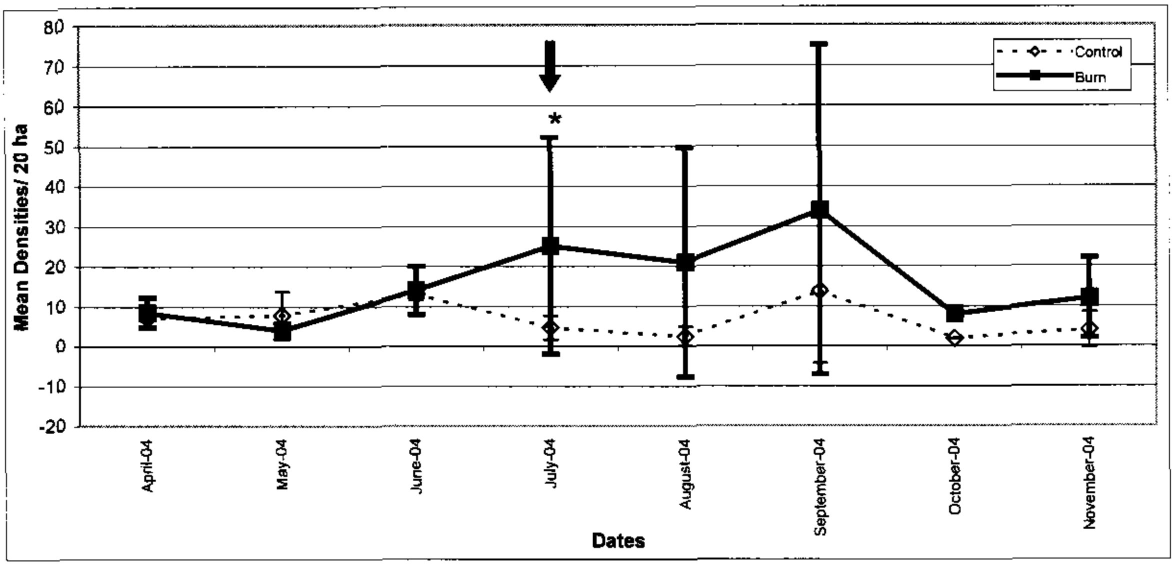

Fig. 3.2.10 The mean density recorded per month, in the mornings, on Burn 2.

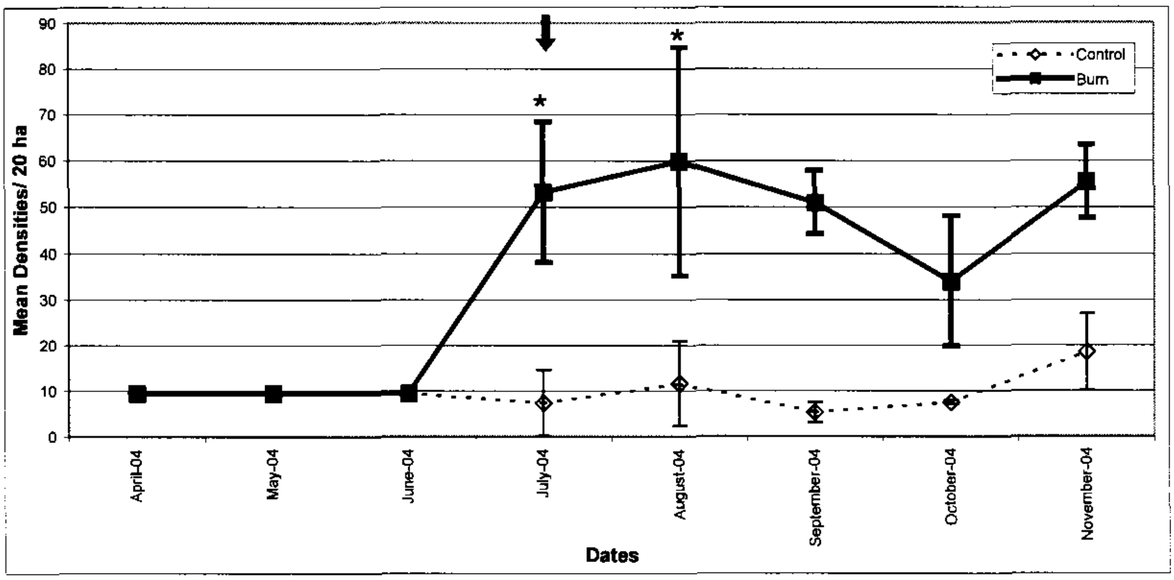

Fig. 3.2.11 The mean density recorded per month, in the mornings, on Burn 3.

3.2.2 Changes over time in species and density

Figures 3.2.9 to 3.2.11 represent the mean density recorded per month for each burn. This was calculated by taking the mean of each site per survey and calculating the mean for each month. The arrows show the time of the fire and the asterisks indicate a significant difference ($P<0.05$, Student's T-test). These tests were only applied to July and August to show the immediate effect of the fire. Standard deviations on all means were also indicated.

Before the fire (Fig. 3.2.9), the Burn and Control Sites differed very little. The Burn Site showed an increase in numbers after the fire and there was a difference between the Burn and Control Sites after the fire. Between October and November the Burn Site showed a decrease in numbers. The Student T-test showed a significant difference both for July and August.

In Fig. 3.2.10 Burn 2 showed almost the same pattern, though there wasn't as much difference between the Control and Burn Sites. Here the Burn Site decreased in density after September. The density was also lower than the density for Burn 1. There was also less of a difference between the Control and Burn Sites after the fire. The Student T-test showed a significant difference only for July.

In Fig. 3.2.11 the Burn Site showed an increase in density after the fire and there was a significant difference between the Burn and Control Sites after the fire. The Burn Site decreased in density after August, but increased again after October. As explained previously, there were no records before the fire. The Student T-test showed a significant difference both for July and August.

All three burns had similar patterns, namely an increase in density after the fire in the Burn Site. The density increased at Burns 2 and 3 (Fig. 3.2.10 and Fig. 3.2.11) at the end of the year, while at Burn 1 (Fig. 3.2.9) it decreased. All three Control and Burn Sites were closer in density at the end of the year. Burn 3 (Fig. 3.2.11) had a larger difference between the Control and Burn Sites than the other two burns. Burns 1 and 3 (Fig. 3.2.9 and Fig. 3.2.11) were closest in pattern. All three burns had a significant difference in the Student T-test directly after the fire.

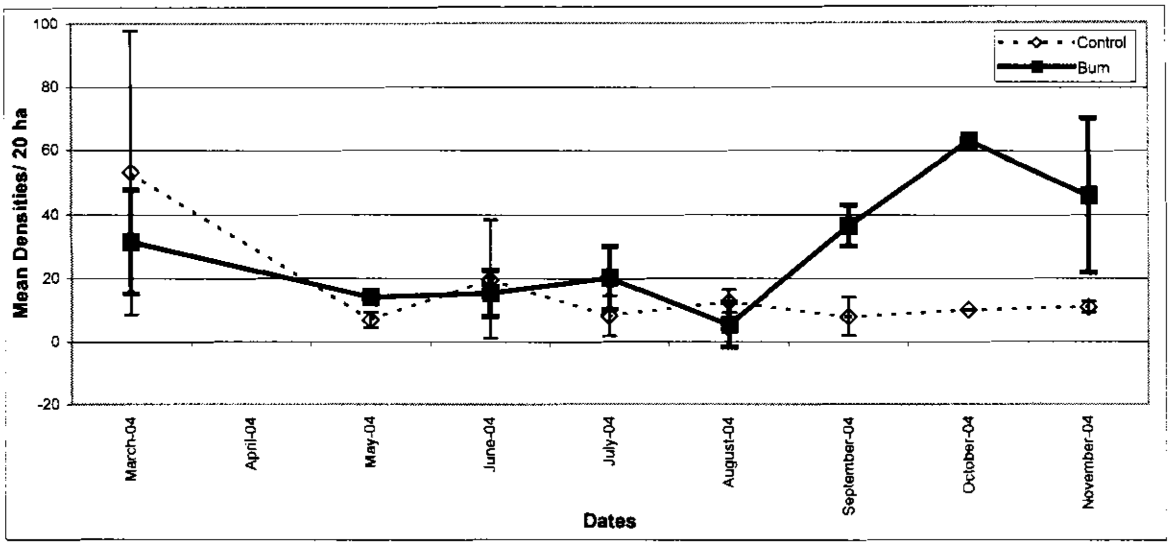

Fig. 3.2.12 The mean density recorded per month, in the mornings, on Burn 1 in the second year after the fire.

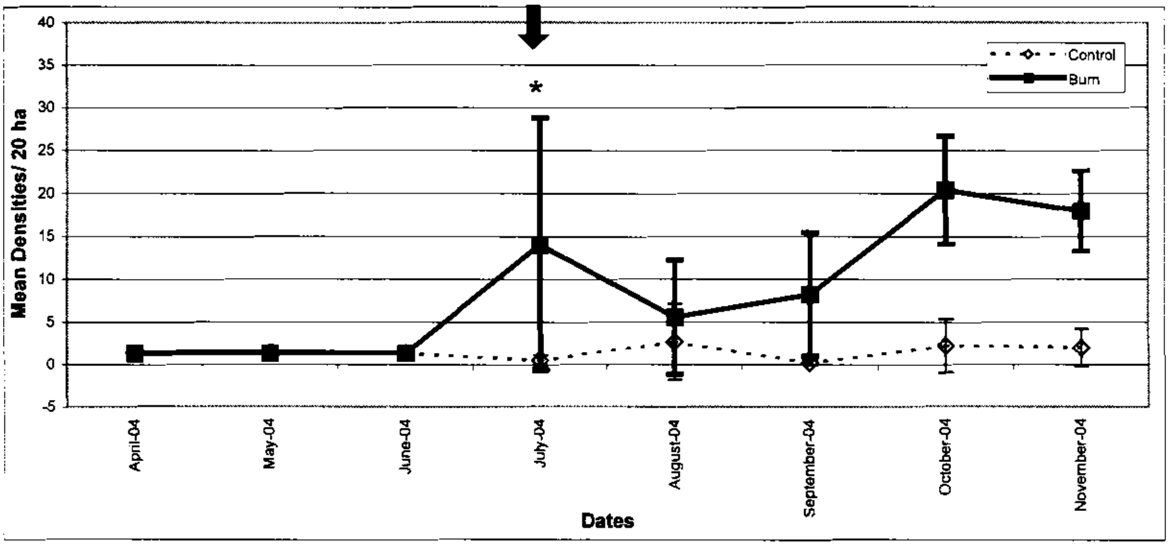

Fig. 3.2.13 The mean density recorded per month, at midday, on Burn 2.

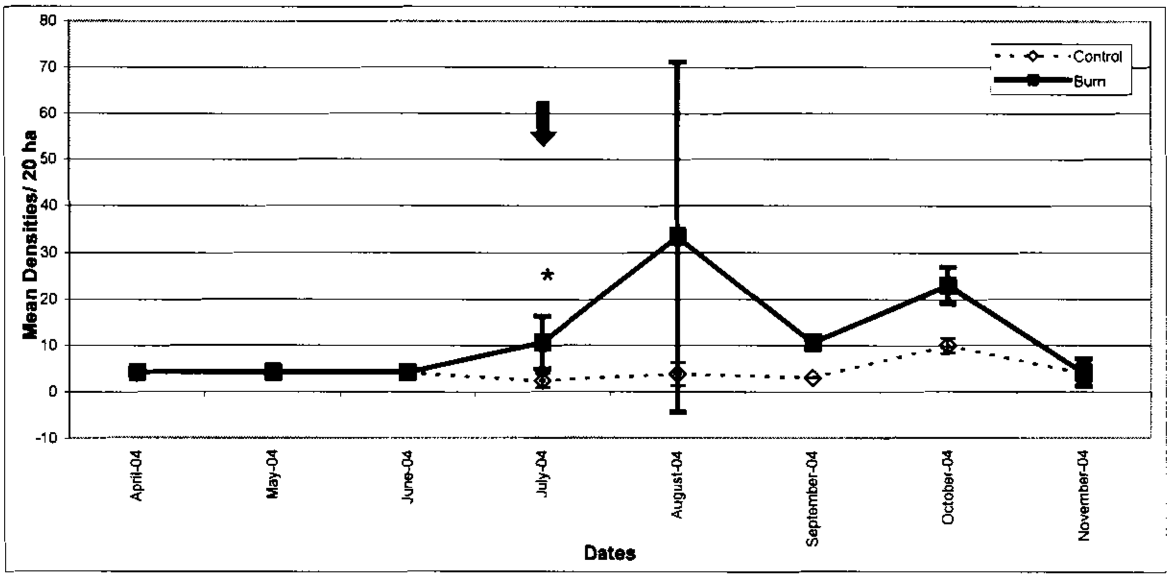

Fig. 3.2.14 The mean density recorded per month, at midday, on Burn 3.

Fig. 3.2.12 represents the mean density recorded per month for Burn 1 in the second year after the fire. The Burn and Control Sites differed very little. There was a decrease in density towards the winter months, but the density increased again after October. There was also more of a difference between the Burn and Control Sites after June. The density was closer to pre-fire levels and showed that the fire's effect on the densities was only temporary.

Fig. 3.2.13 and 3.2.14 represents the mean density recorded per month for Burn 2 and 3 at midday. There were no midday counts before the fire. The Burn Site (Fig. 3.2.13) showed an increase in density after the fire and then a decrease. There was another increase after August until October. In October there was a slight decrease until November. The Student T-test showed a significant difference for July.

The Burn Site (Fig. 3.2.14) showed an increase in density after the fire and there was a difference between the Burn and Control Sites after the fire, although it wasn't very great. The Burn Site decreased in density after August, but increased again after September. There was another decrease after October and the Control and Burn Sites were almost the same in November. The Student T-test showed a significant difference for July.

The patterns of Burns 2 and 3 (Fig. 3.2.13 and Fig. 3.2.14) corresponded partially. There was an increase in density in the Burn Sites after the fire and a return to pre-fire levels at the end of the year. The morning densities were higher than the midday densities. The midday graphs had the same general trends than the morning graphs (Fig. 3.2.9 to Fig. 3.2.11) and were closest in pattern to Fig. 3.2.10. Both burns had a significant difference in the Student T-test directly after the fire.

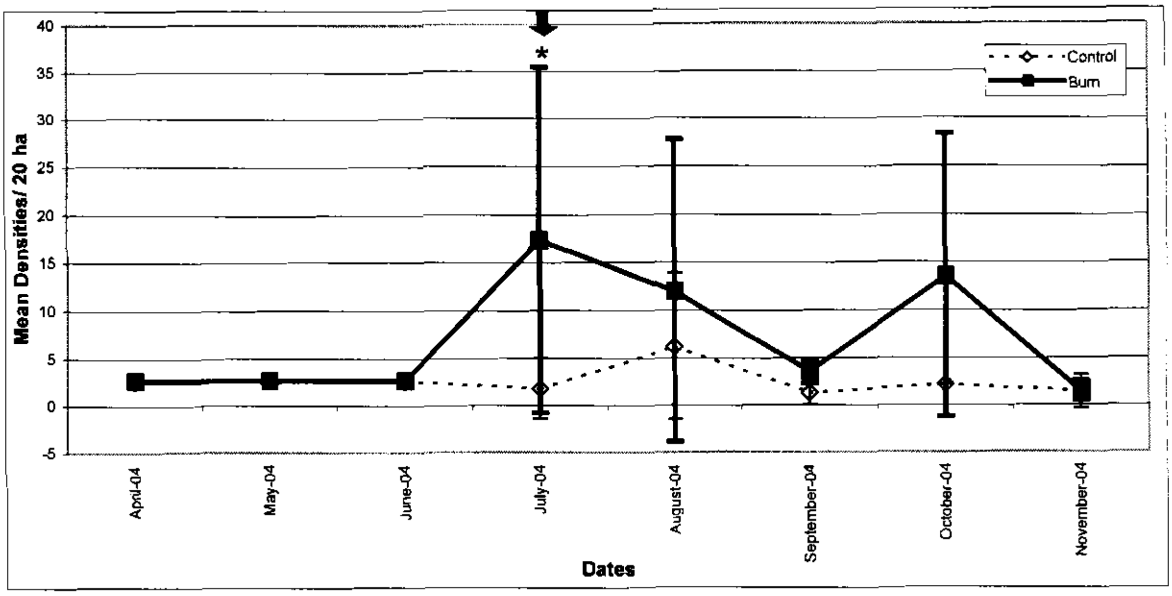

Fig. 3.2.15 The mean density recorded per month, in the evenings, on Burn 2.

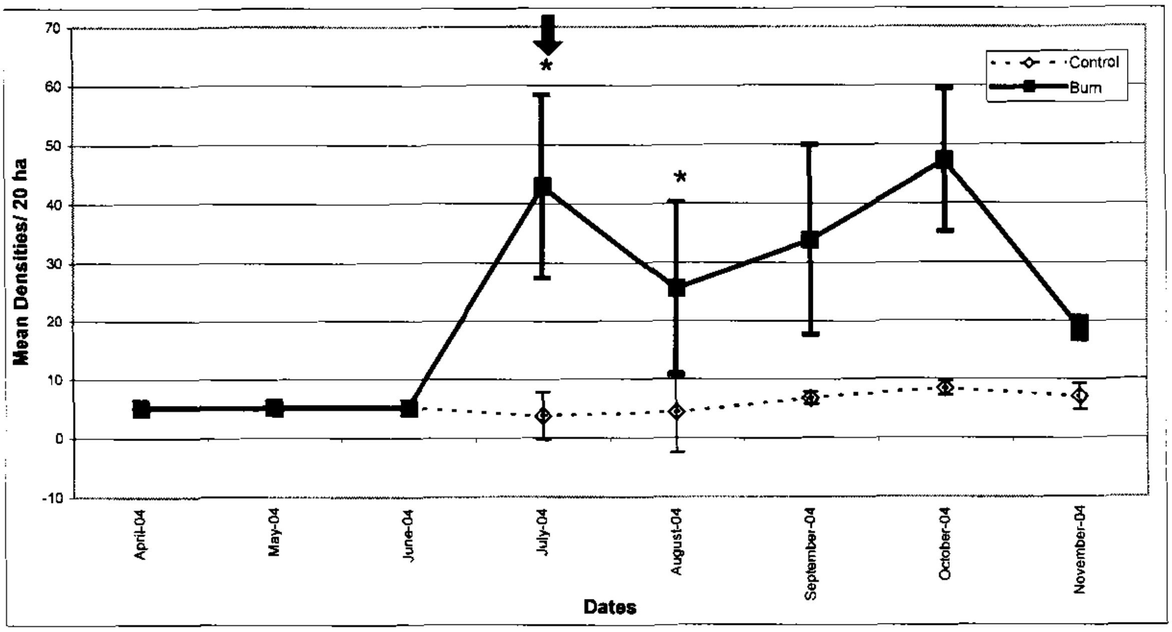

Fig. 3.2.16 The mean density recorded per month, in the evenings, on Burn 3.

Figures 3.2.15 and 3.2.16 represent the mean density recorded per month for Burn 2 and 3 in the evening. There were no evening counts before the fire.

In Fig. 3.2.15 the Burn Site showed an increase in density after the fire and then a decrease until September. In September another increase can be seen. After October the number decreased again and the Control and Burn Sites were almost the same in November. The Student T-test showed a significant difference for July.

In Fig. 3.2.16 the Burn Sites show a significant increase in density after the fire, giving a difference between the Burn and Control Sites after the fire. The Burn Sites decreased in density in August, but increased again in September. There was another decrease after October and the Control and Burn Sites were closer in density in November.

The Student T-test showed a significant difference both for July and August.

Fig. 3.2.15 and Fig. 3.2.16 had similar patterns. The morning density (Fig. 3.2.9 to Fig. 3.2.11) was higher than the evening density. The evening density were the same or slightly higher than the midday density (Fig. 3.2.13 and Fig. 3.2.14). By November, the effect of the fire had almost disappeared. Both burns had a significant difference in the Student T-test directly after the fire.

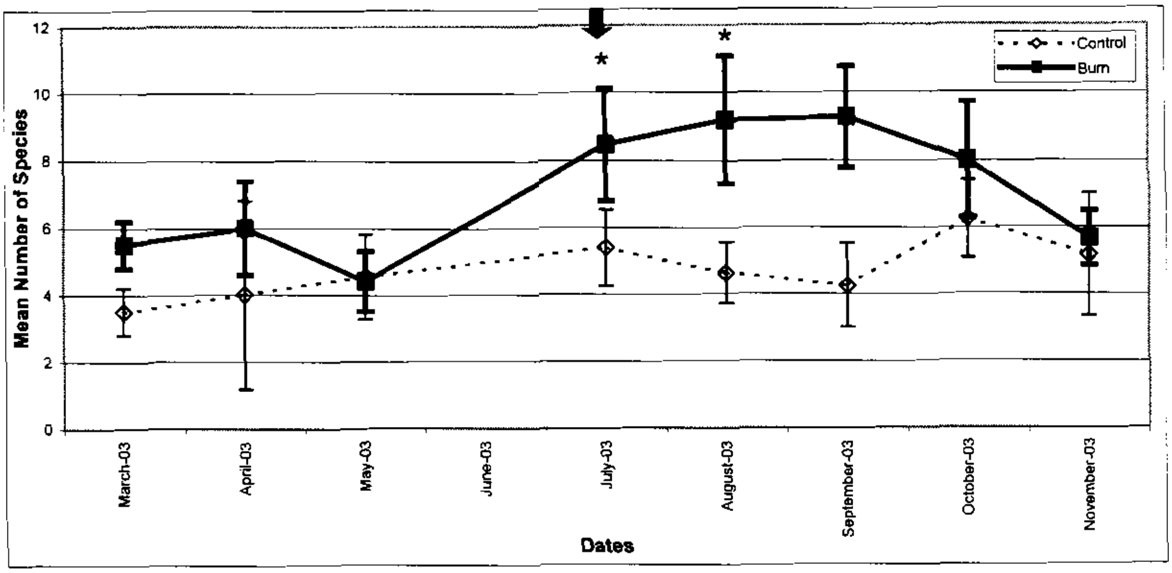

Fig. 3.2.17 The mean number of species recorded per month, in the mornings, on Burn 1.

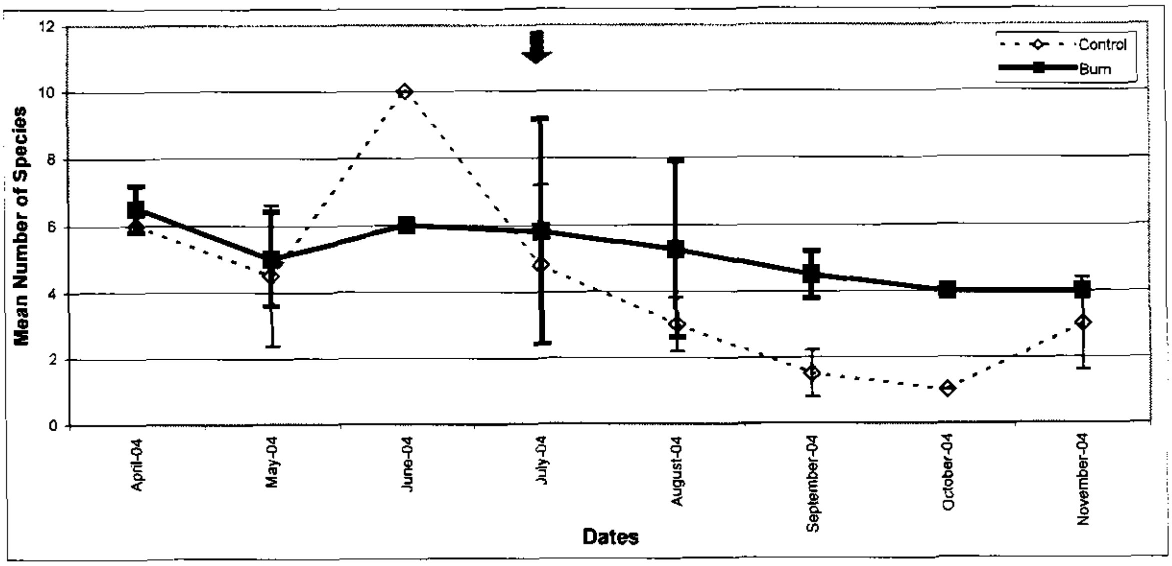

Fig. 3.2.18 The mean number of species recorded per month, in the mornings, on Burn 2.

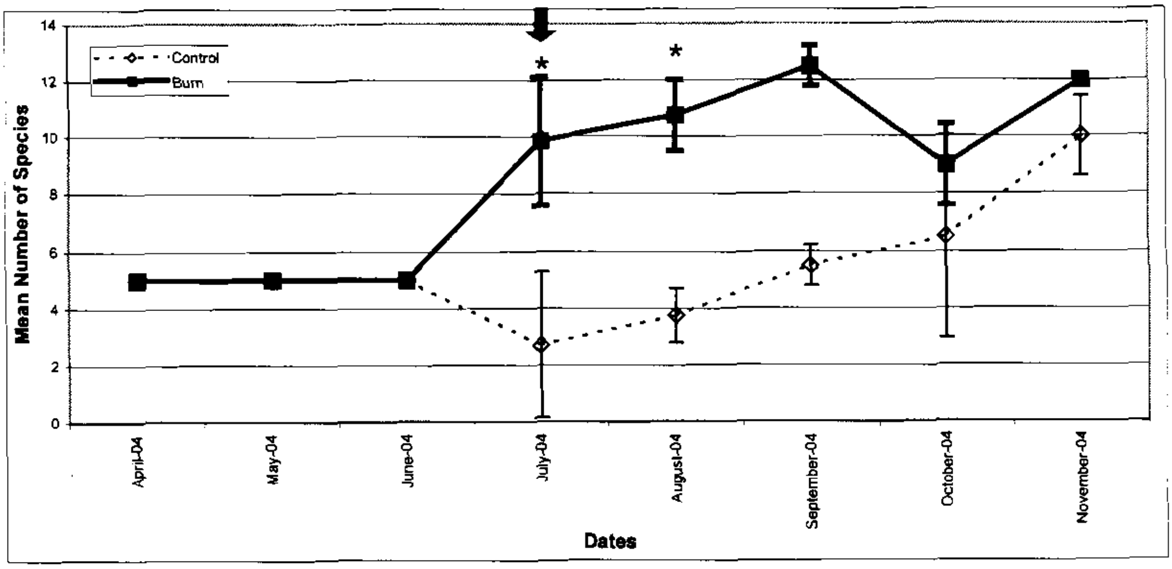

Fig. 3.2.19 The mean number of species recorded per month, in the mornings, on Burn 3.

Figures 3.2.17 to 3.2.19 represent the mean number of species recorded per month for each burn. Fig. 3.2.17 showed an increase in density after the fire in the Burn Site and there was a difference between the Burn and Control Sites after the fire. Between October and November the Burn Site showed a decrease in density and the Burn and Control Sites were almost the same again. Before the fire, the Burn and Control Sites differed very little. The Student T-test showed a significant difference both for July and August.

Fig. 3.2.18 showed the same pattern for the Burn and Control Sites before the fire. In June, there were more species in the Control Site than in the Burn Site. In July the number of species were almost the same and from August to October the Burn Site differed from the Control Site. In November the Burn and Control Sites were almost the same again. There was a decrease in numbers, overall. The Student T-test showed no significant difference for Burn 2.

Fig. 3.2.19 showed an increase in number of species after the fire in the Burn Site and there was a significant difference between the Burn and Control Sites after the fire. The Burn Site decreased in numbers after September, but increased again after October. The Control and Burn Sites were almost the same in October and November. The Control Site showed a general increase after the fire. As explained previously, there were no records before the fire. The Student T-test showed a significant difference both for July and August.

Fig. 3.2.17 and Fig. 3.2.19 were closest in pattern and all three burns had the same general trends. There was an increase in number of species after the fire with a large difference between the Control and Burn Sites. At the end of the year the Control and Burn Sites were closer in numbers of species, and the effects of the fire had almost disappeared.

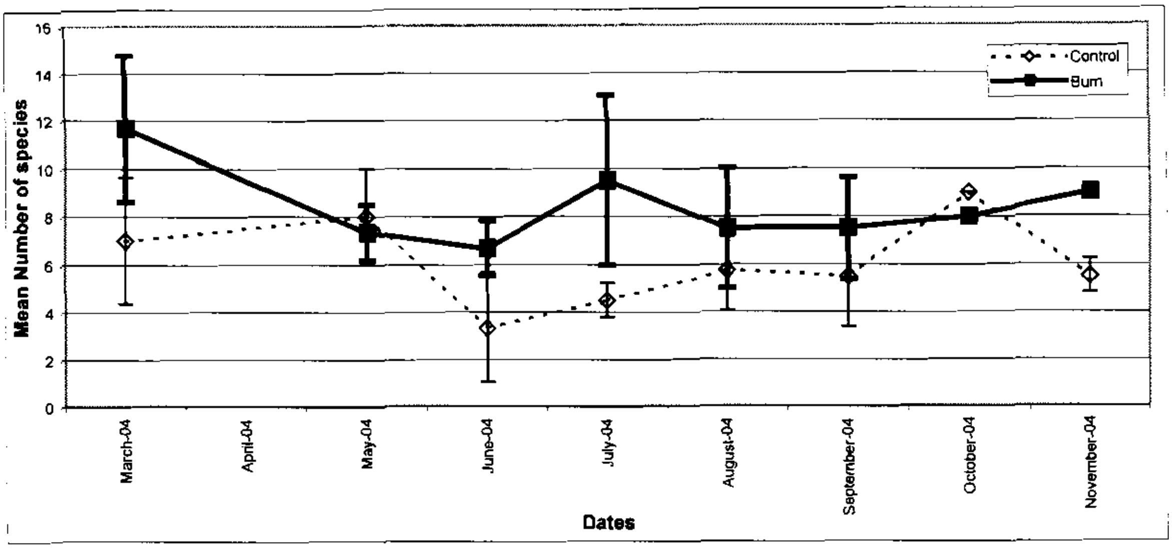

Fig. 3.2.20 The mean number of species recorded per month, in the mornings, on Burn 1 in the second year after the burn.

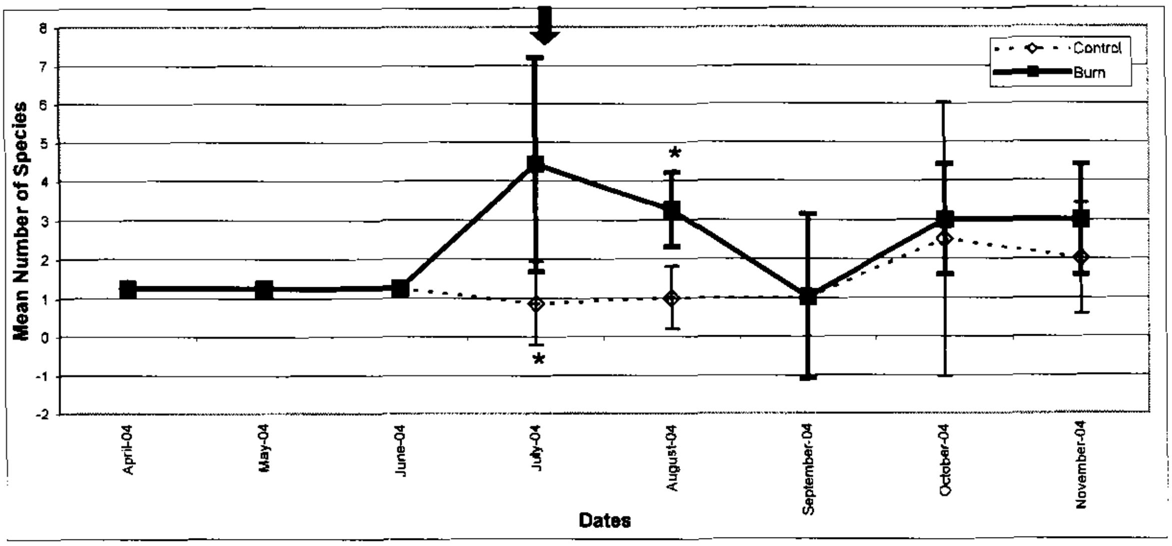

Fig. 3.2.21 The mean number of species recorded per month, at midday, on Burn 2.

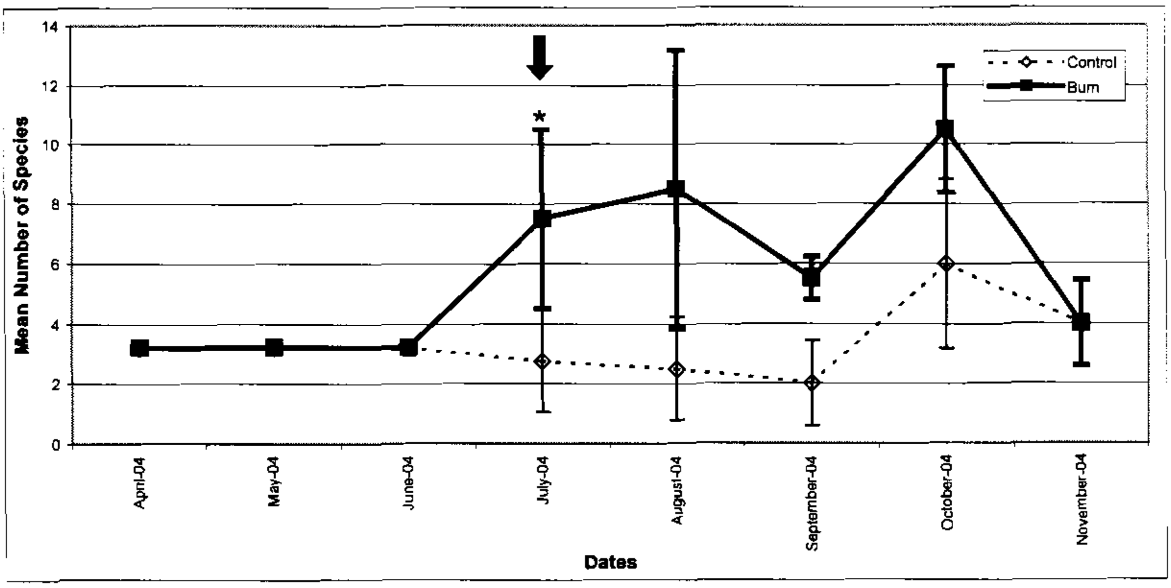

Fig. 3.2.22 The mean number of species recorded per month, at midday, on Burn 3.

Fig. 3.2.20 represents the mean number of species recorded per month for Burn 1 in the second year after the fire. The Burn and Control Sites differed slightly. There was a decrease in numbers towards the winter months, but the densities increased again after September. There was also more of a difference between the Burn and Control Sites in March and after May, until September. There was a general decrease in numbers for both the Control and Burn Sites towards winter and an increase again towards spring. The number of species was closer to pre-fire levels and the effect of the fire was therefore only temporary.

Figures 3.2.21 and 3.2.22 represent the mean number of species recorded per month for Burn 2 and 3 at midday. The arrows show the time of the fire and the asterisks show whether the Student T-test indicated a significant difference.

In Fig. 3.2.21 the Burn Site showed an increase in numbers after the fire and then a general decrease towards the end of the year. There was a slight increase in September. In October there was a slight decrease until November. The Control and Burn Sites were almost the same in October and November. The Student T-test showed a significant difference for both July and August.

In Fig. 3.2.22 the Burn Site showed an increase in numbers after the fire and there was a difference between the Burn and Control Sites after the fire. The Burn Site decreased in numbers in September, but increased again in October before decreasing again in November. The Control and Burn Sites were the same in November. The Control Site showed a slight decrease in numbers toward September and then increased again in October, before decreasing again in November. The Student T-test showed a significant difference for July.

Burns 2 and 3 (Fig. 3.2.21 and Fig. 3.2.22) were close in pattern. There was an increase in number of species in the Burn Sites after the fire and the number of species in the Control and Burn Sites had about the same number of species at the end of the year, showing that the effect of the fire was only temporary and had almost disappeared. The morning number of species was higher than the midday numbers in both cases (Fig. 3.2.18 and Fig. 3.2.19) and although they had the same general trends, their patterns varied from those of the morning numbers. Both burns had a significant difference in the Student T-test directly after the fire.

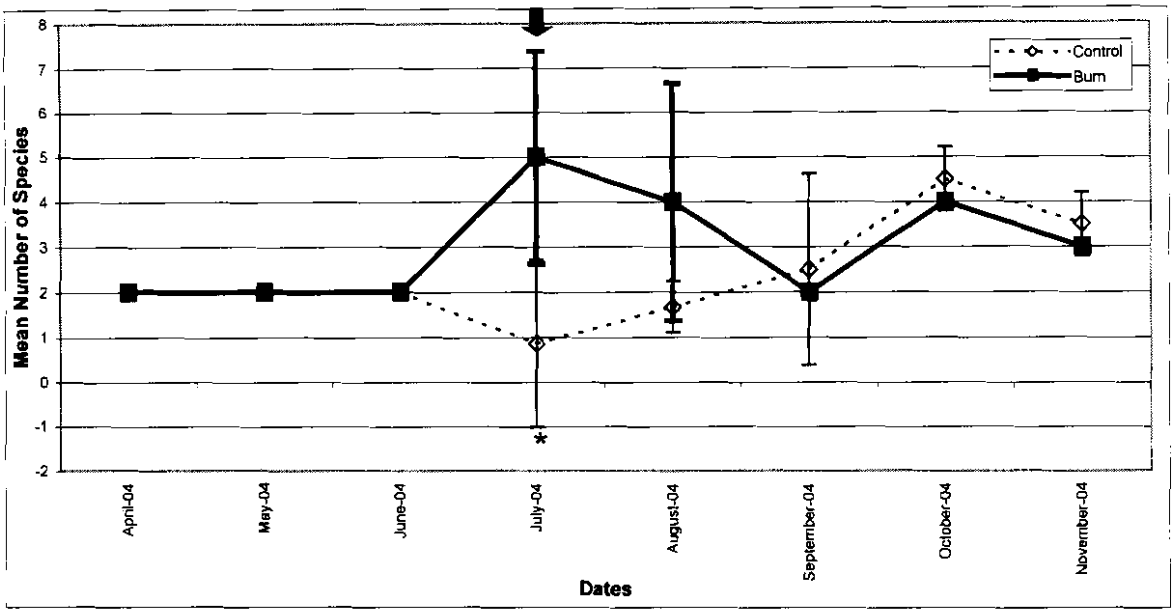

Fig. 3.2.23 The mean number of species recorded per month, in the evenings, on Burn 2.

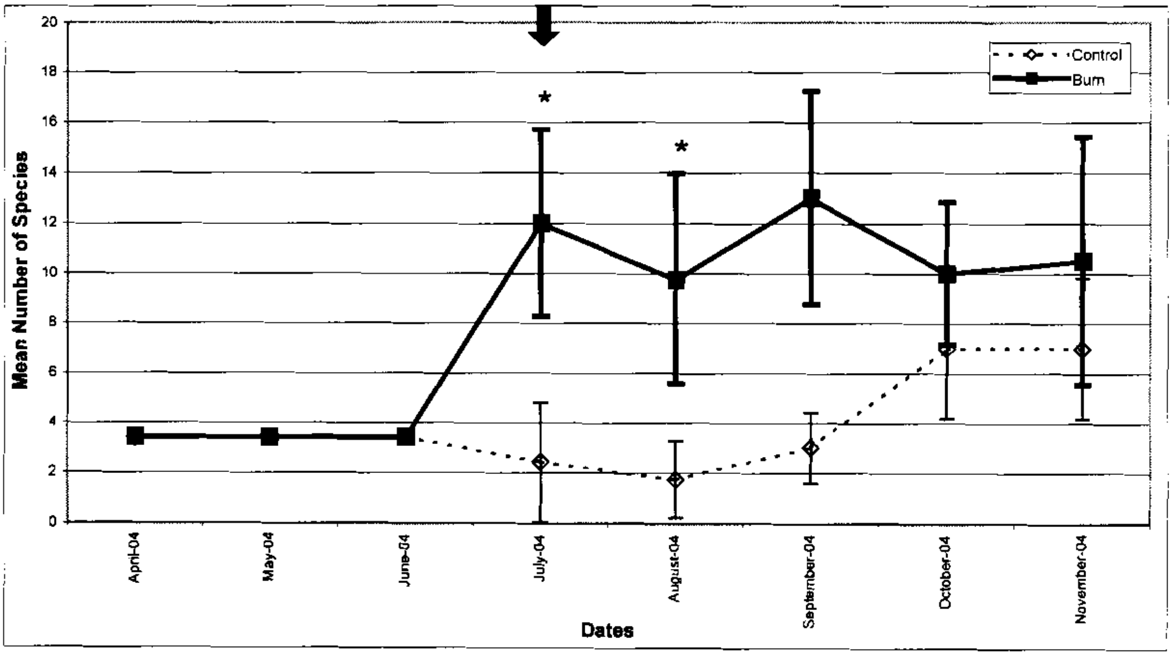

Fig. 3.2.24 The mean number of species recorded per month, in the evenings, on Burn 3.

Figures 3.2.23 to 3.2.24 represent the mean number of species recorded per month for Burn 2 and 3 in the evening. The arrows show the time of the fire and the asterisks show whether the Student T-test indicated a significant difference.

Fig. 3.2.23 showed an increase in numbers after the fire in the Burn Site and then a decrease until September. In September an increase for both the Burn and Control Sites could be seen. After October the numbers decrease again and the Control and Burn Sites were almost the same from September to November, though the Control Site had more species than the Burn Site. The Control Site showed a general increase to the end of the year. The Student T-test showed a significant difference for July.

Fig. 3.2.24 showed an increase in numbers after the fire in the Burn Site, giving a difference between the Burn and Control Sites after the fire. There was a slight decrease in August, which was restored in September. There was another decrease after September, with a slight increase in November. The Control and Burn Sites were closer in numbers in October and November. The Control Site first showed a decrease in numbers, but increased again after August until the end of the year. The Student T-test showed a significant difference both for July and August.

The patterns of Burns 2 and 3 (Fig. 3.2.23 and Fig. 3.2.24) corresponded partially, showing an increase in the Burn Sites after the fire. There was a large difference in number of species between the Control and Burn Sites for the first two months after the fire and this lasted longer for Burn 3 (Fig. 3.2.24). The Burn and Control Sites were closer in number of species at the end of the year, showing that the effects of the fire were disappearing. The morning number of species was higher than the evening numbers in both cases (Fig. 3.2.18 and Fig. 3.2.19). The evening number of species was the same or slightly higher than the midday numbers (Fig. 3.2.21 and Fig 3.2.22). Both burns had a significant difference in the Student T-test directly after the fire.

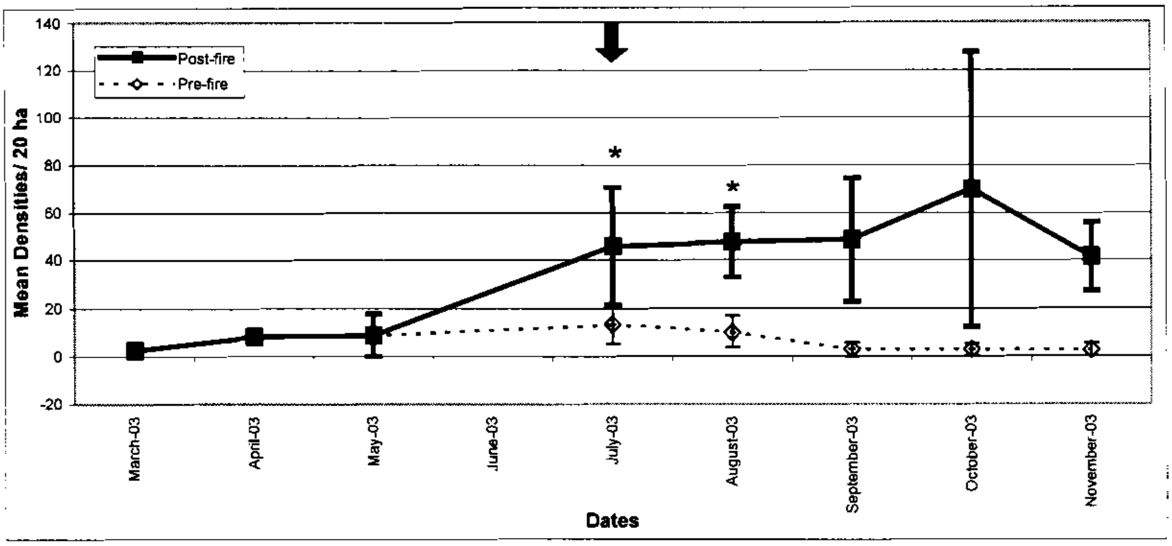

Fig. 3.2.25 Mean density recorded in the mornings before and after the fire on Burn 1. See text for details.

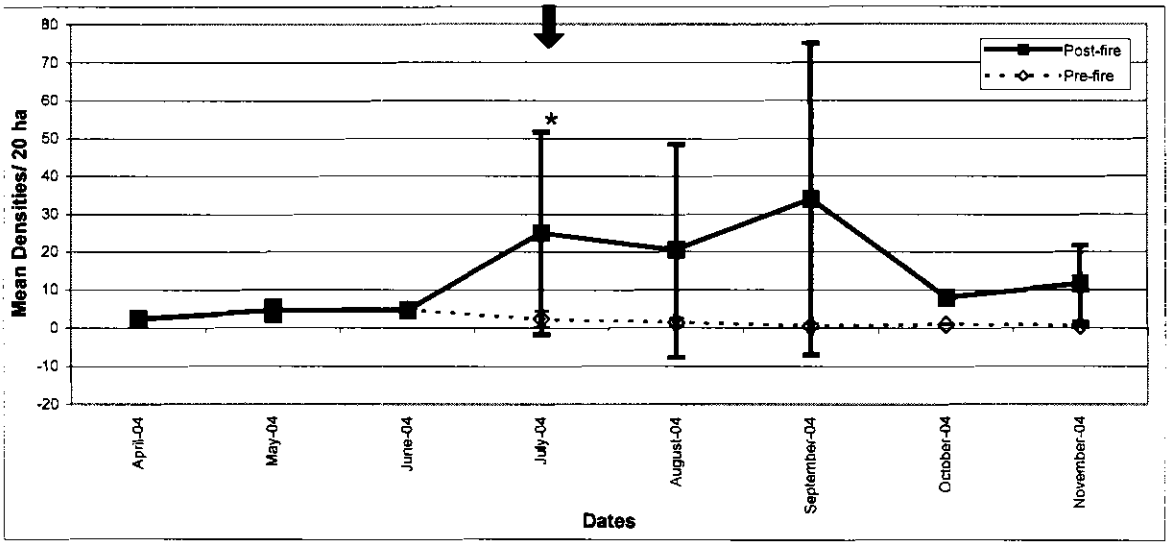

Fig. 3.2.26 Mean density recorded in the mornings before and after the fire on Burn 2. See text for details.

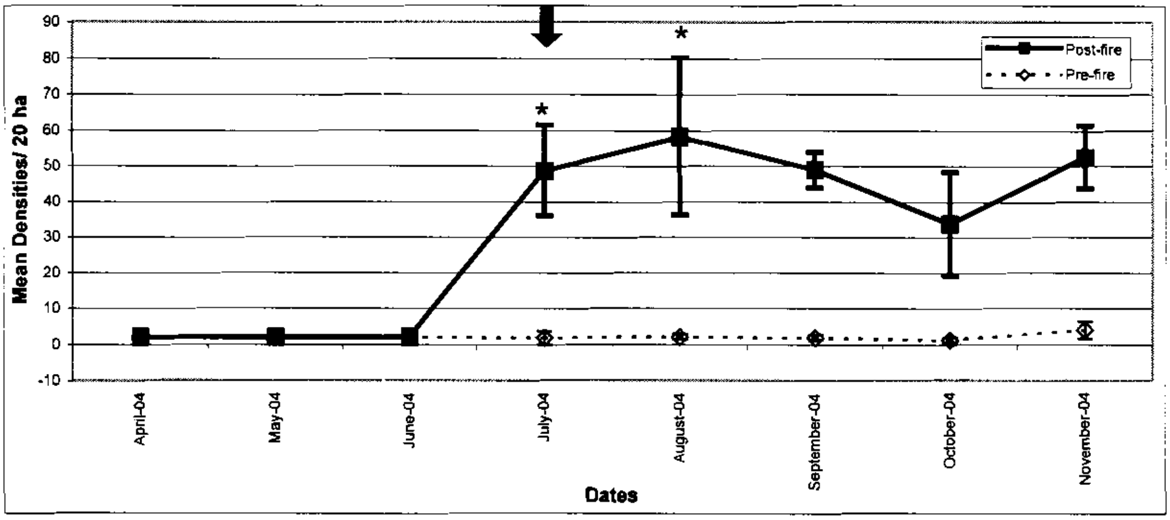

Fig. 3.2.27 Mean density recorded in the mornings before and after the fire on Burn 3. See text for details.

Fig. 3.2.25 to Fig. 3.2.27 show the temporal variation in mean density that was recorded in the mornings before and after the fire. The data from the Control Sites were therefore not included. The mean densities were calculated by first separating the species that were present before the fire from the species that only appeared after the fire, or that increased in numbers after the fire. This first group was designated as the "pre-fire" group, while those that appeared or increased in the Burn Site after the fire were allocated to the "post-fire" group. The split only took place after the fires – therefore no difference in density before the fire itself (March to June).

The density for Burn 1 (Fig. 3.2.25) before the fire showed a slight increase. After the fire the "pre-fire" group slowly decreased while the "post-fire" group slowly increased. In October there was a sharper increase before the density decreased again in November. The Student T-test showed a significant difference in both July and August.

The density for Burn 2 (Fig. 3.2.26) before the fire showed a slight increase. After the fire the "pre-fire" group slowly decreased while the "post-fire" group increased. In August there was a decrease in the "post-fire" group. This increased again in September and decreased again in October. In November there was another slight increase. The Student T-test showed a significant difference for July.

Burn 3 (Fig. 3.2.27) had no pre-fire data. This was calculated by a mean of the "pre-fire" group. Since this group was not known, it was compiled from the other two burns' "pre-fire" groups and adjusted according to Burn 3's "post-fire" group. After the fire the "pre-fire" group slowly decreased while the "post-fire" group had a sharp increase. After August the numbers decreased again until October and increased again sharply in November. The Student T-test showed a significant difference in both July and August.

Fig. 3.2.25 and Fig. 3.2.26 were closest in pattern and Fig. 3.2.27 had the same general trends. The density increased in the Burn Sites after the fire and the Control and Burn Sites were closer in density at the end of the year. These graphs showed the same pattern as Fig. 3.2.9 to Fig. 3.2.11. All three burns had a significant difference for the Student T-test directly after the fire.

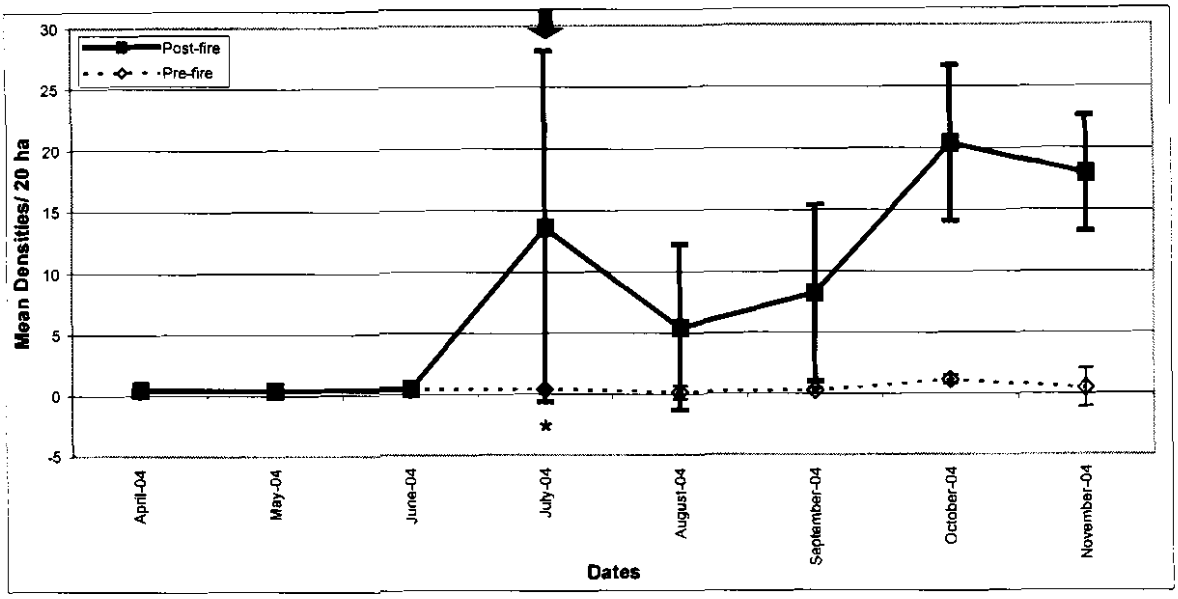

Fig. 3.2.28 Mean density recorded at midday before and after the fire on Burn 2. See text for details.

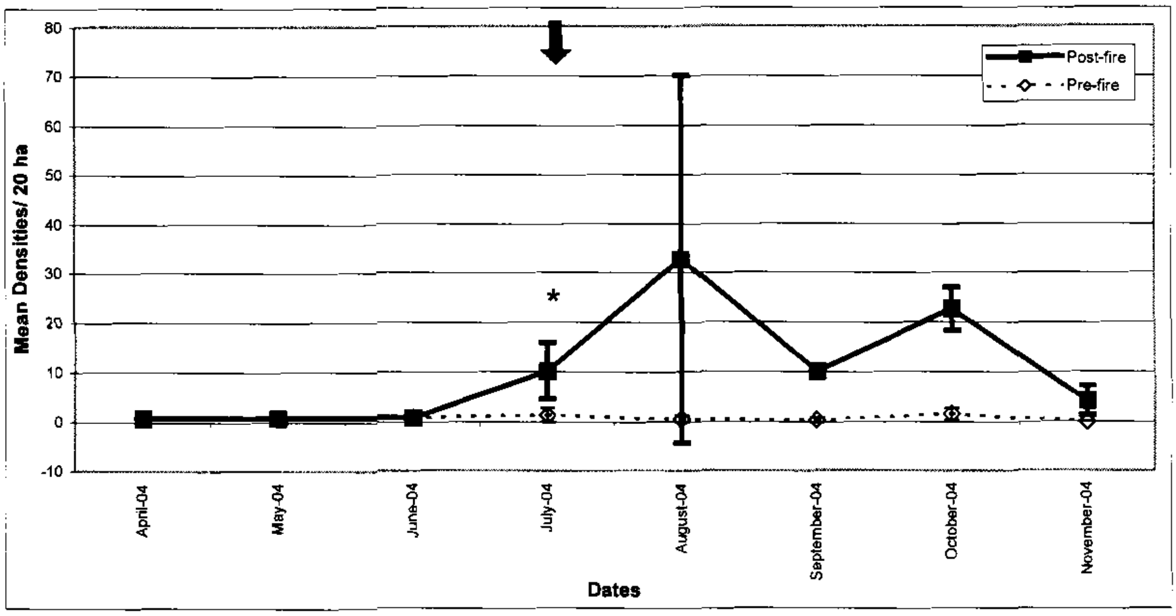

Fig. 3.2.29 Mean density recorded at midday before and after the fire on Burn 3. See text for details.

Fig. 3.2.28 to Fig. 3.2.29 show the mean density that was recorded at midday before and after the fire for Burns 2 and 3. These were calculated in the same way as Fig. 3.2.24 to Fig. 3.2.26. There were no pre-fire data and this was calculated in the same way as Burn 3.

The density for Burn 2 (Fig. 3.2.28) after the fire showed a sharp increase while the "pre-fire" group showed a steady line. The "post-fire" group decreased sharply after June and then decreased slightly after July. In August the numbers increase again until October. In November the numbers decreased slightly. The Student T-test showed a significant difference for July.

The numbers for Burn 3 (Fig. 3.2.29) after the fire showed an increase while the "pre-fire" group showed a steady line. The "post-fire" group decreased sharply after August, increased after September and ended in a decrease in November. The Student T-test showed a significant difference for July.

The patterns of Burns 2 and 3 did not correspond. Fig. 3.2.26 and Fig. 3.2.29 were almost mirror patterns of each other.

The patterns of Burns 2 and 3 (Fig. 3.2.28 and Fig. 3.2.29) corresponded partially. There was an increase in density in the Burn Sites after the fire and a return to pre-fire levels at the end of the year. The morning densities were higher than the midday densities. The midday graphs had the same general trends as the morning graphs (Fig. 3.2.26 to Fig. 3.2.27) and had the same pattern as Fig. 3.2.13 and Fig. 3.2.14. Both burns had a significant difference in the Student T-test directly after the fire.

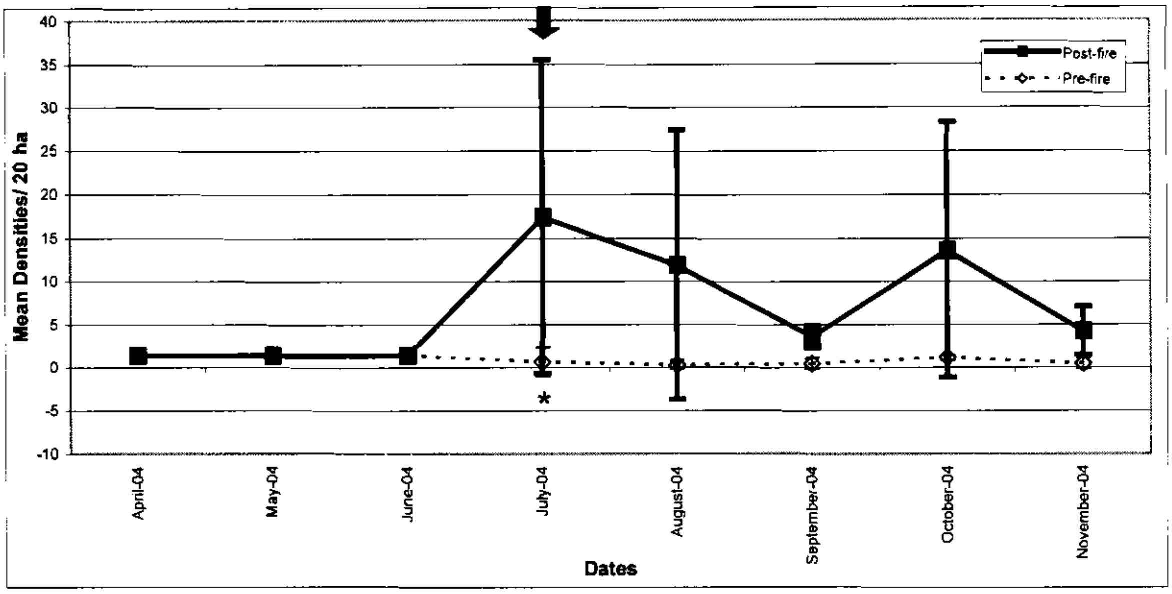

Fig. 3.2.30 Mean density recorded in the evenings before and after the fire on Burn 2.

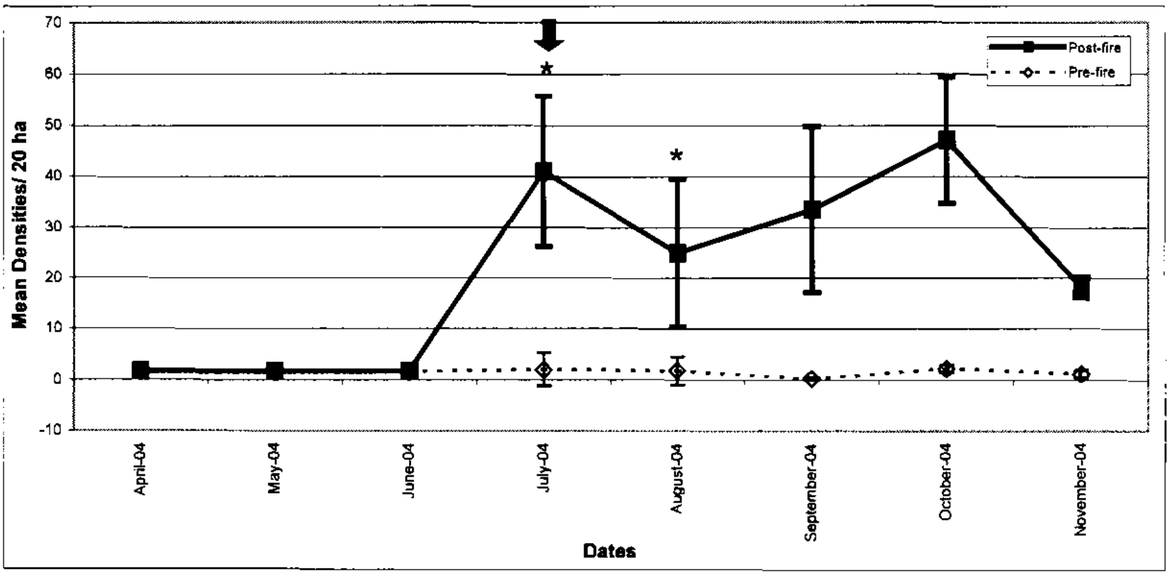

Fig. 3.2.31 Mean density recorded in the evenings before and after the fire on Burn 3.

Fig. 3.2.30 to Fig. 3.2.31 show the mean density that was recorded in the evenings before and after the fire for Burns 2 and 3. These were calculated in the same way as Fig. 3.2.24 to Fig. 3.2.26. There were no pre-fire data and this was calculated in the same way as Burn 3.

In Fig. 3.2.30 the density for Burn 2 after the fire showed an increase while the "pre-fire" group showed a steady line. The "post-fire" group decreased after July and then increased after September. In October the numbers decreased again. The Student T-test showed a significant difference for July.

In Fig. 3.2.31 the density for Burn 3 after the fire showed a sharp increase while the "pre-fire" group showed a steady line. The "post-fire" group decreased after July and increased again after August. Another decrease was seen after October. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.30 and Fig. 3.2.31 had similar patterns. There was an increase in density in the Burn Sites after the fire and a return to pre-fire levels at the end of the year. The morning densities (Fig. 3.2.26 to Fig. 3.2.27) were higher than the evening densities. The evening densities were the same or slightly higher than the midday densities (Fig. 3.2.28 and Fig. 3.2.29) and had the same pattern as Fig. 3.2.15 and Fig. 3.2.16. Both burns had a significant difference in the Student T-test directly after the fire.

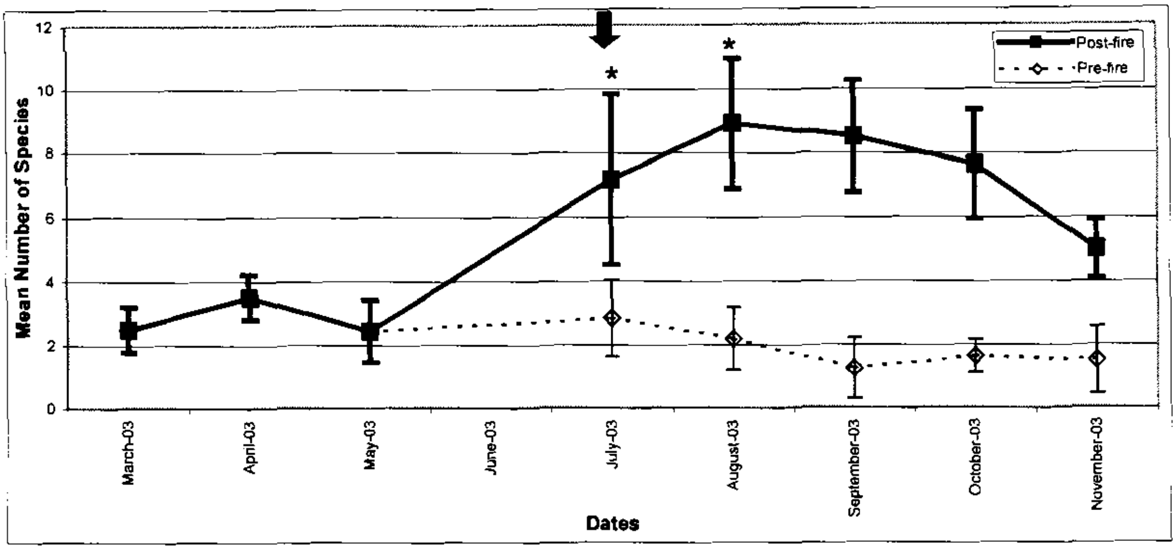

Fig. 3.2.32 Mean number of species recorded in the mornings before and after the fire on Burn 1.

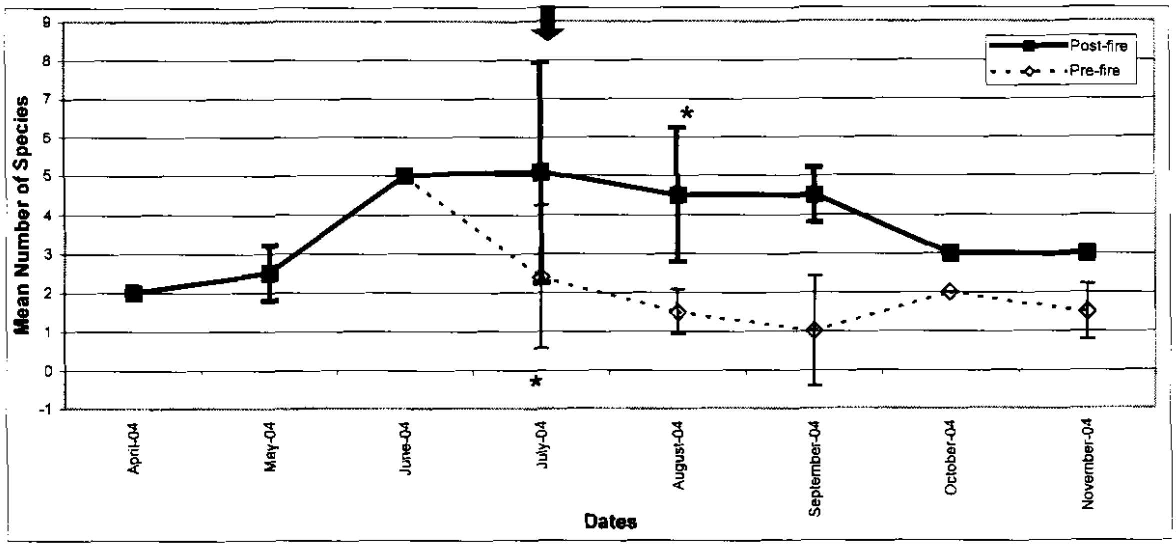

Fig. 3.2.33 Mean number of species recorded in the mornings before and after the fire on Burn 2.

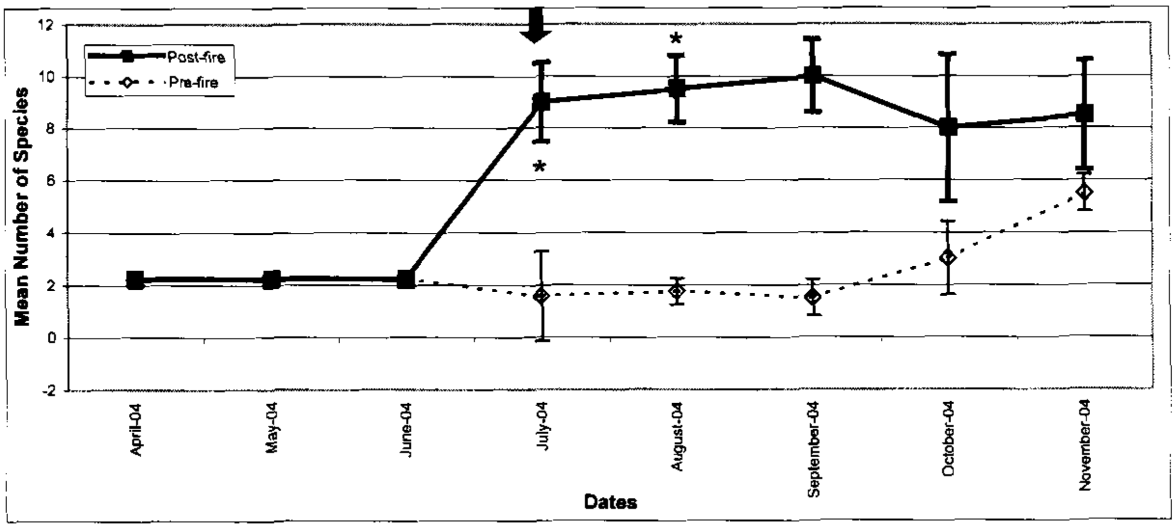

Fig. 3.2.34 Mean number of species recorded in the mornings before and after the fire on Burn 3.

Fig. 3.2.32 to Fig. 3.2.34 show the temporal variation in the mean number of species that were recorded in the mornings before and after the fire. The data from the Control Sites were therefore not included. The mean number of species was calculated by first separating the species that were present before the fire from the species that only appeared after the fire, or that increased in numbers after the fire. This first group was designated as the "pre-fire" group, while those that appeared or increased in the Burn Site after the fire were allocated to the "post-fire" group. The split only took place after the fires – therefore no difference in species richness before the fire itself (March to June).

Fig. 3.2.32 showed an increase in the numbers for Burn 1 before the fire and then a decrease. After the fire the "pre-fire" group slowly decreased while the "post-fire" group gradually increased. After August there was a gradual decrease until the end of the year. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.33 showed an increase in the numbers for Burn 2 before the fire. After the fire the "pre-fire" group decreased until September. There was an increase in October and another decrease in November. The "post-fire" group decreased slightly after the fire and then more sharply after September before steadying in October and November. The number of species was almost the same in October and November. The Student T-test showed a significant difference for both July and August.

Burn 3 (Fig. 3.2.34) had no "pre-fire" data. This was calculated by a mean of the "pre-fire" group. Since this group was not known, it was compiled from the other two burns' "pre-fire" groups and adjusted according to Burn 3's "post-fire" group. After the fire the "pre-fire" group slowly decreased while the "post-fire" group had a sharp increase. After August the numbers decreased again until October and increased again sharply in November. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.32 and Fig. 3.2.34 were closest in pattern and Fig. 3.2.33 had the same general trends as these two graphs. There was an increase in number of species in the Burn Sites directly after the fire and a decrease at the end of the year, showing that the species had started to return to "pre-fire" levels. All three burns had a significant difference for the Student T-test for July and August.

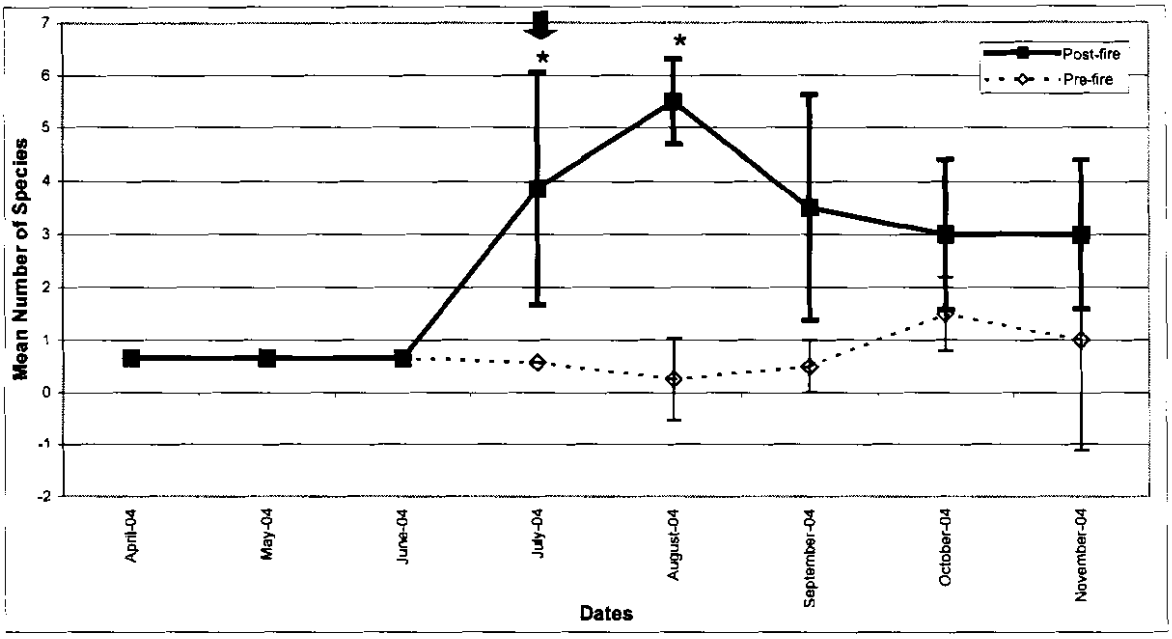

Fig. 3.2.35 Mean number of species recorded at midday before and after the fire on Burn 2.

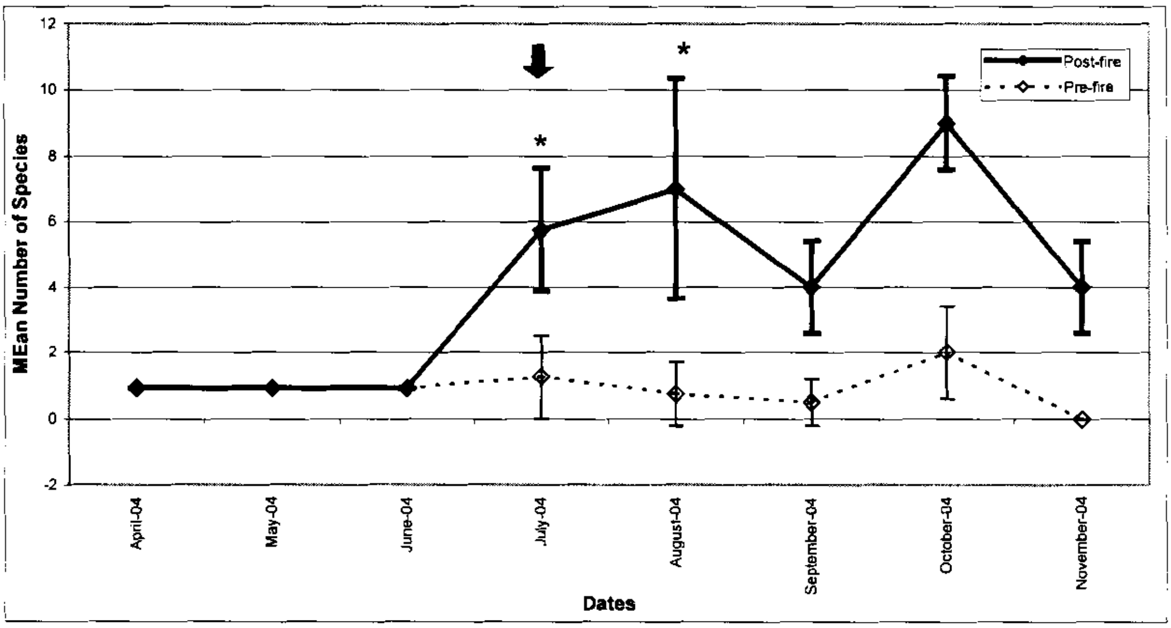

Fig. 3.2.36 Mean number of species recorded at midday before and after the fire on Burn 3.

Fig. 3.2.35 to Fig. 3.2.36 show the mean number of species that were recorded at midday before and after the fire for Burns 2 and 3. There were no "pre-fire" data and this was calculated in the same way as Burn 3 (Fig. 3.2.34).

In Fig. 3.2.35 the numbers for Burn 2 after the fire showed a sharp increase while the "pre-fire" group showed a steady increase until the end of the year. The "post-fire" group decreased after June and then increased in July. In August the numbers increased again. After August there was a decrease until October. In October and November the line was steady. The Student T-test showed a significant difference for both July and August.

In Fig. 3.2.36 the numbers for Burn 3 after the fire showed an increase while the "pre-fire" group showed a steady decrease until September, when there was a slight increase before the next decrease in October. The "post-fire" group increased until August. There was a decrease until September and another increase in October before the numbers ended in a decrease in November. The Student T-test showed a significant difference for both July and August.

Burns 2 and 3 (Fig. 3.2.35 and Fig. 3.2.36) had similar patterns. There was an increase in number of species in the Burn Sites after the fire and a decrease at the end of the year. The differences in the Control and Burn Sites indicate that the fire had an effect on the species and at the end of the year the effects started to disappear. Both burns had a significant difference in the Student T-test for the first two months after the fire. The morning number of species (Fig. 3.2.33 and Fig. 3.2.34) was higher than the midday numbers. The patterns were about the same as those in Fig. 3.2.21 and Fig. 3.2.22.

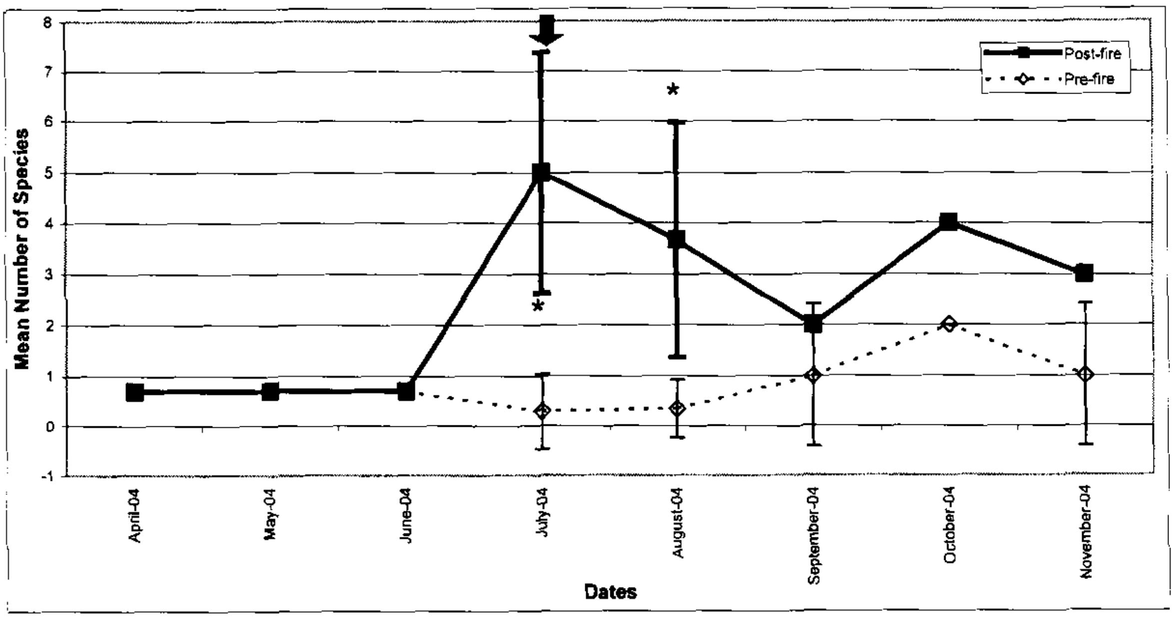

Fig. 3.2.37 Mean number of species recorded in the evenings before and after the fire on Burn 2.

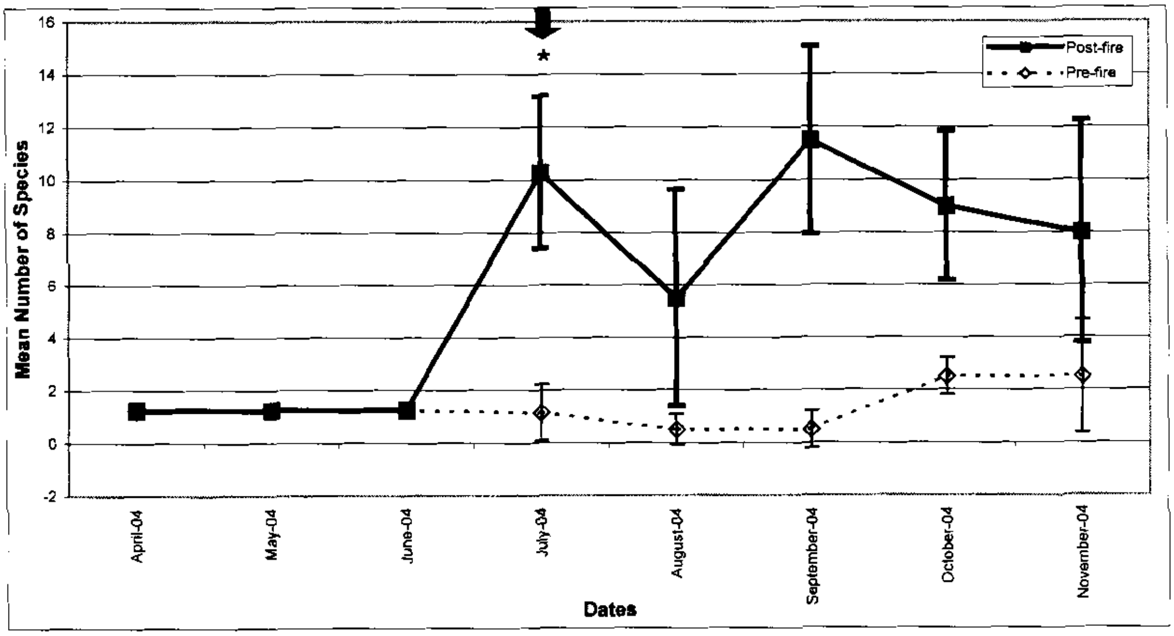

Fig. 3.2.38 Mean number of species recorded in the evenings before and after the fire on Burn 3.

Fig. 3.2.37 to Fig. 3.2.38 show the mean number of species that were recorded in the evenings before and after the fire for Burns 2 and 3. There were no pre-fire data and this was calculated in the same way as Burn 3.

The "pre-fire" group for Burn 2 (Fig. 3.2.37) showed a decrease after the fire before it increased until October and decreased again in November. The "pre-fire" group of Burn 3 (Fig. 3.2.38) showed a steady decrease until September, when there was a slight increase until the end of the year.

The "post-fire" group of Burn 2 (Fig. 3.2.37) increased sharply and then decreased until September. In October there was an increase and another decrease followed in November. The "post-fire" group for Burn 3 (Fig. 3.2.38) showed and increase. The group decreased after July and increased again in September. There was a decrease until the end of the year. The Student T-test showed a significant difference for both July and August in Burn 2 (Fig. 3.2.37), but only for July in Burn 3 (Fig. 3.2.38).

Fig. 3.2.37 and Fig. 3.2.38 were close in patterns. There was an increase in number of species in the Burn Sites after the fire and a decrease at the end of the year, showing that although the fire had an effect on the species, it started to disappear at the end of the year. Both burns had a significant difference for the Student T-test directly after the fire. The morning number of species (Fig. 3.2.33 and Fig. 3.2.34) was higher than the evening numbers. The evening number of species was the same or slightly higher than the midday numbers (Fig. 3.2.35 and Fig. 3.2.36). The patterns were about the same as those in Fig. 3.2.23 and Fig. 3.2.24.

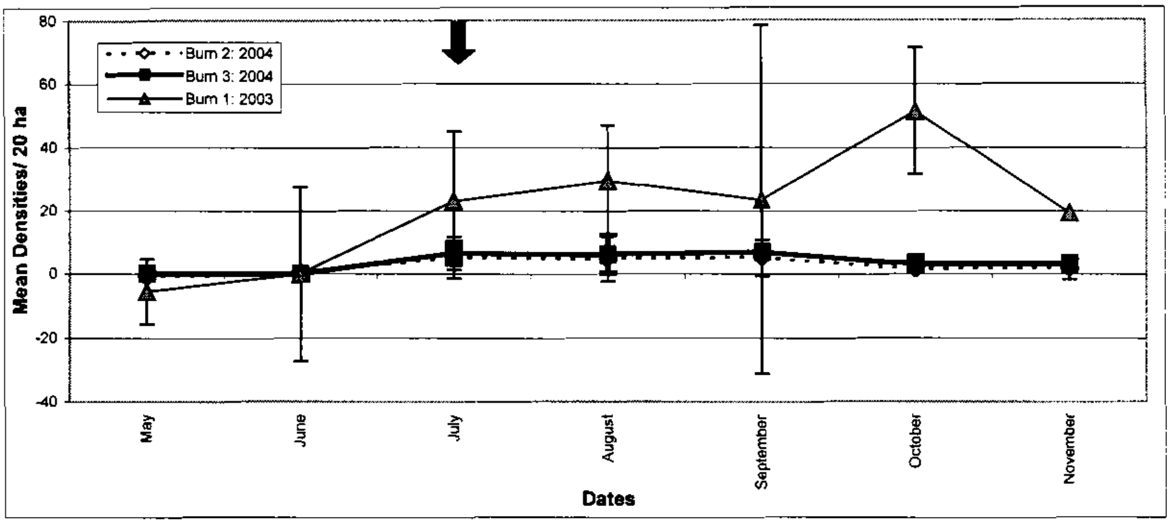

Fig. 3.2.39 The difference between the mean density in the Control and Burn Sites of each burn, recorded in the mornings.

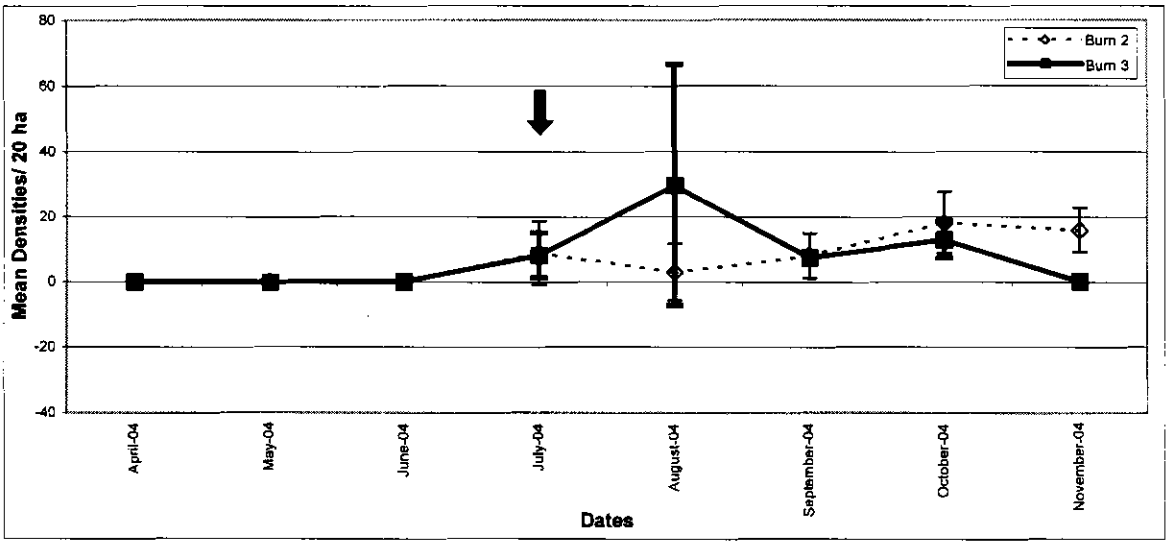

Fig. 3.2.40 The difference between the mean density in the Control and Burn Sites of Burn 2 and 3, recorded at midday.

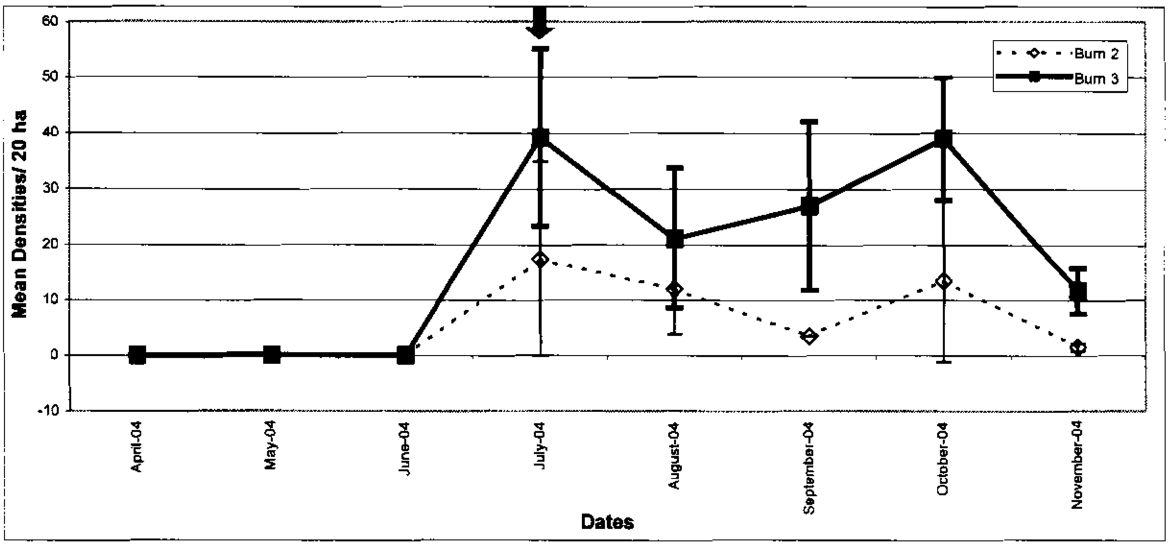

Fig. 3.2.41 The difference between the mean density in the Control and Burn Sites of Burn 2 and 3, recorded in the evenings.

Fig. 3.2.39 to Fig. 3.2.41 show the difference between the mean density that were recorded for the Control and Burn Sites. This was calculated by subtracting the Control Site values from the Burn Site values. Therefore, where the birds had higher densities in the Control Site, the differential will be negative and where they had higher densities in the Burn Site, the differential will be positive.

Burn 1 (Fig. 3.2.39, morning) showed a steady increase from the negative values to the positive values. There was a slight decrease in September, before another increase in October. The line ended in a decrease, but stayed positive. Burn 1 had only morning counts. Burns 2 and 3 (Fig. 3.2.39, morning) showed almost the same pattern as Burn 1, except for a steady line from July until September and a decrease after September, ending in a slight increase at the end of the year. Burn 3 had slightly higher values than Burn 2. Both Burn 1 and 2 (Fig. 3.2.39) started with small negative differentials. Burn 3 (Fig. 3.2.39) started with positive differentials. All three burns ended with positive differentials, though lower than their highest value.

After the fire, Burn 2 (Fig. 3.2.40, midday) showed an increase in July, a decrease in August and another increase until October. The line ended in a slight decrease in November. Burn 3 (Fig. 3.2.40, midday) increased until August, decreased in September and increased again in October. The line ended in a decrease in November. Neither of the two burns had negative differentials.

Burn 2 (Fig. 3.2.41, evening) increased in July and decreased until September. There was another increase in October and a decrease in November. Burn 3 (Fig. 3.2.41, evening) increased in July, decreased in August and increased again until October. The line ended in a sharp decrease in November. Neither of the two burns had negative differentials.

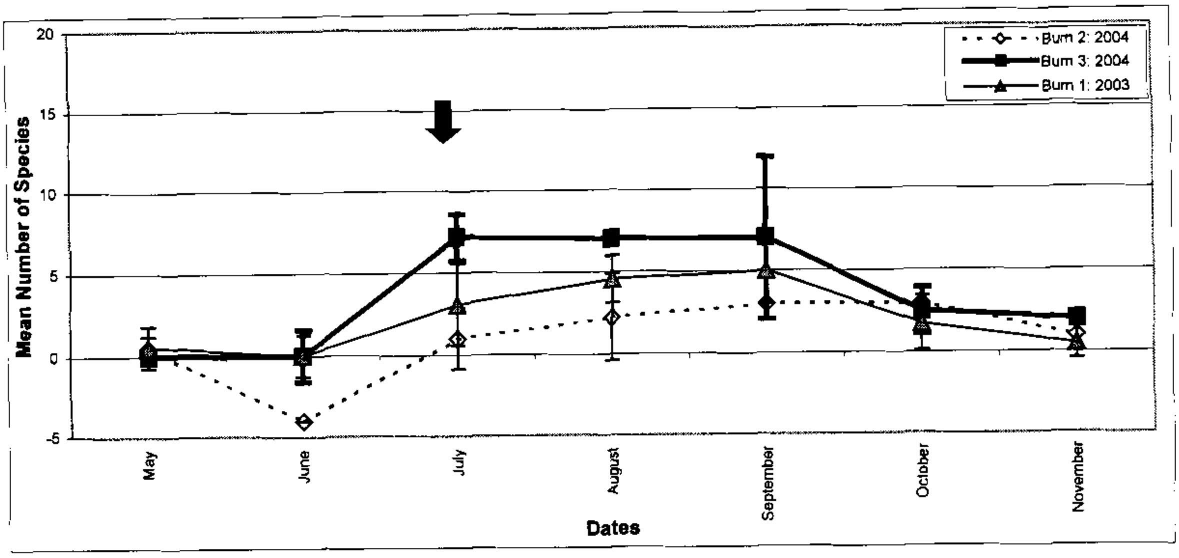

Fig. 3.2.42 The difference between the mean number of species in the Control and Burn Sites of each burn, recorded in the mornings.

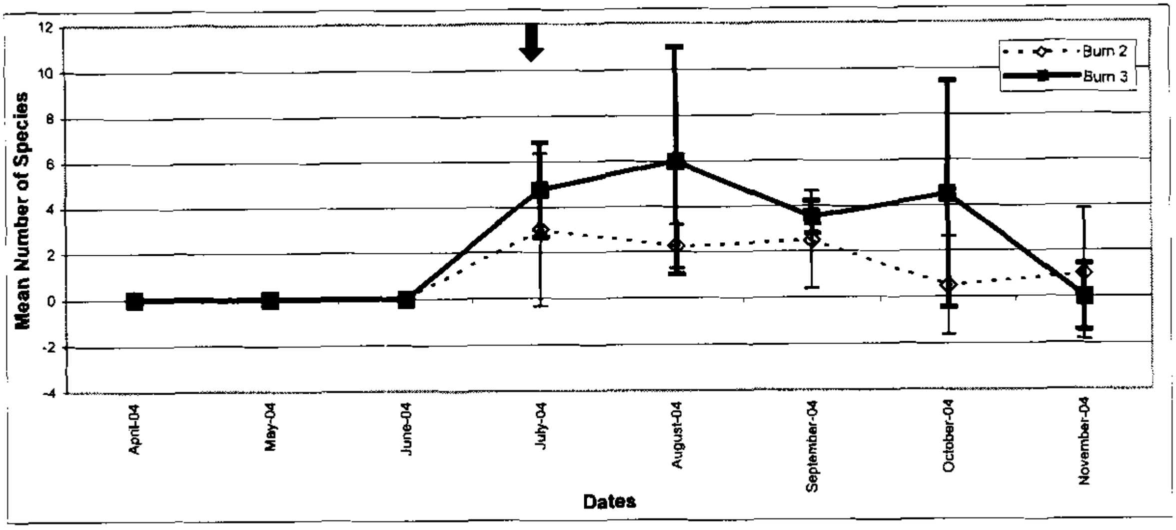

Fig. 3.2.43 The difference between the mean number of species in the Control and Burn Sites of Burn 2 and 3, recorded at midday.

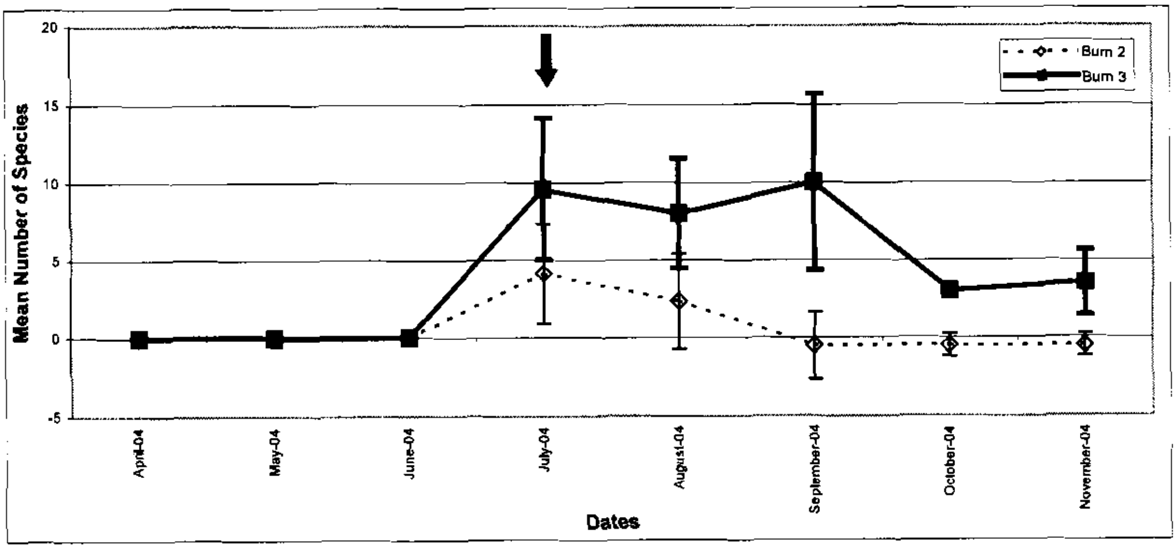

Fig. 3.2.44 The difference between the mean number of species in the Control and Burn Sites of Burn 2 and 3, recorded in the evenings.

Fig. 3.2.42 to Fig. 3.2.44 show the difference between the mean number of species that were recorded in the Control and Burn Sites. This was calculated in the same way as Fig. 3.2.39 to Fig. 3.2.41. No Student T-tests were performed.

In Fig. 3.2.42 the morning number of species for all three burns is shown. Burn 1 showed a slight decrease before steadily increasing until September. After September there was a decrease until November. Burn 2 showed almost the same pattern, except for a decrease in June. The increase after June lasted until September after which it decreased again and the line ended in a decrease in November. Burn 3 showed a slight increase between June and July. After July the species differential remained steady until September and then decreased until November. Only Burn 2 had a negative differential. The three lines showed remarkably similar trends.

In Fig. 3.2.43 the midday numbers for Burn 2 and 3 are shown. After the fire Burn 2 showed an increase in July and then decreased in August. There was a slight increase in September and another decrease in October. The line ended in an increase in November. Burn 3 showed an increase until August and then a decrease in September. There was another increase in October and the line ended in a sharp decrease in November. Neither of the two burns had negative values.

In Fig. 3.2.44 the evening numbers for Burn 2 and 3 are shown. Burn 2 increased in July and decreased until September. There was a steady line from September until the end of the year. Burn 3 increased in July, decreased in August and increased again in September. There was a decrease in October and the line ended in an increase in November. Neither of the two burns had negative values.

In all three graphs the differentials followed a similar trend of an increase after the fire, followed by a steady decrease towards November.

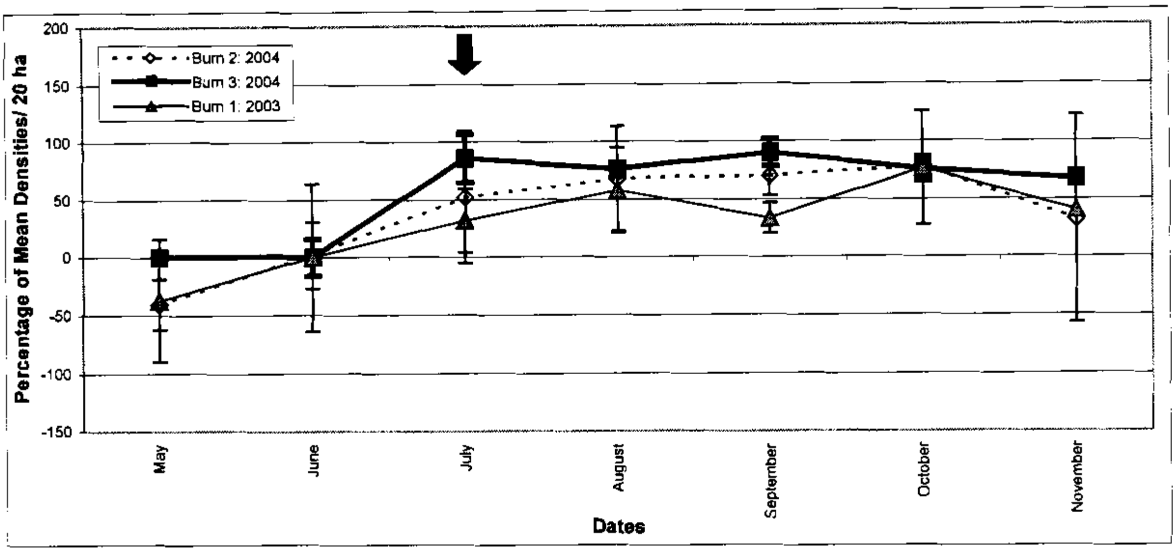

Fig. 3.2.45 The percentages of the difference between the mean density in the Control and Burn Sites for each burn, recorded in the mornings.

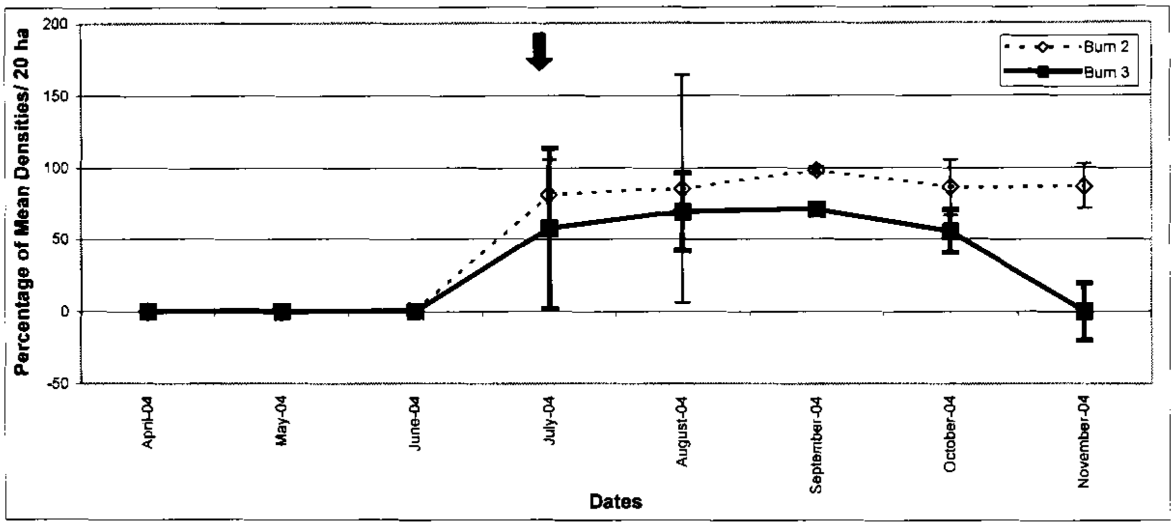

Fig. 3.2.46 The percentages of the difference between the mean density in the Control and Burn Sites for Burn 2 and 3, recorded at midday.

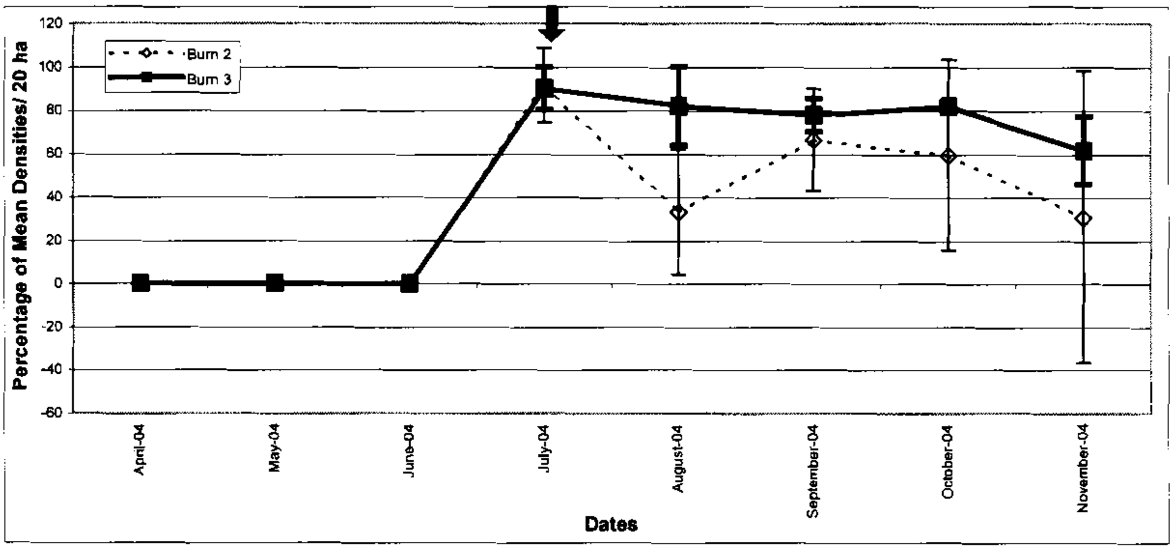

Fig. 3.2.47 The percentages of the difference between the mean density in the Control and Burn Sites for Burn 2 and 3, recorded in the evenings.

Because of the different sizes of the burns, the absolute densities and species might not be the best measure of comparison, but one should rather investigate the differences on a percentage basis for both numbers and species. Please note the differences in the scales of the Y-axes.

Fig. 3.2.45 to Fig. 3.2.47 show the percentage of the differences between the mean densities that were recorded in the three Control and Burn Sites. Burn 1 (Fig. 3.2.45, morning) showed an increase from the beginning of the year until August. There was a decrease in September, an increase in October and another decrease in November. Burn 1 only had morning counts. Burns 2 and 3 had almost the same pattern as Burn 1, but started with negative values.

Burn 2 (Fig. 3.2.45, morning) showed almost the same pattern, but increased a little more in July. There was a small increase in September and another small increase in October. The year ended in a decrease. After the fire, the midday differentials (Fig. 3.2.46) showed a general increase until September. There was a decrease from October until the end of the year. The evening differentials (Fig. 3.2.47) increased in July. There was a sharp decrease in August and an increase in September. After September there was a decrease until the end of the year.

Burn 3 (Fig. 3.2.45, morning) showed a slight increase in July. After July there was a small decrease in August, a small increase in September and a decrease until the end of the year. Both Burn 1 and 2 started with negative values. The midday differentials (Fig. 3.2.46) showed an increase until September and then decreased until the end of the year. Burn 3 ended with a zero differential. The evening differentials (Fig. 3.2.47) increased in July and steadily decreased until September. There was a slight increase in October and another decrease in November. Neither of the two burns had negative values (Fig. 3.2.46 and Fig. 3.2.47).

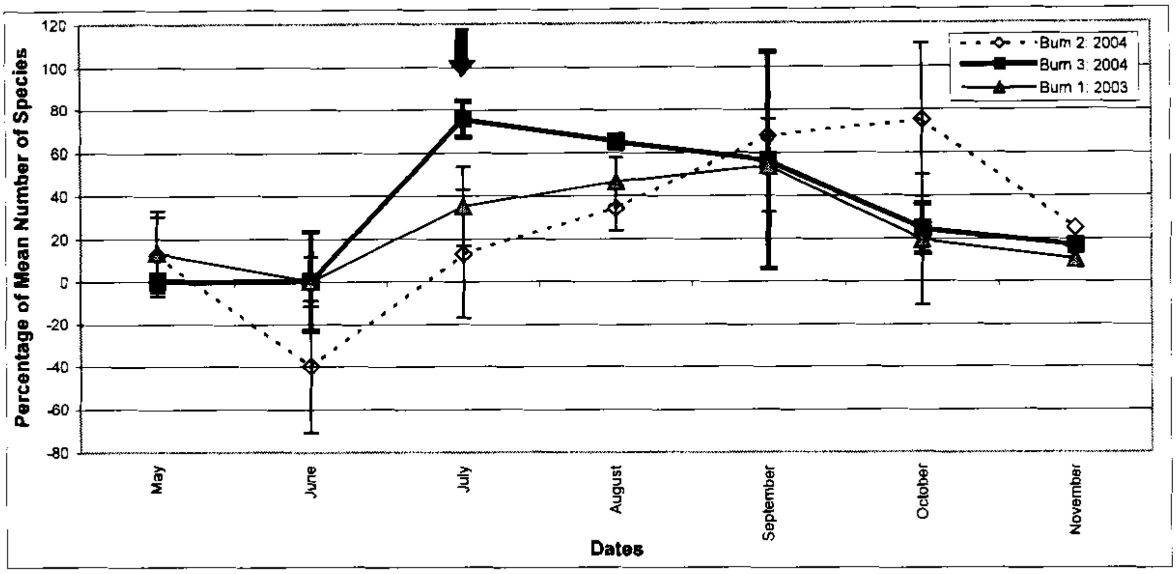

Fig. 3.2.48 The percentages of the difference between the mean number of species in the Control and Burn Sites for each burn, recorded in the mornings.

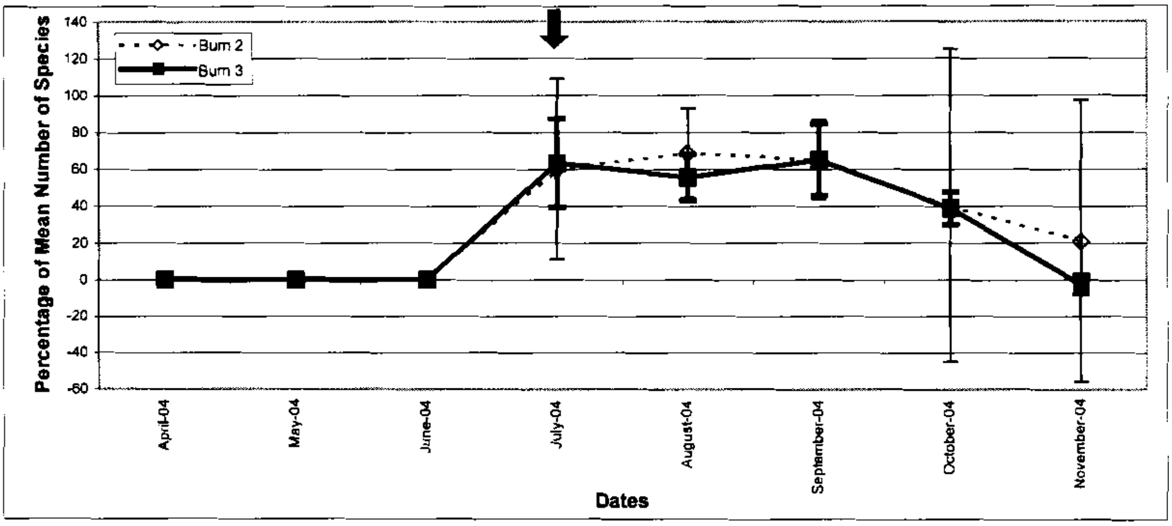

Fig. 3.2.49 The percentages of the difference between the mean number of species in the Control and Burn Sites for Burn 2 and 3, recorded at midday.

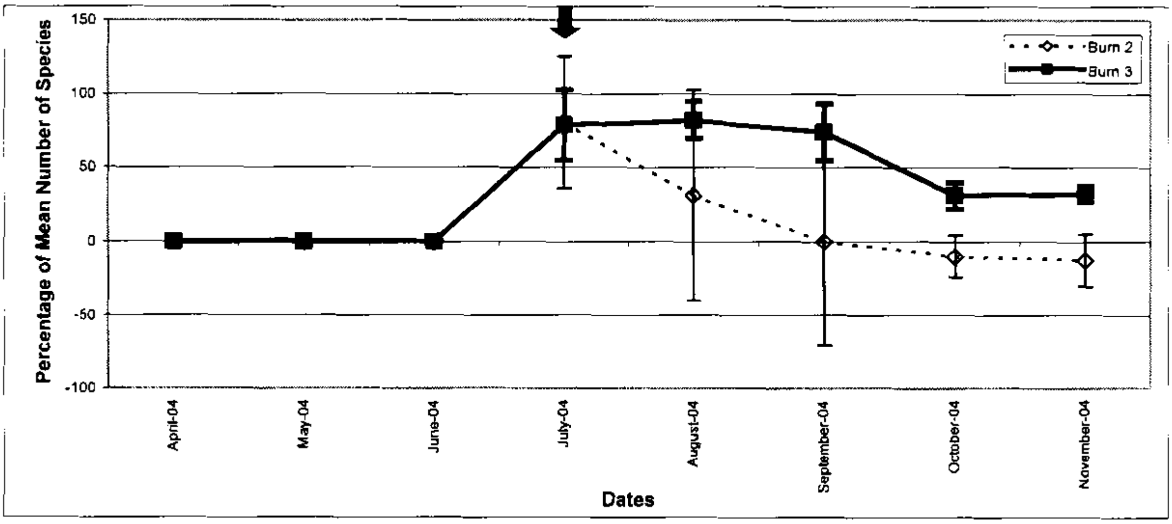

Fig. 3.2.50 The percentages of the difference between the mean number of species in the Control and Burn Sites for Burn 2 and 3, recorded in the evenings.

Fig. 3.2.48 to Fig. 3.2.50 show the percentage of the differences between the mean number of species that were recorded in the three Control and Burn Sites. Please note the differences in the scales of the Y-axes. Fig. 3.2.48 showed a decrease in June for Burn 1 and then a steady increase until September. There was a decrease after September until the end of the year. Burn 2 showed a sharp percentage loss of species in June. After June there was an increase until October. The year ended in a decrease. Burn 3 showed an increase in July and then decreased until September. After September there was a sharper decrease in October and then another decrease until November.

After the fire, both Burns 2 and 3 (Fig. 3.2.49, midday) showed an increase. Burn 2 showed an increase until September before decreasing until the end of the year. Burn 3 showed a decrease in August and another increase in September. After September there was a decrease until the end of the year, ending with a zero value. Neither of the two burns was in the negative side of the graph.

Both Burns 2 and 3 (Fig. 3.2.50, evening) started with an increase in July. Burn 2 decreased after July until the end of the year, ending with values in October and November. Burn 3 showed another slight increase in August and then a slight decrease in September. There was a sharper decrease in October and a slight increase in November.

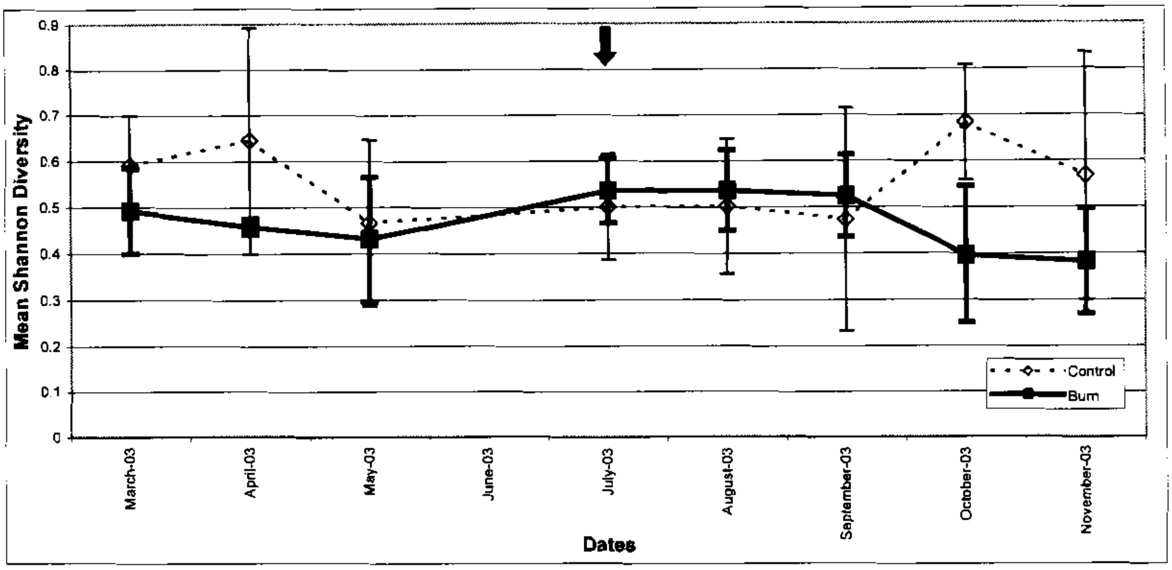

Fig. 3.2.51 The mean Shannon diversity of Burn 1, from surveys recorded in the mornings.

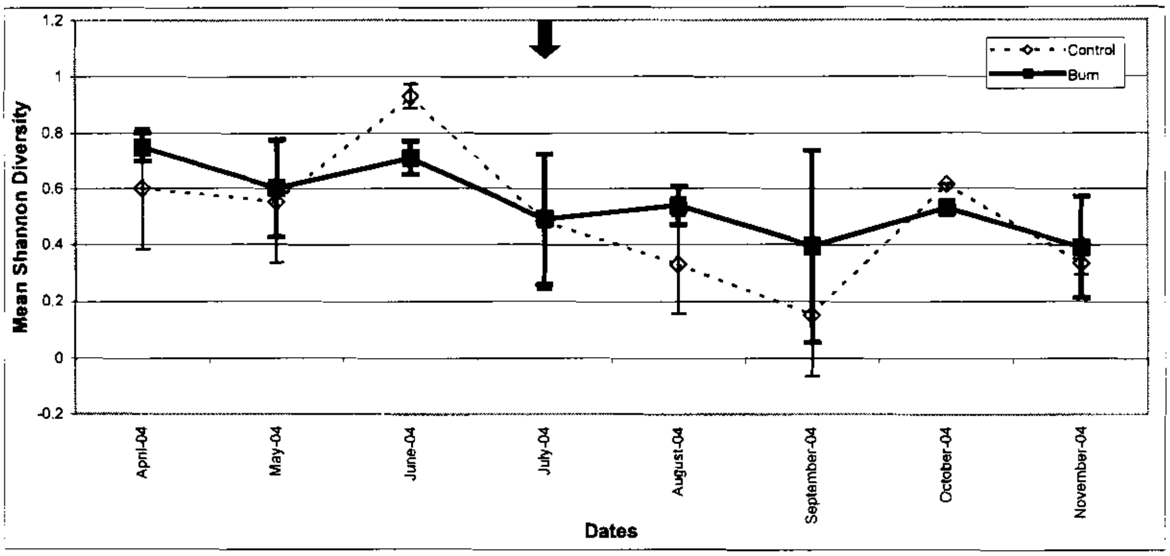

Fig. 3.2.52 The mean Shannon diversity of Burn 2, from surveys recorded in the mornings.

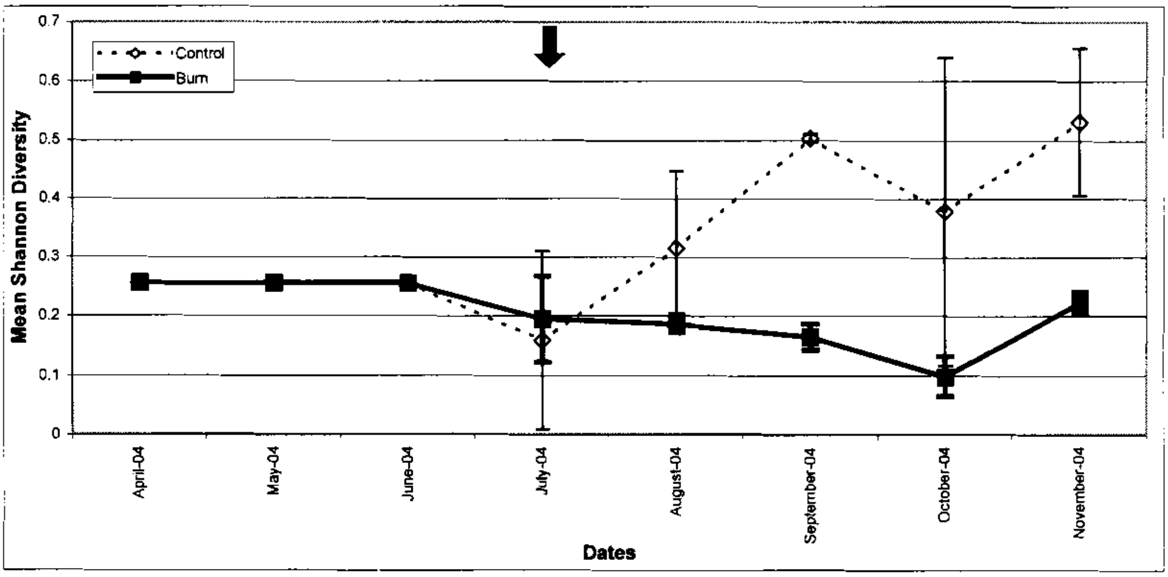

Fig. 3.2.53 The mean Shannon diversity of Burn 3, from surveys recorded in the mornings.

3.2.3 Effect of fire on the Shannon diversity

Fig. 3.2.51 to Fig. 3.2.53 show the mean Shannon diversity of each of the three burns that were calculated from surveys recorded in the mornings. This was calculated using the programme *Primer 5*. Please note the differences of the Y-axes scales in the graphs comparing the burns.

Fig. 3.2.51 showed an increase for the Control Site of Burn 1 between March and April, before decreasing in May. There was a slight increase in diversity until July. The diversity was the same between July and August and there followed a decrease in September. There was an increase in diversity in October, before a decrease in November. The Burn Site showed a decrease in diversity between March and May. An increase in diversity followed until July. There was a slight increase in diversity in August, a slight decrease in September and another decrease in October. The line ended in a decrease in November. The Student T-test showed no significant differences for July and August.

Fig. 3.2.52 showed a slight decrease in diversity for Burn 2 between April and May for the Control Site. There was an increase in diversity in June, followed by a decrease until September. There was an increase in diversity in October followed by another decrease in November. The Burn Site showed a decrease in diversity between April and May, followed by an increase in June. There was another decrease in diversity in July, followed by a slight increase in August. A decrease was seen in September, followed by an increase. The year ended in a decrease in diversity in November. The Student T-test showed no significant differences for July and August.

Fig. 3.2.53 showed a decrease in diversity for Burn 3 in July for the Control Site. This was followed by an increase until September. There was another decrease in diversity in October. The line ended in an increase in diversity in November in the Control Site, much higher than the corresponding diversity in the Burn Site. The Burn Site showed a slight decrease in diversity in July and August. This was followed by another decrease in September and October. There was an increase in diversity in November. The Student T-test showed no significant differences for July and August.

Overall, the Shannon diversity graphs opposite showed no clear corresponding pattern or trend that could be associated with the observed changes in numbers and species, as was found in the previous sections of this Chapter. Fig. 3.2.52 and Fig. 3.2.53 were closest in pattern. All three burns ended the year with a lower diversity in the Burn Sites than at the beginning of the year. Burns 1 and 2 (Fig. 3.2.51 and Fig. 3.2.52) also had a lower diversity at the end of the year than directly after the fire, while Burn 3 (Fig. 3.2.53) had a slightly higher diversity at the end of the year than directly after the fire.

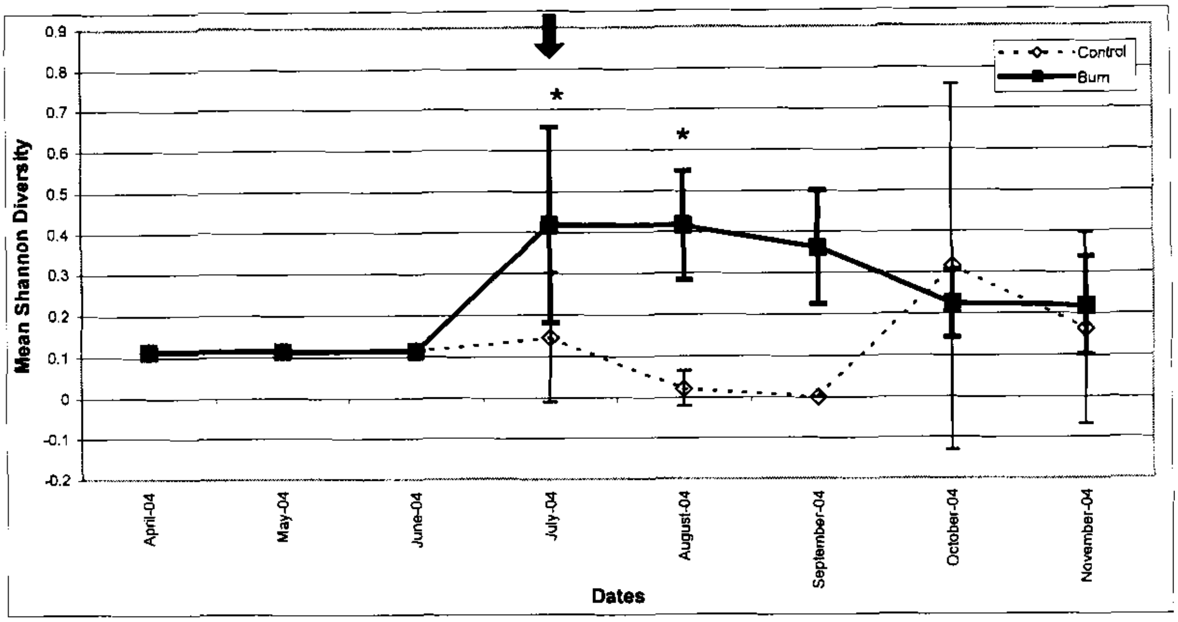

Fig. 3.2.54 The mean Shannon diversity of Burn 2, from surveys recorded at midday.

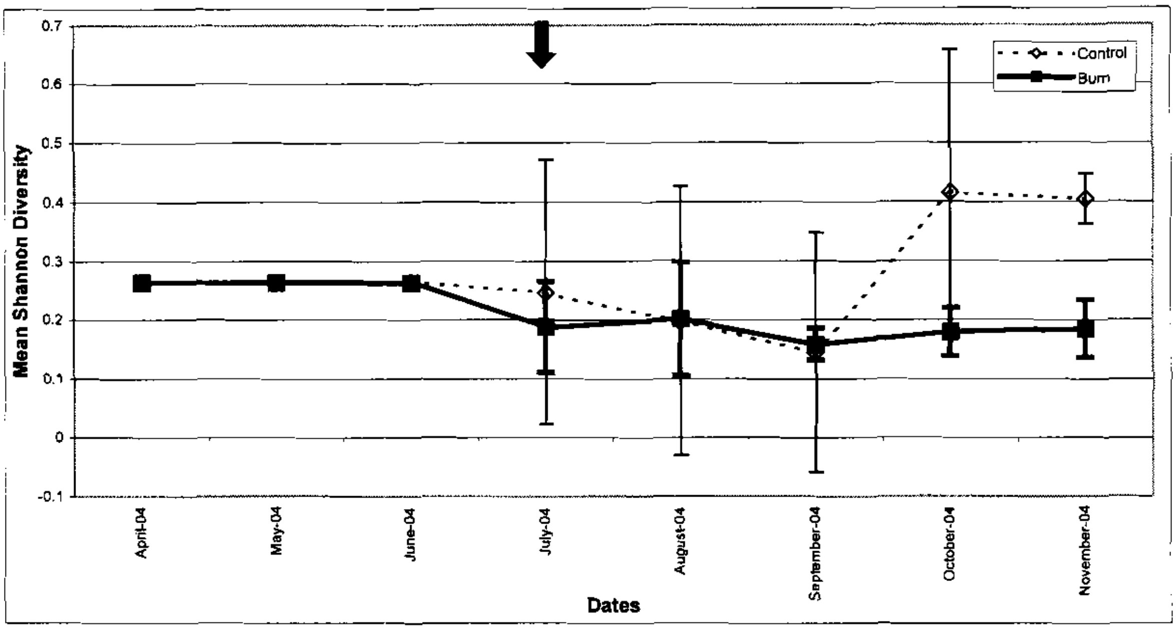

Fig. 3.2.55 The mean Shannon diversity of Burn 3, from surveys recorded at midday.

Fig. 3.2.54 to Fig. 3.2.55 show the mean Shannon diversity of each of Burns 2 and 3 that were calculated from surveys recorded at midday. Fig. 3.2.54 showed a slight increase in diversity in July for the Control Site of Burn 2. This was followed by a decrease in August. There was a slight decrease in diversity in September, followed by an increase in October. The line ended in a decrease in diversity in November. The Burn Site showed an increase in diversity in July, and a very slight decrease in August. This was followed by a decrease in September and October. There was steady diversity between October and November. The Student T-test showed significant differences for both July and August.

Fig. 3.2.55 showed a decrease in diversity until September for the Control Site of Burn 3. There was an increase in diversity in October and a very slight decrease between October and November. The Burn Site showed a decrease in diversity in July. There was a very slight increase between July and August, followed by a decrease in September. There was another increase in October and November. The Student T-test showed no significant differences.

The patterns of Burns 2 and 3 (Fig. 3.2.54 and Fig. 3.2.55) did not correspond. Burn 2 (Fig. 3.2.54) had a large difference between the Control and Burn Sites after the fire and this difference was very small at the end of the year, while it was the opposite for Burn 3 (Fig. 3.2.55). Both burns had a lower diversity in the Burn Sites at the end of the year than directly after the fire. Only Burn 2 (Fig. 3.2.54) had a significant difference for the Student T-test. The diversity was higher in the mornings (Fig. 3.2.52 and Fig. 3.2.53) than at midday. Burn 3 (Fig. 3.2.55) had a similar pattern in the morning (Fig. 3.2.53) and at midday.

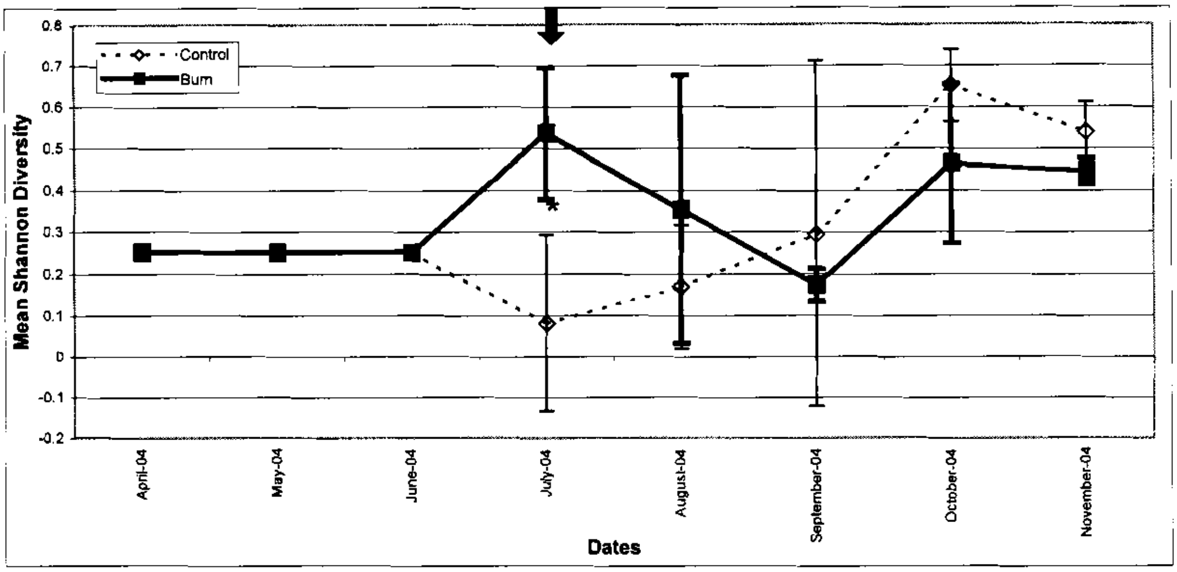

Fig. 3.2.56 The mean Shannon diversity of Burn 2, from surveys recorded in the evenings.

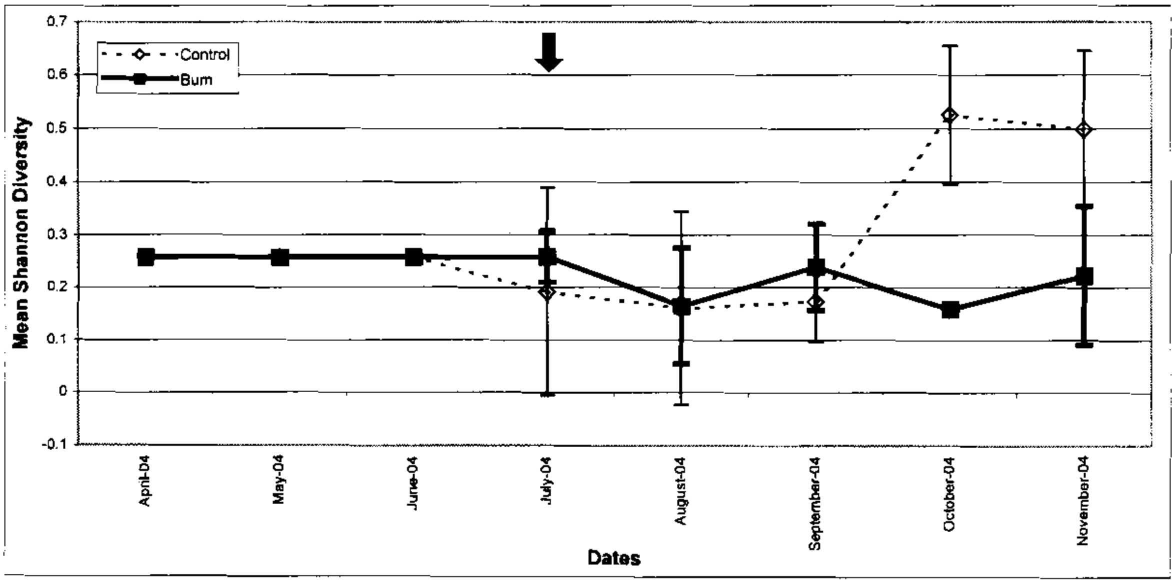

Fig. 3.2.57 The mean Shannon diversity of Burn 3, from surveys recorded in the evenings.

Fig. 3.2.56 to Fig. 3.2.57 show the mean Shannon diversity for each of Burns 2 and 3 that were calculated from surveys recorded in the evenings. Fig. 3.2.56 showed a decrease in diversity in July for the Control Site of Burn 2. There was an increase until October, followed by another decrease in November. The Burn Site showed an increase in diversity in July, before decreasing until September. There was an increase in diversity in October and a very slight decrease in November. The Student T-test showed a significant difference in July.

Fig. 3.2.57 showed a decrease in diversity until August for the Control Site of Burn 3. There was a very slight increase in diversity in September and a stronger increase in October, followed by a decrease in November. The Burn Site showed a steady diversity in July. There was a decrease in August, followed by an increase in September. There was another decrease in October and another increase in November. The Student T-test showed no significant differences for Burn 3.

Burns 2 and 3 (Fig. 3.2.56 and Fig, 3.2.57) had similar patterns for the Control Sites, but there were no similarities between the Burn Sites. Only Burn 2 (Fig. 3.2.56) had a significant difference for the Student T-test. The diversity was higher in the mornings (Fig. 3.2.52 and Fig. 3.2.53). The evening diversity was higher than the midday diversity (Fig. 3.2.54 and Fig. 3.2.55).

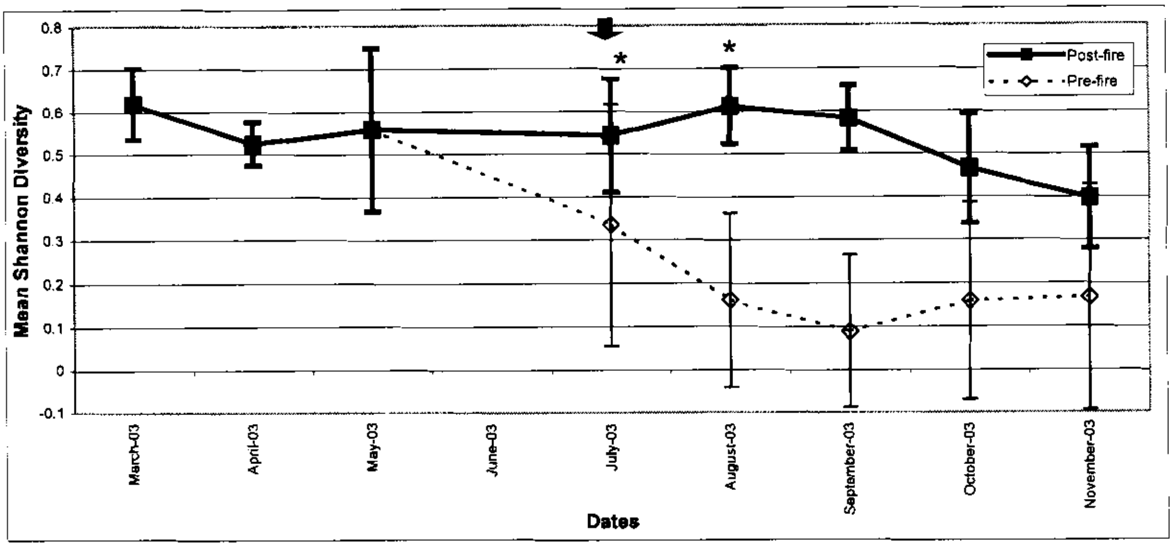

Fig. 3.2.58 The mean Shannon diversity of Burn 1, before and after the fire, from surveys recorded in the mornings.

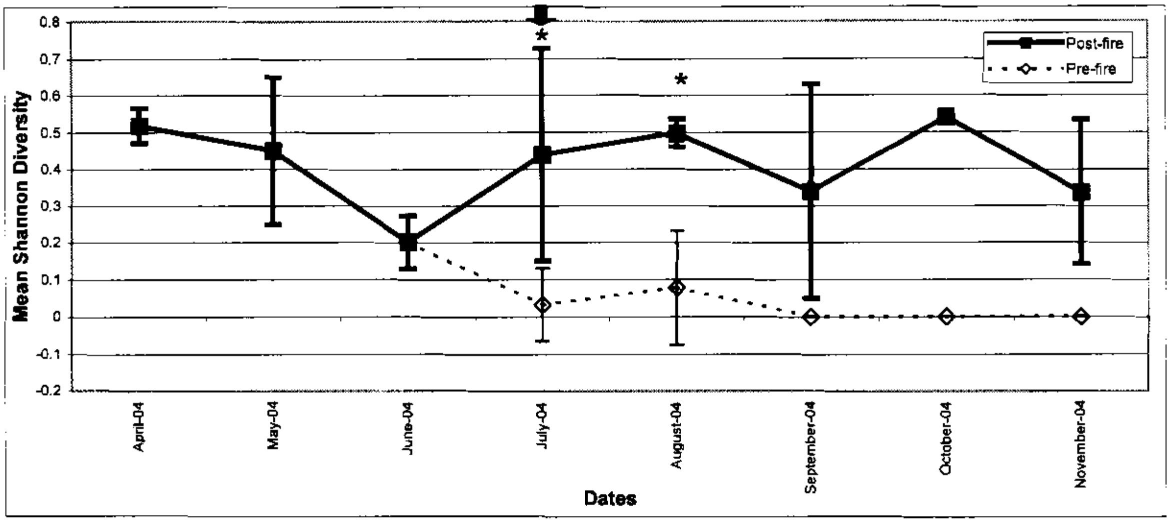

Fig. 3.2.59 The mean Shannon diversity of Burn 2, before and after the fire, from surveys recorded in the mornings.

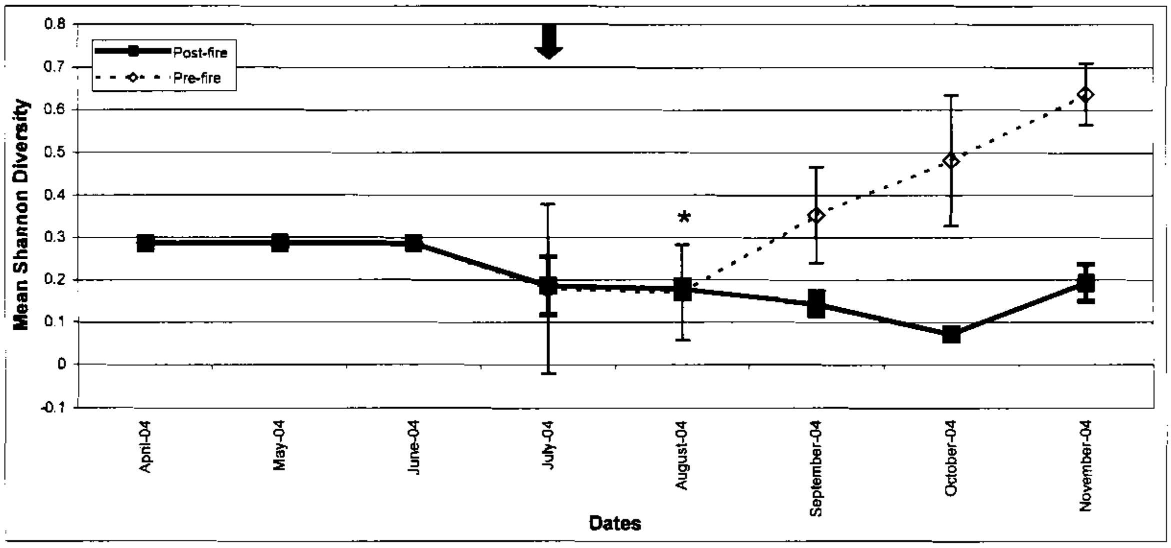

Fig. 3.2.60 The mean Shannon diversity of Burn 3, before and after the fire, from surveys recorded in the mornings.

Fig. 3.2.58 to Fig. 3.2.60 show the temporal variation in the mean Shannon diversity for each of the three Burn Sites before and after the fire. The data from the Control Sites were therefore not included. The mean diversities were calculated by first separating the species that were present before the fire from the species that only appeared after the fire, or that increased in numbers after the fire. This first group was designated as the "pre-fire" group, while those that appeared or increased in the Burn Site after the fire were allocated to the "post-fire" group. The split only took place after the fires – therefore no difference in diversity before the fire itself (March to June).

Fig. 3.2.58 showed a decrease in diversity for Burn 1 between March and April in the Control Site. There was an increase in May, followed by a decrease until September. There was an increase in diversity in October, followed by a very slight increase in November. The Burn Site showed a decrease between March and April, followed by an increase in May. There was a slight decrease in diversity in July and an increase in August. There was a decrease in diversity until November. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.59 showed a decrease in diversity for both the Control and Burn Sites of Burn 2 until June. There was a decrease until July for the Control Site. There was an increase in diversity in August, followed by another decrease in September. There was zero diversity from September until November. The Burn Site showed an increase in diversity from June until August. There was a decrease in September, followed by another increase in October. The line ended in a decrease in diversity in November. The student T-test showed a significant difference for both July and August.

Fig. 3.2.60 showed a decrease in diversity in July for the Control Site of Burn 3. There was a very slight decrease between July and August, followed by an increase in diversity until November. The Burn Site showed the same diversity as the Control Site until August. There was a decrease in diversity until October. The line ended in an increase in diversity in November. The student T-test showed a significant difference for August.

Burns 1 and 2 had a similar pattern, although the timing did not correspond. There was an increase in diversity in the Burn Sites after the fire. Fig. 3.2.58 and Fig. 3.2.59 were closest in pattern, as they also ended in a decrease at the end of the year. These two graphs had a large difference between the Control and Burn Sites, which had become less of a difference at the end of the year. Burn 3's (Fig. 3.2.60) Control and Burn Sites were closer in diversity. Burns 1 and 2 had a significant difference for the Student T-test for August.

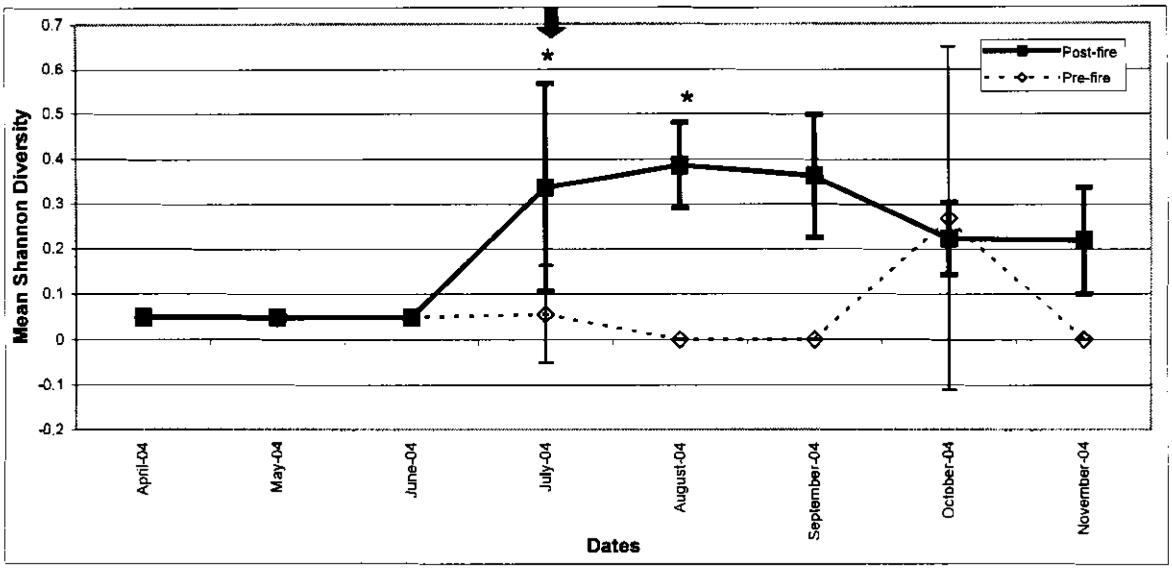

Fig. 3.2.61 The mean Shannon diversity of Burn 2, before and after the fire, from surveys recorded at midday.

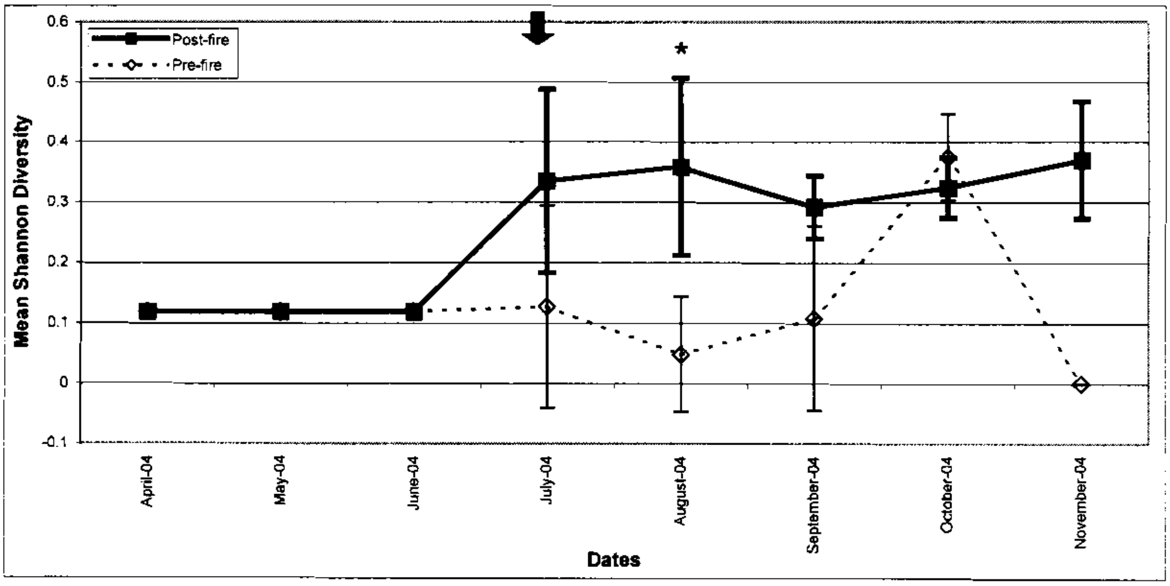

Fig. 3.2.62 The mean Shannon diversity of Burn 3, before and after the fire, from surveys recorded at midday.

Fig. 3.2.61 to Fig. 3.2.62 show the mean Shannon diversity of each of Burns 2 and 3 before and after the fire, calculated from surveys recorded at midday. In Fig. 3.2.61 Burn 2 showed a slight increase in diversity in July in the Control Site. There was a decrease in August, followed by zero diversity between August and September. There was an increase in diversity in October, followed by a decrease in November. The Burn Site showed an increase in diversity in July and August, followed by a decrease until October. The year ended in a slight decrease in diversity until zero in November. The Student T-test showed a significant difference for both July and August.

In Fig. 3.2.62 Burn 3 showed a very slight increase in diversity in July in the Control Site. There was a decrease in August, followed by an increase until October. The line ended in a decrease until zero diversity in November. The Burn Site showed an increase in diversity in July and August, followed by a decrease in September. There was an increase in diversity until November. The Student T-test showed a significant difference for August.

The patterns of Burns 2 and 3 (Fig. 3.2.61 and Fig. 3.2.62) were close in pattern, although they did not correspond completely. There was an increase in the Burn Sites after the fire and both burns had zero diversity in the Control Site at the end of the year. Both burns had a significant difference for the Student T-test for August. The midday graphs had similar patterns to the morning graphs (Fig. 3.2.59 and Fig. 3.2.60). The morning diversity was higher than the midday diversity.

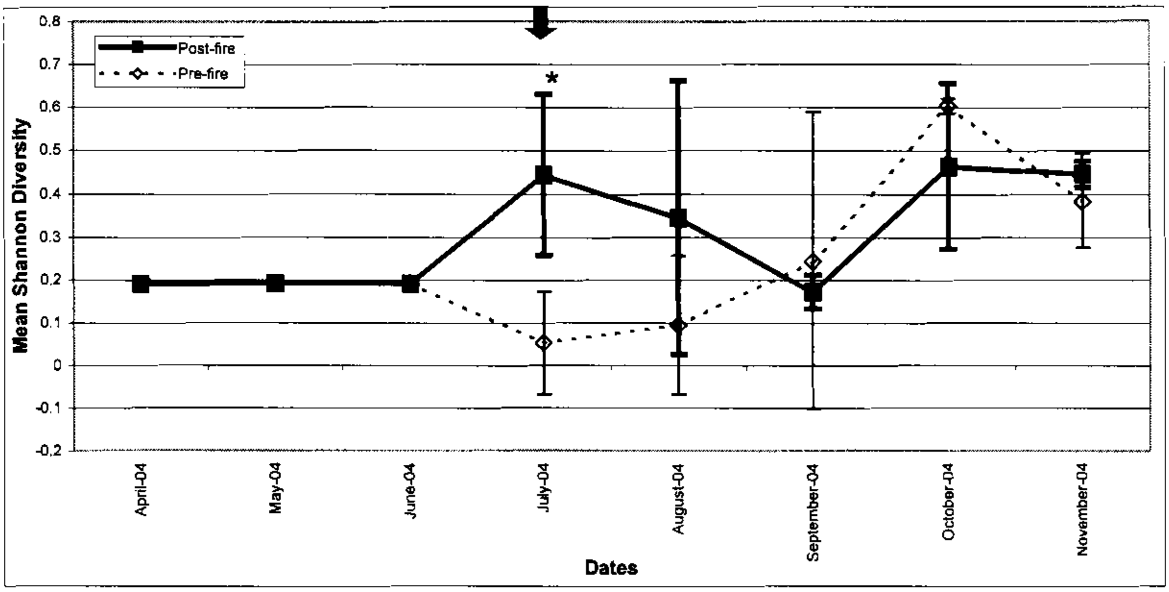

Fig. 3.2.63 The mean Shannon diversity of Burn 2, before and after the fire, from surveys recorded in the evenings.

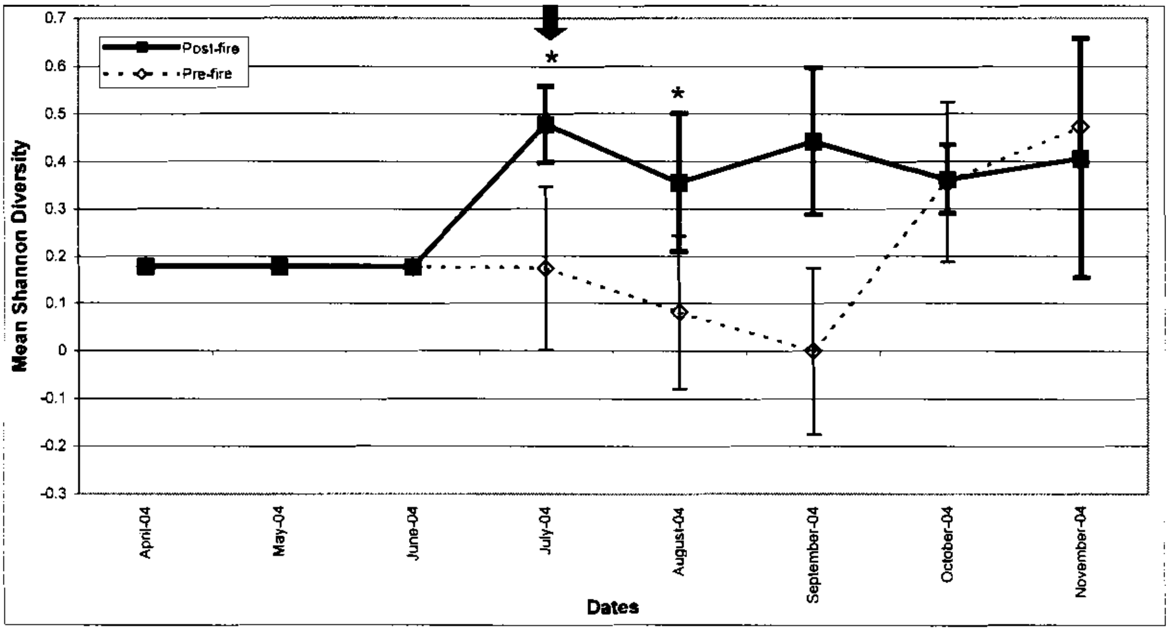

Fig. 3.2.64 The mean Shannon diversity of Burn 3, before and after the fire, from surveys recorded in the evenings.

Fig. 3.2.63 to Fig. 3.2.64 show the mean Shannon diversity of each of Burns 2 and 3 before and after the fire, calculated from surveys recorded in the evenings. Burn 2 (Fig. 3.2.63) showed a decrease in diversity in July in the Control Site. There was an increase in August, followed by an increase until October. There was a decrease in diversity in November. The Burn Site showed an increase in diversity in July, followed by a decrease until September. There was an increase in October and the year ended in a very slight decrease in diversity in November. The Student T-test showed a significant difference for July.

Burn 3 (Fig. 3.2.64) showed a slight decrease in diversity in July, followed by a decrease until September in the Control Site. There was a sharp increase in October, followed by another increase in November. The Burn Site showed an increase in diversity in July, followed by a decrease in August. There was another increase in diversity in September, followed by another decrease in October. The year ended in an increase in diversity in November. The Student T-test showed a significant difference for both July and August.

The patterns of Burns 2 and 3 (Fig. 3.2.63 and Fig. 3.2.64) did not correspond completely, even though they had the same general trends. Both burns had an increase in diversity in the Burn Sites after the fire and both burns had a lower diversity at the end of the year than directly after the fire. Both burns had a significant difference for the Student T-test directly after the fire. The diversity was higher in the mornings (Fig. 3.2.59 and Fig. 3.2.60). The evening diversity was higher than the midday diversity (Fig. 3.2.61 and Fig. 3.2.62).

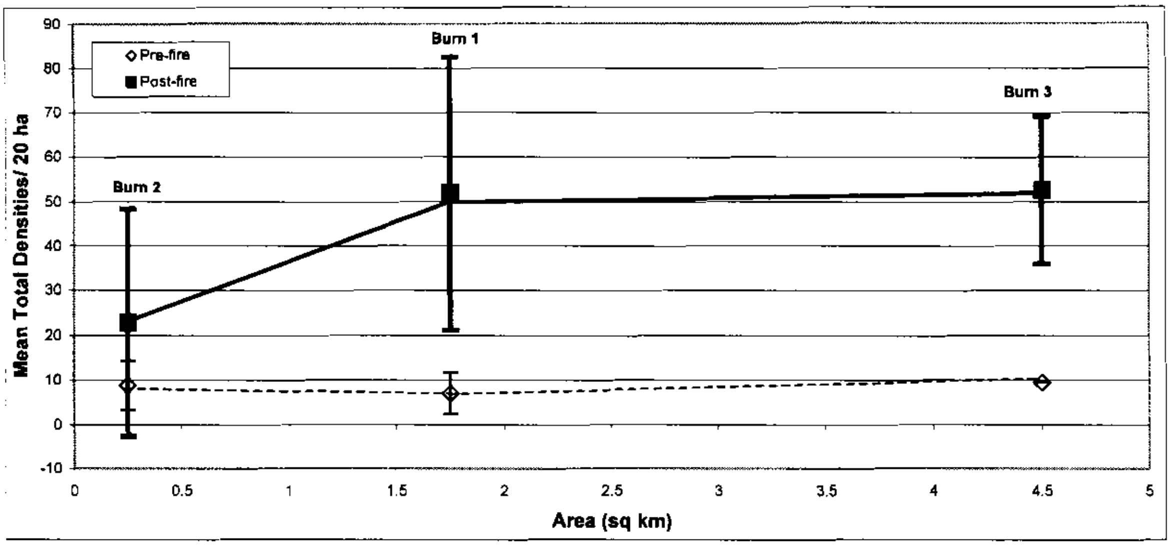

Fig. 3.2.65 The mean total densities for the entire area (km^2) of each burn (Burn Sites only).

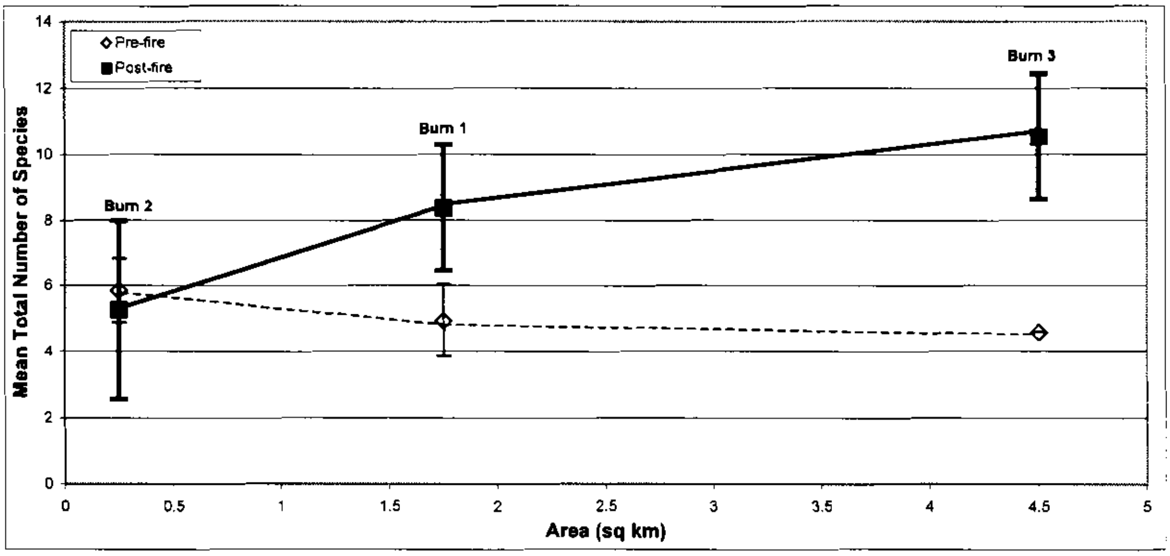

Fig. 3.2.66 The mean total number of species for the entire area (km^2) of each burn (Burn Sites only).

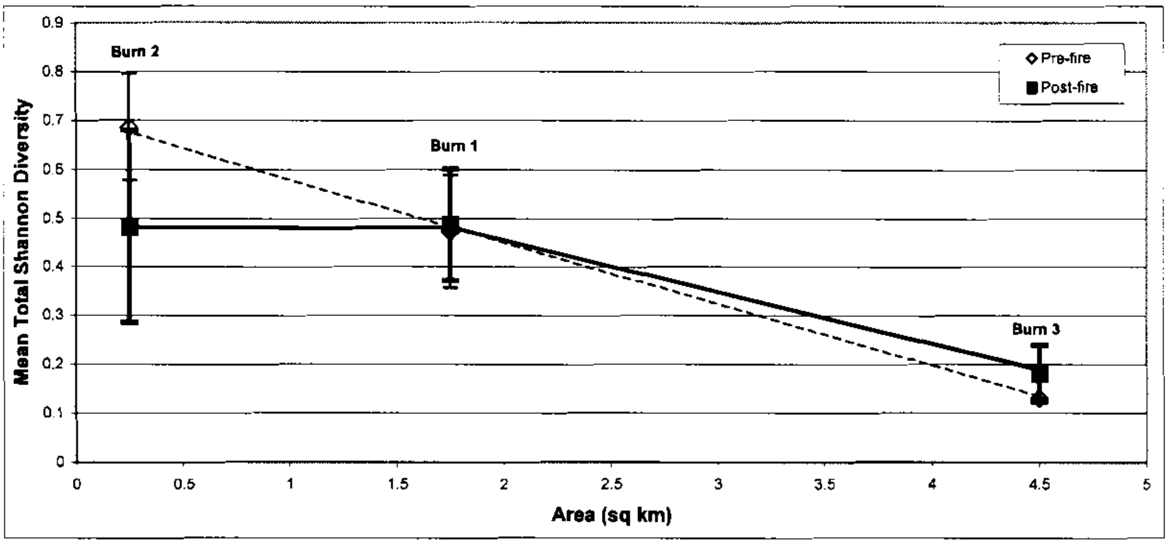

Fig. 3.2.67 The mean total Shannon Diversity for the entire area (km^2) of each burn (Burn Sites only).

3.2.4 Effect of the size of the burn

The size of the burn (km^2) could also play a role and will be considered in this Section. The following graphs were calculated using the mean densities of the entire year in the Burn Site before the fire and again after the fire, and calculated for the total area (km^2) of each burn (X-axis) (Fig. 3.2.65 to Fig. 3.2.70). Statistics other than standard deviation were not calculated, due to too many differences between the different Burns.

Fig. 3.2.65 showed the mean total densities (Fig. 3.2.9 to Fig. 3.2.11) in the Burn Site of each burn before and after the fire. Burn 2 was the smallest of the three burns. Burn 1 was in the middle and Burn three was the largest of the three burns. The three burns show almost the same densities before the fire. Burn 2 had lower numbers than the other two burns after the fire. Burns 1 and 3 had almost the same densities after the fire.

Fig. 3.2.66 showed the mean total number of species (Fig. 3.2.17 to Fig. 3.2.19) in the Burn Site of each burn before and after the fire. Burn 2 had slightly more species before the fire than the other two burns. Burn 3 had the lowest number of species before the fire although it was almost the same as Burn 1. After the fire Burn 2 had the lowest number of species and Burn 3 had the highest number of species. The species showed that their number increased as the area of the burn increased, which was not quite the same for the numbers.

Fig. 3.2.67 showed the mean total Shannon diversity (Fig. 3.2.51 to Fig. 3.2.53) in the Burn Site of each burn before and after the fire. Burn 2 had the highest diversity of the three burns before the fire, followed by Burn 1 and then Burn 3, with the lowest diversity. After the fire, Burn 3 had the lowest diversity. Burns 1 and 2 had the same diversity after the fire.

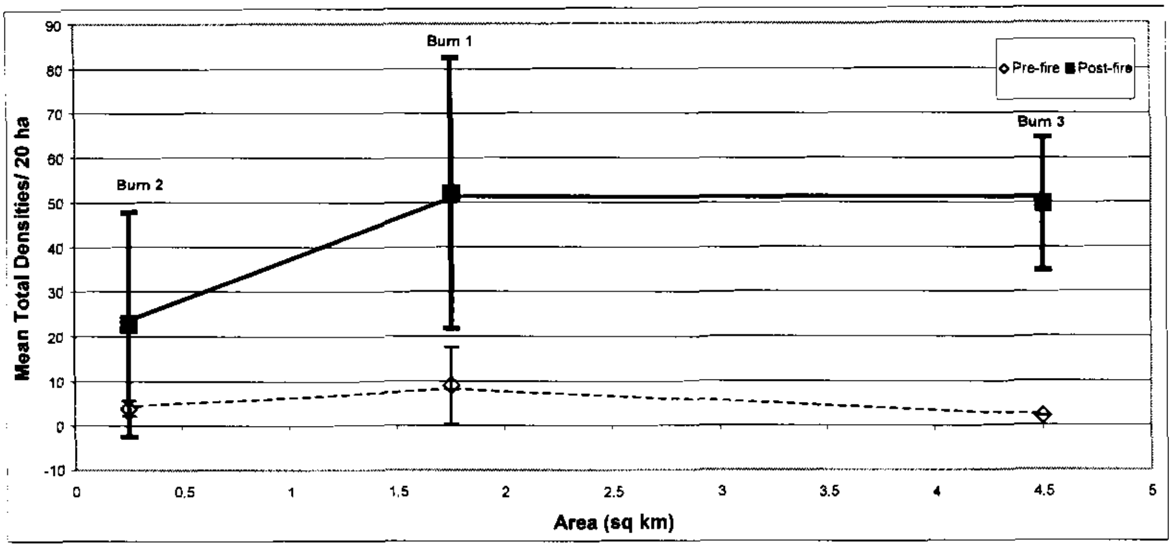

Fig. 3.2.68 The difference between the mean total densities in the Control and Burn Sites for the entire area (km^2) of each burn.

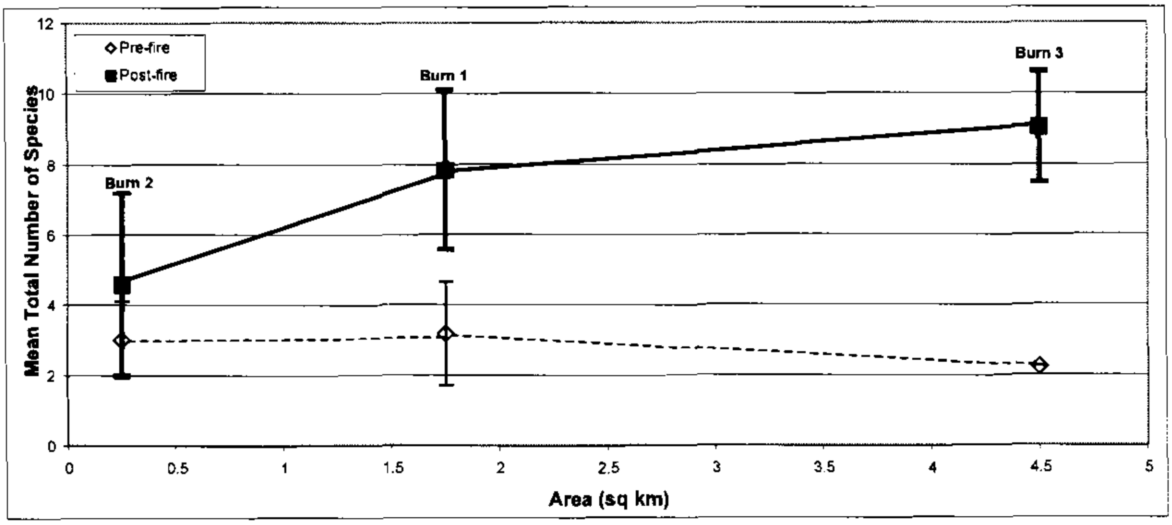

Fig. 3.2.69 The difference between the mean total number of species in the Control and Burn Sites for the entire area (km^2) of each burn.

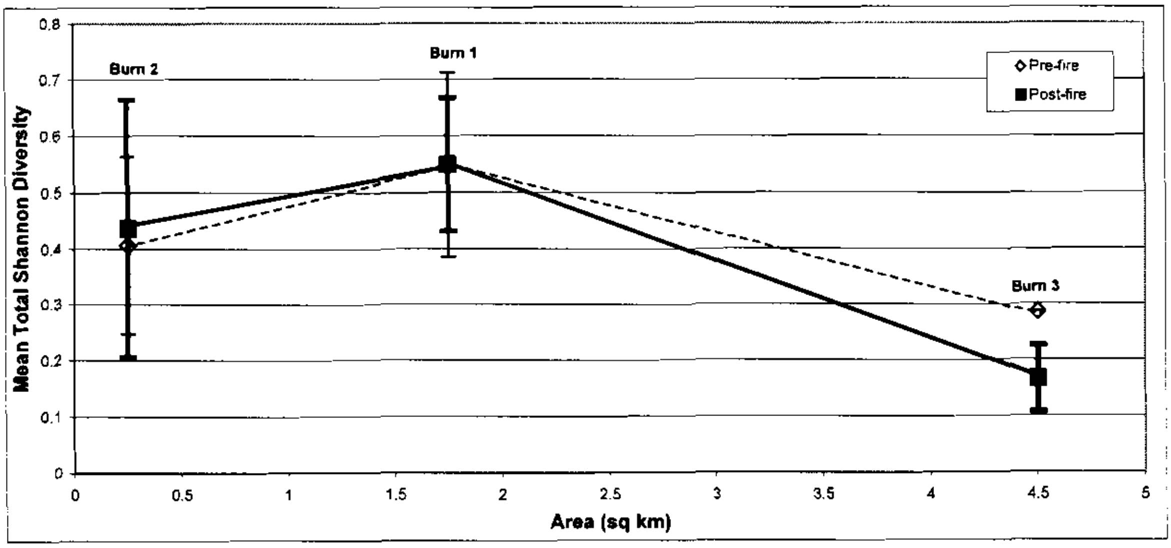

Fig. 3.2.70 The difference between the mean total Shannon diversity in the Control and Burn Sites for the entire area (km^2) of each burn.

Fig. 3.2.88 showed the difference between the mean total densities in the Control and Burn Sites (Fig. 3.2.45 to Fig. 3.2.47) for each burn. Before the fire the densities was almost the same for all three burns. Burn 3 had the lowest numbers while Burn 1 had the highest. After the fire Burn 2 had the lowest numbers, with Burns 1 and 3 almost the same. Burn 1 again had the highest densities.

Fig. 3.2.89 showed the difference between the mean total number of species in the Control and Burn Sites (Fig. 3.2.52 to Fig. 3.2.54) for each burn. Before the fire the number of species was almost the same for the three burns. Burn 3 had the lowest number of species. Burn 1 had slightly more species than Burn 2 before the fire. After the fire Burn 2 had the lowest number of species and Burn 3 had the highest number of species. The species showed that their number increased as the area of the burn increased, which was not quite the same for the numbers.

Fig. 3.2.90 showed the difference between the mean total Shannon diversity in the Control and Burn Sites (Fig. 3.2.78 to Fig. 3.2.80) for each burn. Before the fire, the diversity was highest at Burn 1. Burn 3 had the lowest diversity. The same pattern was seen after the fire. The diversity was almost the same before and after the fire for Burns 2 and 3. Burn 1 had the same diversity before and after the fire.

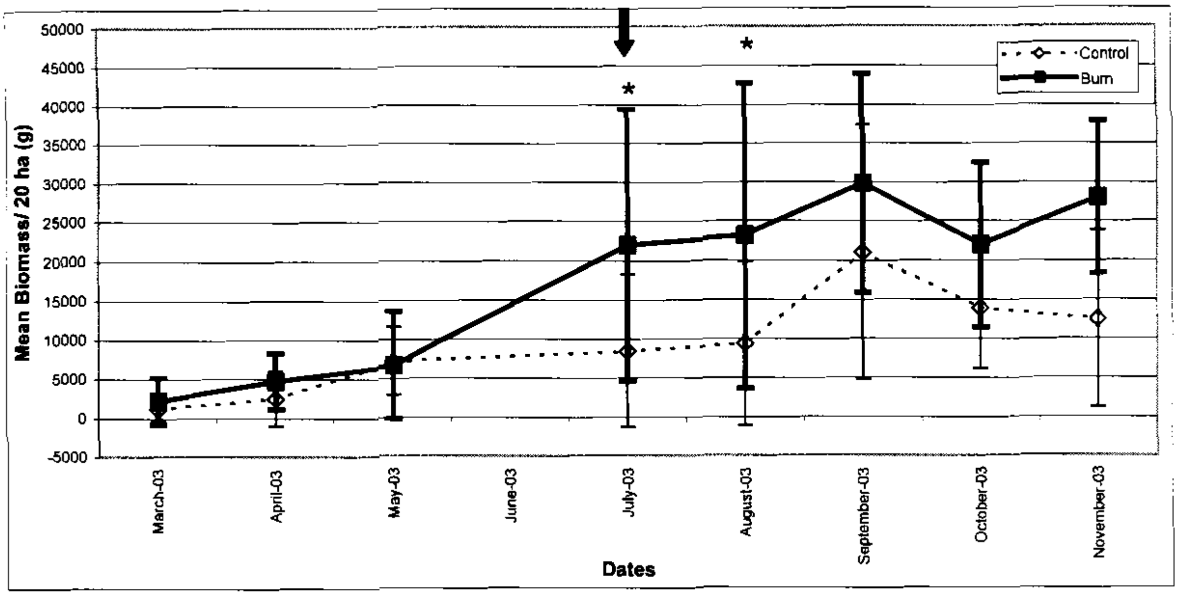

Fig. 3.2.71 The mean biomass/20 ha for all the birds of Burn 1, recorded in the morning.

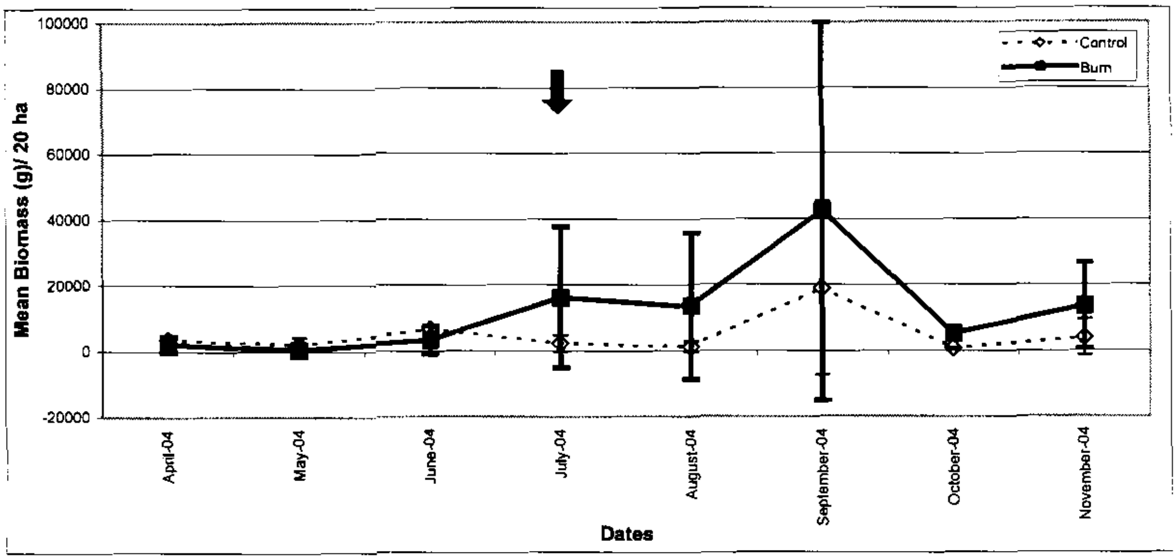

Fig. 3.2.72 The mean biomass/20 ha for all the birds of Burn 2, recorded in the morning.

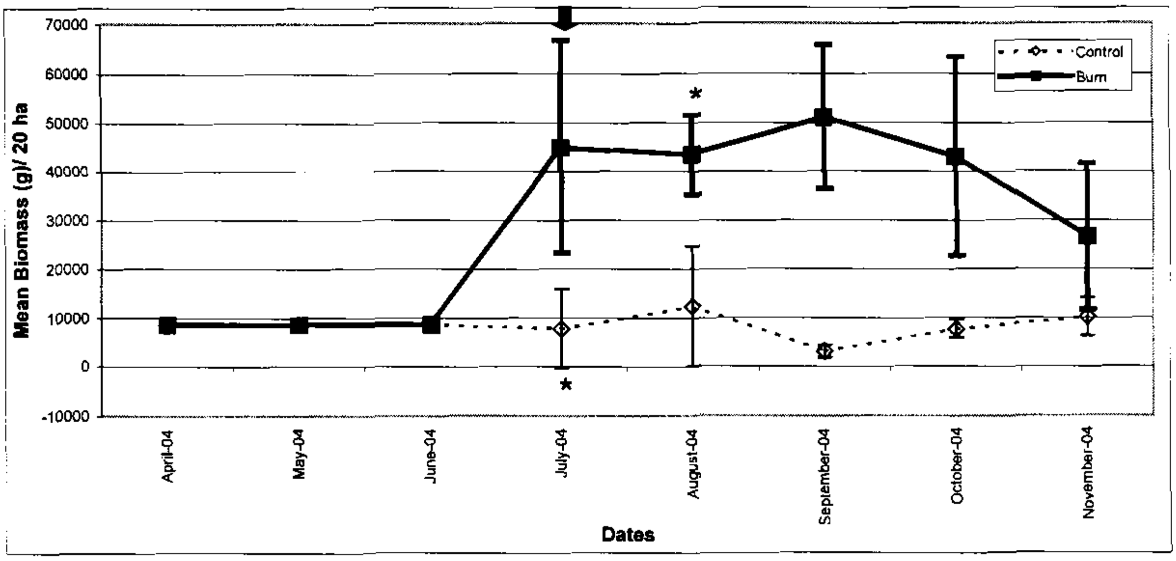

Fig. 3.2.73 The mean biomass/20 ha for all the birds of Burn 3, recorded in the morning.

3.2.5 Effect of fire on the biomass

Fig. 3.2.71 to Fig. 3.2.73 show the mean biomass/20 ha for all the birds for each of the three burns recorded in the mornings. This was calculated by the mean of the biomass as in Maclean (1993). The monthly mean was then calculated.

Burn 1 (Fig. 3.2.71) showed an increase in biomass until August and another sharper increase in September for the Control Site. This was followed by a decrease until November. The Burn Site showed the same pattern, but with a higher biomass than the Control Site. The increase in July was also higher than in the Control Site. The Burn Site ended in an increase in biomass in November. The Student T-test showed a significant difference for both July and August.

Burn 2 (Fig. 3.2.72) showed a slight decrease in biomass in May in the Control Site. There was a slight increase in June, followed by a decrease until August. There was another increase in biomass in September, followed by a decrease in October and another increase in November. The Burn Site showed a decrease in biomass in May and an increase in June. There was another decrease in July, followed by an increase in September. This was followed by a decrease in biomass in October and the line ended in an increase in November. The Student T-test showed no significant difference for Burn 2.

Burn 3 (Fig. 3.2.73) showed a slight decrease in biomass in July for the Control Site. There was an increase in August, followed by a decrease in September. There was an increase in biomass after September until November. The Burn Site showed an increase in biomass in July, followed by a slight decrease in August. There was an increase in biomass in September and a decrease until November. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.71 and Fig. 3.2.72 were closest in pattern. Although Fig. 3.2.73 had the same general trends as Fig. 3.2.71, the Burn Site had a larger biomass than the Control Site and the year ended in a decrease in biomass. All three burns showed an increase in biomass in the Burn Sites directly after the fire. Only Burns 1 and 3 (Fig. 3.2.71 and Fig. 3.2.73) had a significant difference for the Student T-test.

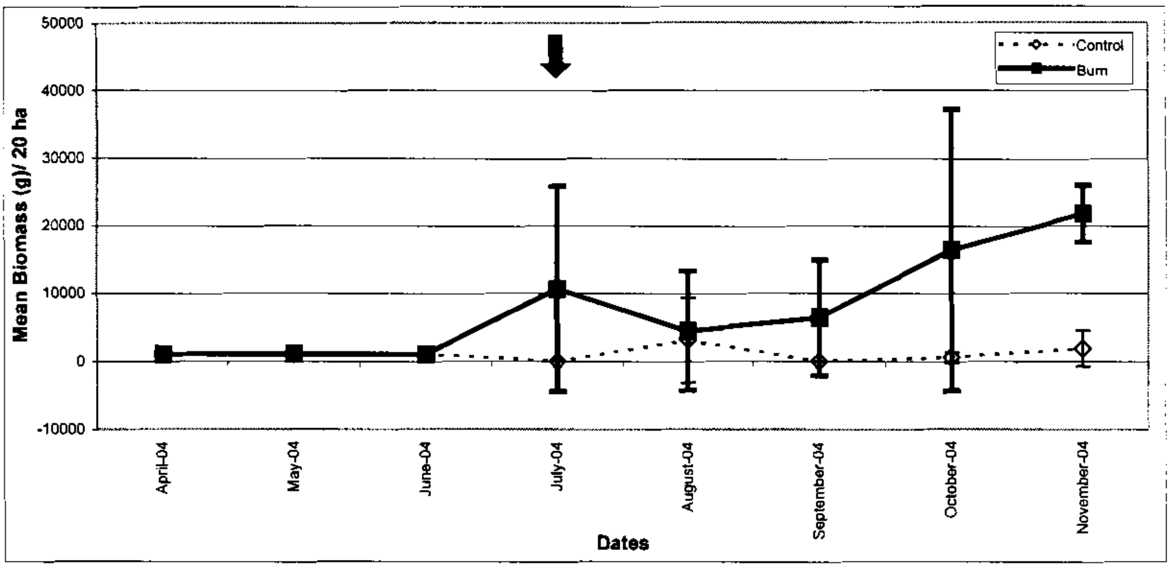

Fig. 3.2.74 The mean biomass/20 ha for all the birds of Burn 2, recorded at midday.

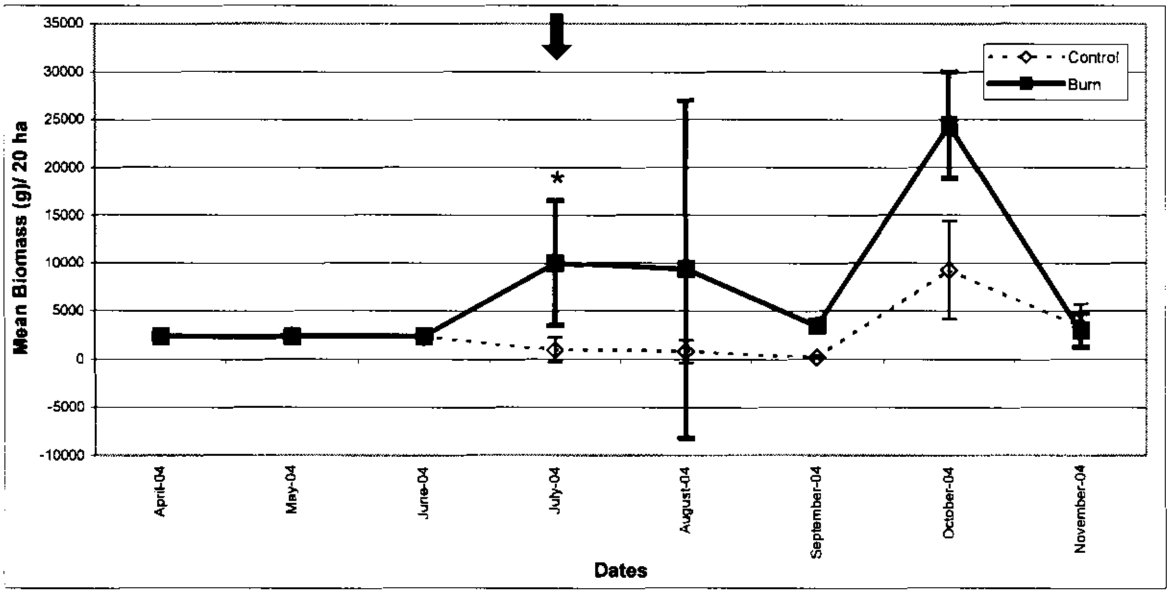

Fig. 3.2.75 The mean biomass/20 ha for all the birds of Burn 3, recorded at midday.

Fig. 3.2.74 to Fig. 3.2.75 show the mean biomass/20 ha for all the birds of each of Burns 2 and 3 recorded at midday. In Fig. 3.2.74 Burn 2 showed a slight decrease in biomass in June for the Control Site. June and July had almost zero biomass. There was an increase in biomass in August, followed by another decrease to almost zero biomass in September. There was a slight increase in October and another increase in November. The Burn Site showed a sharp increase in biomass in June and a sharp decrease in July. There was slight decrease in biomass in August, followed by an increase until November. The Student T-test showed no significant difference for Burn 2.

In Fig. 3.2.75 Burn 3 showed a decrease in biomass until September for the Control Site. The biomass was almost zero in September. There was an increase in biomass in October, followed by another decrease in November. The Burn Site showed an increase in biomass in July, followed by a decrease until September. There was a sharp increase in biomass in October and a sharp decrease in November. The Student T-test showed a significant difference for July.

The patterns of Burns 2 and 3 (Fig. 3.2.74 and Fig. 3.2.75) did not correspond, although they had the same general trends. Both burns had an increase in biomass in the Burn Sites after the fire. Both Control and burn Sites were close in biomass. Only Burn 3 (Fig. 3.2.75) had a significant difference for the Student T-test directly after the fire. The biomass of the morning (Fig. 3.2.72 and Fig. 3.2.73) and midday did not show any particular pattern. Burn 2 (Fig. 3.2.74) had the same biomass in the morning (Fig. 3.2.72) and at midday. Compared to the morning and evening data (Fig. 3.2.73 and Fig. 3.2.77), Burn 3 (Fig. 3.2.75) had the lowest biomass at midday.

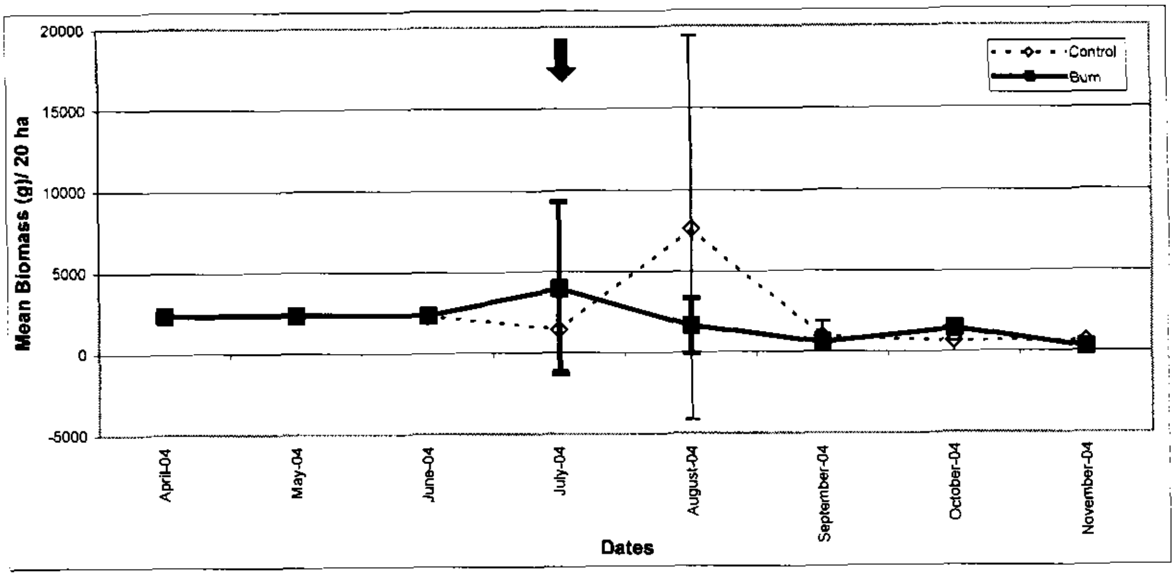

Fig. 3.2.76 The mean biomass/20 ha for all the birds of Burn 2, recorded in the evening.

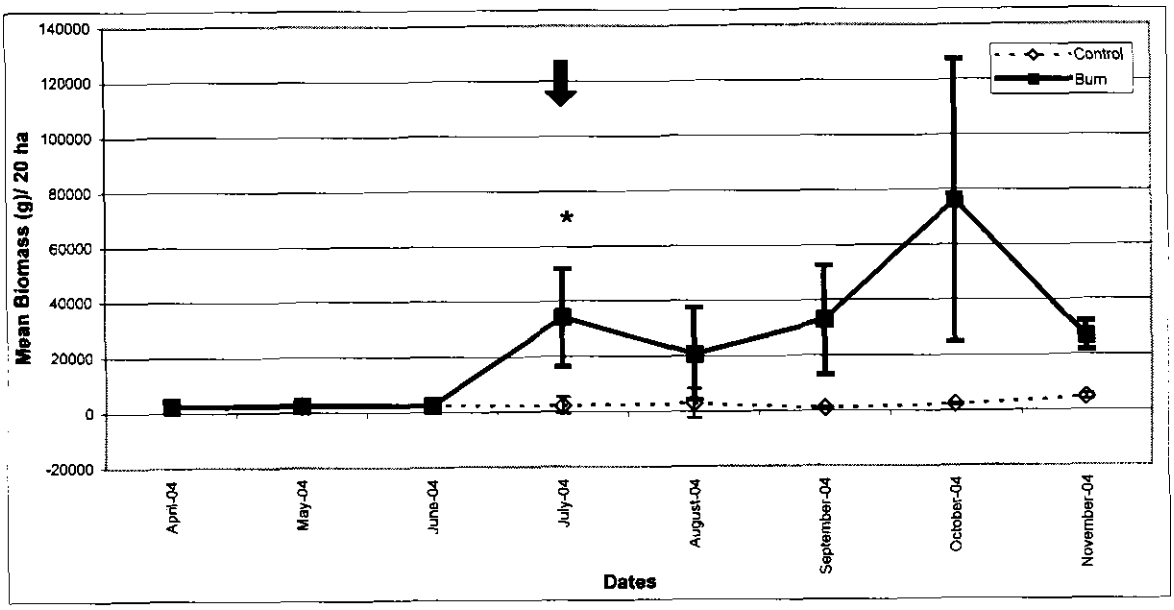

Fig. 3.2.77 The mean biomass/20 ha for all the birds of Burn 3, recorded in the evening.

Fig. 3.2.76 to Fig. 3.2.77 show the mean biomass/20 ha for all the birds of each of Burns 2 and 3 recorded in the evenings. Fig. 3.2.76 showed a decrease in biomass in June for the Control Site of Burn 2. There was an increase in July. There was a decrease in biomass in August, followed by another decrease in September. September and November had almost the same biomass with a slight decrease in November. The Burn Site showed an increase in biomass in June and a decrease until September. There was a slight increase in biomass in October, followed by a decrease in November. The Student T-test showed no significant difference for Burn 2.

Fig. 3.2.77 showed almost the same biomass for the whole year in the Control Site of Burn 3. There was a slight increase in biomass in August, followed by a slight decrease in September to almost zero biomass. This was followed by a slight increase in biomass until November. The Burn Site showed an increase in biomass in July, followed by a decrease in August. There was an increase in biomass until October and a sharp decrease in November. The Student T-test showed a significant difference for July.

The patterns of Burns 2 and 3 (Fig. 3.2.76 and Fig. 3.2.77) were similar. Both burns had an increase in biomass in the Burn Sites directly after the fire and both had a lower biomass at the end of the year than directly after the fire. The biomass of the morning (Fig. 3.2.72 and Fig. 3.2.73), midday (Fig. 3.2.74 and Fig. 3.2.75) and evening did not show any particular pattern. Burn 2 (Fig. 3.2.76) had a lower biomass in the evening than in the morning (Fig. 3.2.72). Burn 3 (Fig. 3.2.77) had the highest biomass in the evening, compared to the morning and midday data (Fig. 3.2.73 and Fig. 3.2.75).

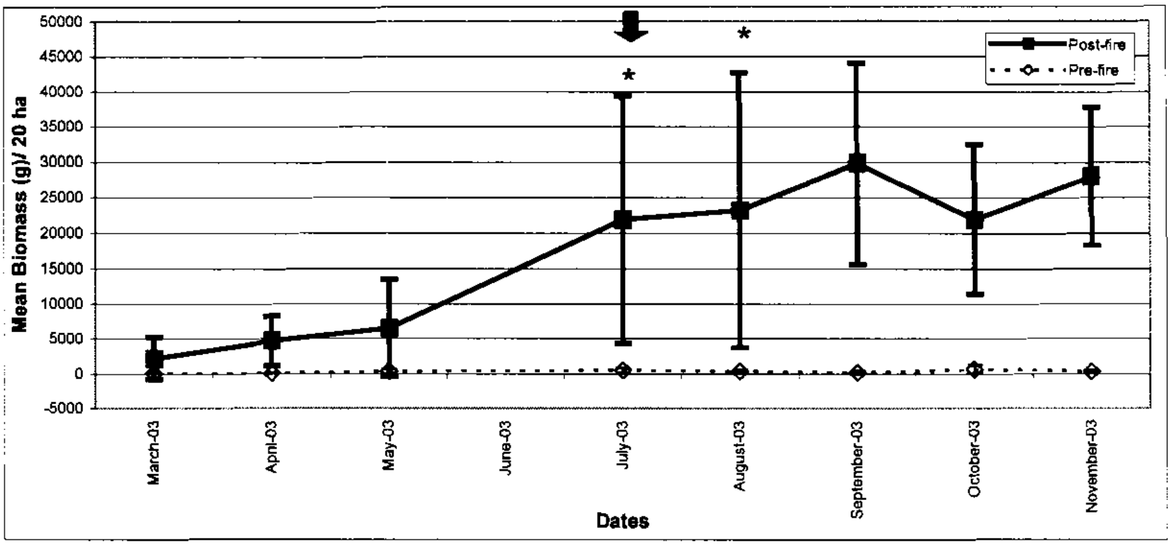

Fig. 3.2.78 The mean biomass/20 ha before and after the fire on Burn 1, recorded in the morning.

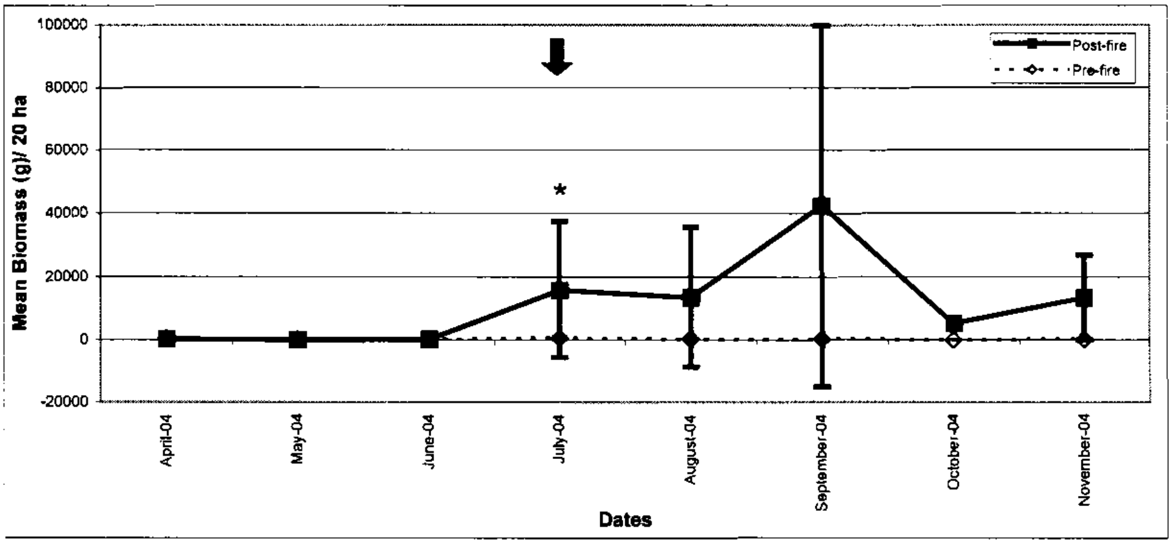

Fig. 3.2.79 The mean biomass/20 ha before and after the fire on Burn 2, recorded in the morning.

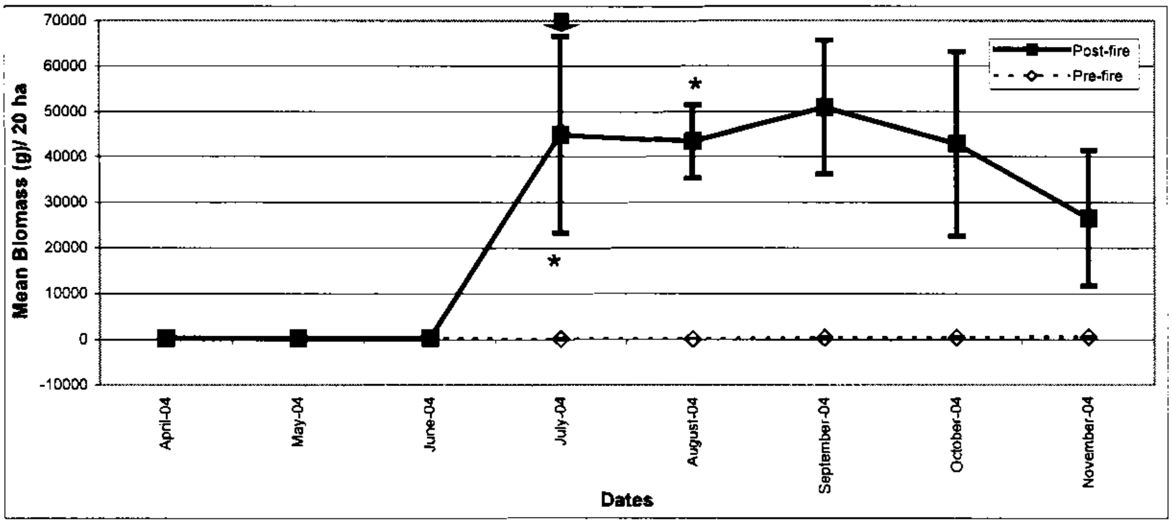

Fig. 3.2.80 The mean biomass/20 ha before and after the fire on Burn 3, recorded in the morning.

Fig. 3.2.78 to Fig. 3.2.80 show the temporal variation in the mean biomass/20 ha for all the birds before and after the fire for each of the three burns recorded in the mornings. The data from the Control Sites were therefore not included. The biomass means were calculated by first separating the species that were present before the fire from the species that only appeared after the fire, or that increased in numbers after the fire. This first group was designated as the "pre-fire" group, while those that appeared or increased in the Burn Site after the fire were allocated to the "post-fire" group. The split only took place after the fires – therefore no difference in biomass before the fire itself (March to June). Please note the difference in the biomass scales in the graphs.

Fig. 3.2.78 showed almost the same biomass throughout the year for birds that were present before the fire on Burn 1. There was a slight increase in biomass until August, followed by a slight decrease in September. Another slight increase was seen in October. This was followed by a decrease in November. The Burn Site showed an increase in biomass for the birds that remained until September. There was a decrease in October and the year ended in an increase in biomass in November. The Student T-test showed a significant difference for both July and August, the months following the fire.

Fig. 3.2.79 showed almost the same biomass throughout the year for birds that were present before the fire on Burn 2. There was a slight increase in biomass until September, followed by a slight decrease in October. The line ended in an increase in November. The Burn Site showed an increase in biomass for the birds that were present after the fire in July, followed by a decrease in August. There was an increase in September and another decrease in biomass in October. The year ended in an increase in biomass in November. The Student T-test showed a significant difference for July, but not August.

Fig. 3.2.80 showed almost the same biomass throughout the year for birds that were present before the fire on Burn 3. There was a slight increase in biomass in July, followed by a slight decrease in August. Another slight increase was seen until November. The Burn Site showed an increase in biomass for the birds that were present after the fire in July, followed by a slight decrease in August. There was a slight increase in biomass in September and another decrease until November. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.78 and Fig. 3.2.79 were closest in pattern and Fig. 3.2.80 had the same general trends. All three burns had an increase in biomass in the Burn Sites directly after the fire. Burns 1 and 2 (Fig. 3.2.78 and Fig. 3.2.79) ended the year in an increase in biomass. All three burns showed a large difference between the Control and Burn Sites. All three burns had a significant difference directly after the fire.

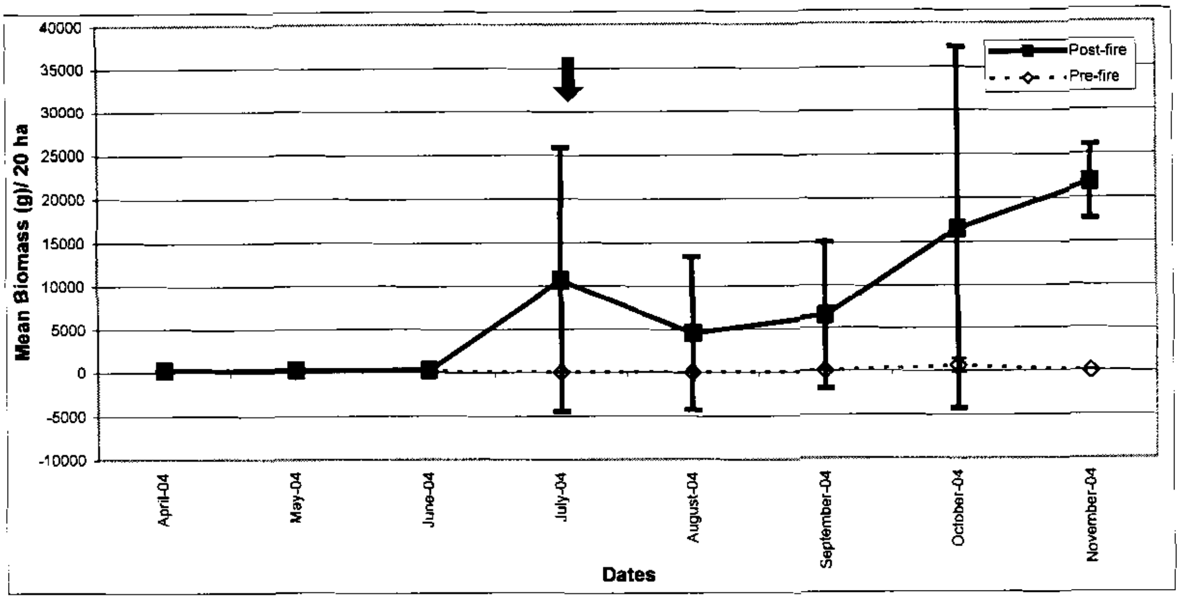

Fig. 3.2.81 The mean biomass/20 ha before and after the fire on Burn 2, recorded at midday.

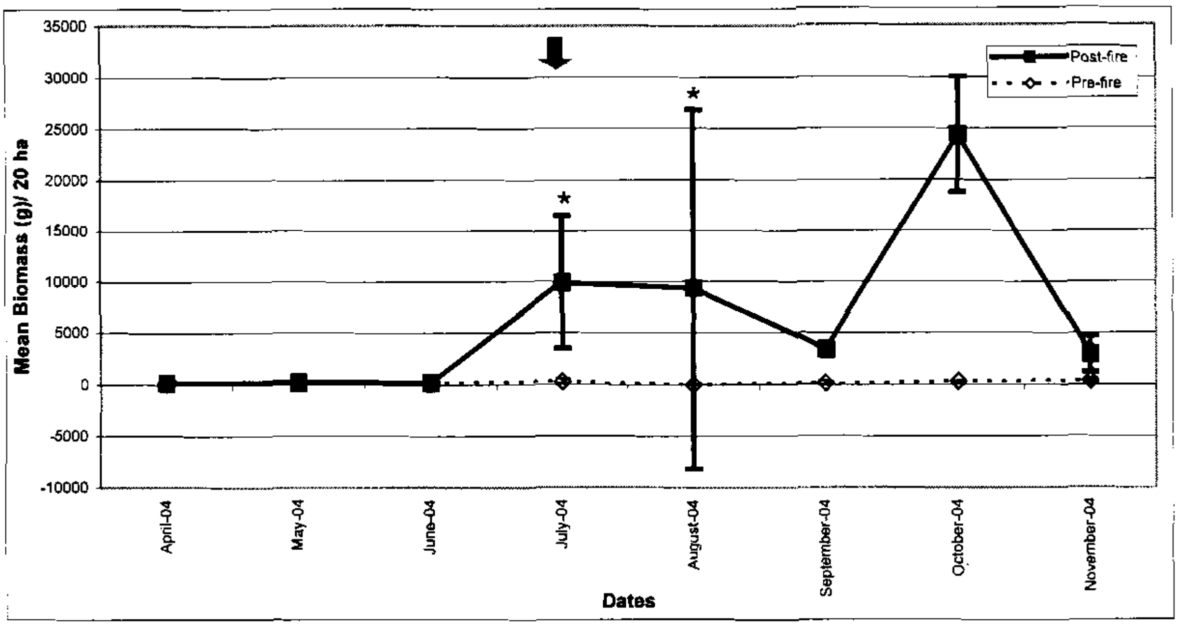

Fig. 3.2.82 The mean biomass/20 ha before and after the fire on Burn 3, recorded at midday.

Fig. 3.2.81 to Fig. 3.2.82 show the mean biomass/20 ha for all the birds of each of Burns 2 and 3 recorded at midday. Fig. 3.2.81 showed almost the same biomass throughout the year for birds that were present before the fire on Burn 2. There was a slight decrease in biomass from June until September. An increase in biomass can be seen in October, followed by another decrease in November. The Burn Site showed a sharp increase in biomass in June for the birds that were present after the fire. There was a decrease in July and August. There was an increase in biomass in from September until November. The Student T-test showed no significant difference for Burn 2.

Fig. 3.2.82 showed almost the same biomass for the whole year in the Control Site for the birds that were present before the fire on Burn 3. There was a slight increase in biomass in July, followed by a slight decrease in August and September. This was followed by a slight increase in biomass until November. The Burn Site showed an increase in biomass in July, followed by a decrease from August until September. There was a sharp increase in biomass in October and a sharp decrease in November. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.81 and Fig. 3.2.82 had the same general trends. Both burns had an increase in biomass in the Burn Sites directly after the fire. Burn 3's (Fig. 3.2.82) Control and Burn Sites were almost the same at the end of the year, while Burn 2's (Fig. 3.2.81) Control and Burn Sites had a large difference in biomass. Only Burn 3 (Fig. 3.2.82) had a significant difference for the Student T-test after the fire. The midday graphs had the same general trends as the morning graphs (Fig. 3.2.79 and Fig. 3.2.80). Burn 2 (Fig. 3.2.81) had the same biomass in the morning (Fig. 3.2.79) and at midday. Burn 3 had the lowest biomass at midday.

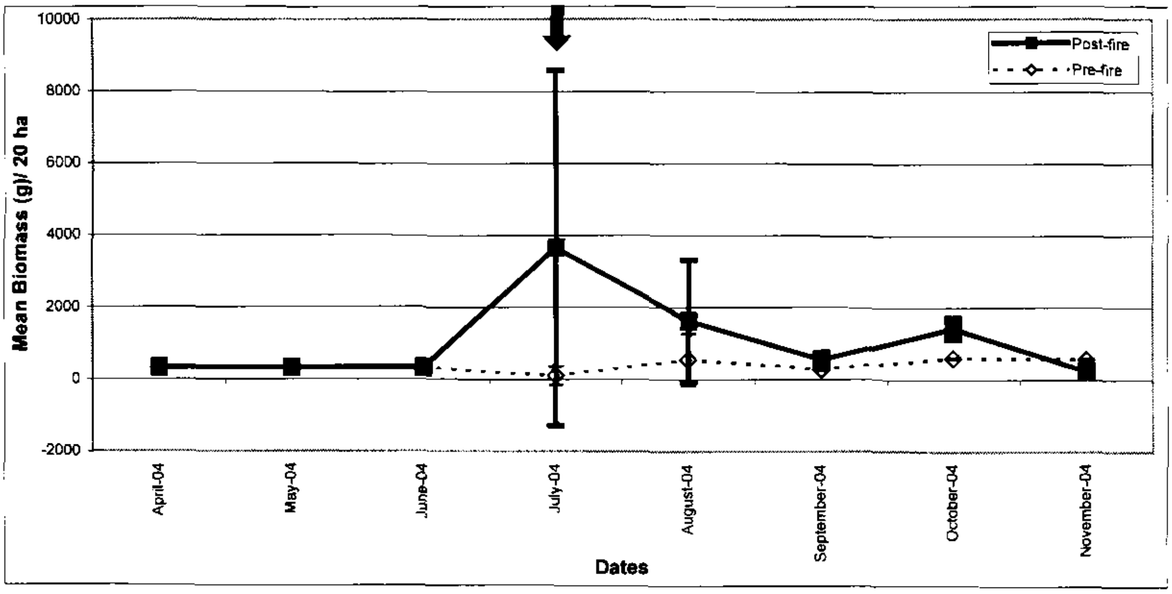

Fig. 3.2.83 The mean biomass/20 ha before and after the fire on Burn 2, recorded in the evening.

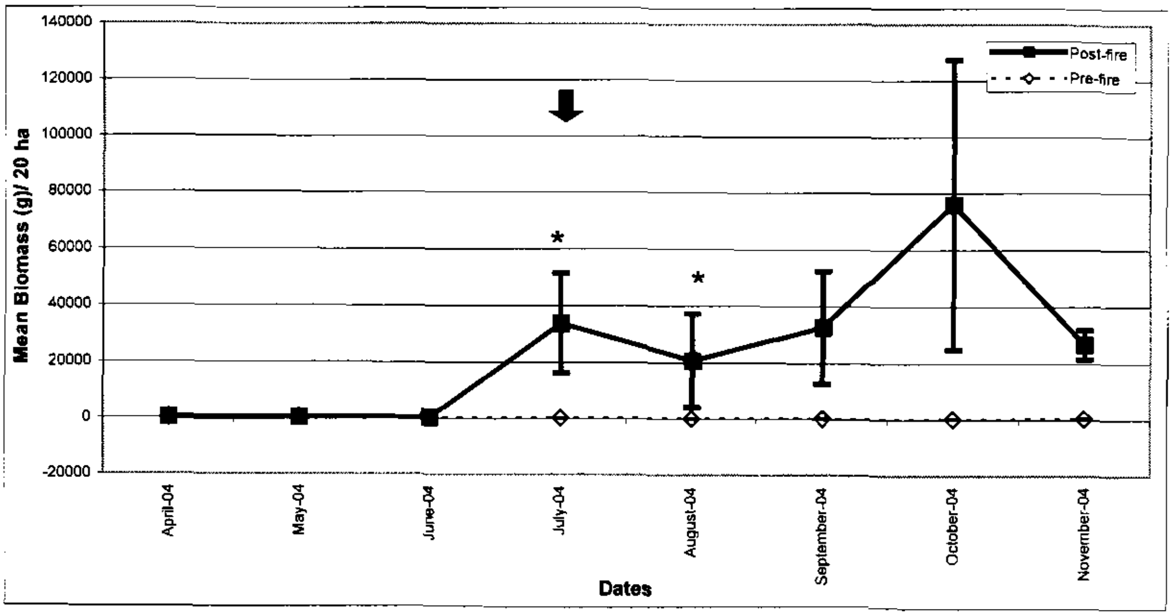

Fig. 3.2.84 The mean biomass/20 ha before and after the fire on Burn 3, recorded in the evening.

Fig. 3.2.83 to Fig. 3.2.84 show the mean biomass/20 ha for all the birds for Burns 2 and 3 recorded in the evenings. Fig. 3.2.83 showed a decrease in biomass in July for the birds that were present before the fire on Burn 2. There was an increase in August, followed by another decrease in biomass in September. An increase in biomass can be seen in October, followed by a slight decrease in November. The Burn Site showed an increase in biomass in July and a decrease until September. There was a slight increase in biomass in October, followed by a decrease in November. The before and post-fire biomass was almost the same from September to November, with the pre-fire biomass higher than the post-fire biomass in November. The Student T-test showed no significant difference for Burn 2.

Fig. 3.2.84 showed almost the same biomass for the whole year for the birds that were present before the fire on Burn 3. The biomass was so small as to appear zero grams for the whole year. It was thus almost impossible to tell the trends without looking at the numbers itself. This will be discussed in Chapter 4. The Burn Site showed an increase in biomass in July, followed by a decrease in August. There was an increase in biomass from September until October and a sharp decrease in November. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.83 and Fig. 3.2.84 had similar patterns. Both burns had an increase of biomass in the Burn Sites directly after the fire and ended the year in a decrease. The Control and Burn Sites had almost the same biomass at the end of the year for both burns. Both burns had a lower biomass at the end of the year than directly after the fire. Only Burn 3 (Fig. 3.2.84) had a significant difference in the Student T-test. Burn 2 (Fig. 3.2.93) had a lower biomass in the evening than in the morning (Fig. 3.2.79). When compared to the morning and midday data (Fig. 3.2.80 and Fig. 3.2.82), Burn 3 had the highest biomass in the evening.

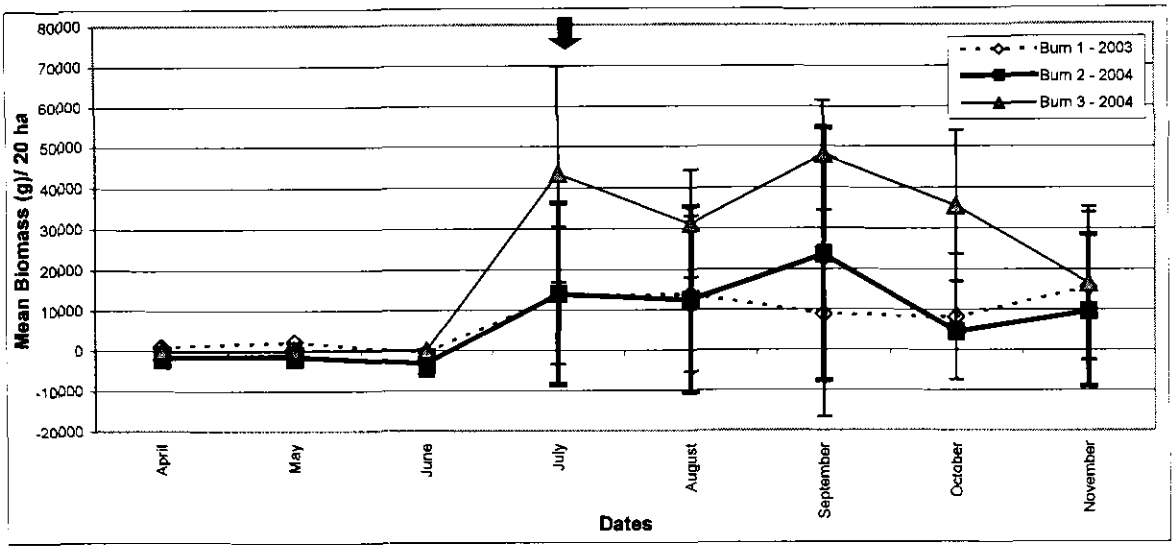

Fig. 3.2.85 The difference between the mean biomass/20 ha in the Control and Burn Sites of each burn, recorded in the morning.

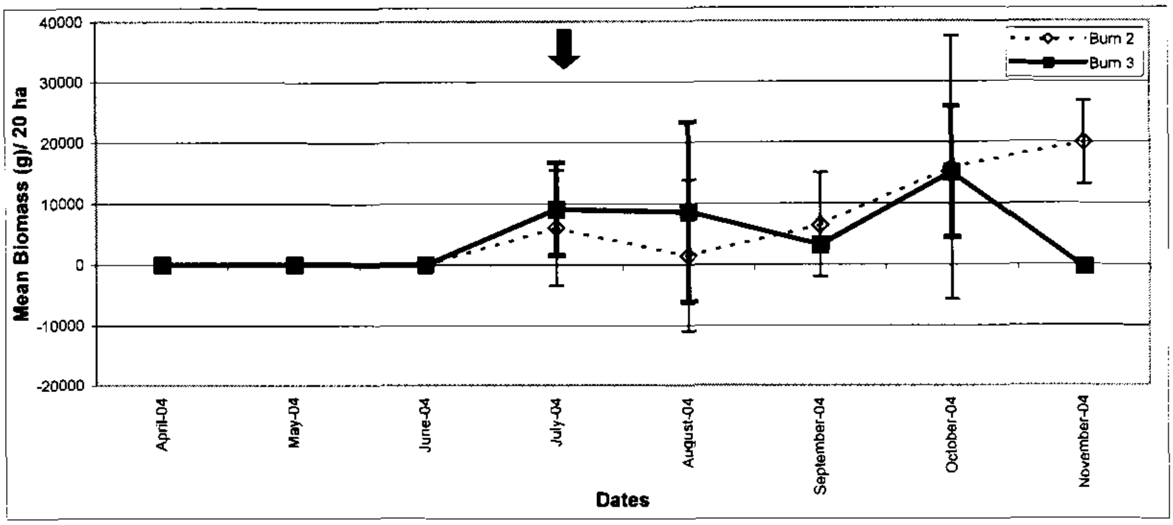

Fig. 3.2.86 The difference between the mean biomass/20 ha in the Control and Burn Sites of Burns 2 and 3, recorded at midday.

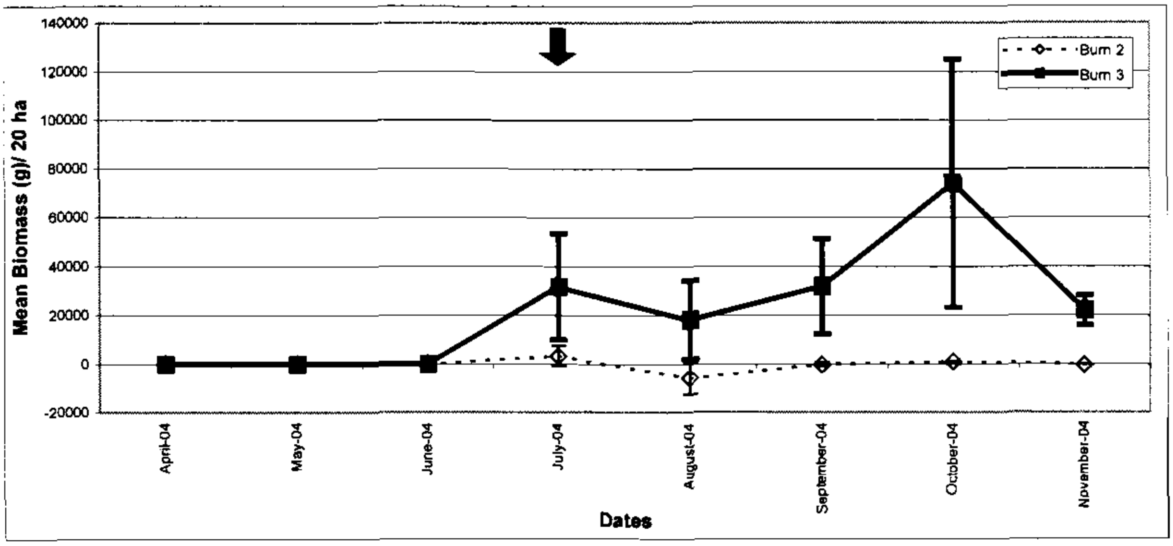

Fig. 3.2.87 The difference between the mean biomass/20 ha in the Control and Burn Sites for Burns 2 and 3, recorded in the evenings.

Fig. 3.2.85 to Fig. 3.2.87 show the difference between the biomass/20 ha in the Control and Burn Sites of each of the three burns. This was calculated by subtracting the Control Site from the Burn Site. A positive value means a higher biomass in the Burn Site and a negative value means a higher biomass in the Control Site.

Burn 1 (Fig. 3.2.85, morning) showed an increase in May, followed by a decrease in June. There was another increase in July, followed by a slight decrease in August and a longer decrease in September and October. The year ended in an increase in November. The biomass stayed positive and therefore higher in the Burn Site. Burn 1 had no midday and evening counts.

Burn 2 (Fig. 3.2.85, morning) started with a negative value and had a slight decrease in June, followed by an increase in July. There was a slight decrease in August and another increase in September. A sharp decrease can be seen in October and the year ended in an increase in November. After July the biomass had positive values and therefore a higher biomass in the Burn Site. Burn 2 (Fig. 3.2.86, midday) showed a sharp increase in June and a sharp decrease in July. There was another decrease in August. The year ended in an increase after August until November. The biomass had positive values and therefore a higher biomass in the Burn Site. Burn 2 (Fig. 3.2.87, evening) showed a slight increase in July followed by a slight decrease to become negative in August. September showed a slight increase, but was still negative. There was another increase in October to become positive, followed by a slight decrease to become negative again in November.

Burn 3 (Fig. 3.2.85, morning) showed an increase in July, followed by a decrease in August. There was another increase in September and another decrease after September until November. The biomass was positive and therefore had a higher biomass for the Burn Site.

Burn 3 (Fig. 3.2.86, midday) showed an increase in July and a decrease in August. This was followed by another decrease in September. There was an increase in October and the year ended in a decrease in November. The biomass stayed positive and therefore had a higher biomass in the Burn Site.

Burn 3 (Fig. 3.2.87) showed an increase in July and a decrease in August. There was an increase after August until October, followed by a decrease in November. The biomass stayed positive and therefore had a higher biomass in the Burn Site.

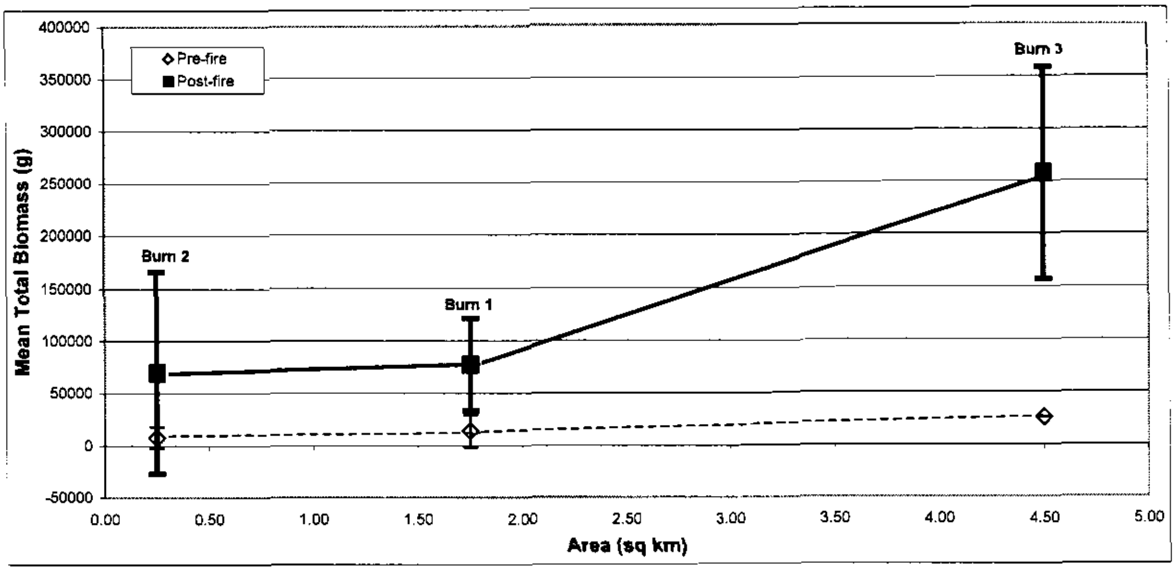

Fig. 3.2.88 The mean total biomass for the entire area (km^2) of each burn (Burn Sites only).

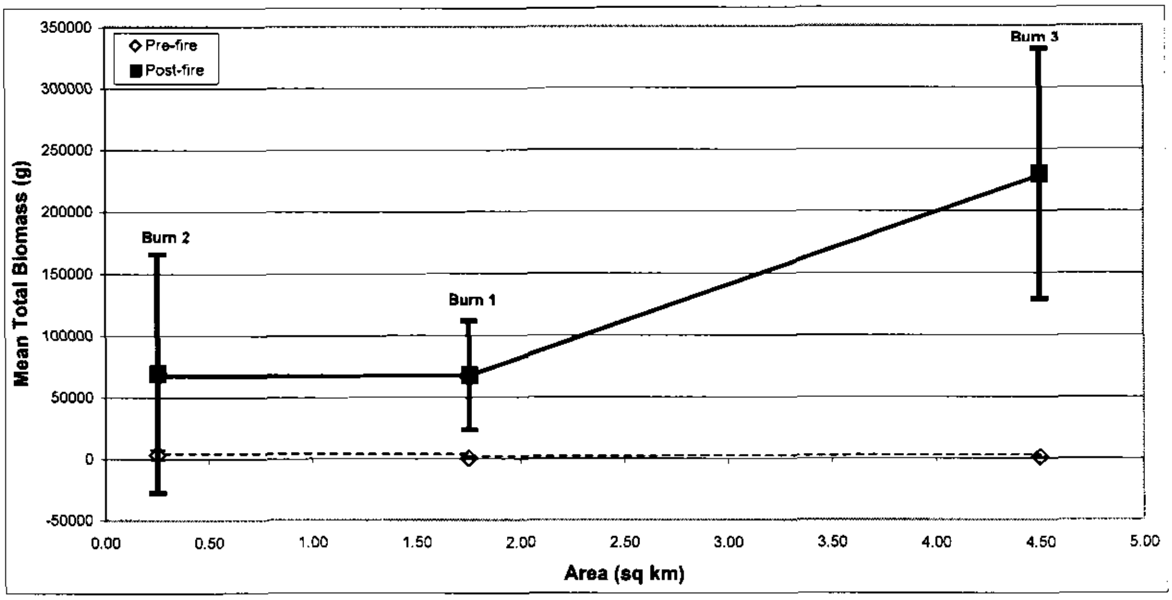

Fig. 3.2.89 The difference of mean total biomass in the Control and Burn Sites for the entire area (km^2) of each burn.

Fig. 3.2.88 showed the mean total biomass for the entire area (km^2) of each burn. The same pre- and post-fire species were used as before (Fig. 3.2.78 to Fig. 3.2.80). Only the values from the Burn Site of each burn were taken to calculate the mean total biomass for the area (km^2). This did not include the Control Site. The Student T-test was not calculated for these two graphs. The biomass before the fire was almost the same for all three burns. Burn 2 had the lowest biomass and Burn 3 had the highest biomass. After the fire Burn 1 had a slightly higher biomass than Burn 2. Burn 2 had the lowest biomass and Burn 3 had the highest biomass, much higher than the other two burns. The biomass increased as the area of the burn increased.

Fig. 3.2.89 showed the difference of mean biomass/20 ha in the Control and Burn Sites for the entire area of each burn. The biomass before the fire was very low, but still positive and therefore the mean biomass was higher in the Burn Site before the fire. Burn 2 had the highest biomass and Burn 3 had the lowest biomass. After the fire the biomass was also positive and therefore there was a higher biomass in the Burn Site. Burn 2 had a slightly higher biomass than Burn 1. Burn 1 had the lowest biomass and Burn 3 had the highest biomass.

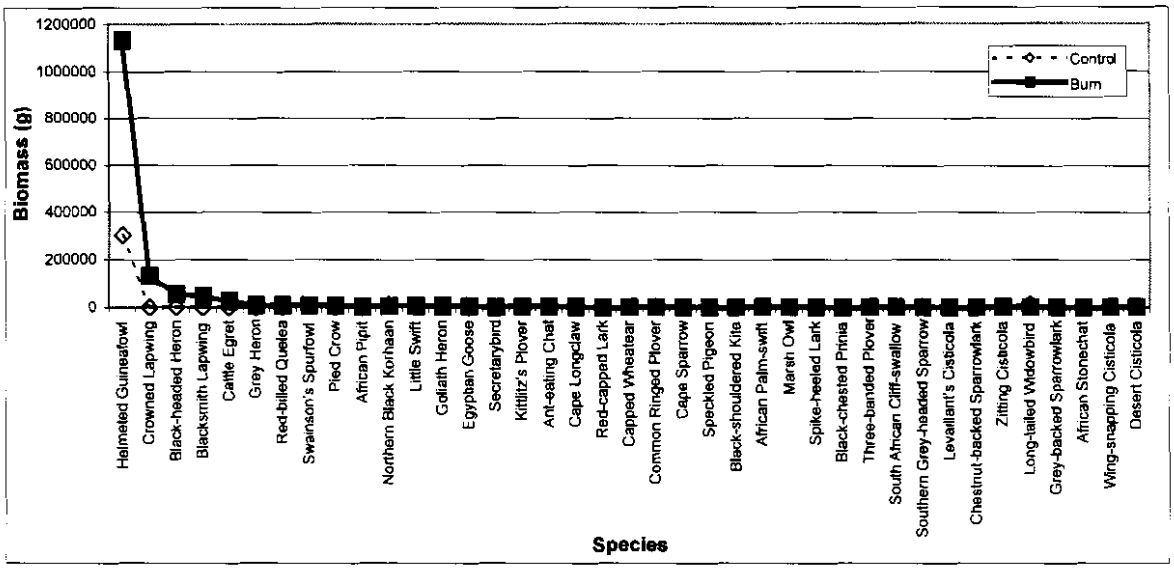

Fig. 3.2.90 The total biomass of each species for July 2003 of Burn 1.

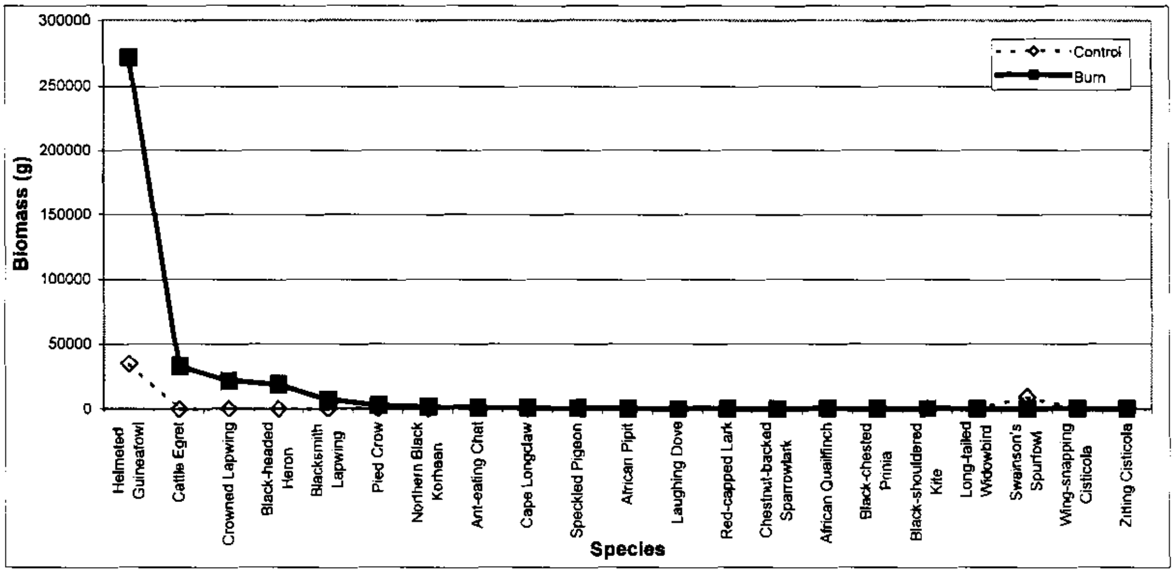

Fig. 3.2.91 The total biomass of each species for July 2004 of Burn 2.

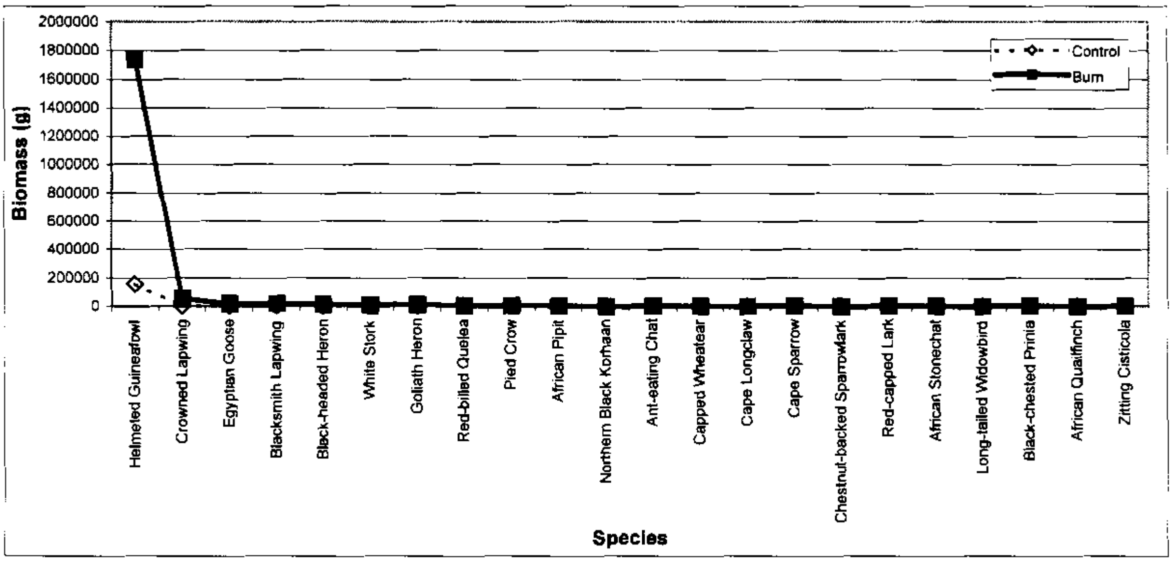

Fig. 3.2.92 The total biomass of each species for July 2004 of Burn 3.

Fig. 3.2.90 to Fig. 3.2.92 show the biomass for each of the species that was recorded in July, for each of the three burns. This was calculated by multiplying the densities for each species recorded in July with their mean biomass from Maclean (1993). Please note the differences in the scales of the Y-axes.

In each of the three burns the Helmeted Guineafowl had the highest biomass and a Cisticola had the lowest biomass. In Burn 1 (Fig. 3.2.90) the Desert Cisticola had the lowest biomass and in Burns 2 and 3 (Fig. 3.2.91 and Fig. 3.2.92) the Zitting Cisticola had the lowest biomass.

In the Burn Sites, Burn 3(Fig. 3.2.92) had the highest Helmeted Guineafowl biomass and Burn 2 (Fig. 3.2.91) had the lowest biomass.

The Control Site of each of the burns had a lower biomass than its respective Burn Site. Burn 3 (Fig. 3.2.92) had the highest Helmeted Guineafowl biomass and Burn 2 (Fig. 3.2.91) had the lowest biomass. At Burn 2 (Fig. 3.2.91) Swainson's Spurfowl had a higher biomass in the Control Site than in the Burn Site. This was the only species and the only burn that showed a higher biomass in the Control Site than in the Burn Site, but this was only slightly so.

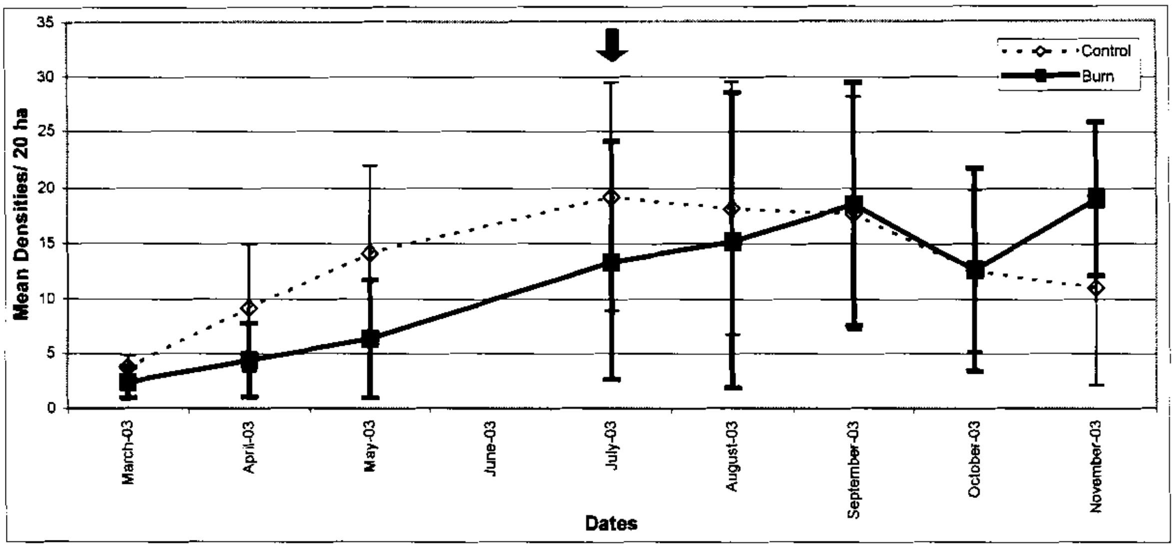

Fig. 3.2.93 The mean density in the Grass Breeding Guild of Burn 1.

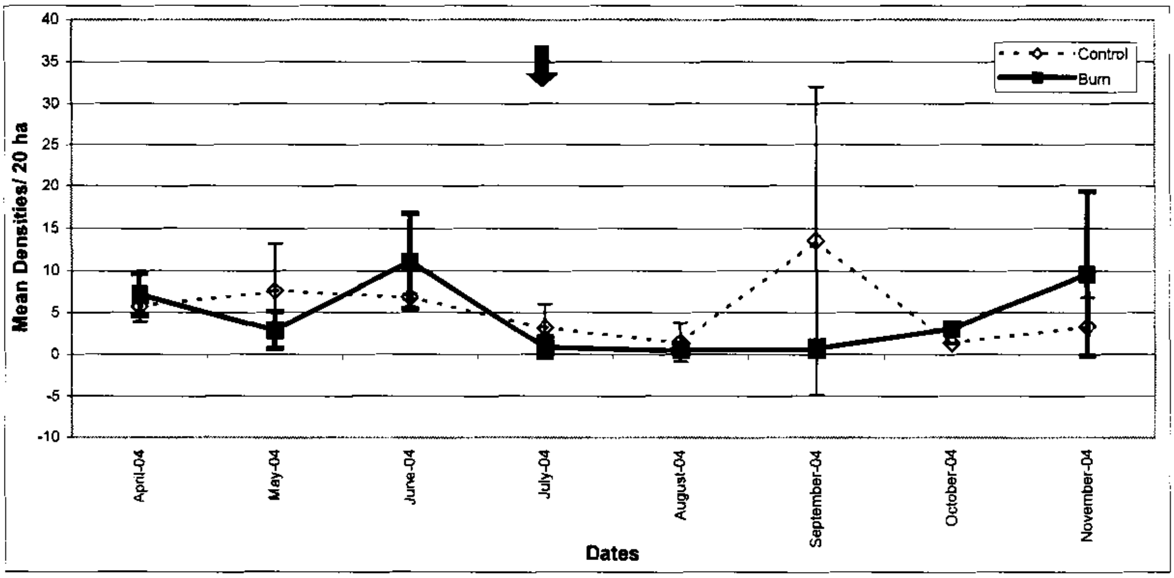

Fig. 3.2.94 The mean density in the Grass Breeding Guild of Burn 2.

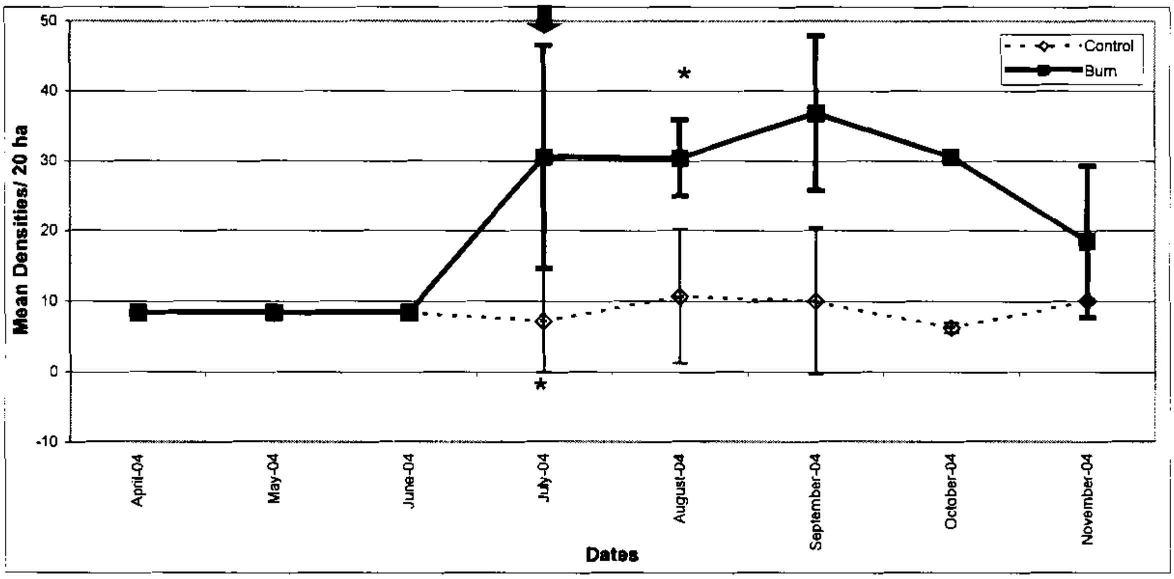

Fig. 3.2.95 The mean density in the Grass Breeding Guild of Burn 3.

3.2.6 Effect of fire on the Breeding Guilds

The guilds (Fig. 3.2.93 to Fig. 3.2.134) used only the morning data. Fig. 3.2.93 to Fig. 3.2.95 show the mean density in the Grass Breeding Guild of each of the three burns. These graphs represent the morning surveys. This was calculated by allocating each of the species to a guild (Chapter 2.6, Table 2.6.1) before calculating the densities.

Fig. 3.2.93 showed an increase in the density in the Control Site of Burn 1 until July. There was a slight decrease between August and September and another decrease in numbers until November. The Burn Site showed an increase in density from March to September. In October there was a decrease in numbers and an increase in November. The Control and Burn Sites had almost the same numbers in September and October. The Student T-test showed no significant difference for Burn 1.

Fig. 3.2.94 showed an increase in density in the Control Site of Burn 2 in May, followed by a decrease until August. There was an increase in numbers in September, followed by a decrease in October and another increase in November. The Burn Site showed a decrease in density in May, followed by an increase in June. There was a decrease in numbers in July and August, until almost zero density, and a very slight increase in September. The numbers increased again after September until the end of the year. The Student T-test showed no significant difference for Burn 2.

Fig. 3.2.95 showed a slight decrease in density in the Control Site of Burn 3 in July. There was an increase in density in August, followed by a very slight decrease in September. There was another decrease in October and an increase in November. The Burn Site showed an increase in density in July and the density was the same for July and August. September showed an increase in the density, followed by a decrease until November. The Student T-test showed a significant difference for both July and August.

The three graphs each had different patterns. Fig. 3.2.93 and Fig. 3.2.95 had the same general trends, although the year ended differently for each graph. Burns 1 and 3 (Fig. 3.2.93 and Fig. 3.2.95) had an increase in numbers in the Burn Sites directly after the fire, while Burn 2 (Fig. 3.2.94) had a decrease. Only Burn 3 had a large difference between the Burn and Control Sites. Only Burn 3 had a significant difference in the Student T-test.

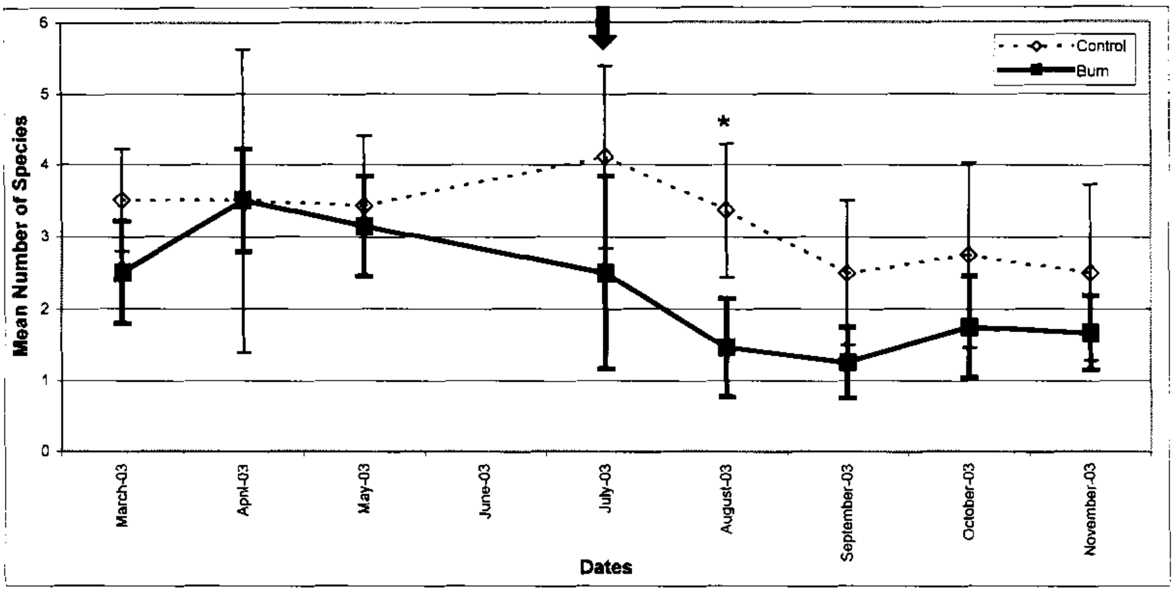

Fig. 3.2.96 The mean number of species in the Grass Breeding Guild of Burn 1.

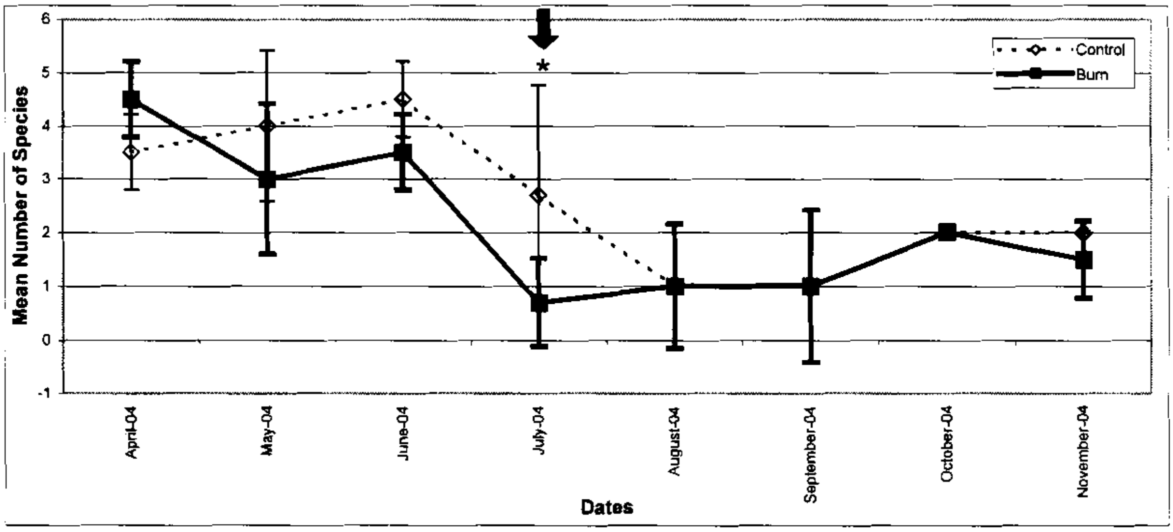

Fig. 3.2.97 The mean number of species in the Grass Breeding Guild of Burn 2.

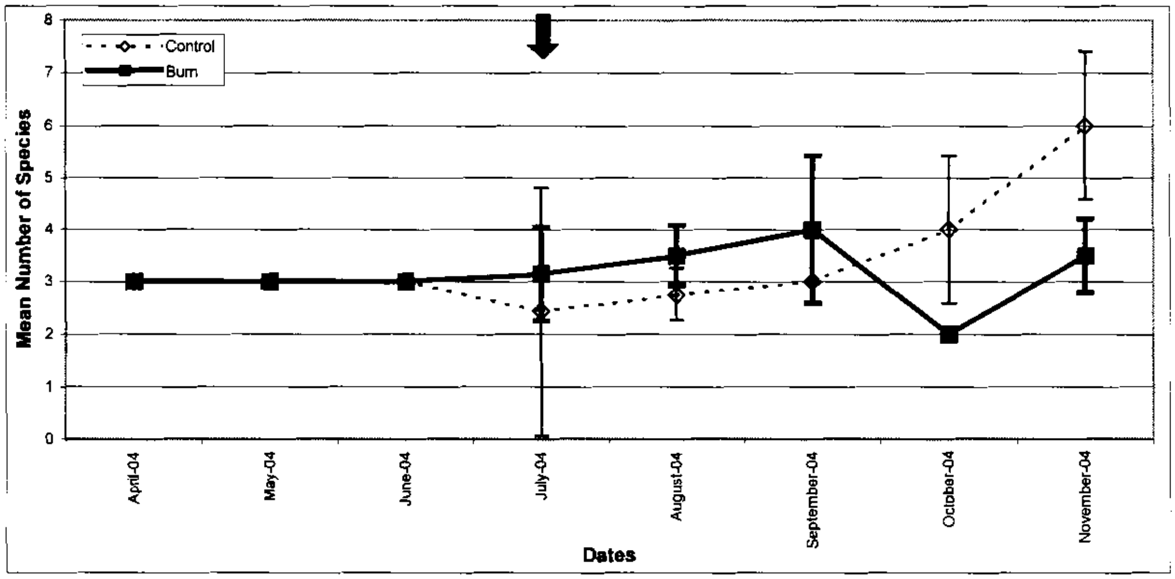

Fig. 3.2.98 The mean number of species in the Grass Breeding Guild of Burn 3.

Fig. 3.2.96 to Fig. 3.2.98 show the mean number of species in the Grass Breeding Guild of each of the three burns. These graphs represent the morning surveys. They were calculated by allocating each of the species to a guild and then calculating the number of species as was done before.

Burn 1 (Fig. 3.2.96) had the same number of species in the Control Site in March and April. There was a slight increase in numbers in May, followed by another increase in July. There was a decrease in number of species between August and September and an increase in October. The number of species decreased in November. The Burn Site showed an increase in number of species between March and April. There was a decrease in number of species between May and September, followed by an increase in October. The year ended in a slight decrease in number of species. The Student T-test showed a significant difference in August.

Burn 2 (Fig. 3.2.97) showed an increase in number of species in the Control Site between May and June, followed by a decrease between June and August. The number of species was the same between August and September. There was an increase in number of species in October. The number of species was the same between October and November. The Burn Site showed a decrease in number of species between April and May, followed by an increase in June. There was a sharp decrease in number of species in July, followed by a n increase in August. The number of species was the same between August and September. The number of species increased in October and decreased again in November. The Student T-test showed a significant difference for August.

Burn 3 (Fig. 3.2.98) showed a slight decrease in number of species in the Control Site in July. There was an increase in number of species between July and September, followed by another sharper increase until November. The Burn Site showed an increase in number of species between July and September and a decrease in October. There was an increase in number of species in November. The Student T-test showed no significant difference for Burn 3.

Fig. 3.2.96 and Fig. 3.2.97 had the same general trends and were closest in pattern. They both decreased in number of species in the Burn Sites directly after the fire, while Fig. 3.2.98 increased. They both also decreased at the end of the year, while Fig. 3.2.98 increased. The three Burn and Control Sites were close in number of species. Burns 1 and 2 (Fig. 3.2.96 and Fig. 3.2.98) had a significant difference for the Student T-test, but not in the same month. The species had the same general trends as the densities (Fig. 3.2.93 to Fig. 3.2.95).

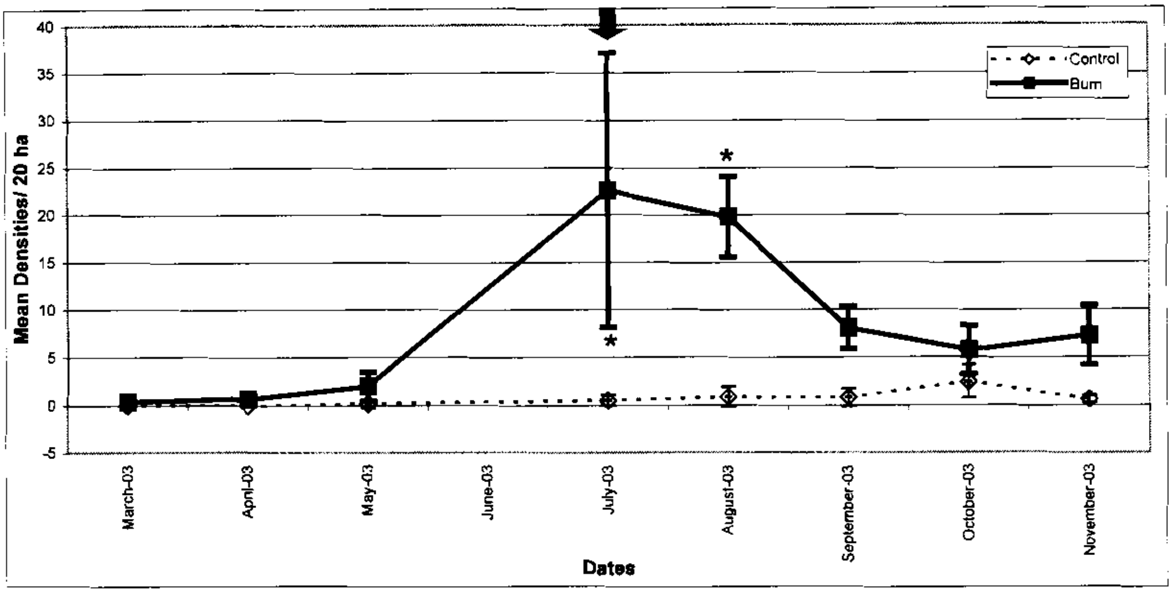

Fig. 3.2.99 The mean density in the Ground Breeding Guild of Burn 1.

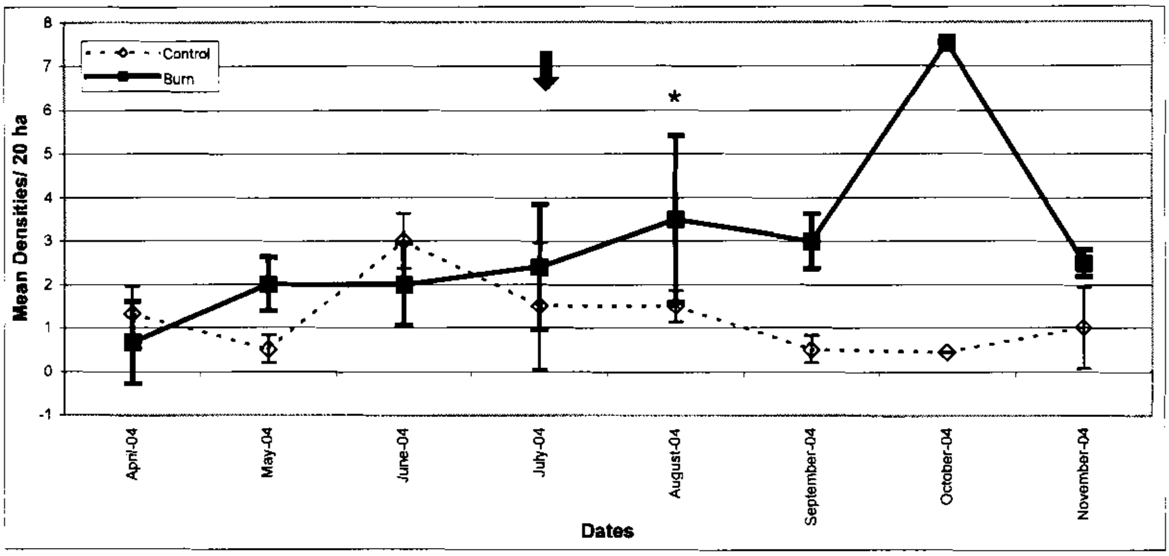

Fig. 3.2.100 The mean density in the Ground Breeding Guild of Burn 2.

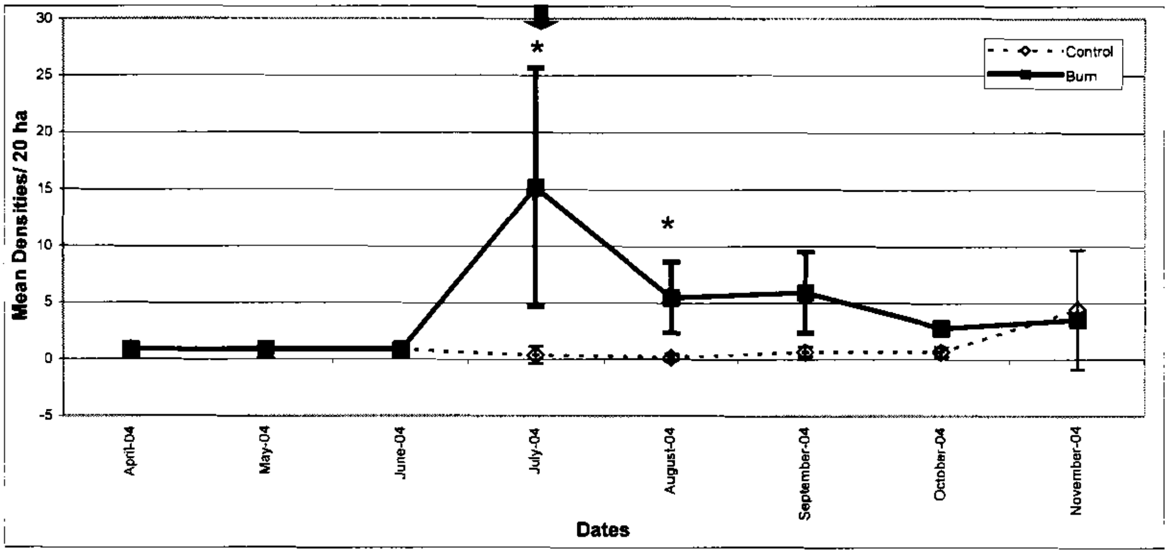

Fig. 3.2.101 The mean density in the Ground Breeding Guild of Burn 3.

Fig, 3.2.99 to Fig. 3.2.101 show the mean density in the Ground Breeding Guild of each of the three burns. Burn 1 (Fig. 3.2.99) had zero density in the Control Site between March and May. There was a slight increase in density in July and August. The density was the same between August and September. There was an increase in October and a decrease in density in November. The Burn Site showed an increase in density between March and May, followed by a sharper increase between May and July. The density decreased between July and October and increased in November. The Student T-test showed a significant difference in both July and August.

Burn 2 (Fig. 3.2.100) showed a decrease in density in the Control Site between March and April and an increase between April and May. There was an increase in density in June followed by a decrease in density in July. The density was the same between July and August and this was followed by a decrease in September. The density was the same again between September and October. There was an increase in density in November. The Burn Site showed an increase in density between April and May. The density was the same between May and June and was followed by an increase between June and August. There was a decrease in September and a sharp increase in density in October. The density decreased sharply in November. The Student T-test showed a significant difference for August.

Burn 3 (Fig. 3.2.101) showed a slight decrease in density in the Control Site in July, followed by another slight decrease to almost zero in August. There was an increase in density in September and the density were the same between September and October. November had another increase in density. The Burn Site showed a sharp increase in density in July, followed by a sharp decrease in August. There was a slight increase in density in September, followed by a decrease in October and a slight increase in November. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.99 and Fig. 3.2.101 were closest in pattern. Fig. 3.2.100 also showed an increase in density in the Burn Sites after the fire, but had a different pattern when compared with the other two burns. All three burns had an increase directly after the fire, but Burn 2 (Fig. 3.2.100) decreased at the end of the year, while Burns 1 and 3 (Fig. 3.2.99 and Fig. 3.2.101) increased. All three Control and Burn Sites were close to the Control density at the end of the year. All three burns had a significant difference for the Student T-test for August.

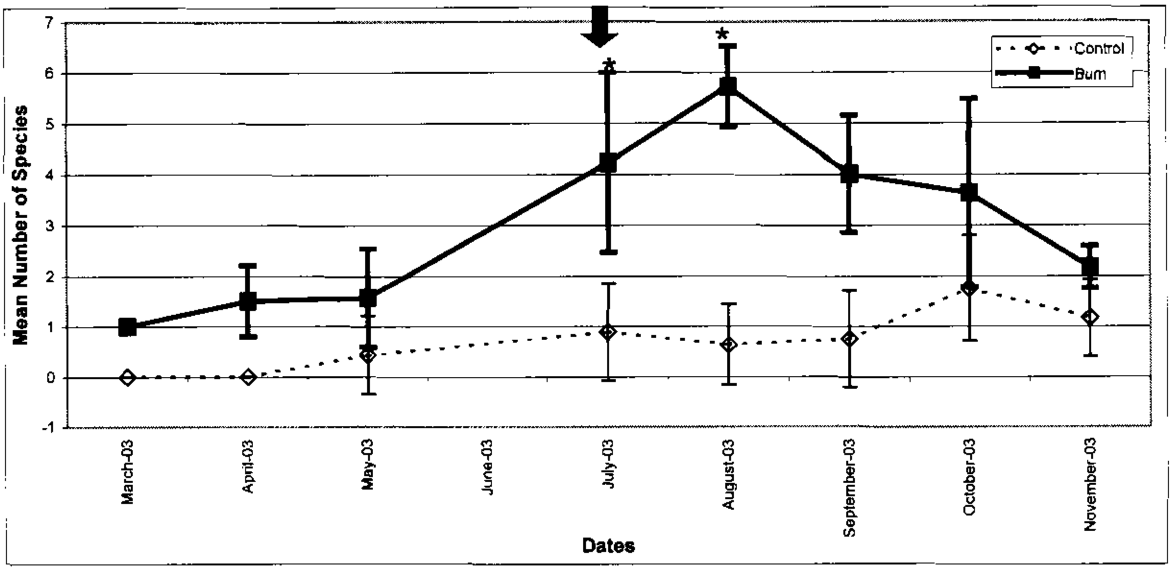

Fig. 3.2.102 The mean number of species in the Ground Breeding Guild of Burn 1.

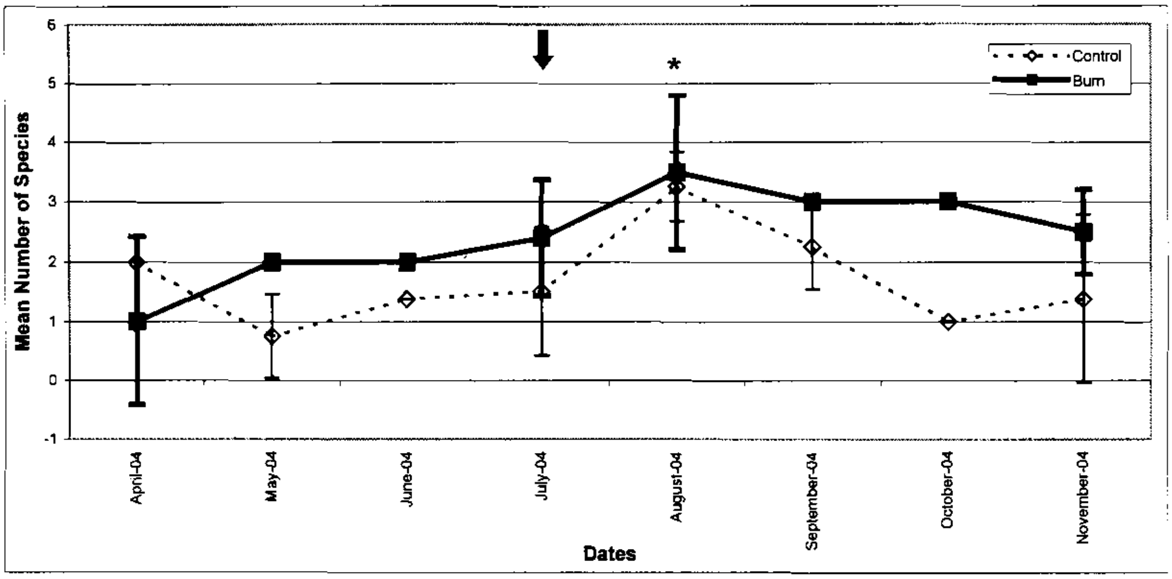

Fig. 3.2.103 The mean number of species in the Ground Breeding Guild of Burn 2.

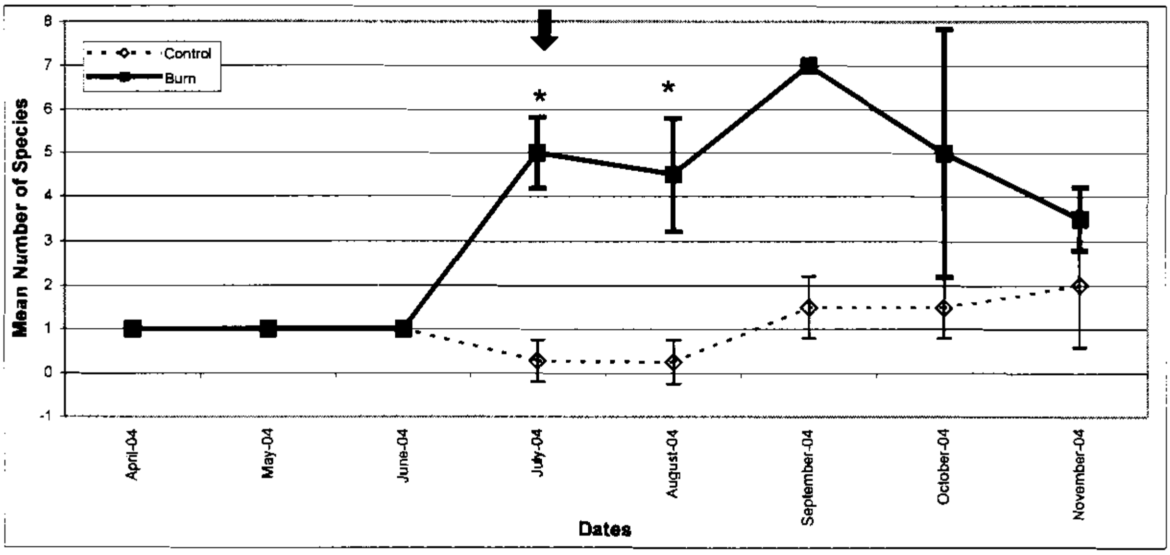

Fig. 3.2.104 The mean number of species in the Ground Breeding Guild of Burn 3.

Fig. 3.2.102 to Fig. 3.2.104 show the mean number of species in the Ground Breeding Guild of each of the three burns. Burn 1 (Fig. 3.2.102) had the same number of species in the Control Site between March and April. There was an increase in number of species in May. This was followed by another increase in number of species in July. There was a decrease in number of species in August and a slight increase in September. There was another increase in number of species between September and October and a decrease in November. The Burn Site showed an increase in number of species between March and April. This was followed by a very slight increase in May and another increase between July and August. There was a decrease in number of species between August and September, followed by another decrease in November. The Student T-test showed a significant difference in both July and August.

Burn 2 (Fig. 3.2.103) showed a decrease in number of species in the Control Site between April and May. There was an increase in June. The numbers were the same between June and July, followed by an increase in number of species in August. There was a decrease in numbers between August and October. There was an increase in November. The Burn Site showed an increase in number of species in May. The numbers were the same between May and June. There was an increase between June and August, followed by a decrease in September. The numbers were the same between September and October. There was a decrease in number of species in November. The Student T-test showed a significant difference for August.

Burn 3 (Fig. 3.2.104) showed a slight decrease in number of species in the Control Site in July, followed by another decrease in August. There was an increase in numbers in September. The numbers were the same between September and October. There was an increase in number of species in November. The Burn Site showed an increase in number of species in July, followed by a decrease in August and an increase in September. There was a decrease in number of species between September and November. The Student T-test showed a significant difference for both July and August.

All three graphs had the same general trends and were close in pattern. Fig. 3.2.102 and Fig. 3.2.104 had the same patterns. All three burns had an increase in number of species in the Burn Sites directly after the fire and a decrease at the end of the year. All three Control and Burn Sites had almost the same number of species at the end of the year. Only Burns 1 and 3 (Fig. 3.2.102 and Fig. 3.2.104) had a large difference between the Control and Burn Sites. All three burns had a significant difference for the Student T-test for August. The species had the same general trends as the densities (Fig. 3.2.99 to Fig. 3.2.101).

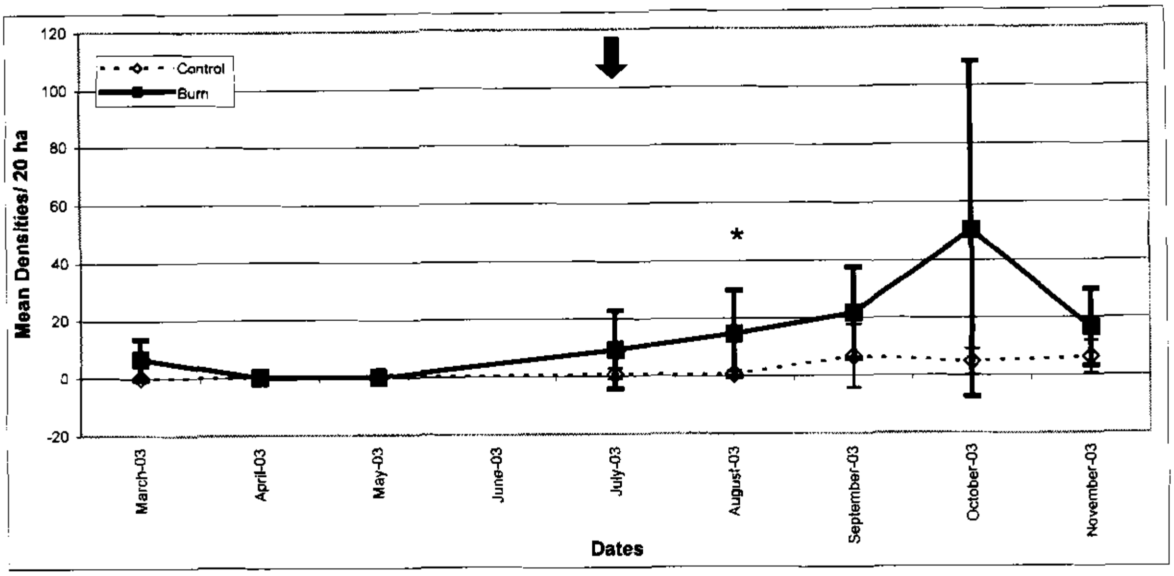

Fig. 3.2.105 The mean density in the Other Breeding Guild of Burn 1.

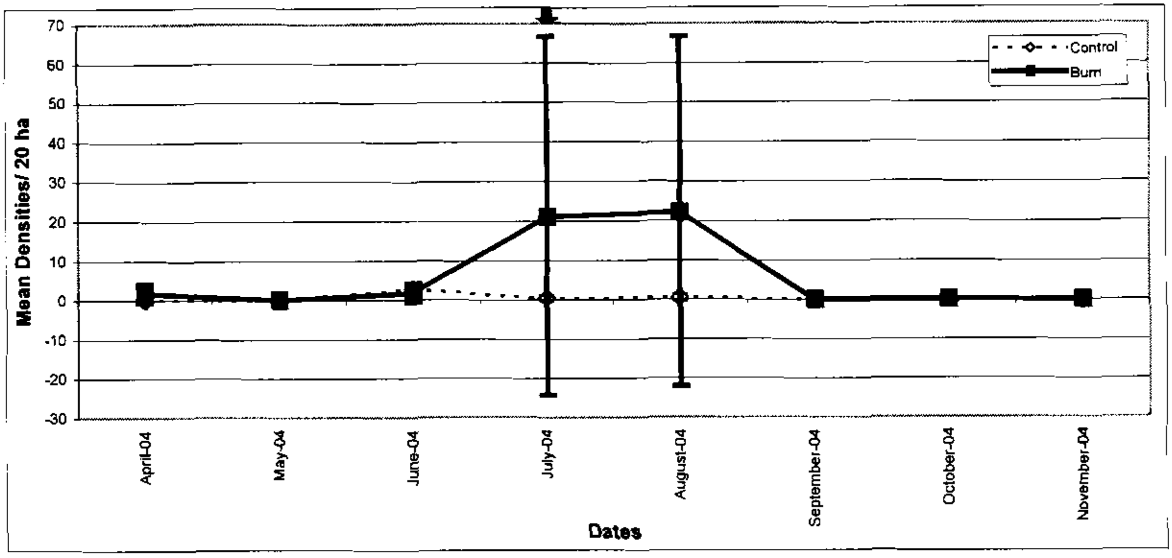

Fig. 3.2.106 The mean density in the Other Breeding Guild of Burn 2.

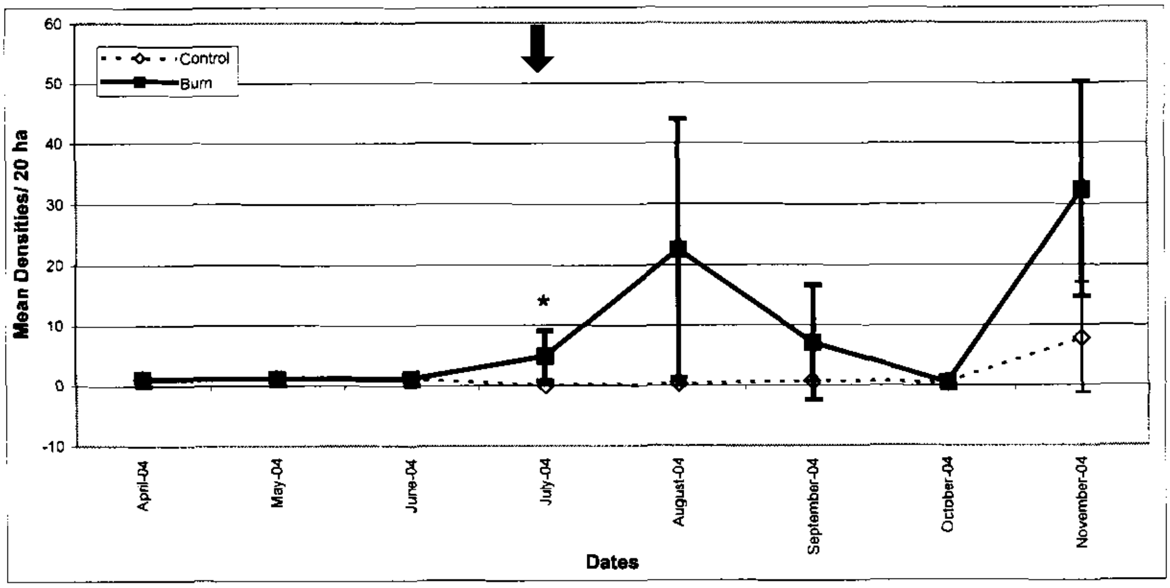

Fig. 3.2.107 The mean density in the Other Breeding Guild of Burn 3.

Fig, 3.2.105 to Fig. 3.2.107 show the mean density in the Other Breeding Guild of each of the three burns. Burn 1 (Fig. 3.2.105) showed zero density between March and July. This was followed by a slight increase between July and September in the Control Site. There was a slight decrease in density in October and a slight increase in November. The density was the same for the Burn and Control Sites between April and May. The Burn Site showed a decrease in density between March and April, followed by a steady density between April and May. The density increased between May and October. There was a decrease in density in November. The Student T-test showed a significant difference for August.

Burn 2 (Fig. 3.2.106) had zero density in April and May. There was an increase in density in the Control Site in June. The density was the same between July and August. There was a decrease in density in September, until zero. This lasted until November. The Burn Site showed a decrease in density between April and May, followed by a very slight increase in density in June. There was another increase in July and a very slight increase in August, followed by a decrease in density between August and September. There were zero density between September and November. The Control and Burn Sites were almost the same between September and November. The Student T-test showed no significant difference for Burn 2.

Burn 3 (Fig. 3.2.107) showed a slight decrease in density in the Control Site in July. There was an increase in density in August, followed by a slight decrease in density in September and October. The year ended in an increase in November. The Burn Site showed an increase in density in July and August. There was a decrease in density between August and October, followed by a sharp increase in density in November. The Student T-test showed a significant difference for July.

Fig. 3.2.105 and Fig. 3.2.107 had similar patterns. All three burns had an increase in density in the Burn Sites directly after the fire, but ended differently from each other. Burns 1 and 3 (Fig. 3.2.105 and Fig. 3.2.107) had a significant difference for the Student T-test, but for different months.

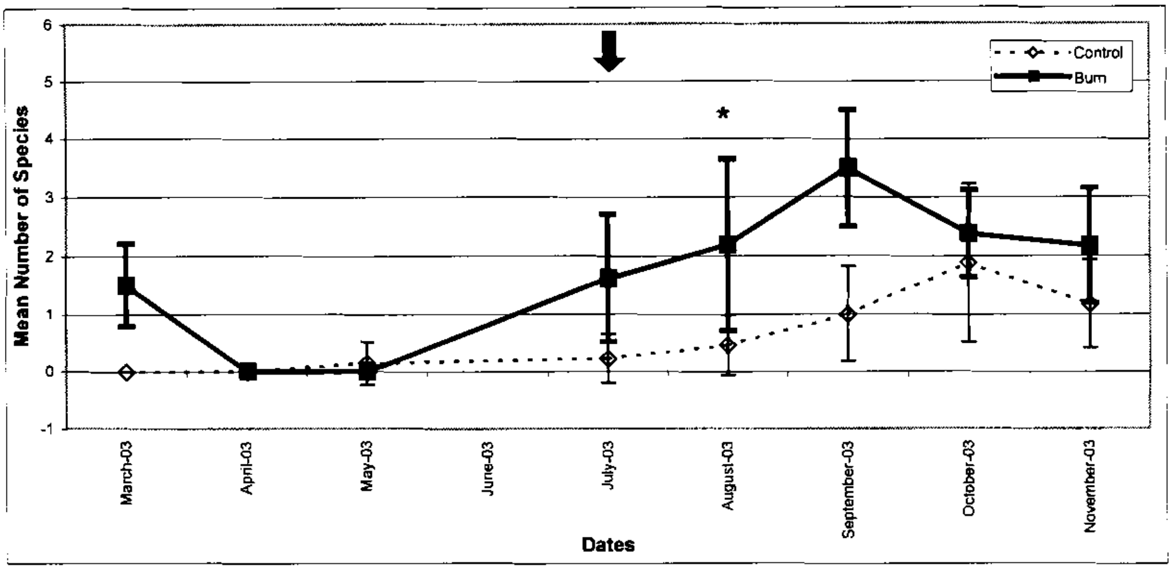

Fig. 3.2.108 The mean number of species in the Other Breeding Guild of Burn 1.

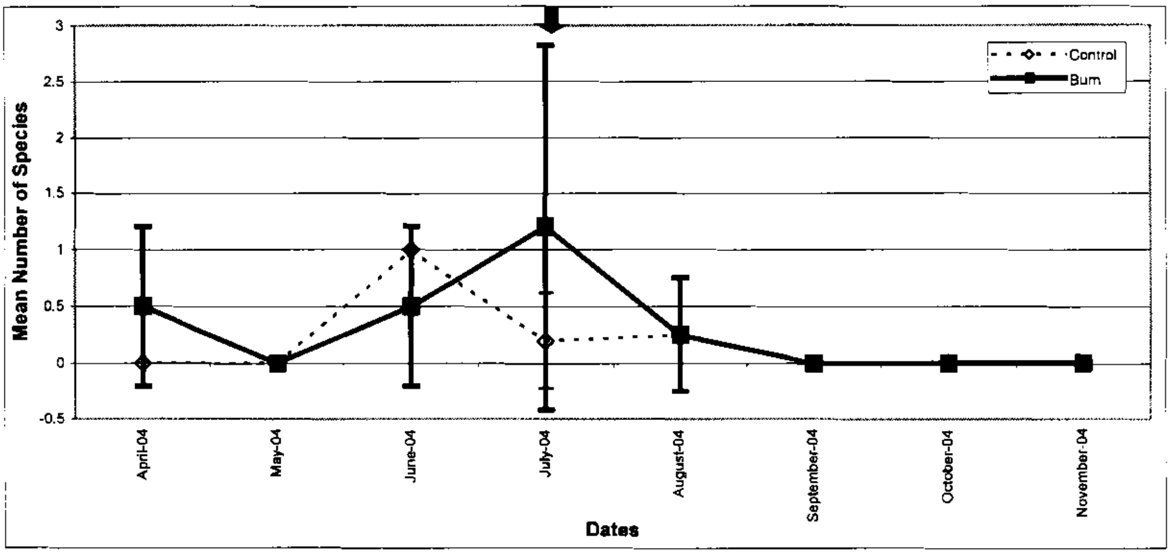

Fig. 3.2.109 The mean number of species in the Other Breeding Guild of Burn 2.

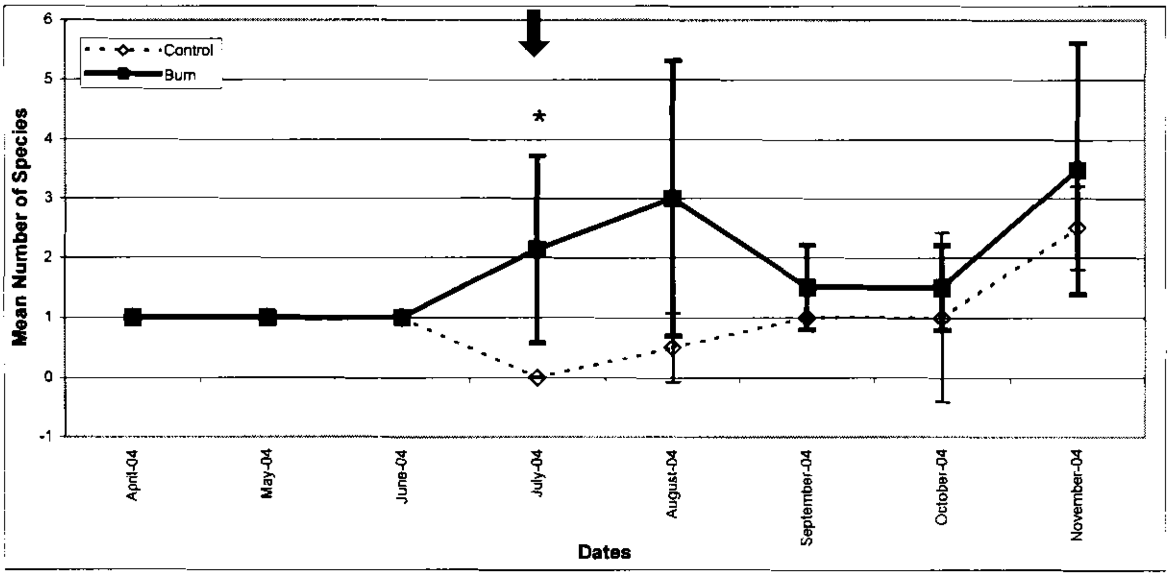

Fig. 3.2.110 The mean number of species in the Other Breeding Guild of Burn 3.

Fig. 3.2.108 to Fig. 3.2.110 show the mean number of species in the Other Breeding Guild of each of the three burns. Burn 1 (Fig. 3.2.108) showed the same number of species between March and April, which was zero, followed by an increase in number of species until October in the Control Site. There was a decrease in November. The Burn Site showed a decrease in number of species between March and April. The numbers were zero between April and May. This was followed by an increase between May and September. There was a decrease in number of species between September and November. The Student T-test showed a significant difference for August.

Burn 2 (Fig. 3.2.109) showed zero number of species between April and May. There was an increase in number of species in the Control Site in June, followed by a decrease in number of species in July. There was a slight increase in August and a decrease in September, until zero number of species. The number of species was the same between September and November. The Burn Site showed a decrease in number of species between April and May, followed by an increase until July. There was a decrease in August and September, until zero. The number of species was the same between September and November. The Student T-test showed no significant difference for Burn 2.

Burn 3 (Fig. 3.2.110) showed a decrease in number of species in the Control Site in July, followed by an increase until September. The number of species was the same between September and October. There was an increase in number of species in November. The Burn Site showed an increase in number of species in July and August, followed by a decrease in September. The numbers were the same between September and November. There was an increase in number of species in November. The Student T-test showed a significant difference for July.

Although the graphs had the same general trends and were close in pattern, they did not correspond completely. Fig. 3.2.108 and Fig. 3.2.110 were closest in pattern. All three burns had an increase in number of species in the Burn Sites directly after the fire. The number of species had the same general trends as the densities (Fig. 3.2.105 to Fig. 3.2.107).

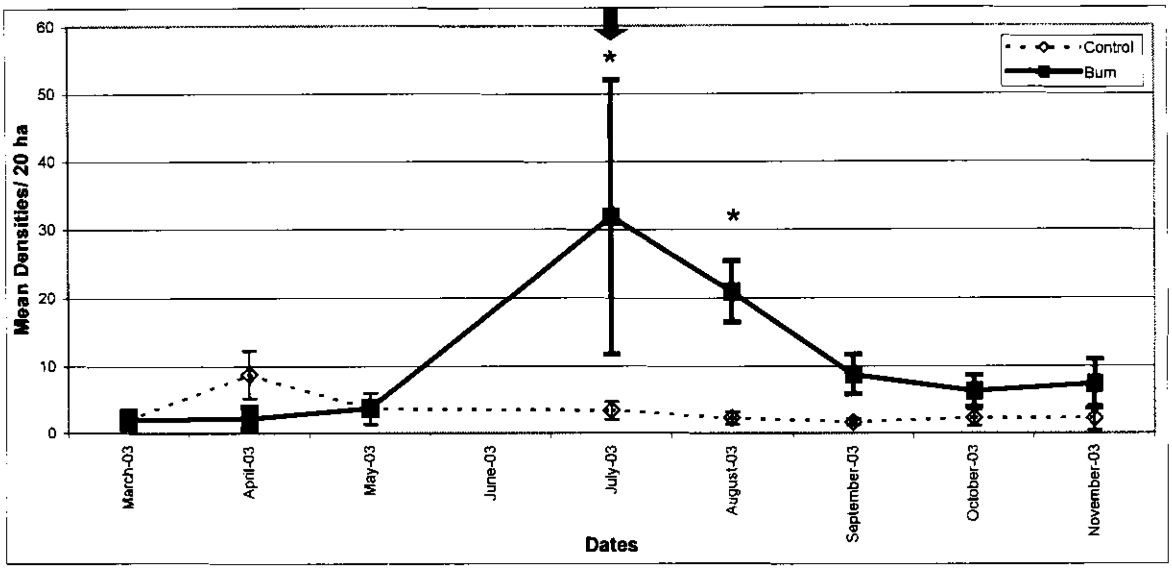

Fig. 3.2.111 The mean density in the Predator Feeding Guild of Burn 1.

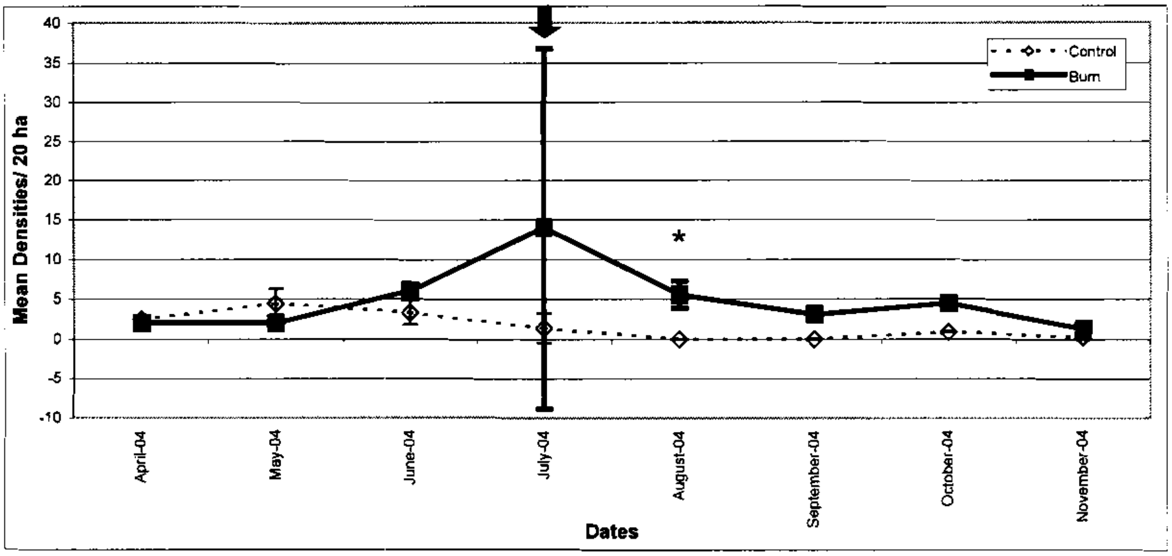

Fig. 3.2.112 The mean density in the Predator Feeding Guild of Burn 2.

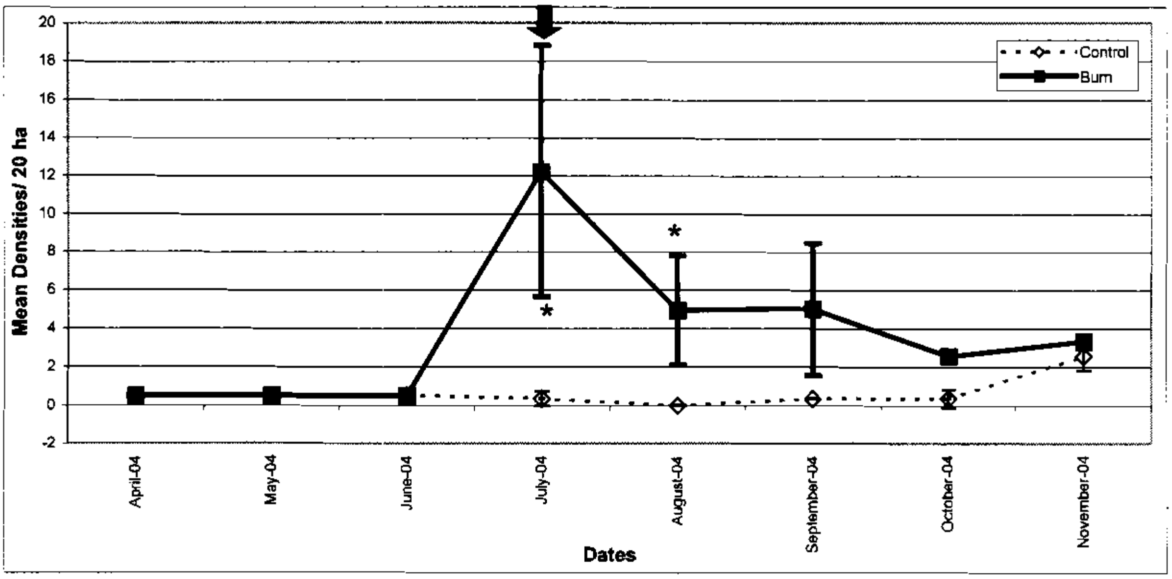

Fig. 3.2.113 The mean density in the Predator Feeding Guild of Burn 3.

3.2.7 Effect of fire on the Feeding Guilds

Fig, 3.2.111 to Fig. 3.2.113 show the mean density in the Predator Feeding Guild of each of the three burns (Chapter 2, Table 2.6.1). Fig. 3.2.111 showed an increase in density between March and April in the Control Site of Burn 1, followed by a decrease in density in May. There was a slight decrease in density between May and July, followed by another decrease in August and September. A slight increase can be seen between September and October. The density was the same between October and November. The Burn Site showed the same density between March and April, followed by a slight increase in May. There was an increase in density between May and July, followed by a decrease between August and October. An increase in density can be seen in November. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.112 showed an increase in density in the Control Site of Burn 2 between April and May, followed by a decrease between June and August. The density was zero from August to September, followed by a slight increase in September and a decrease in November. The Burn Site showed the same density between April and May, followed by an increase in density between May and July. There was a decrease between July and September, followed by a slight increase in October and a slight decrease in density in November. The Control and Burn Sites were almost the same throughout the year except for July. The Student T-test showed a significant difference for August.

Fig. 32.113 showed a slight increase in density in July in the Control Site of Burn 3. There was a slight decrease in density to zero between July and August, followed by a slight increase in September. The density was the same between September and October. There was another increase in density in November. The Burn Site showed a sharp increase in density in July, followed by a decrease in August. The density was the same between August and September. There was another decrease in density in October, followed by an increase in density in November. The density was almost the same for the Control and Burn Sites in November. The Student T-test showed a significant difference for both July and August.

All three burns had the same pattern. There was an increase in density in the Burn Sites directly after the fire and a decrease at the end of the year. The Control and Burn Sites had almost the same density at the end of the year. The density was lower at the end of the year than directly after the fire. All three burns had a significant difference for the Student T-test for August.

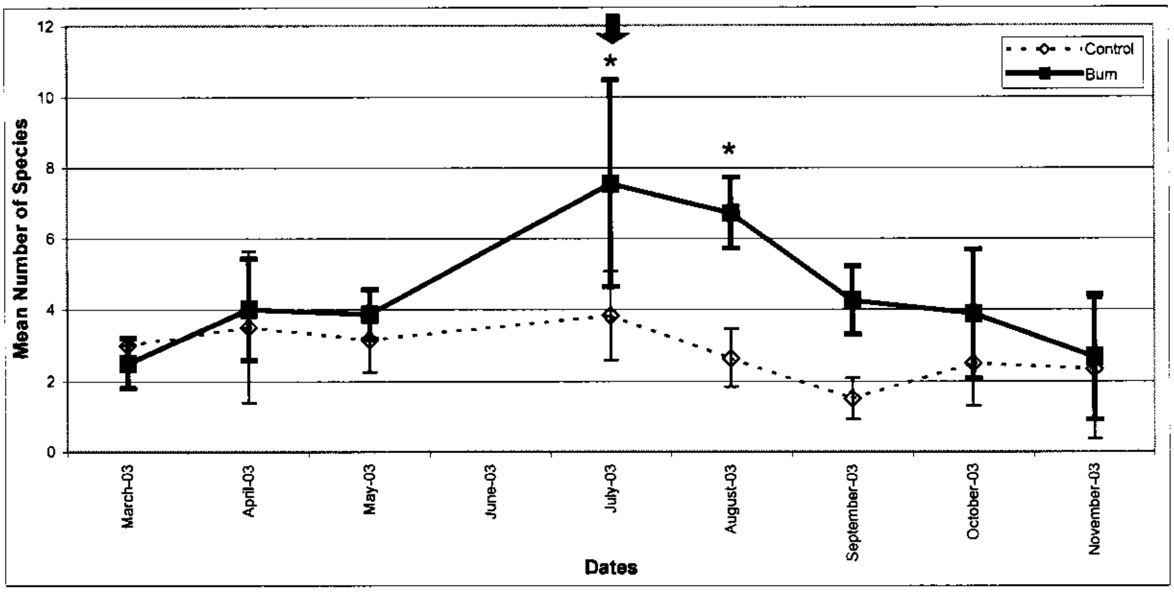

Fig. 3.2.114 The mean number of species in the Predator Feeding Guild of Burn 1.

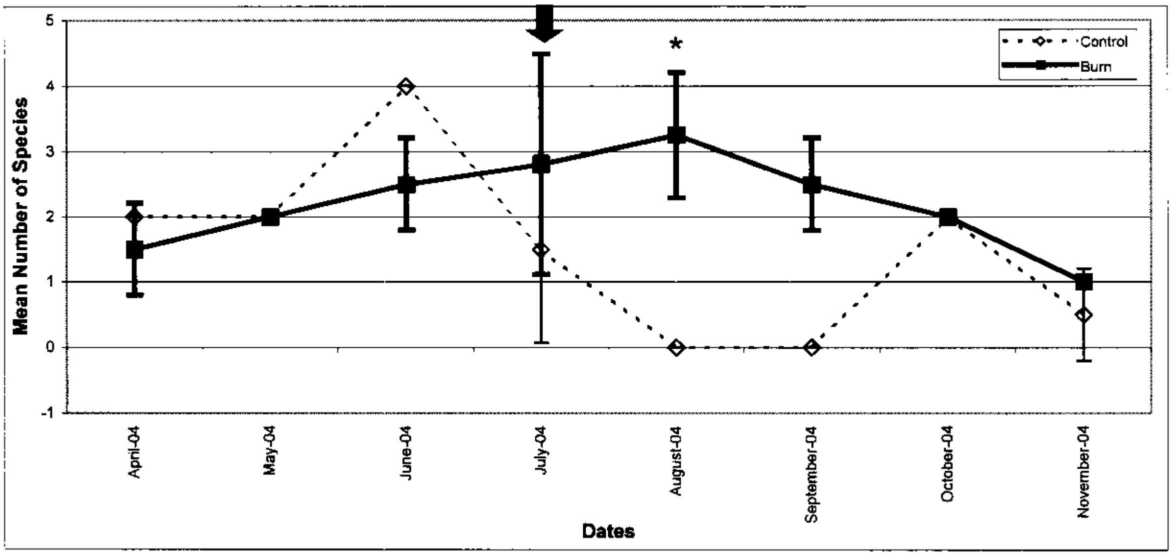

Fig. 3.2.115 The mean number of species in the Predator Feeding Guild of Burn 2.

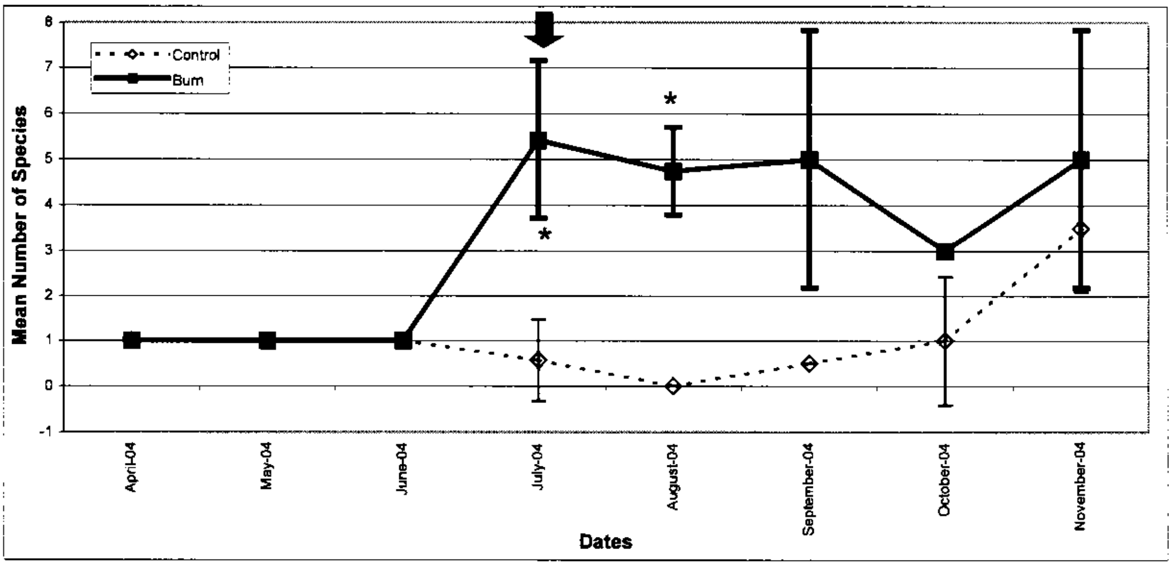

Fig. 3.2.116 The mean number of species in the Predator Feeding Guild of Burn 3.

Fig. 3.2.114 to Fig. 3.2.116 show the mean number of species in the Predator Feeding Guild of each of the three burns. Fig. 3.2.114 showed an increase in number of species between March and April, followed by a decrease in May in the Control Site of Burn 1. The number of species increased between May and July, followed by a decrease between July and September. There was an increase in number of species in October, followed by a very slight decrease in November. The Burn Site showed an increase in number of species between March and April. This was followed by a slight decrease in May and another increase until July. There was a decrease in number of species between July and November. The Student T-test showed a significant difference for both July and August.

Fig. 3.2.115 showed an increase in same number of species between April and May in the Control Site of Burn 2. There was an increase in number of species in June, followed by a decrease until August. There were no species recorded between August and September. There was an increase in number of species in October and a decrease in November. The Burn Site showed an increase in number of species between April and August, followed by a decrease between August and November. The Student T-test showed a significant difference for August.

Fig. 3.2.116 showed a slight decrease in number of species in July in the Control Site of Burn 3, followed by a further decrease in August to zero. This was followed by an increase in number of species in September and October. There was another, sharper increase in number of species in November. The Burn Site showed an increase in number of species in July and a decrease in August. The number of species showed an increase between August and September. There was a decrease in number of species in October, followed by an increase in November. The Student T-test showed a significant difference for both July and August.

All three burns had the same pattern. There was an increase in number of species in the Burn Sites directly after the fire and Burns 1 and 2 (Fig. 3.2.114 and Fig. 3.2.115) had a decrease at the end of the year, while Burn 3 (Fig. 3.2.116) had an increase. All three Control and Burn Sites were close in number of species at the end of the year. All three burns had a lower number of species at the end of the year than directly after the fire. All three burns had a significant difference for the Student T-test for August. The species had the same general trends as the densities (Fig. 3.2.111 to Fig. 3.2.113).

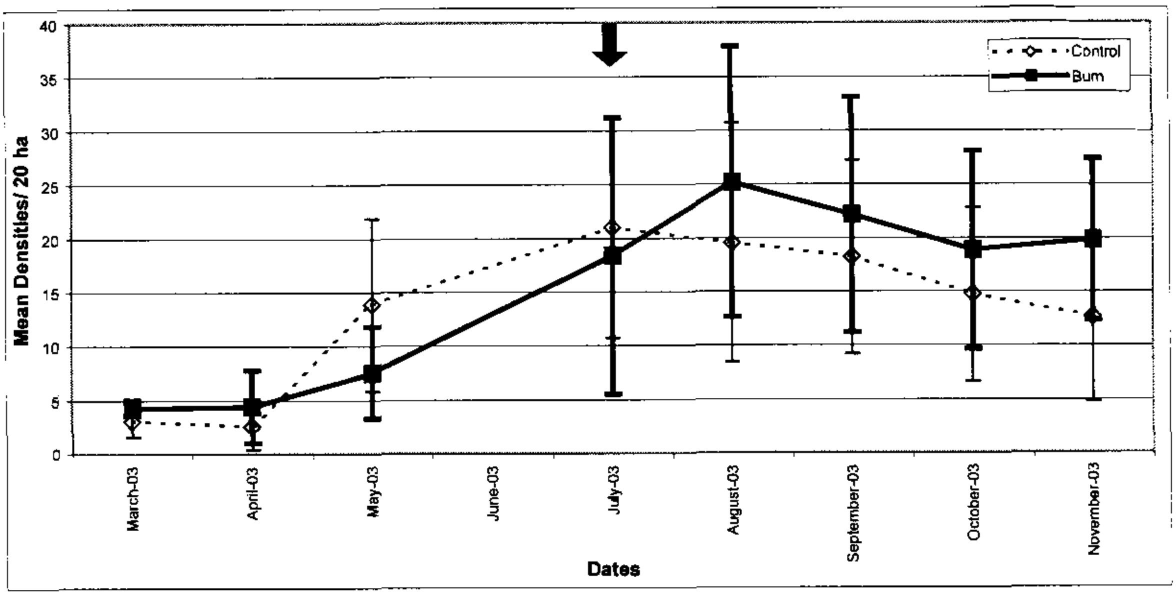

Fig. 3.2.117 The mean density in the Omnivore Feeding Guild of Burn 1.

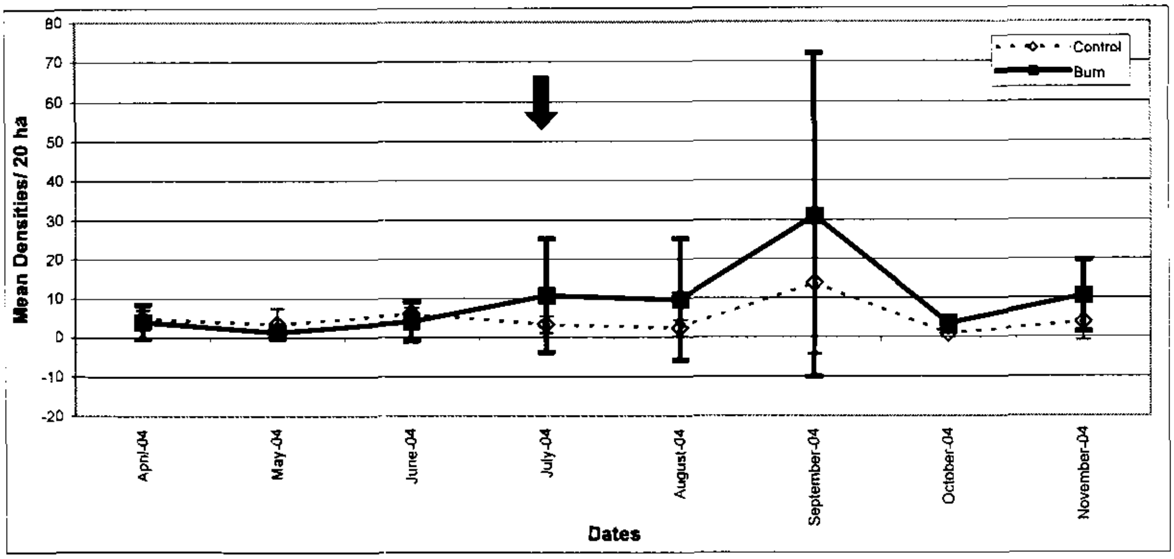

Fig. 3.2.118 The mean density in the Omnivore Feeding Guild of Burn 2.

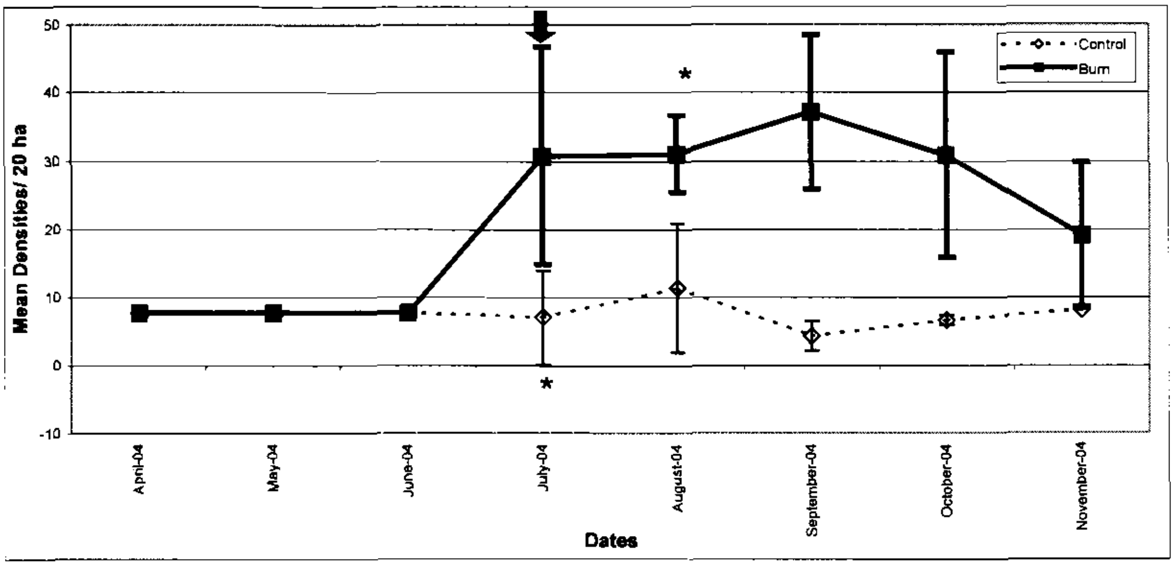

Fig. 3.2.119 The mean density in the Omnivore Feeding Guild of Burn 3.

Fig, 3.2.117 to Fig. 3.2.119 show the mean density in the Omnivore Feeding Guild of each of the three burns. Fig. 3.2.117 showed a slight decrease in density between March and April in the Control Site of Burn 1, followed by an increase in May and another increase until July. There was a decrease in density between July and November. The Burn Site showed an increase in density between March and May, followed by another increase until August. There was a decrease in density in September and again in October, followed by an increase in density in November. The Student T-test showed no significant difference for Burn 1.

Fig. 3.2.118 showed a very slight decrease in density in the Control Site of Burn 2 between April and May, followed by a slight increase in June. There was a slight decrease in density in July and August, followed by an increase in September. The density decreased to almost zero in October and increased again in November. The Burn Site showed a decrease in density between April and May, followed by an increase in June. There was a very slight decrease between July and August, followed by an increase in density in September. There was a decrease in density between September and October and an increase in November. The Control and Burn Sites were almost the same between April and June. The Student T-test showed a significant difference for August.

Fig. 3.2.119 showed a slight decrease in density in July in the Control Site of Burn 3. There was an increase in density between July and August, followed by a decrease in September. The density increased between September and November. The Burn Site showed an increase in density in July, followed by a very slight decrease in August and another increase in September. There was a decrease in density between September and November. The Student T-test showed a significant difference for both July and August.

All three graphs had the same pattern. There was an increase in density in the Burn Sites directly after the fire and Burns 1 and 2 (Fig. 3.2.117 and Fig. 3.2.118) had an increase at the end of the year, while Burn 3 (Fig. 3.2.119) had a decrease. All three Control and Burn Sites were close in density at the end of the year. Only Burn 3 had a significant difference for the Student T-test.

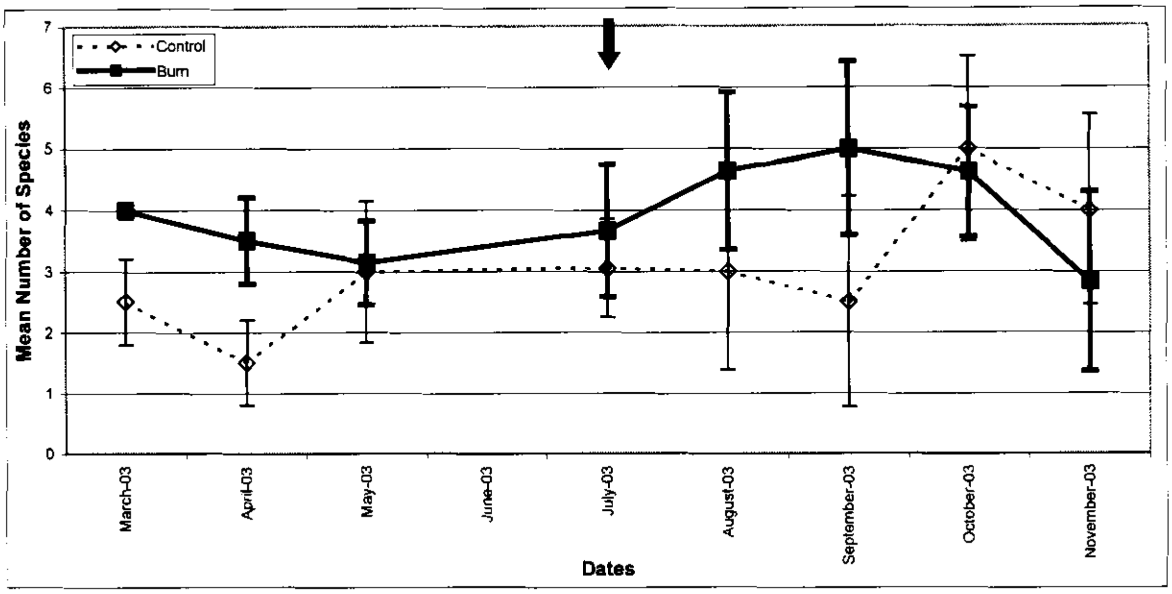

Fig. 3.2.120 The mean number of species in the Omnivore Feeding Guild of Burn 1.

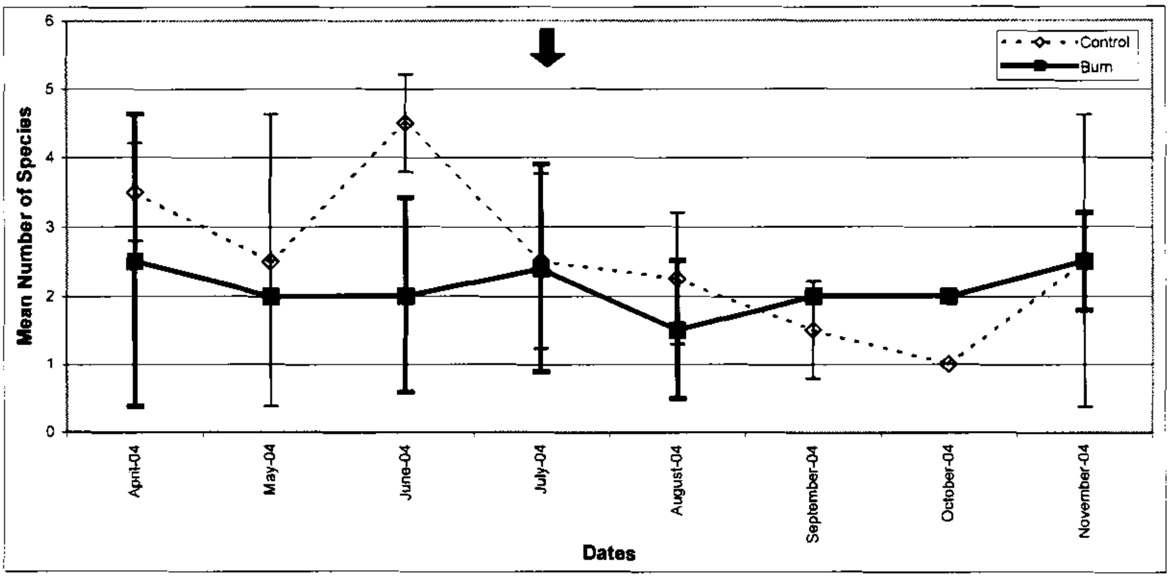

Fig. 3.2.121 The mean number of species in the Omnivore Feeding Guild of Burn 2.

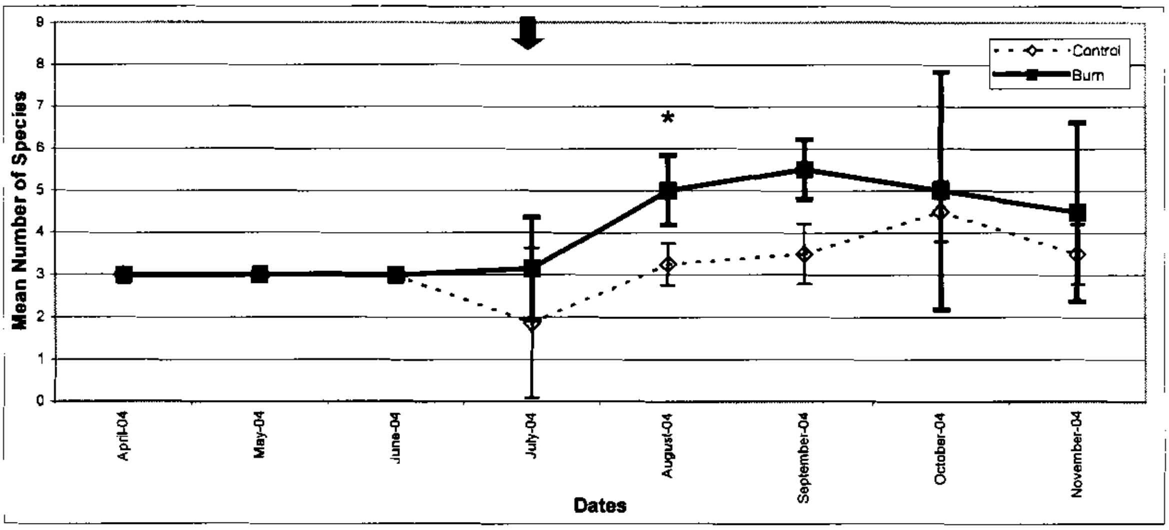

Fig. 3.2.122 The mean number of species in the Omnivore Feeding Guild of Burn 3.

Fig. 3.2.120 to Fig. 3.2.122 show the mean number of species in the Omnivore Feeding Guild of each of the three burns. Fig. 3.2.120 showed a decrease in number of species between March and April, followed by an increase in May in the Control Site of Burn 1. There was another increase in number of species between May and July, followed by a decrease between July and September. There was an increase in number of species in October, followed by a decrease in November. The Burn Site showed a decrease in number of species between March and May. There was an increase in number of species between May and July, followed by another increase in August and September. This was followed by a decrease between September and October and another decrease in number of species in November. The Student T-test showed no significant difference for Burn 1.

Fig. 3.2.121 showed a decrease in number of species in May in the Control Site of Burn 2 and an increase in June. There was a decrease in number of species in July and another between July and October. There was an increase in number of species in November. The Burn Site showed a decrease in number of species between April and May. The numbers were the same between May and June, followed by an increase in July. There was a decrease in number of species between July and August and an increase in September. The number of species was the same between September and October. There was an increase in November. The Student T-test showed no significant difference for Burn 2.

Fig. 3.2.122 showed a decrease in number of species in July in the Control Site of Burn 3, followed by an increase between July and October. There was a decrease in number of species in November. The Burn Site showed an increase in number of species between July and September and a decrease between September and November. The Student T-test showed a significant difference for August.

Fig. 3.2.120 and Fig. 3.2.122 had the same pattern. Both had an increase in number of species in the Burn Sites after the fire and a decrease at the end of the year. Fig. 3.2.121 had an increase directly after the fire, followed by a decrease. It ended the year in an increase. All three Control and Burn Sites had almost the same number of species at the end of the year. Only Burn 3 (Fig. 3.2.123) had a significant difference for the Student T-test. Fig. 3.2.120 and Fig. 3.2.122 had the same general trends as Fig. 3.2.117 and Fig. 3.2.119.

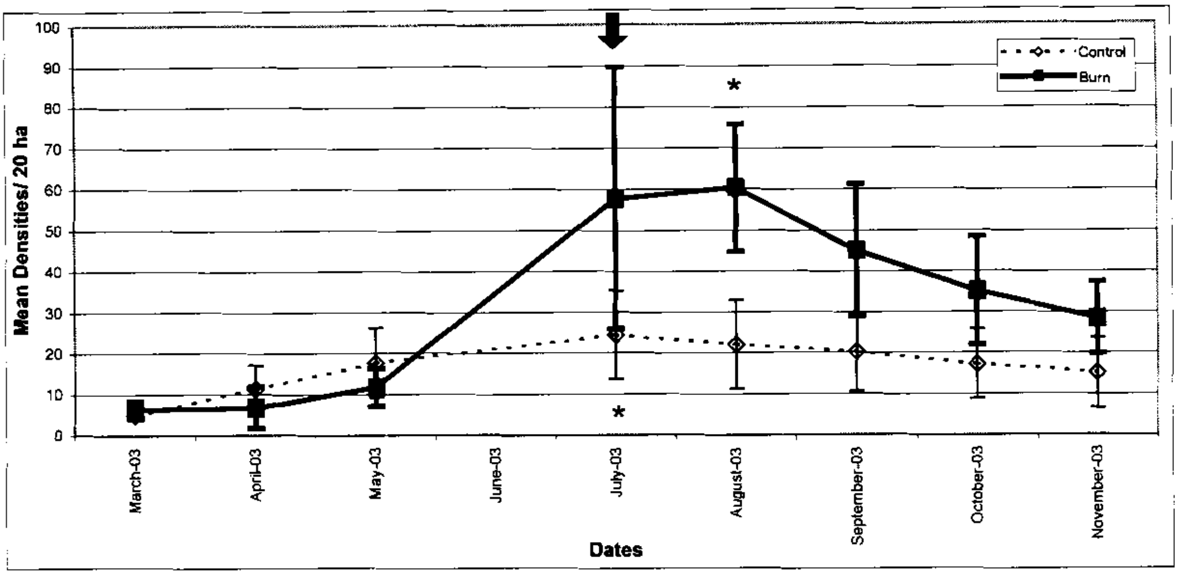

Fig. 3.2.123 The mean density in the Terrestrial Habitat Feeding Guild of Burn 1.

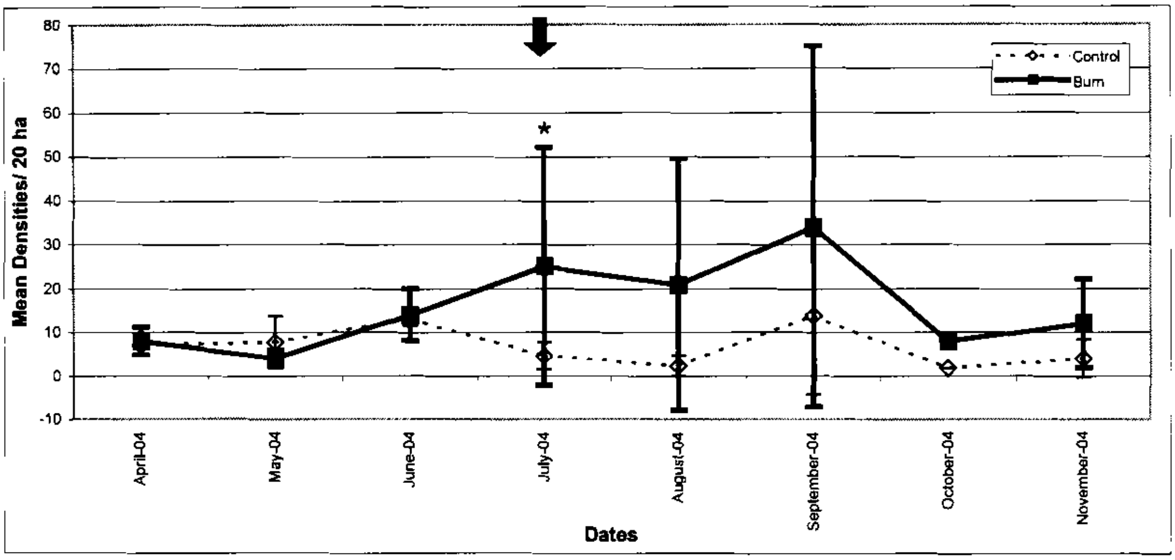

Fig. 3.2.124 The mean density in the Terrestrial Habitat Feeding Guild of Burn 2.

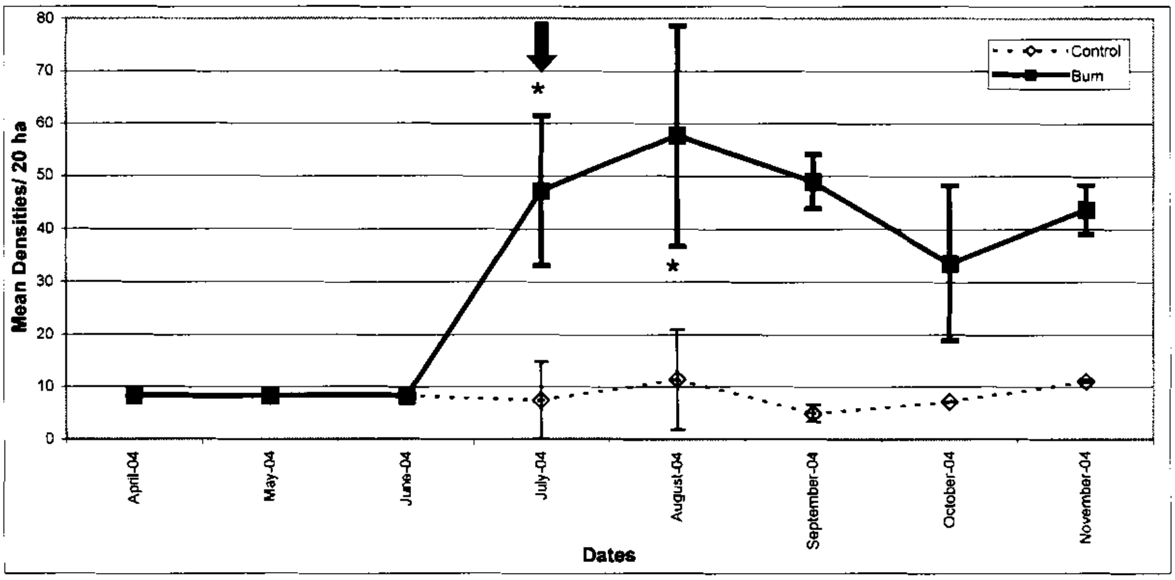

Fig. 3.2.125 The mean density in the Terrestrial Habitat Feeding Guild of Burn 3.

3.2.8 Effect of fire on the Habitat Feeding Guilds

Fig. 3.2.123 to Fig. 3.2.125 show the mean density in the Terrestrial Habitat Feeding Guild of each of the three burns. The Habitat Feeding Guild has been shortened to Habitat Guild in Table 2.6.1 (Chapter 2). There were only two groups, namely those that caught their food on the ground (such as lapwings and chats) and those that caught their food in or from the air (such as swallows and swifts). The densities and species were then calculated.

In Fig. 3.2.123 Burn 1 showed an increase in density between March and July in the Control Site, followed by a decrease between August and November. The Burn Site showed the same density between March and April, followed by an increase in density between April and May and another, sharper increase in July. There was a smaller increase in August. There was a decrease in density between August and November. The Student T-test showed a significant difference for both July and August.

In Fig. 3.2.124 Burn 2 showed a very slight increase in density in the Control Site between April and June, followed by a decrease between June and August. There was an increase in density in September and a decrease in October. The year ended in an increase in density in November. The Burn Site showed a decrease in density between April and May, followed by an increase between May and July. There was a decrease in August, followed by an increase in density in September. There was another decrease in density in October and the year ended in an increase in November. The Control and Burn Sites were almost the same between April and June. The Student T-test showed a significant difference for July.

In Fig. 3.2.125 Burn 3 showed a slight decrease in density in the Control Site in July. There was an increase in density between July and August, followed by a decrease in September. The density increased between September and November. The Burn Site showed an increase in density in July, followed by another increase in August. There was a decrease in density between August and October, followed by an increase in November. The Student T-test showed a significant difference for both July and August.

All three graphs had the same pattern. There was an increase in density in the Burn Sites after the fire. Burns 2 and 3 (Fig. 3.2.124 and Fig. 3.2.125) had an increase at the end of the year, while Burn 1 (Fig. 3.2.123) had a decrease. Burns 1 and 2's Control and Burn Sites were closer in density than Burn 3. All three burns had lower densities at the end of the year than directly after the fire. All three burns had a significant difference for the Student T-test directly after the fire.

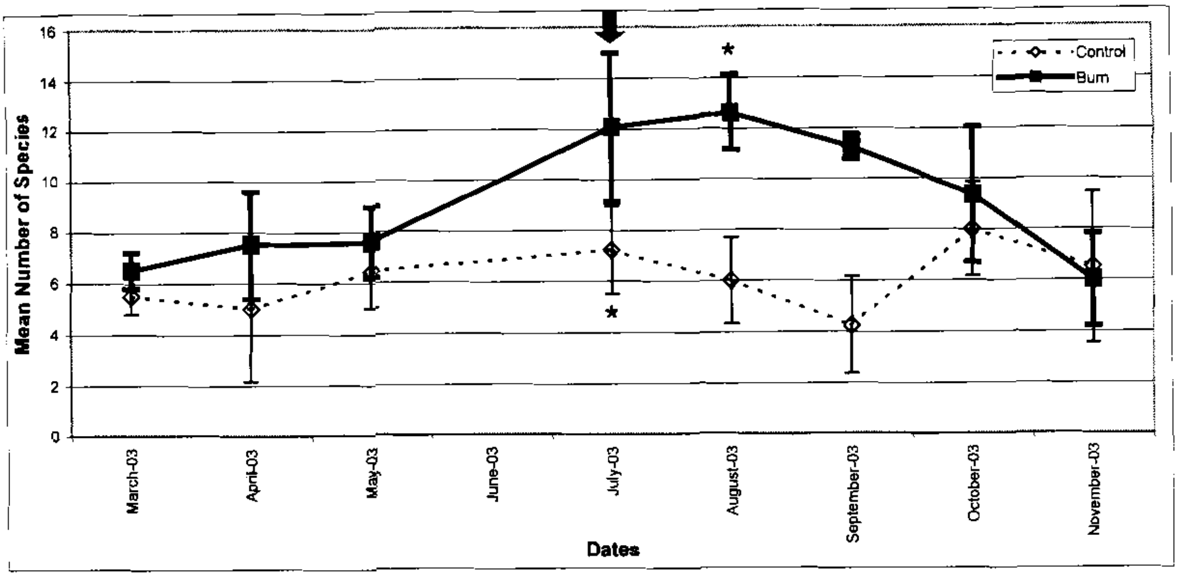

Fig. 3.2.126 The mean number of species in the Terrestrial Habitat Feeding Guild of Burn 1.

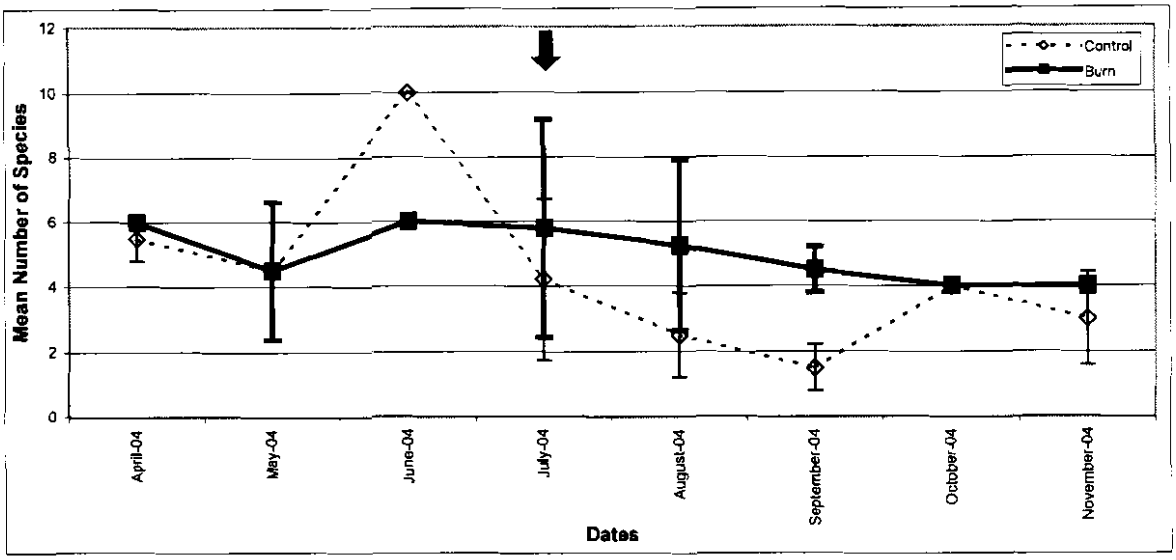

Fig. 3.2.127 The mean number of species in the Terrestrial Habitat Feeding Guild of Burn 2.

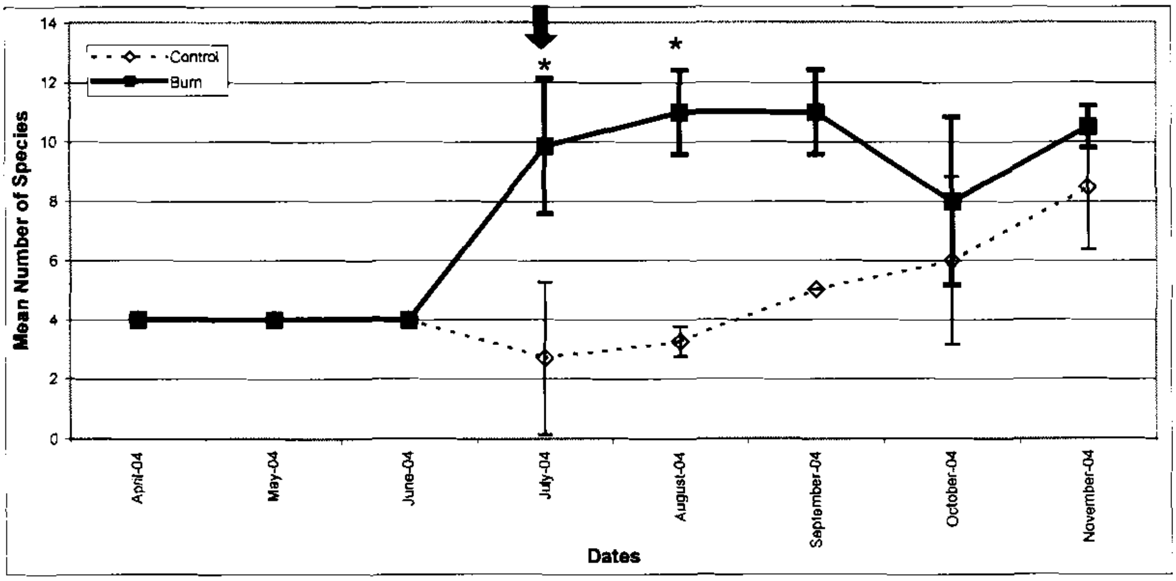

Fig. 3.2.128 The mean number of species in the Terrestrial Habitat Feeding Guild of Burn 3.

Fig. 3.2.126 to Fig. 3.2.128 show the mean number of species in the Terrestrial Habitat Feeding Guild of each of the three burns. In Fig. 3.2.126 Burn 1 showed a decrease in number of species between March and April, followed by an increase in May in the Control Site. There was another increase in number of species between May and July, followed by a decrease between July and September. This was followed by an increase in October and another decrease in November. The Burn Site showed an increase in number of species between March and April and the same number of species between April and May. There was an increase in number of species between May and August, followed by a decrease between August and November. The Student T-test showed a significant difference for both July and August.

In Fig. 3.2.127 Burn 2 showed a decrease in number of species between April and May and an increase in June. There was a decrease in number of species between June and September, followed by an increase in October and another decrease in November. The Burn Site showed a decrease in number of species between April and May, followed by an increase in June and a decrease in number of species between June and November. The Student T-test showed no significant difference for Burn 2.

In Fig. 3.2.128 Burn 3 showed a decrease in number of species in the Control Site in July, followed by an increase between July and November. The Burn Site showed an increase in number of species in July, followed by another increase between July and September. There was a decrease in number of species in October and an increase in November. The Student T-test showed a significant difference for both July and August.

All three burns had the same pattern. There was an increase in number of species in the Burn Sites after the fire. Burns 1 and 2 (Fig. 3.2.126 and Fig. 3.2.127) had a decrease at the end of the year, while Burn 3 (Fig. 3.2.128) had an increase. All three Control and Burn Sites were closer in numbers of species at the end of the year. All three burns had lower numbers at the end of the year than directly after the fire. Burns 1 and 3 (Fig. 3.2.126 and Fig. 3.2.128) had a significant difference for the Student T-test after the fire. The species had the same general trends as the densities (Fig. 3.2.123 to Fig. 3.2.125).

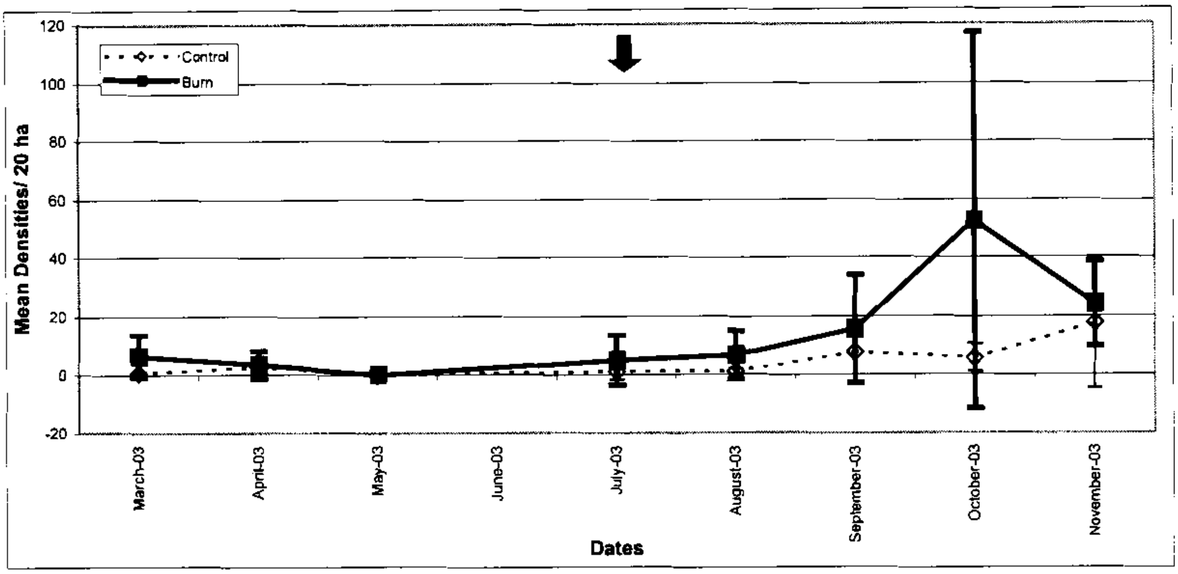

Fig. 3.2.129 The mean density in the Aerial Habitat Feeding Guild of Burn 1.

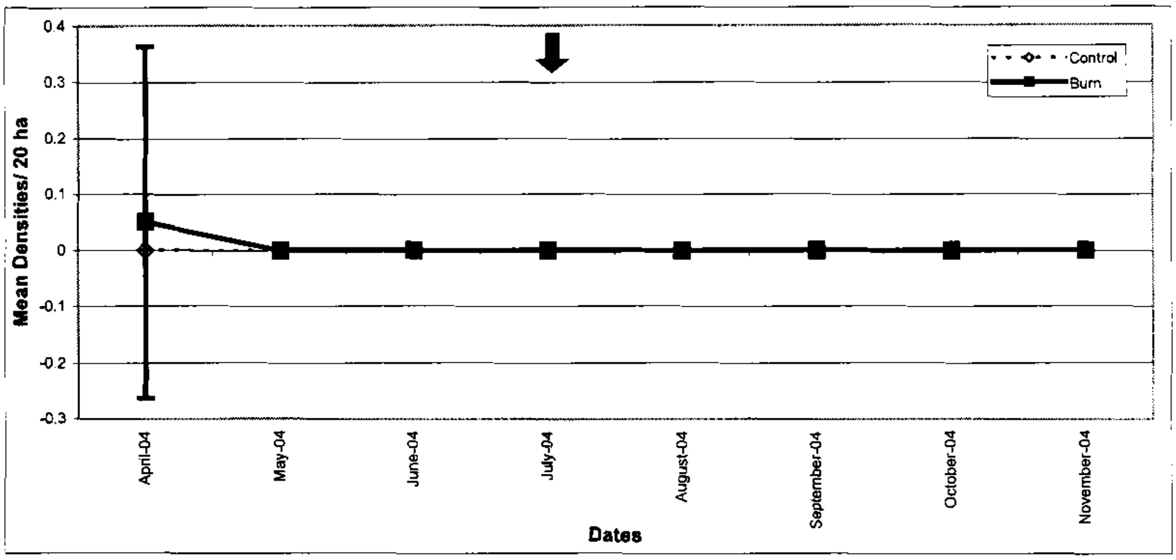

Fig. 3.2.130 The mean density in the Aerial Habitat Feeding Guild of Burn 2.

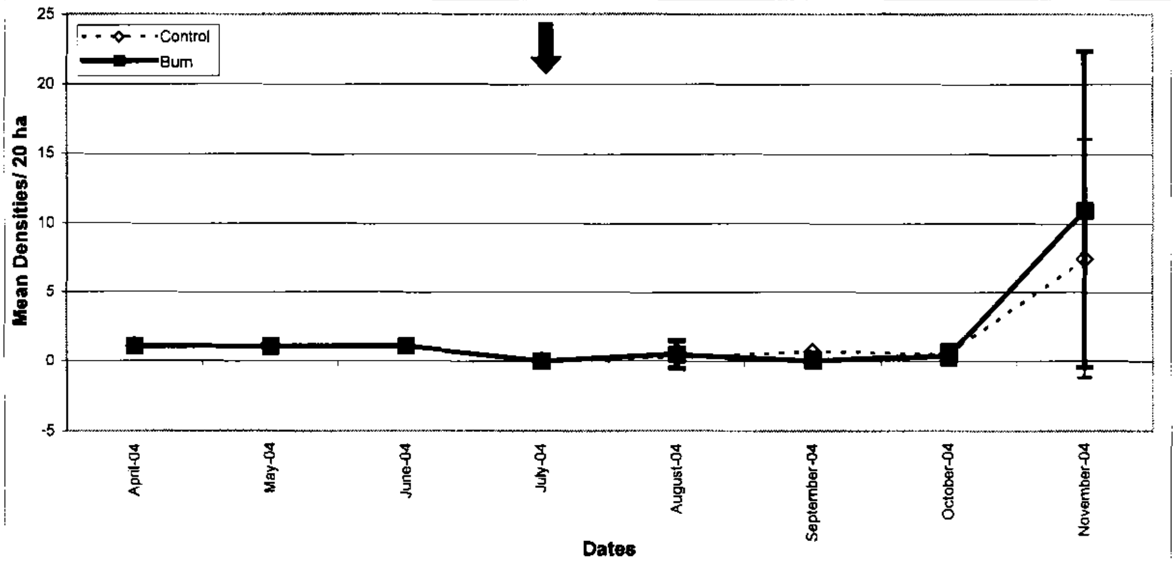

Fig. 3.2.131 The mean density in the Aerial Habitat Feeding Guild of Burn 3.

Fig, 3.2.129 to Fig. 3.2.131 show the mean density in the Aerial Habitat Feeding Guild of each of the three burns. In Fig. 3.2.129 Burn 1 showed an increase between March and April. There was a decrease in density in May in the Control Site of the Aerial Habitat Feeding Guild. There was a slight increase in density in July. July and August had the same density. This was followed by another increase in September. There was a decrease in density between September and October and an increase in November. The Burn Site showed a decrease in density between March and May. There were zero density in May and this was followed by an increase between May and July and another increase between July and October. There was a decrease in density in November. The Student T-test showed no significant difference for Burn 1.

In Fig. 3.2.130 Burn 2 had low densities in April and showed zero density for the rest of the year. The same could be seen in the Burn Site, although there were larger densities in April. The Student T-test showed no significant difference Burn 2.

In Fig. 3.2.131 Burn 3 showed a decrease in density in the Control Site in July, There was an increase in density between July and August, followed by another increase in September. The density decreased between September and October and increased in November. The Burn Site showed a decrease in density in July, followed by an increase in August. There was a decrease in density between August and September, followed by an increase in October and another increase in November. The Control and Burn Sites were very close in density throughout the year. The Student T-test showed no significant difference for Burn 3.

Fig. 3.2.130 and Fig. 3.2.131 had similar patterns. Both had a decrease in densities in the Burn Sites after the fire, while Fig. 3.2.129 had an increase. All three Control and Burn Sites did not have much difference between them. Only Burn 3 (Fig. 3.2.131) ended the year with an increase in numbers. None of the three burns had a significant difference for the Student T-test.

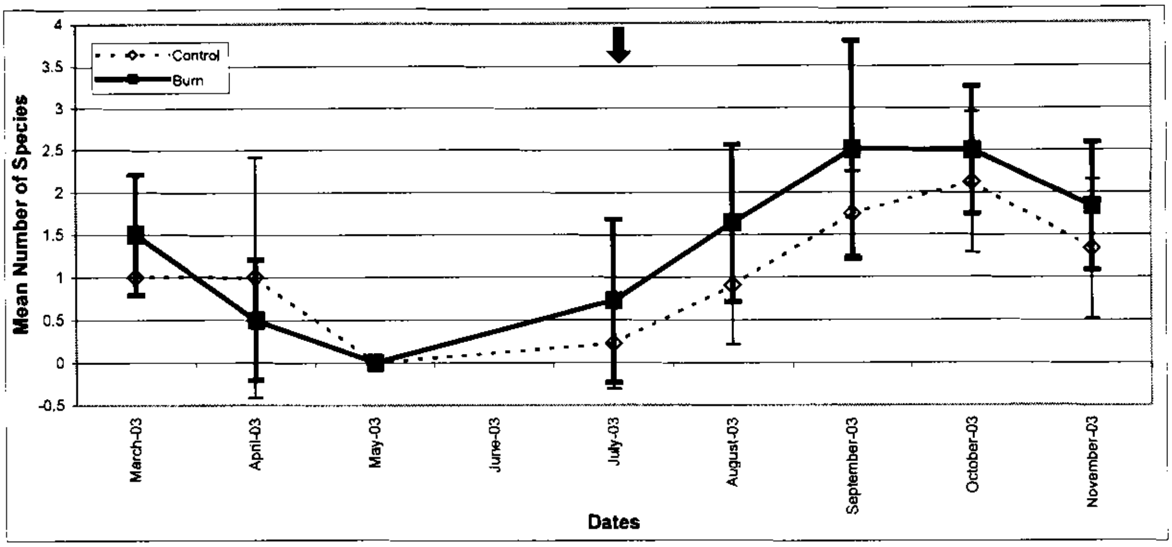

Fig. 3.2.132 The mean number of species in the Aerial Habitat Feeding Guild of Burn 1.

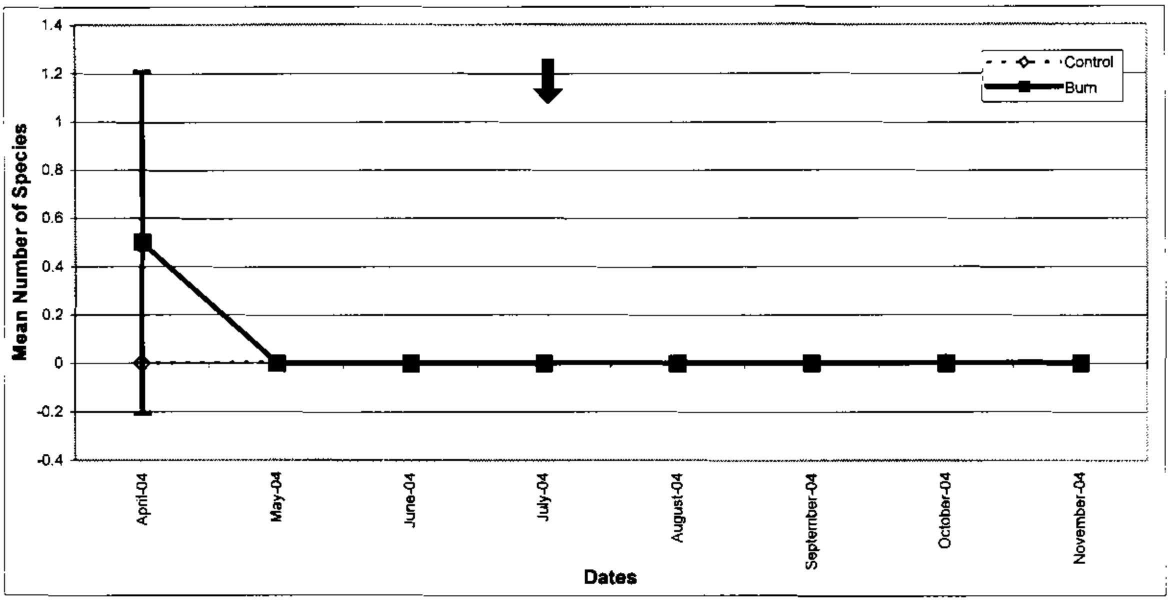

Fig. 3.2.133 The mean number of species in the Aerial Habitat Feeding Guild of Burn 2.

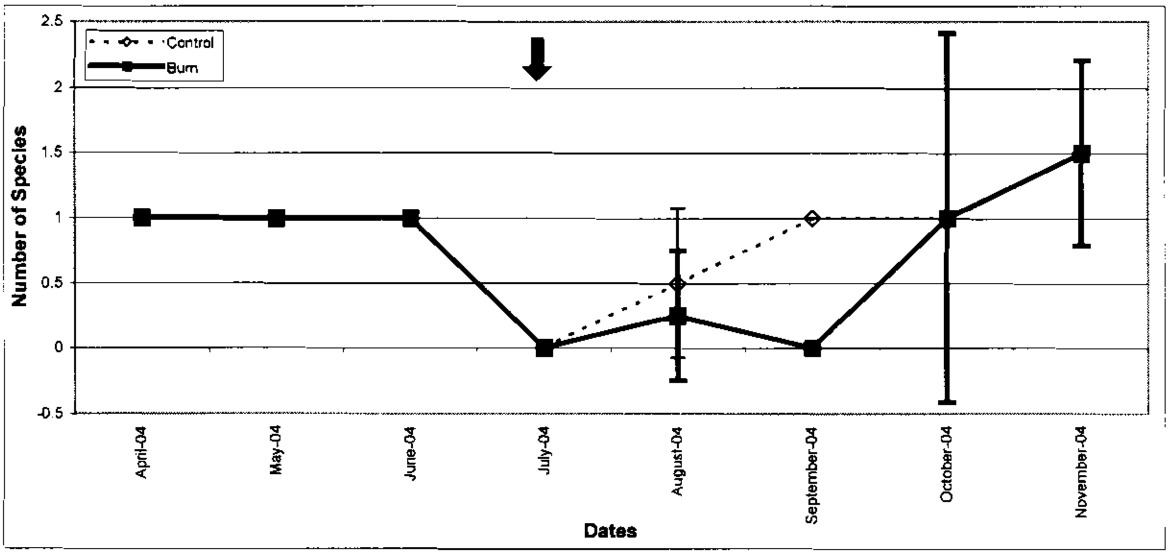

Fig. 3.2.134 The mean number of species in the Aerial Habitat Feeding Guild of Burn 3.

Fig. 3.2.132 to Fig. 3.2.134 show the mean number of species in the Aerial Habitat Feeding Guild of each of the three burns. In Fig. 3.2.132 Burn 1 showed the same number of species for March and April in the Control Site. There was a decrease in number of species between April and May, followed by an increase between May and July. There was another increase in number of species between July and October, followed by a decrease in November. The Burn Site showed a decrease in number of species between March and April and an increase between April and September. The number of species was the same between September and October and this was followed by a decrease in November. The Student T-test showed no significant difference for Burn 1.

In Fig. 3.2.133 Burn 2 showed a small number of species in April and zero number of species for the rest of the year. The same was seen in the Burn Site, but with a larger number of species in April. The Student T-test showed no significant difference for Burn 2.

In Fig. 3.2.134 Burn 3 showed a decrease in number of species to zero in the Control Site in July, followed by an increase between July and September. The number of species was the same between September and October. There was an increase in number of species in November. The Burn Site showed a decrease in number of species in July and an increase between July and August. There was a decrease in numbers in September, followed by an increase in October and another increase in November. The Burn and Control Sites had the same numbers in July, October and November (not visible on graph). The Student T-test showed no significant difference for Burn 3.

None of the graphs had the same patterns. Burn 1 (Fig. 3.2.132) showed an increase in number of species in the Burn Sites after the fire and a decrease at the end of the year. Burn 2 (Fig. 3.2.133) had a decrease after the fire. Burn 3 (Fig. 3.2.134) also had a decrease after the fire and had an increase at the end of the year. All three Control and Burn Sites were close in number of species. None of the three burns had a significant difference for the Student T-test. Fig. 3.2.133 had the same pattern as Fig. 3.2.130.

Chapter 4: Discussion and Conclusion

"The power of flight gave birds the edge over most other creatures. They could travel further and wider in search of food and live where no other creature could go. Millions of years of evolution have adapted each bird species to fit into its own little niche and pre-programmed it to feed, to migrate, to nest and breed in its own particular place and manner. Birds have adapted so well to the demands of and trials set by our planet that Sir David Attenborough believes they may be the most successful creatures on earth, more successful even than insects." Davies (2003)

This chapter deals with the discussion of the materials and methods, the data and literature and the conclusions of the study. A few recommendations on future studies and methods, as well as burning at Barberspan will be made at the end of the chapter.

4.1 Sources of bias

There are a number of different methods available to count birds in fire and ecological studies, but point and transect counts seemed to be preferred above the others (Mills, 2004; Pons, Lambert, Rigolot & Prodon, 2003; Herrando, Brotons, Del Amo & Llacuna, 2002; Bibby *et al.*, 2000; Davis *et al.*, 2000; Jansen, Little & Crowe, 1999; Madden, Hansen & Murphy, 1999; Reynolds & Krausman, 1998; Robel *et al.*, 1998; Van't Hul *et al.*, 1997 and Pons & Prodon, 1996).

I decided on the point count method because of the initially planned size and shapes of the areas to be burned. The open nature of the grassland would also have made movement of the observer using transects much more conspicuous, because I had to move between points. The resultant disturbance of my movement between points was compensated for, by waiting 5 minutes at each point before counting.

With hindsight it was obvious that counts should have lasted only 10 minutes (Bibby *et al*, 2000). I started with the 20-minute count because there was only one burn to start with. With the fire burning out of control, a second Burn (Burn 2) had to be planned for the next year. When Burn 3 was opportunistically added, as well as the addition of the midday and evening counts for Burns 2 and 3, it was not possible to collect all the post-fire data with 20-minute counts. I therefore had to revert to 10-minute counts in the second year of the study (Chapter 2.5). The data was converted to density, as described in Chapter 2, to make the data between the three burns comparable. Although some bias might have been introduced by the conversion, the temporal trends were much larger than this, and therefore not obscuring the eventual findings. The conversion was also based on specially planned timed counts.

Another bias might have been the detectability of birds. Smaller birds become less detectable with an increase in distance from the observer (Bibby *et al*, 2000) at a rate faster than for larger birds. Together with the reduction in vegetation due to the fires in the Burn Sites, as compared to the Control Sites where the vegetation remained, birds would become more detectable in the Burn Sites, adding to the bias. Conversion of the data using techniques such as distance sampling for each bird, and then using a programme such as Distance 5, to correct for detectability per species per site was not done in this study. The main reason was that Distance requires a good number of observations per bird specie per site for conversion to densities. The only species for which large numbers were available were for Quelea and swallows, which were easily and accurately counted (Quelea were always in swarms with a maximum of about 100, swallows were counted in flight, and therefore not amenable to distance measurement), and Helmeted Guineafowl, that are large enough for easy and accurate counting. Also, observation conditions were very good, and the radius that was sampled was relatively small. In addition, when inspecting Tables 3.2.2 and 3.2.3, it is obvious that some of the larger species increased in numbers after the fire (Helmeted Guineafowl and Blacksmith Lapwing), but the numbers of other large species became less or even disappeared, such as the Long-tailed Widowbird. On the other hand, some smaller species also changed in numbers; some increasing, such as the African Pipit and Red-capped Lark, while the Zitting Cisticola disappeared completely after the fire at all three Burn Sites. The Black-chested Prinia seemed to be quite site-tenacious at some of the Burn Sites, indicating good observation conditions. This shows that the methods used were adequate (although not perfect) in determining the relative changes in bird densities and species, with respect to fires, in grasslands, such as at Barberspan.

4.2 Discussion of data

The data will be discussed and compared under different subject headings. Under each subject heading I will discuss the associated data and compare the three burns. Where relevant, I will also compare across the different subject headings.

4.2.1 Effect of fire on the density of birds

The graphs addressing number of birds (measured as density – number of birds/20 ha) include Fig. 3.2.1 to Fig. 3.2.2, Fig. 3.2.9 to Fig. 3.2.16, Fig. 3.2.25 to Fig. 3.2.31, Fig. 3.2.39 to Fig. 3.2.41, Fig. 3.2.45 to Fig. 3.2.47, Fig. 3.2.65 and Fig. 3.2.68.

All three burns (Fig. 3.2.9 to Fig. 3.2.11) showed the same general trends, namely an increase in the densities after the fire and a decrease towards the end of the year (Herrrando *et al.*, 2002 and Robel *et al.*, 1998). When analysed according to birds being present before and after the fire (Fig. 3.2.25 to Fig. 3.2.27), again the same general pattern for each of the three burns, as illustrated in Fig. 3.2.9 to Fig. 3.2.11, was evident. The pre-fire densities showed little variation, while the post-fire data clearly showed an increase in the densities after the fire, which returned to pre-fire levels at the end of the year. As the vegetation recovered and food abundance or availability and other conditions returned to pre-fire levels, the birds that frequented the burn areas reduced in numbers.

The densities from Burn 1's second year (Fig. 3.2.12, both Control and Burn) were closer to the pattern before the fire (Fig. 3.2.9), showing a return to pre-fire levels after the vegetation had recovered. There was, however, an increase in numbers again at the end of 2004 (September to November) in the burned area (Fig. 3.2.12). From my observations the burned area was slightly greener during this time when compared with the control area (possibly due to the fire more than a year ago), although no vegetation measurements were taken. Although there is no direct explanation for this increase, it does indicate the possibility that the effects of a fire might be more extended, and that longer periods of surveys are required to determine the duration of the effect of a fire on bird numbers in grasslands.

The morning, midday and evening counts (Fig. 3.2.9 to Fig. 3.2.11 and Fig. 3.2.13 to Fig. 3.2.16) had the same trends, although the densities were less at midday and in the evening, when compared with the morning surveys. The differences between the Control and Burn Sites (Fig. 3.2.39) showed that Burns 2 and 3 were close with regard to the magnitude of change in bird numbers, although Burn 1 had a similar pattern, but attracted more birds. The midday and evening data (Fig. 3.2.40 and Fig. 3.2.41) also showed that Burns 2 and 3 had comparable trends. The percentages (Fig. 3.2.45 to Fig. 3.2.47) of Fig. 3.2.39 to Fig. 3.2.41 showed that all three burns had the same pattern.

All the analyses of changes in bird numbers (Fig. 3.2.9 to Fig. 3.2.16, Fig. 3.2.25 to Fig. 3.2.31, Fig. 3.2.39 to Fig. 3.2.41, Fig. 3.2.45 to Fig. 3.2.47, Fig. 3.2.65 and Fig. 3.2.68) showed an increase in densities in the Burn Sites, while the numbers in the control areas remained fairly constant, or decreased slightly. This strongly indicates that fire does have an effect on the bird numbers. The fire attracted more birds to the area, presumably because of a combination of increase in food abundance or availability, newly available habitat or breeding opportunities. The fire killed insects, small mammals and reptiles, creating a food source for herons and other carnivorous and insectivorous birds (Dean, 1987; Searle, 1982; Barbour, 1968 and Paintin, 1965). When this immediate food source was gone, some of the birds left again. Others came or stayed to make use of the newly available habitat and breeding opportunities. These post-fire colonisers left once the vegetation recovered from the fire.

The increase in numbers, evident from the graphs, were mainly caused by swallows, swifts and Helmeted Guineafowl (*Numida meleagris)*, but also by the Crowned Lapwing (*Vanellus coronatus)*, which were attracted by the sudden food abundance or availability and habitat. Therefore, fire clearly had an effect on the densities at Barberspan, as evidenced by the differences between the Burn and Control Sites; but this effect was only temporary. The densities increased in the Burn Sites after the fire and later returned to pre-fire levels and composition as the vegetation started to recover. I therefore found that the effect of fire on the densities in grasslands such as at Barberspan was only temporary, as was also found by Reynolds and Krausman, (1998), Robel *et al.* (1998), and Van't Hul *et al.* (1997). However, even though the effect seemed to have been temporary, masked by regrowth of the grass in the summer in both Burn and Control Sites, the results from Burn 1 suggest that longer-term effects (two years or longer) might be possible. The reason for this might be the removal of moribund grass by the fire in the Burn Sites, while these were left in the Control Sites (remember that there are no large grazers in the Barberspan Nature Reserve). This removal effect might have been carried over to the next season.

4.2.2 Effect of fire on species richness

The graphs and tables addressing number of species include Fig. 3.2.3 to Fig. 3.2.8, Table 3.2.2 to Table 3.2.4, Fig. 3.2.17 to Fig. 3.2.24, Fig. 3.2.32 to Fig. 3.2.38, Fig. 3.2.42 to Fig. 3.2.44 and Fig. 3.2.48 to Fig. 3.2.50.

Fig. 3.2.3 to Fig. 3.2.8 showed which of the species frequented the Control Site more than the Burn Site after the fire. This is made clearer in Tables 3.2.2 to 3.2.4. The species marked in grey showed a positive reaction to the fire. They were attracted to the Burn Sites after the fire and most stayed until the end of the year. The species marked with grey could therefore be regarded as post-fire colonisers. They arrived after the fire had occurred and took advantage of the change in conditions. The same trend was also found by Pons and Prodon (1996).

The species marked in yellow (Tables 3.2.2 to 3.2.4) also reacted positively to the fires, although there were burns where they did not appear. They seemed to prefer vegetation cover rather than open ground, but took the opportunity during the day to take advantage of the sudden abundance or availability of food at two of the burns. I observed that when raptors approached, they returned to the cover of the vegetation in the adjacent Control Sites or unburned areas. They can therefore not be regarded as post-fire colonisers, but rather as post-fire opportunists.

The species that are marked with green (Tables 3.2.2 to 3.2.4) showed a negative reaction (fire-sensitive) to all the fires and chose to stay in the vegetation cover of the Control Sites. They were sensitive to the fire and were likely affected by the fire because of the loss of vegetation cover. The Black-chested Prinia (*Prinia flavicans*) appeared quite site tenacious at Burn 3. It stayed in the area even after the burn and can be considered site-tenacious, as was found for other birds in the Mediterranean by Pons and Prodon (1996). Fig. 3.2.3 to 3.2.5 also showed that although the Burn Site attracted the majority of the species, some of them were still seen at the Control Site after the fire.

At Burn 1 only three species had left the Control Site completely after the fire (Appendix D: African Quailfinch (*Ortygospiza atricollis*), Common House-martin (*Delichon urbica*) and Grey-backed Sparrowlark (*Eremopterix verticalis*)) and these three species were rarely sighted before the fire. At the Burn Site, two species had left (Barn Swallow (*Hirundo rustica*) and White-winged Widowbird (*Euplectes albonotatus*)), one of which was sighted only once and the other frequented the Control Site after the fire. At Burn 2 (Appendix D), three species left the Control Site after the fire (African Stonechat (*Saxicola torquata*), Crowned Lapwing (*Vanellus coronatus*) and Egyptian Goose (*Alopochen aegyptiacus*)), all of them frequenting the Burn Site after the fire. At Burn Site 2, six species had left (Black-chested Prinia (*Prinia flavicans*), Desert Cisticola (*Cisticola aridulus*), Greater Striped Swallow (*Hirundo cucullata*), Marsh Owl (*Asio capensis*), Spike-heeled Lark (*Chersomanes albofasciata*) and Zitting Cisticola (*Cisticola juncidis*)). Because there were no pre-fire surveys, fire-sensitive species could not be established for Burn 3.

When looking at the number of species, it can be seen that species richness was greater on the Burn Site at each of the three burns after the fires, when compared with their respective Control Sites (Fig. 3.2.17 to Fig. 3.2.19 and Fig. 3.2.21 to Fig. 3.2.24). The number of species was about the same in the Control and Burn Sites before the fire. The number of species returned to almost pre-fire levels at the end of the year. Burn 1's second year (Fig. 3.2.20) showed that the Burn and Control Sites had returned to pre-fire levels. Records at midday (Fig. 3.2.21 to Fig. 3.2.22) and in the evening (Fig. 3.2.23 to Fig. 3.2.24) showed the same general trends as those of the mornings (Fig. 3.2.17 to Fig. 3.2.19). The number of species did not vary much throughout the day.

The pre-fire and post-fire species trends (Fig. 3.2.32 to Fig. 3.2.38) showed the same general patterns as Fig. 3.2.17 to Fig. 3.2.19 (species not differentiated in pre- and post-fire groups). The number of species was higher on the Burn Sites after the fire, but the Burn and Control Site were closer in numbers at the end of the year. The difference between the Control and Burn Sites (Fig. 3.2.42 to Fig. 3.2.44) showed almost the same general trend for all three burns in the mornings. The patterns between Burns 2 and 3 were also close at midday and in the evenings. The number of species was higher in the Control Site, or was equal in both sites before the fire. The number of species was higher in the Burn Site after the fire and returned to almost the original level at the end of the year. The trends in species richness, expressed as percentages, (Fig. 3.2.48 to Fig. 3.2.50) showed about the same patterns as Fig. 3.2.42 to Fig. 3.2.44, confirming the effect that that fire attracts species otherwise not present in unburned grasslands. It also shows for all three burns, when the grass started to grow again (by November), that many of the species have started to leave.

Herons, egrets and birds of prey arrived at the Burn Sites very quickly after the fire, presumably to take advantage of the insects, small mammals and reptiles that were killed by the fire, and probably also to take advantage of the open ground to hunt (Dean, 1987; Searle, 1982 and Barbour, 1968). The prey of the raptors was compromised by reduced vegetation cover in which to hide, and was therefore more vulnerable on the open ground. These opportunistic birds mostly stayed for only a few days. The herons were usually the first to arrive, searching for food while the ground was still smoking. The Cattle Egrets (*Bubulcus ibis*) arrived a few hours later or the next day. The herons and egrets stayed only for a day or two, until the kills from the fire were gone and then left again. They did not colonise the area or stay to breed. These species were likely associated with Barberspan itself (Black-headed Heron (*Ardea melanocephala*)), or the adjacent farms (Cattle Egrets), and probably returned to their usual habitats when the immediate food source was gone. Other species (Ant-eating Chats (*Myrmecocichla formicivora*), and Black-chested Prinia (*Prinia flavicans*)) were more site-tenacious. The Ant-eating Chats that were in the Burn Sites before the fire, stayed, but the fire also attracted additional Ant-eating Chats, presumably from territories close by. Aggression between presumably resident and opportunistic Ant-eating Chats were observed in the Burn Sites, but this was never observed in the Control Sites. Therefore, both the Ant-eating Chats and the Black-chested Prinias were present in the area before the fire and stayed in the area, even after the fire had taken away the vegetation cover. The Crowned Lapwings (*Vanellus coronatus*) were post-fire colonisers. Although they were not always the first birds to arrive, they established territories within which they acted aggressively towards other birds. They did not leave even in bad weather. The Northern Black Korhaan (*Eupodotis afraoides*), Helmeted Guineafowl (*Numida meleagris*) and Swainson's Spurfowl (*Pternistes swainsonii*) mostly utilised the area in the daytime and returned to vegetation cover in the evening. With danger nearby, they fled to the nearest vegetation cover.

The number of species was about the same on the Control and Burn Sites before the fire (Fig. 3.2.17 to Fig. 3.2.18). The number of species was higher on the Burn Site after the fire and returned to about the same level as the pre-fire conditions at the end of the year, when vegetation started to recover. The fire therefore had an effect on species richness, but it was only temporary. This trend was also found by other authors (Mills, 2004; Reynolds & Krausman, 1998; Robel *et al.*, 1998 and Van't Hul *et al.*, 1997). The species that preferred the vegetation cover left the area after the fire, but later returned when the vegetation recovered. The fire did, however, attract species that were rarely seen at Barberspan (such as Pearl-breasted (*Hirundo dimidiata*) and Red-breasted Swallows (*Hirundo semirufa*)), and also attracted species that normally make use of the farmlands next to the reserve (Red-billed Quelea (*Quelea quelea*), and Cattle Egrets).

4.2.3 Effect of fire on the calculated Shannon diversity

The graphs addressing Shannon diversity include Fig. 3.2.51 to Fig. 3.2.64. Overall, the Shannon diversity graphs showed no clear corresponding pattern or trend that could be associated with the observed changes in numbers and species (previous sections) for neither the morning (Fig. 3.2.51 to Fig. 3.2.53), midday (Fig. 3.2.54 and Fig. 3.2.55), nor evening surveys (Fig. 3.2.56 and Fig. 3.2.57).

Although the diversity stayed about the same, the species composition changed, first because of seasonal migrations and then again due to birds leaving or colonising after the fire. The fire also had an effect on number of species and number of birds (Sections 4.2.1 and 4.2.2). This will therefore change the biodiversity, but not necessarily the calculated Shannon diversity index (Magurran, 1988). In the summer months after the respective fires, when the migratory species were present and vegetation started to recover, the species composition returned to what is was before. However, not all the changes in species composition, number of species or number of birds were reflected in the calculated Shannon diversity index. This is a recognised shortcoming of calculated indexes (Magurran, 1988). The Shannon index showed that the diversity stayed about the same in the Burn Sites after the fire, but this did not reflect the changes that were observed. Therefore, diversity indexes may not be a good metric to use to investigate the effects of fire on birds.

However, the diversity trends, calculated on birds present before the fire and those that colonised after the fire (Fig. 3.2.58 to Fig. 3.2.64) clearly showed the effect of the fire. All, with one exception (Fig.3.2.60) showed a higher diversity in the Burn Sites of each of the three burns. The diversity started to return to the pre-fire situation by the end of the year. The pre-fire and post-fire data showed that the fire did have an effect on the diversity, when differentiating between species as I did. As was the case for bird numbers and species richness (see preceding sections), the diversity returned to pre-fire levels when the vegetation recovered later in the season.

4.2.4 Effect of fire on biomass

The graphs addressing biomass are Fig. 3.2.71 to Fig. 3.2.87, and Fig. 3.2.90 to Fig. 3.2.92. The general pattern showed that the fire had a clear effect on biomass (measured as g/20ha). All three burns showed an increase in biomass after the fire (Fig. 3.2.71 to Fig. 3.2.73). The biomass was almost equal in the Burn and Control Sites before the fire, but higher in the Burn Sites after the fire. There was a return to the pre-fire levels at the end of the year. The pre-fire and post-fire data (Fig. 3.2.78 to Fig. 3.2.84) also showed that the Burn Site had a higher biomass after the fire. Since the species that were attracted to the fire and the open ground seemed, in general, to be heavier than the smaller species that frequented the unburned areas, it is an obvious explanation as to why the Burn Sites had a higher biomass than the Control Sites after the fire.

The fire opportunists and fire-colonisers frequenting the Burn Sites included Helmeted Guineafowl (*Numida meleagris*), Crowned Lapwing (*Vanellus coronatus*), Egyptian Goose (*Alopochen aegyptiacus*), Spike-heeled Lark (*Chersomanes albofasciata*), and other species, which had a larger individual biomass. Smaller species were also attracted to the Burn Sites in large numbers, and included Southern Red Bishop (*Euplectes orix*), South African Cliff-swallow (*Hirundo spilodera*), Red-billed Quelea (*Quelea quelea*) and other species. They all contributed to the larger biomass found in the Burn Sites. The Control Sites mostly included smaller species such as African Quailfinch (*Ortygospiza atricollis*), African Stonechat (*Saxicola torquata*), Desert Cisticola (*Cisticola aridulus*), Long-tailed Widowbird (*Euplectes progne*), Spike-heeled Lark (*Chersomanes albofasciata*), Wing-snapping Cisticola

(*Cisticola ayresii*), Zitting Cisticola (*Cisticola juncidis*) and other small species, or were seen in small numbers, giving the Control Site a much smaller biomass. These species might therefore be regarded as fire-sensitive species, or at least species that cannot maintain themselves in areas that have been burned.

The fire therefore had an effect on the biomass in the burned areas, concentrating larger birds in the Burn Sites, from the adjacent unburned areas, where they occurred in much lower densities. At the end of the year, the biomass started to return to pre-fire levels. Therefore, the fire had only a temporary effect on the biomass. The larger birds left again when the vegetation started recovering; the smaller birds then also returned. A longer period of observation might have provided additional information on long-term effects on biomass, as was indicated in Fig. 3.2.12, that showed an increase in densities again, in the summer season, in the second year after the fire (Burn 1).

I have shown in previous sections that numbers of birds, as well as the numbers of species (expressed as changes in both densities and as percentages) increased in the burn sites after the Burns. The effect was that, although some species left the Burn Sites after the fires, others moved in or increased in numbers, to such an extend that the biomass densities (g/20ha) was also increased. The net gain in biomass was therefore significantly greater, than the loss. This observation is of course also relevant to bird densities and species richness, and will be dealt with in Section 4.3.

4.2.5 Effect of the size of the burned area

The graphs addressing the size of the burned area include Fig. 3.2.65 to Fig. 3.2.70, Fig. 3.2.88, and Fig. 3.2.89. The densities were higher for the Burn Site for post-fire data, when compared with the pre-fire numbers, for all three burns (Fig. 3.2.65 and Fig. 3.2.68). The number of species showed the same pattern (Fig. 3.2.66 and Fig. 3.2.69). The larger the Burn Site therefore, the more species were present, which was not as clear with the densities. The number of species and densities may therefore not always be correlated, although the data showed that they had the same patterns.

The pre-fire and post-fire data showed a closer Shannon Diversity for Burns 1 and 3 (Fig. 3.2.67). Burns 1 and 2 had the same diversity after the fire. Burn 2 had the highest diversity before the fire, and Burn 3 the lowest. After the fire, Burn 3 still had the lowest diversity (Fig. 3.2.67). The Shannon Diversity was the same before and after the fire for Burn 1 (Fig. 3.2.70). The pre- and post-fire data were close in diversity for both Burns 2 and 3. Burn 1 had the highest diversity before and after the fire, while Burn 3 had the lowest.

The diversity did not show the same patterns as the number of species and the densities (Fig. 3.2.65 to Fig. 3.2.70). There was no correlation between the change in diversity and the size of the burn. This implied that the Shannon diversity might not be a good metric to determine the effects of the fire on the size of the area burned on birds. Burns 1 and 2 were almost equal in biomass (Fig. 3.2.88 and 3.2.89), while Burn 3 had a higher biomass after the fire. The three burns were almost equal in biomass before the fire.

The data showed that the size of the area burned had an effect on the birds. The larger the area that was burned, the more birds were attracted to the fire. With a larger area burned, there was more food and also more habitat available after the fire, therefore more birds could make use of the area after the fire. Optimal foraging probably was the reason why larger fire attracted more birds and species. The Optimal Foraging Theory is explained in Begon *et al.* (1996). It would be more advantageous for a consumer to spend more time in a higher profitable patch. The Optimal Foraging Theory depends on differentials in profitability, the average profitability of the environment as a whole, the distance between patches, etc. There is also interest in the situation in which foragers deplete the resources of one patch. The initial rate of intake will be high, but as the resources are depleted, the rate of intake will decline (Begon *et al.*, 1996). With the larger fires (Burns 1 and 3), there was probably more food (resource) available than at the smaller fire (Burn 2) and this explained why more birds stayed longer at the larger fires. With the smaller fire and less food, the birds may also leave sooner as the resource is depleted sooner. The food resource at the larger burn will last longer and thus the birds may stay longer, providing a likely explanation for the observed effects of fire on grasslands, such as at Barberspan, on densities, species richness and biomass of birds.

4.2.6 Comparing densities, number of species, Shannon Diversity and biomass

The densities, number of species and biomass all increased after the fire and decreased again at the end of the year when vegetation started to recover from the fire. The fire had an effect, but it was only temporary. The effects was caused by the sudden abundance or availability of food as the fire killed insects, reptiles and other animals that could not escape, and also breeding opportunities. New habitat (open ground) also became available. The species that had occupied the habitat before had left when the vegetation cover was burned. Although some of the other studies had different results (Gabrey, Afton and Wilson, 2001; Fitzgerald and Tanner, 1992), there was a clear difference between the Control and Burn Sites in this study. This corresponded to the findings of various authors (Mills, 2004; Herrando *et al.*, 2002; Davis *et al.*, 2000; Reynolds & Krausman, 1998; Robel *et al.*, 1998; Van't Hul *et al.*, 1997 and Pons & Prodon, 1996).

The densities (Fig. 3.2.9 to Fig. 3.2.11), number of species (Fig. 3.2.17 to Fig. 3.2.19) and biomass (Fig. 3.2.71 to Fig. 3.2.73) showed the same trends with regards to fire in grassland. Though the data seem related, it may not always be so. A higher number of birds may not mean a higher number of species. The number of birds from a single species can increase (e.g. there can be more swallows) without the number of species increasing. A higher biomass may not mean that there were a higher number of birds. The number of birds can stay the same, but the species composition may change. Therefore larger birds may arrive and change the biomass, but the number of birds will remain the same. It may be better to interpret biomass, number of birds (densities) and number of species together with species composition (Appendix D) for the final evaluation of the results.

Species that left the burned area due to the fire started to return to the Burn Sites at the end of the year. Other species that colonised the Burn Sites, left as soon as the food abundance or availability was reduced, or when the vegetation had recovered, by November. Some of the birds (such as Crowned Lapwing (*Vanellus coronatus*) and Red-capped Lark (*Calandrella cinerea*)) that arrived after the fire, stayed to breed. These temporal trends in bird species richness and densities were also found by other authors: (Mills, 2004; Madden *et al.*, 1999; Reynolds & Krausman, 1998; Robel *et al.*, 1998 and Van't Hul *et al.*, 1997). Therefore, bird numbers and composition, after a single fire in grasslands such as at Barberspan, returned to close to original levels and composition with time, although there might be effects still discernable in a subsequent year, as indicated in Fig.3.2.12.

The Shannon diversity also changed, but the effect was not as clear as with the numbers, species and biomass. The species composition, number of species and number of birds changed. This all contributed to changing the diversity (Magguran, 1988), but was not reflected in the Shannon diversity index. Therefore, diversity may not be a good measure to quantify the effects of fire on birds.

Overall, it seems that optimal foraging would be one of the best theoretically-based explanations for the observed effects and trends, although breeding opportunities and reaction to predation also play a role. Evaluation of the different guilds might add additional information to this argument.

4.2.7 Guilds

The graphs addressing guilds include Fig. 3.2.93 to 3.2.134.

4.2.7.1 Effect of fire on Breeding Guilds

The grass breeding birds (Fig. 3.2.93 and Fig. 3.2.94) had higher densities in the Control Sites of Burns 1 and 2, while their densities were higher in the Burn Site of Burn 3 (Fig. 3.2.95), after the fires. The number of species (Fig. 3.2.96 to Fig. 3.2.98) of the Grass Breeding Guild showed the same tendencies when compared with its densities. The number of species for the Grass Breeding Guild was equal between the Control and Burn Sites of Burn 2 at the end of the year (Fig. 3.2.97). While the birds used the grass cover for habitat and breeding, they also used the burned areas to forage for food.

The Ground Breeding Guild had higher densities on the Burn Sites of all three burns after the fire (Fig. 3.2.99 to Fig. 3.2.101). This is possibly explained by the availability of food, but more likely by the newly-available habitat created by the fire. The birds colonised the new habitat and some stayed there to breed. Since Burn 2 (Fig. 3.2.100) was a smaller burn, there was less habitat available, giving it smaller densities than Burns 1 and 3 (Fig.3.2.99 and Fig. 3.2.101). Burn 3 took place at the same time as Burn 2. Because Burn 3 was much larger, it might have drawn the birds away from Burn 2. The number of species (Fig. 3.2.102 to Fig. 3.2.104) had similar patterns as their respective densities, and was consistently higher in the Burn Sites.

Birds that used trees, bushes, reeds, buildings and water to breed, were grouped in the "Other Breeding Guild" (Fig. 3.2.105 to Fig. 3.2.110). The Burn and Control Sites had the same densities and almost the same number of species before the fire. None of the burns showed the same pattern, although each of them showed that these birds mainly arrived after the fire and stayed until the vegetation started to return to pre-fire conditions. These birds did not stay to breed, since there was no breeding habitat available. The number of species (Fig. 3.2.108 to Fig. 3.2.110) had the same patterns as their respective densities (Fig. 3.2.105 to Fig. 3.2.107). The densities and number of species started to return to pre-fire levels at the end of the year.

4.2.7.2 Effect of fire on Feeding Guilds

The Predator Feeding Guild (Fig. 3.2.111 to Fig. 3.2.116) included carnivores and insectivores. The densities were higher in the Burn Site of all three burns after the fire. The peaks in densities, apparent after the fire for this guild (Fig. 3.2.111 to Fig. 3.2.113), were mainly caused by swallows, swifts, herons and egrets that were attracted to the fire in search of food opportunities. The densities of each burn started to return to pre-fire levels at the end of the year. The number of species (Fig. 3.2.114 to Fig. 3.2.116) was higher in the Burn Sites of each burn after the fire. All three burns showed an increase in number of species immediately after the fire and a return to pre-fire levels at the end of the year. The number of species had the same trends as their respective densities. The birds were opportunists and took advantage of the kills from the fire. Some might have stayed for other food sources that became more available or abundant after the fire.

The Omnivore Feeding Guild had higher densities (Fig. 3.2.117 to Fig. 3.2.119) in the Burn Site after the fire. Burns 1 and 2's Control and Burn Sites were close in densities, while there was a larger difference between Burn 3's Control and Burn Sites. It was clear from the data that the birds were drawn to the fire because of the sudden food abundance or availability. The densities started to return to pre-fire levels at the end of the year. The number of species (Fig. 3.2.120 to Fig. 3.2.122) had the same temporal trends as their respective densities. The Control and Burn Sites of all three burns were close in number of species. The number of species started to return to pre-fire levels at the end of the year. Optimal foraging may have played a role here. The birds arrived after the fire to forage for food on the Burn Sites, and stayed until the food was depleted or the habitat became unsuitable to them.

4.2.7.3 Effect of fire on Habitat Feeding Guilds

The densities (Fig. 3.2.123 to Fig. 3.2.125) of the Ground Habitat Feeding Guild were higher in the Burn Site of all three burns after the fire. This showed that these birds took advantage of the food sources that became more abundant or available after the fire. The number of species (Fig. 3.2.126 to Fig. 3.2.128) had similar patterns as their respective densities. The number of species was almost the same in the Control and Burn Sites of the three burns at the end of the year.

The densities of the Aerial Habitat Feeding Guild, such as swallows and swifts, were only slightly higher in the Burn Site of Burn 1 after the fire (Fig. 3.2.129). The Control and Burn Sites were very close in densities for Burn 3 (Fig. 3.2.131). Burn 2 (Fig. 3.2.130) had no birds after April; the birds may have been attracted to the much larger Burn 3. The number of species (Fig. 3.2.133) had the same pattern as the densities for Burn 2. There was more difference in the number of species between the Control and Burn Sites of Burns 1 and 3 (Fig. 3.2.132 and Fig. 3.2.134). Burn 3 (Fig. 3.2.134) had more species in the Control Site after the fire, and the Control and Burn Sites were equal in number of species at the end of the year. The birds probably took advantage of the higher number of insects after the fire. Burn 1 (Fig. 3.2.129 and Fig. 3.2.132) had higher densities and number of species than Burns 2 (Fig. 3.2.130 and Fig. 3.2. 133) and 3 (Fig. 3.2.131 and Fig. 3.2.134). Burn 1 took place after a good rain season and may have had more insects available after the fire than Burns 2 and 3.

4.2.7.4 Comparing the guilds

The guilds (Fig.3.2.93 to Fig. 3.2.134) showed that the fire attracted the birds to the burns mainly because of the availability of food, but also because of habitat and breeding. I found some nests with eggs and later with young that confirmed that the ground-breeding birds were using the Burn Sites for breeding. Breeding activity was not used in subsequent analyses. Robel *et al* (1998) found no difference in the nesting success after the fire and no long-term effects on the nests or nesting success. They did, however, find that there was an effect on the species using the site for nesting. Petersen and Best (1987) also found no effect on breeding success. At Barberspan, the fire had an effect on the densities and the number of species of the Breeding Guilds (Fig. 3.2.93 to Fig. 3.2.110). There were more birds and more species after the fire in most of the Breeding Guilds. Only the Grass Breeding Guild (Fig. 3.2.93 to Fig. 3.2.98) had higher densities and number of species in the Control Sites. Before the fires, the areas were mostly used by the birds of the Grass Breeding Guild, but following the fires, the birds of the Ground Breeding Guild colonised the burned areas. The Grass Breeding birds at Burn 3 of the Grass Breeding Guild may have made use of the burned areas after the fire because of the availability of food (Fig. 3.2.95), but not for breeding. Overall, it seems that the effects of the fire were only temporary for the Breeding Guilds.

The omnivores and predators (Fig. 3.2.111 to Fig. 3.2.122) had higher densities and number of species in the Burn Sites after the fire, when compared with before. The Predator Guild consisted mostly of insectivores (Appendix D) after the fire. The presence of the omnivores and predators in the Burn Sites showed that the insects and reptiles were probably more abundant as a food source after the fire, and that this attracted the birds to the fire. Some of the species stayed to take advantage of the new habitat. Dean (1987) also found that the insectivorous birds were in greater abundance after the fire, although the raptors also increased in abundance. Dean (1987) and Mills (2004) found that the number of granivorous birds were generally low after a fire, which was also found in this study. I therefore excluded granivores from further analyses, as they did not have sufficient numbers to show in the graphs. Pons and Prodon (1996) on the other hand found that the granivorous birds dominated the area after the fire. The effect of the fire was only temporary and the densities and number of species started to return to pre-fire levels at the end of the year.

The Habitat Feeding Guild analysis also showed that the densities of the Terrestrial Habitat Feeding Guild (Fig. 3.2.123 to Fig. 3.2.128) were higher than the Aerial Habitat Feeding Guild (Fig. 3.2.129 to Fig. 3.2.134) in the Burn Sites after the fire. Thus, there seemed to have been little effective change in food availability for the Aerial Feeding Guild in the Burn Sites, when compared with the Control Sites. The fire had a larger effect on the species from the Terrestrial Habitat Feeding Guild than it did on the species from the Aerial Habitat Feeding Guild. The effect of the fire was also only temporary, and the densities and number of species started to return to pre-fire levels at the end of the year.

Though some of the species from the Ground Breeding Guild (Fig. 3.2.135 to Fig. 3.2.141) did breed, most of the birds that were seen on the Burn Sites were rather attracted by the food resources. The effect of optimal foraging (Begon *et al.*, 1996) may be the best explanation here. When looking at Fig. 3.2.95, the birds were feeding on the open ground rather than in the safety of the vegetation cover. They were therefore attracted to the Burn Site by the opportunity to feed. Birds that breed elsewhere were also attracted to the fire by the apparent increase in food availability. Some of the birds stayed only long enough to feed on the kills of the fire before they left again.

The Feeding Guilds showed that predators and omnivores were attracted to the fire. The insectivores and omnivores were in majority (Appendix D), again giving evidence that the optimal foraging may be an explanation why the birds were attracted to the fire. The same effect was shown for the Habitat Feeding Guilds. Most of the birds had higher numbers after the fire and took advantage of the food resources. The Aerial Habitat Feeding birds did not stay to colonise the area or to breed in the new habitat after the fire. They usually arrived during the early mornings and left again in the evenings, staying only to hunt for food.

4.3 Synthesis

The aims of this study (Chapter 1.3) was to determine the effects that fire had on the terrestrial birds of Barberspan and also to develop some recommendations on future burning at Barberspan and further studies. The objectives were set as follows:

- To investigate the effects of fire on bird numbers
- To investigate the effects of fire on bird species
- To investigate the effects of fire on bird diversity using Shannon Index
- To investigate the effects of fire on avian biomass
- To investigate the effects of the surface area of the burn on birds

- To develop recommendations on:
  - Further research and,
  - Future burning at Barberspan.

The data indicated that there was an effect on the birds, mainly attracting them to a sudden abundance or availability of food after the fire, but also to new habitat and breeding opportunities. Some of the birds, such as the Black-headed Heron (*Ardea melanocephala*) and Cattle Egret (*Bubulcus ibis*) apparently only stayed briefly to take advantage of the abundance of food and as soon as it was depleted, they left again. Other birds, such as the Crowned Lapwing and Red-capped Lark (*Calandrella cinerea*), stayed to take advantage of the newly available habitat and breeding opportunities.

Although the graphs (Fig. 3.2.51 to Fig. 3.2.57) showed different patterns, there was a change in the densities and the number of species after the fire (Fig. 3.2.9 to Fig. 3.2.24). This caused changes in the diversity as a result of the fire. There were also confounding changes in the species composition (Appendix D), firstly with the departure of the migratory birds at the end of summer (seasonal changes), and then again after the fires. Although there were obvious significant changes in the diversity, this was not reflected in the Shannon diversity index. The surface area of the burn also had no clear effect on the diversity, giving the lowest diversity on the Burn Site for the largest of the three burns (Burns 3). This shows that diversity is not a good metric to measure for the effects of the fire on birds.

The densities, number of species and biomass clearly showed that the fire had a temporary effect on the birds and that levels started returning to pre-fire levels when the grass started to grow again. Burn 1's second year showed that the birds returned to the area when the grass had recovered to its normal height and that the birds that occupied the area after the fire had mostly left, with a few exceptions.

The surface area of the burn also had an effect on the birds. Numbers, species and biomass were less on a smaller burn. Burn 2 was the smallest of the three burns, followed by Burn 1, while Burn 3 was the largest of the three burns. Burn 2 had the least number of birds and species and also had the lowest biomass, while Burn 3 had the highest number of birds and species and the highest biomass. Therefore, the smaller the burn was, the less the effect the fire had on the birds of the area.

The guilds also showed that the fire had an effect on the birds. Omnivores, and insectivores to a lesser extent, were more common in the Burn Sites, when compared with their respective Control Sites. Ground-breeding birds were also more common in the Burned Sites, followed by grass breeding birds, showing that the birds had not left the area completely, but only shifted temporarily to the adjoining Control Sites and still utilised the Burn Sites.

The Optimal Foraging Theory (Begon *et al.*, 1996) may be the best explanation for the attraction of birds to the fire. Some of the birds did not stay to breed, but only arrived after the fire to take advantage of the apparent increase in food availability (Dean, 1987). The size of the surface area that was burned supports the theory. The larger a fire, the more food should be available in that area, and thus more birds would be attracted to the larger fire than to the smaller fire. This was seen at Burns 2 and 3, which took place almost at the same time. The larger Burn 3 had a higher density when compared with the smaller Burn 2. The guilds also support the Optimal Foraging Theory. Insectivores and omnivores were in the majority (Appendix D). There was little vegetation left after the fire, and therefore little food for herbivores or granivores. Most of the carnivores stayed only long enough to feed on the prey that was killed in the fire before they left again.

The island effect (Begon *et al.*, 1996) can also be seen in the Burn Sites of the three burns. The burned areas could be considered as "islands" in the "sea" of grassland. Burned areas have little vegetation cover and are surrounded by the grassland, which has substantial vegetation cover. The grassland is unsuitable, or less suitable than the burned area, to the species that used the area for habitat and to find food. The "island" was only temporary and the vegetation returned to normal height. The colonisers of the new "island" in the "sea" of grass left again and probably returned to their usual habitats.

Since the burned area was new and only temporary, and the food source was also only temporary, intraspecific and interspecific competition was created for the habitat as well as for the food (Begon *et al.*, 1996; Wiens, 1989). The temporary shift of the grass breeding birds to the adjoining areas also created competition as the birds that were already present had to defend their habitat and food-resources against the newcomers. Therefore the fire did not only have an effect on the birds in the area that was burned, but also on the birds in the areas adjoining the burned area.

Since the effects of the fire was only temporary and the grass started to grow again at the end of the year, and had returned to normal height by the beginning of the next year (Burn 1), the competition was also only temporary and the balance between the Burn Sites and the adjoining Control Sites were more or less restored. There might still be relicts of the effect present, as at the end of the 2nd year there was an increase in density again (Fig. 3.2.12).

Though the competition for habitat and food-resources is only temporary in both the Burn and Control Sites, this gives rise to territoriality (Begon *et al.*, 1996). The birds that colonised the area after the fire defended it against intruders, for example, Ant-eating Chat (*Myrmecocichla formicivora*), and also defending it against predators such as the Crowned Lapwing (*Vanellus coronatus*). Some birds were so fiercely territorial that they did not even leave their habitat to take cover in strong wind, heat or rain as did some of the other birds.

Other species used the area, but sought cover at night or when predators appeared, only utilising the area for food (for example, Helmeted Guineafowl (*Numida meleagris*)). This resulted in competition for the food, but not for the habitat.

Niche differentiation and in particular, differential resource utilisation was seen at Barberspan. This means that different species live in the same habitat, but use different resources (Begon *et al.*, 1996; Wiens, 1989). There were granivorous, insectivorous, predators and herbivorous species present in the grassland before the fire and also after the fire. These species thus utilised different food resources in the same habitat and as a result could live together.

Some of the species left when the conditions changed, making habitat and resources available to other species (Wiens, 1989). Some species disappeared because they were only summer visitors (for example, Barn Swallow (*Hirundo rustica*), Common House-martin (*Delichon urbica*), and Greater Striped Swallow (*Hirundo cucullata*)), but some of them stayed for the first few days of the fire (for example, Lesser Kestrel *Falco naumanni* and White Stork (*Ciconia ciconia*)).

The fire was a disturbance and changed the environment (vegetation) temporarily. This also changed the availability of food and habitat and thus the species composition (Appendix D). Birds are highly mobile (Wiens, 1989) and they left after the fire (fire-sensitive), while other species arrived to take advantage of the burned area (fire-colonisers and opportunists). Some, however, stayed and are site-tenacious (Pons & Prodon, 1996). The birds that left the area after the fire, returned when the vegetation started to recover at the end of the year. According to Wiens (1989), disturbance increases the heterogeneity of environments and of the communities that occupy them.

The fires probably had effects over a larger area larger than the burned areas itself. Some of the species left the burned area after the fire (e.g. Long-tailed Widowbirds and Cisticolas), but as the Control Areas were already colonised before the fire, and there were no apparent increases in the numbers there, they had to move out further, and may even have left the reserve to colonise the grasslands on the farms close to the reserve.

Some of the species that colonised the newly burned habitats may have come from the Control Sites next to the fire, but most of them probably came from an area larger than that, e.g. the farms next to Barberspan. The numbers of birds and numbers of species in the Control Sites did not decrease at the same rate as the Burn Sites increased. The birds therefore had to come from elsewhere, decreasing the number of birds and number of species there.

The Cattle Egret and Red-billed Quelea normally foraged on the farms next to Barberspan, but were seen only seen on the Burn Sites after the fires. The Black-headed Herons were normally found next to the pan, but also took advantage of the Burn Sites for a day or two after the fire, before they went back to their usual habitat. The Cattle Egrets also returned to the farms next to Barberspan after a day or two, while the Quelea stayed longer at the Burn Sites. The swallows and swifts came from the silos and elsewhere in the mornings, used the Burn Sites to catch insects and returned in the evenings. Thus, with this evidence, the fire possibly had an effect, not only on the Burn and Control Sites in Barberspan, but also on the farms next to the pan.

4.4 Conclusions

> *Field studies consistently reveal the direct role of disturbance and successional processes in structuring avian habitats and communities. Conservation strategies involving the management of disturbance through some combination of flooding, application of fire, or the expression of wildfire and use of certain types of silviculture have the potential to diversify avian habitats at the local, landscape and regional scale. Many aspects of the disturbance ecology of birds require further research (Brawn, Robinson & Thompson. 2001).*

- The fire had an effect on the densities of the birds. The densities increased after the fire and started to decrease at the end of the year. This showed that the effect of the fire was possibly temporary. Birds were attracted to the fire most likely due to the increased availability of food, and also because of newly available habitat or breeding opportunities.
- The fire had an effect on the number of species and on the species composition. The number of species increased after the fire and returned to pre-fire levels at the end of the year. This showed that the effect of the fire on the number of species was probably temporary. The species that normally used the habitat (fire-sensitive), left after the fire, and other species (fire-colonisers) colonised the area. Some of these species stayed to breed. Some of the original species remained in the area after the fire (site-tenacious). The species that had left after the fire, started to return at the end of the year. The species were mainly attracted to the fire because of food availability, but also because of habitat and breeding opportunities. They left at the end of the year when the vegetation started to recover.
- There was little change in the diversity, as measured by the Shannon index. The densities of the birds, the species composition and number of species changed, but this was not reflected in the Shannon index. Therefore, the Shannon index is not a good measure to quantify the effect of fire on birds, at least in cases such as at Barberspan.
- The fire had and effect on the total avian biomass present in the burned areas. The biomass increased after the fire, because larger birds were attracted to the fire. Smaller species were also attracted to the Burn Sites, but in much larger numbers than the Control Sites. At the end of the year, these birds left again, and the biomass returned to pre-fire levels. Therefore, the effect of the fire on the biomass was temporary.
- Morning, midday and evening surveys for densities, number of species, diversity and biomass had the same, but more variable trends. Bird activity was less at midday than in the mornings and evenings, therefore the density, number of species, diversity and biomass decreased at midday and started to increase again in the evenings. Activity in the evenings was still less than in the mornings.
- The size of the burned areas had an effect on the birds. More birds per hectare were attracted to the larger fires (Burns 1 and 3), when compared with the smaller fire at Burn

2. There was probably more food available on the larger areas per patch, and therefore more birds could make use of the areas for a longer period.

❖ The guilds showed that the birds were probably attracted to the fire because of the availability of food rather than habitat or breeding opportunities. The fire had an effect on the Breeding Guilds, but not many of the fire-colonising species used the area to breed. The fire had a more pronounced effect on the Feeding Guilds and Habitat Feeding Guilds, attracting the birds because of food resources that became available after the fire.

❖ Therefore, optimal foraging probably played a significant role in explaining the differences found between larger and smaller fires. The birds that colonised the area after the fire, stayed until the food was depleted before they left again. Some of the larger birds only took the opportunity to feed on the prey killed immediately after the fire, and left after a day or two.

❖ The island effect was also seen in the Burned Sites. The burned areas could be considered as "islands" in the "sea" of grassland. These "islands" were colonised shortly after the fire (fire-colonisers and opportunists). The larger islands had a higher density in birds, greater species richness and more total avian biomass. The island effect was only temporary and disappeared again as the vegetation recovered.

❖ The fires probably had an effect over an area larger than the burned areas themselves. There were no apparent increases in density or species richness in the Control Sites after the fire, and therefore the birds that left had to move out further. The number of birds and number of species in the Control Sites did not decrease at the same rate as the increases seen at the Burn Sites, showing that the birds probably were attracted from a larger area than that immediately surrounding the burned areas. Cattle Egrets and Red-billed Queleas normally foraged on the farms next to the reserve. The swallows and swift also came from elsewhere than the reserve.

4.5 Recommendations

4.5.1 General recommendations

● The study should be longer than a year, to include long-term effects of the fire.

● Future studies should include vegetation surveys before and after the fire.

❖ Surveys on areas larger than the burned and control areas should be included in the study.

● The effects of fire on grassland birds in different parts of the country should be considered.

❖ A study comparing the effects of fire in grasslands and savannahs should be considered.

● Breeding and food surveys should be considered for future studies.

● A better method of establishing bird density should be employed.

4.5.2 Future burning at Barberspan

- Although not specifically investigated, middle to late winter burning may be the best at Barberspan. This does not disturb the breeding habits of the grassland birds later in the summer, and may even provide temporary habitat for ground breeding birds in the early summer.
- Patch burning should be considered at Barberspan. Relatively-large patches rather than smaller patches should be burned. Areas of the same vegetation type as the burned patch should be left unburned. This can be a refuge for the birds that leave.
- Consideration should be given to introduce larger herbivores that can control the vegetation. Therefore, there would be less moribund vegetation build-up and burning can be done less frequently. The disturbance would thus be less for the birds, and the presence of larger herbivores in itself might attract additional bird species.
- Conservation and management of the reserve should therefore include both the terrestrial and aquatic birds.

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Appendices

"The relationship between bird assemblages and vegetation structure may, however, be complex and modification of the structural complexity of the habitat (i.e. species composition, biomass, cover, etc.) could be detrimental to habitat-specific bird assemblages if the habitat is no longer sufficient quality to maintain healthy populations (Morrison, 1986).

Appendix A is a list of the species that were seen and captured during the research period at Barberspan. Appendix B lists the species seen by others and myself at Barberspan during my two-year study. Appendix C is a list of some of the other animals I have seen at Barberspan during my two-year study and these were included for interest.

Appendix D is a list of the species from before and after the fire at each of the three burns. This can be used to see which of the species disappeared, which stayed and which arrived after the fire. It can also be used to compare the Burn and Control Sites of each burn with each other.

Appendix A:

List of species from research at Barberspan (1962)

English	*Afrikaans*	*Scientific*
1. *(6)* Great Crested Grebe	Kuifkopdobbertjie	*Podiceps cristatus*
2. *(7)* Black-necked Grebe	Swartnekdobbertjie	*Podiceps nigricollis*
3. *(8)* Little Grebe	Kleindobbertjie	*Tachybaptus ruficollis*
4. *(49)* Great White Pelican	Witpelikaan	*Pelecanus onocrotalus*
5. *(50)* Pink-backed pelican	Kleinpelikaan	*Pelecanus rufescens*
6. *(55)* White-breasted Cormorant	Witborsduiker	*Phalacrocorax neglectus*
7. *(58)* Reed Cormorant	Rietduiker	*Phalacrocorax africanus*
8. *(60)* African darter	Afrikaanse Slanghalsvoël	*Anhinga rufa*
9. *(62)* Grey Heron	Bloureier	*Ardea cinerea*
10. *(63)* Black-headed Heron	Swartkopreier	*Ardea melanocephala*
11. *(64)* Goliath Heron	Reusereier	*Ardea goliath*
12. *(66)* Great Egret	Grootwitreier	*Egratta alba*
13. *(67)* Little Egret	Kleinwitreier	*Egretta garzetta*
14. *(68)* Yellow-billed Egret	Geelbekreier	*Egretta intermedia*
15. *(69)* Black Heron	Swartreier	*Egretta ardesiaca*
16. *(71)* Cattle Egret	Veereier	*Bubulcus ibis*
17. *(81)* Hamerkop	Hamerkop	*Scopus umbretta*
18. *(83)* White Stork	Witooievaar	*Ciconia ciconia*
19. *(84)* Black Stork	Grootswartooievaar	*Ciconia nigra*
20. *(85)* Abdim's Stork	Kleinswartooievaar	*Ciconia abdimii*
21. *(89)* Marabou Stork	Maraboe	*Leptotilos crumeniferus*
22. *(91)* African Sacred Ibis	Skoorsteenveër	*Threskiornis aethiopicus*
23. *(93)* Glossy Ibis	Glansibis	*Plegadis falcinellus*
24. *(94)* Hadeda Ibis	Hadeda	*Bostrychia hagedash*
25. *(95)* African Spoonbill	Lepelaar	*Platalea alba*
26. *(96)* Greater Flamingo	Grootflamink	*Phoenicopterus ruber*
27. *(97)* Lesser Flamingo	Kleinflamink	*Phoenicopterus minor*
28. *(99)* White-faced Duck	Nonnetjie-eend	*Dendrocygna viduata*
29. *(101)* White-backed Duck	Witrugeend	*Thalassornis leuconotus*
30. *(102)* Egyptian Goose	Kolgans	*Alopochen aegyptiacus*

31. *(103)* South African Shelduck	Kopereend	*Tadorna cana*
32. *(104)* Yellow-billed Duck	Geelbekeend	*Anas Undulata*
33. *(105)* African Black Duck	Swarteend	*Anas sparsa*
34. *(106)* Cape Teal	Teeleend	*Anas capensis*
35. *(108)* Red-billed Teal	Rooibekeend	*Anas erythrorhyncha*
36. *(112)* Cape Shoveler	Kaapse Slopeend	*Anas smithii*
37. *(113)* Southern Pochard	Bruineend	*Netta erythrophthalma*
38. *(115)* Comb Duck	Knobbeleend	*Sarkidiornis melanotos*
39. *(116)* Spur-winged Goose	Wildemakou	*Plectropterus gambensis*
40. *(117)* Maccoa Duck	Bloubekeend	*Oxyura maccoa*
41. *(118)* Secretarybird	Sekretarisvoël	*Sagittarius serpentarius*
42. *(122)* Cape Vulture	Kransaasvoël	*Gyps coprotheres*
43. *(126)* Black Kite	Swartwou	*Milvus migrans*
44. Yellow-billed Kite	Geelbekwou	*Milvus aegyptius*
45. *(127)* Black-shouldered Kite	Blouvalk	*Elanus caeruleus*
46. *(132)* Tawny Eagle	Roofarend	*Aquila rapax*
47. *(148)* African Fish Eagle	Visarend	*Haliaeetus vocifer*
48. *(157)* Little Sparrowhawk	Kleinsperwer	*Accipiter minullus*
49. *(159)* Shikra	Gebande Sperwer	*Accipiter badius*
50. *(160)* African Goshawk	Afrikaanse Sperwer	*Accipiter tachiro*
51. *s(165)* African Marsh-harrier	Afrikaanse Vleivalk	*Circus ranivorus*
52. *(167)* Pallid Harrier	Witborsvleivalk	*Circus macrourus*
53. *(169)* African Harrier-hawk	Kaalwangvalk	*Polyboroides typus*
54. *(170)* Osprey	Visvalk	*Pandion haliaetus*
55. *(171)* Peregrine Falcon	Swerfvalk	*Falco peregrinus*
56. *(172)* Lanner Falcon	Edelvalk	*Falco biarmicus*
57. *(173)* Eurasian Hobby	Europese Boomvalk	*Falco subbuteo*
58. *(179)* Red-footed Falcon	Westelike Rooipootvalkie	*Falco vespertinus*
59. *(180)* Amur Falcon	Oostelike Rooipootvalkie	*Falco amurensis*
60. *(181)* Rock Kestrel	Kransvalk	*Falco (tinnunculus) rupicolis*
61. *(182)* Greater Kestrel	Grootrooivalk	*Falco rupicoloides*
62. *(183)* Lesser Kestrel	Kleinrooivalk	*Falco naumanni*
63. *(186)* Pygmy Falcon	Dwergvalk	*Polihierax semitorquatus*

64. *(188)* Coqui Francolin	Swempie	*Peliperdix sephaena*
65. *(193)* Orange River Francolin	Kalaharipatrys	*Scleroptila levaillantoides*
66. *(194)* Swainson's Spurfowl	Bosveldfisant	*Pternistes swainsonii*
67. *(200)* Common Quail	Afrikaanse Kwartel	*Coturnix coturnix*
68. *(201)* Harlequin Quail	Bontkwartel	*Coturnix delegorguei*
69. *(203)* Helmeted Guineafowl	Gewone Tarentaal	*Numida meleagris*
70. *(207)* Wattled Crane	Lelkraanvoël	*Grus carunculatus*
71. *(208)* Blue Crane	Bloukraanvoël	*Anthropoides paradisea*
72. *(212)* African Crake	Afrikaanse Riethaan	*Crecopsis egregia*
73. *(213)* Black Crake	Swartriethaan	*Amaurornis flavirostris*
74. *(223)* African Purple Swamphen	Grootkoningriethaan	*Porphyrio madagascariensis*
75. *(228)* Red-knobbed Coot	Bleshoender	*Fulica cristata*
76. *(239b)* Northern Black Korhaan	Witvlerkswartkorhaan	*Eupodotis afraoides*
77. *(245)* Common Ringed Plover	Ringnekstrandkiewiet	*Charadrius hiaticula*
78. *(246)* White-fronted Plover	Vaalstrandkiewiet	*Charadrius marginatus*
79. *(247)* Chestnut-banded Plover	Rooibandstrandkiewiet	*Charadrius pallidus*
80. *(248)* Kittlitz's Plover	Geelborsstrandkiewiet	*Charadrius pecuarius*
81. *(249)* Three-banded Plover	Driebandstrandkiewiet	*Charadrius tricollaris*
82. *(255)* Crowned Lapwing	Kroonkiewiet	*Vanellus coronatus*
83. *(258)* Blacksmith Lapwing	Bontkiewiet	*Vanellus crassirostris*
84. *(262)* Ruddy Turnstone	Steenloper	*Arenaria interpres*
85. *(263)* Terek Sandpiper	Terekruiter	*Xenus cinereus*
86. *(264)* Common Sandpiper	Gewone Ruiter	*Actitis hypoleucos*
87. *(266)* Wood Sandpiper	Bosruiter	*Tringa glariola*
88. *(269)* Marsh Sandpiper	Moerasruiter	*Tringa stagnatilis*
89. *(270)* Common Greenshank	Groenpootruiter	*Tringa nebularia*
90. *(274)* Little Stint	Kleinstrandloper	*Calidris minuta*
91. *(284)* Ruff	Kemphaan	*Philomachus pugnax*
92. *(289)* Eurasian Curlew	Grootwulp	*Numenius arquata*
93. *(294)* Pied Avocet	Bontelsie	*Recurvirostra avosetta*
94. *(295)* Black-winged Stilt	Rooipootelsie	*Himantopus himantopus*
95. *(297)* Spotted Thick-knee	Gewone Dikkop	*Burhinus capensis*
96. *(300)* Temminck's Courser	Trekdrawwertjie	*Cursorius temminckii*
97. *(301)* Double-banded Courser	Dubbelbanddrawwertjie	*Rhinoptilus africanus*

98. *(303)* Bronze-winged Courser	Bronsvlerkdrawwertjie	*Rhinoptilus chalcopterus*
99. *(315)* Grey-headed Gull	Gryskopmeeu	*Larus cirrocephalus*
100. *(322)* Caspian Tern	Reusesterretjie	*Sterna caspia*
101. *(339)* White-winged Tern	Witvlerksterretjie	*Chlidonias leucopterus*
102. *(344)* Namaqua Sandgrouse	Kelkiewyn	*Pterocles namaqua*
103. *(346)* Yellow-throated Sandgrouse	Geelkeelsandpatrys	*Pterocles gutturalis*
104. *(349)* Speckled Pigeon	Kransduif	*Columba guinea*
105. *(352)* Red-eyed Dove	Grootringduif	*Streptopelia semitorquata*
106. *(354)* Cape Turtle-dove	Gewone Tortelduif	*Streptopelia capicola*
107. *(355)* Laughing Dove	Rooiborsduif	*Streptopelia senegalensis*
108. *(356)* Namaqua Dove	Namakwaduifie	*Oena capensis*
109. *(386)* Diderick Cuckoo	Diederikkie	*Chrysococcyx caprius*
110. *(391)* Burchell's Coucal	Gewone Vleiloerie	*Centropus burchelli*
111. *(392)* Barn Owl	Nonnetjie-uil	*Tyto alba*
112. *(393)* African Grass-owl	Grasuil	*Tyto capensis*
113. *(395)* Marsh Owl	Vlei-uil	*Asio capensis*
114. *(396)* African Scops-owl	Skopsuil	*Otus senegalensis*
115. *(398)* Pearl-spotted Owlet	Witkoluil	*Glaucidium capense*
116. *(401)* Spotted Eagle-owl	Gevlekte Ooruil	*Bubo africanus*
117. *(406)* Rufous-cheeked Nightjar	Rooiwangnaguil	*Caprimulgus rufigena*
118. *(411)* Common Swift	Europese Windswael	*Apus apus*
119. *(412)* African Black Swift	Swartwindswael	*Apus barbatus*
120. *(415)* White-rumped Swift	Witkruiswindswael	*Apus caffer*
121. *(416)* Horus Swift	Horuswindswael	*Apus horus*
122. *(417)* Little Swift	Kleinwindswael	*Apus affinis*
123. *(425)* White-backed Mousebird	Witkruismuisvoël	*Colius colius*
124. *(426)* Red-faced Mousebird	Rooiwangmuisvoël	*Urocolius indicus*
125. *(428)* Pied Kingfisher	Bontvisvanger	*Ceryle rudis*
126. *(430)* Half-collared Kingfisher	Blouvisvanger	*Alcedo semitorquata*
127. *(431)* Malachite Kingfisher	Kuifkopvisvanger	*Alcedo cristata*
128. *(438)* European Bee-eater	Europese Byvreter	*Merops apiaster*
129. *(441)* Southern Carmine Bee-eater	Rooiborsbyvreter	*Merops nubicoides*

130. *(445)* Swallow-tailed Bee-eater	Swaelstertbyvreter	*Merops hirundineus*
131. *(446)* European Roller	Europese Troupant	*Coracius garrulus*
132. *(449)* Purple Roller	Groottroupant	*Coracius naevia*
133. *(451)* African Hoopoe	Hoephoep	*Upupa africana*
134. *(457)* African Grey Hornbill	Grysneushoringvoël	*Tockus nasutus*
135. *(465)* Acacia Pied Barbet	Bonthoutkapper	*Tricholaema leucomelas*
136. *(474)* Greater Honeyguide	Grootheuningwyser	*Indicator indicator*
137. *(486)* Cardinal Woodpecker	Kardinaalspeg	*Dendropicos fuscescens*
138. *(492)* Melodious Lark	Spotlewerik	*Mirafra cheniana*
139. *(494)* Rufous-naped Lark	Rooineklewerik	*Mirafra africana*
140. *(506)* Spike-heeled Lark	Vlaktelewerik	*Chersomanes albofasciata*
141. *(507)* Red-capped Lark	Rooikoplewerik	*Calandrella cinerea*
142. *(511)* Stark's Lark	Woestynlewerik	*Eremalauda starki*
143. *(515)* Chestnut-backed Sparrowlark	Rooiruglewerik	*Eremopterix leucotis*
144. *(516)* Grey-backed Sparrowlark	Grysruglewerik	*Eremopterix verticallis*
145. *(517)* Black-eared Sparrowlark	Swartoorlewerik	*Eremopterix australis*
146. *(518)* Barn Swallow	Europese Swael	*Hirundo rustica*
147. *(519)* Angola Swallow	Angolaswael	*Hirundo angolensis*
148. *(520)* White-throated Swallow	Witkeelswael	*Hirundo albigularis*
149. *(524)* Red-breasted Swallow	Rooiborsswael	*Hirundo semirufa*
150. *(526)* Greater Striped Swallow	Grootstreepswael	*Hirundo cucullata*
151. *(528)* South African Cliff-swallow	Familieswael	*Hirundo spilodera*
152. *(530)* Common House-martin	Huisswael	*Delichon urbica*
153. *(532)* Sand Martin	Europese Oewerswael	*Riparia riparia*
154. *(533)* Brown-throated Martin	Afrikaanse Oewerswael	*Riparia paludicola*
155. *(534)* Banded Martin	Gebande Oewerswael	*Riparia cincta*
156. *(544)* African Golden Oriole	Afrikaanse Wielewaal	*Oriolus auratus*
157. *(547)* Cape Crow	Swartkraai	*Corvus capensis*
158. *(548)* Pied Crow	Witborskraai	*Corvus capensis*
159. *(552)* Ashy Tit	Akasiagrysmees	*Parus cinerascens*

160. *(563)* Southern Pied Babbler	Witkatlagter	*Turdoides bicolor*
161. *(567)* African Red-eyed Bulbul	Rooioogtiptol	*Pycnonotus nigricans*
162. *(583)* Short-toed Rock-thrush	Korttoonkliplyster	*Monticola brevipes*
163. *(586)* Mountain Wheatear	Bergwagter	*Oenanthe monticola*
164. *(587)* Capped Wheatear	Hoëveldskaapwagter	*Oenanthe pileata*
165. *(589)* Familiar Chat	Gewone Spekvreter	*Cercomela familiaris*
166. *(591)* Sickle-winged Chat	Vlaktespekvreter	*Cercomela sinuata*
167. *(595)* Ant-eating Chat	Swartpiek	*Myrmecocichla formicivora*
168. *(596)* African Stonechat	Gewone Bontrokkie	*Saxicola torquata*
169. *(601)* Cape Robin-chat	Gewone Janfrederik	*Cossypha caffra*
170. *(615)* Kalahari Scrub-robin	Kalahariwipstert	*Cercotrichas paean*
171. *(619)* Garden Warbler	Tuinsanger	*Sylvia borin*
172. *(620)* Common Whitethroat	Witkeelsanger	*Sylvia communis*
173. *(621)* Chestnut-vented Tit-babbler	Bosveldtjeriktik	*Parisoma subcaeruleum*
174. *(625)* Icterine Warbler	Spotsanger	*Hippolais icterina*
175. *(628)* Great Reed-warbler	Grootrietsanger	*Acrocephalus arundinaceus*
176. *(631)* African Reed-warbler	Kleinrietsanger	*Acrocephalus baeticatus*
177. *(634)* Sedge Warbler	Europese Vleisanger	*Acrocephalus schoenobaenus*
178. *(635)* Lesser Swamp-warbler	Kaapse Rietsanger	*Acrocephalus gracilirostris*
179. *(643)* Willow Warbler	Hofsanger	*Phylloscopus trochilus*
180. *(653)* Yellow-bellied Eremomela	Geelpensbossanger	*Eremomela icteropygialis*
181. *(661)* Cape Grassbird	Grasvoël	*Sphenoeacus afer*
182. *(664)* Zitting Cisticola	Landeryklopkloppie	*Cisticola juncidis*
183. *(665)* Desert Cisticola	Woestynklopkloppie	*Cisticola aridulus*
184. *(666)* Cloud Cisticola	Gevlekte Klopkloppie	*Cisticola textrix*
185. *(667)* Wing-snapping Cisticola	Kleinste Klopkloppie	*Cisticola ayresii*
186. *(681)* Neddicky	Neddikkie	*Cisticola fulvicapillus*
187. *(685)* Black-chested Prinia	Swartbandlangstertjie	*Prinia flavicans*
188. *(688)* Rufous-eared Warbler	Rooioorlangstertjie	*Malcorus pectoralis*
189. *(689)* Spotted Flycatcher	Europese Vlieëvanger	*Muscicapa striata*
190. *(697)* Chat Flycatcher	Grootvlieëvanger	*Bradornis infuscatus*

191. *(698)* Fiscal Flycatcher	Fiskaalvlieëvanger	*Sigelus silnes*
192. *(706)* Fairy Flycatcher	Feevlieëvanger	*Stenostira scita*
193. *(713)* Cape Wagtail	Gewone Kwikkie	*Motacilla capensis*
194. *(717)* Long-billed Pipit	Nicholsonse Koester	*Anthus similis*
195. *(723)* Bushveld Pipit	Bosveldkoester	*Anthus caffer*
196. *(727)* Cape Longclaw	Oranjekeelkalkoentjie	*Macronyx capensis*
197. *(731)* Lesser Grey Shrike	Gryslaksman	*Lanius minor*
198. *(732)* Common Fiscal	Fiskaallaksman	*Lanius collaris*
199. *(733)* Red-backed Shrike	Rooiruglaksman	*Lanius collurio*
200. *(739)* Crimson-breasted Shrike	Rooiborslaksman	*Laniarius atrococcineus*
201. *(746)* Bokmakierie	Bokmakierie	*Telophorus zeylonus*
202. *(759)* Pied Starling	Witgatspreeu	*Spreo bicolor*
203. *(760)* Wattled Starling	Lelspreeu	*Creatophora cinerea*
204. *(779)* Marico Sunbird	Maricosuikerbekkie	*Cinnyris mariquensis*
205. *(783)* Southern Double-collared Sunbird	Kleinrooibandsuikerbekkie	*Cinnyris chalybea*
206. *(796)* Cape White-eye	Kaapse Glasogie	*Zosterops virens*
207. *(799)* White-browed Sparrow-weaver	Koringvoël	*Plocepasser mahali*
208. *(800)* Sociable Weaver	Versamelvoël	*Philetairus socius*
209. *(801)* House Sparrow	Huismossie	*Passer domesticus*
210. *(802)* Great Sparrow	Grootmossie	*Passer motitensis*
211. *(803)* Cape Sparrow	Gewone Mossie	*Passer melanurus*
212. *(804)* Southern Grey-headed Sparrow	Gryskopmossie	*Passer diffuses*
213. *(806)* Scaly-feathered Finch	Baardmannetjie	*Sporopipes squamifrons*
214. *(814)* Southern Masked-weaver	Swartkeelgeelvink	*Ploceus velatus*
215. *(821)* Red-billed Quelea	Rooibekkwelea	*Quelea quelea*
216. *(824)* Southern Red Bishop	Rooivink	*Euplectes orix*
217. *(826)* Yellow-crowned Bishop	Goudgeelvink	*Euplectes afer*
218. *(829)* White-winged Widowbird	Witvlerkflap	*Euplectes albonotatus*
219. *(831)* Red-collared Widowbird	Rooikeelflap	*Euplectes ardens*

220. *(832)* Long-tailed Widowbird	Langstertflap	*Euplectes progne*
221. *(842)* Red-billed Firefinch	Rooibekvuurvinkie	*Lagonosticta senegala*
222. *(852)* African Quailfinch	Gewone Kwartelvinkie	*Ortygospiza atricollis*
223. *(856)* Red-headed Finch	Rooikopvink	*Amadina erythrocephala*
224. *(861)* Shaft-tailed Whydah	Pylstertrooibekkie	*Vidua regia*
225. *(870)* Black-throated Canary	Bergkanarie	*Serinus atrogularis*
226. *(878)* Yellow Canary	Geelkanarie	*Serinus flaviventris*
227. *(886)* Cinnamon-breasted Bunting	Klipstreepkoppie	*Emberiza tahapisi*

(Farkas, 1962)

Appendix B:

List of species seen recently at Barberspan

English	*Afrikaans*	*Scientific*
228. *(1)* Common Ostrich	Volstruis	*Struthio camelus*
229. *(6)* Great Crested Grebe	Kuifkopdobbertjie	*Podiceps cristatus*
230. *(8)* Little Grebe	Kleindobbertjie	*Tachybaptus ruficollis*
231. *(49)* Great White Pelican	Witpelikaan	*Pelecanus onocrotalus*
232. *(50)* Pink-backed pelican	Kleinpelikaan	*Pelecanus rufescens*
233. *(55)* White-breasted Cormorant	Witborsduiker	*Phalacrocorax neglectu*
234. *(58)* Reed Cormorant	Rietduiker	*Phalacrocorax africanus*
235. *(60)* African darter	Afrikaanse Slanghalsvoël	*Anhinga rufa*
236. *(62)* Grey Heron	Bloureier	*Ardea cinerea*
237. *(63)* Black-headed Heron	Swartkopreier	*Ardea melanocephala*
238. *(64)* Goliath Heron	Reusereier	*Ardea goliath*
239. *(66)* Great Egret	Grootwitreier	*Egretta alba*
240. *(67)* Little Egret	Kleinwitreier	*Egretta garzetta*
241. *(69)* Black Heron	Swartreier	*Egretta ardesiaca*
242. *(71)* Cattle Egret	Veereier	*Bubulcus ibis*
243. *(72)* Squacco Heron	Gewone Ralreier	*Ardeola ralloides*
244. *(76)* Black-crowned Night-heron	Gewone Nagreier	*Nycticorax nycticorax*
245. *(83)* White Stork	Witooievaar	*Ciconia ciconia*
246. *(90)* Yellow-billed Stork	Nimmersat	*Mycteria ibis*
247. *(91)* African Sacred Ibis	Skoorsteenveër	*Threskiornis aethiopicus*
248. *(93)* Glossy Ibis	Glansibis	*Plegadis falcinellus*
249. *(94)* Hadeda Ibis	Hadeda	*Bostrychia hagedash*
250. *(95)* African Spoonbill	Lepelaar	*Platalea alba*
251. *(96)* Greater Flamingo	Grootflamink	*Phoenicopterus ruber*
252. *(97)* Lesser Flamingo	Kleinflamink	*Phoenicopterus minor*
253. *(99)* White-faced Duck	Nonnetjie-eend	*Dendrocygna viduata*
254. *(102)* Egyptian Goose	Kolgans	*Alopochen aegyptiacus*
255. *(103)* South African		

	Shelduck	Kopereend	*Tadorna cana*
256.	*(104)* Yellow-billed Duck	Geelbekeend	*Anas Undulata*
257.	*(105)* African Black Duck	Swarteend	*Anas sparsa*
258.	*(106)* Cape Teal	Teeleend	*Anas capensis*
259.	*(107)* Hottentot Teal	Gevlekte Eend	*Anas hottentota*
260.	*(108)* Red-billed Teal	Rooibekeend	*Anas erythrorhyncha*
261.	*(112)* Cape Shoveler	Kaapse Slopeend	*Anas smithii*
262.	*(116)* Spur-winged Goose	Wildemakou	*Plectropterus gambensis*
263.	*(118)* Secretarybird	Sekretarisvoël	*Sagittarius serpentarius*
264.	*(127)* Black-shouldered Kite	Blouvalk	*Elanus caeruleus*
265.	*(137)* African Hawk-eagle	Afrikaanse Jagarend	*Hieraaetus fasciatus*
266.	*(148)* African Fish Eagle	Visarend	*Haliaeetus vocifer*
267.	*(149)* Steppe Buzzard	Bruinjakkalsvoël	*Buteo vulpinus*
268.	*(162)* Southern Pale Chanting Goshawk	Bleeksingvalk	*Melierax canorus*
269.	*(164)* Eurasian Marsh-harrier	Europese Vleivalk	*Circus aeruginosus*
270.	*(173)* Eurasian Hobby	Europese Boomvalk	*Falco subbuteo*
271.	*(180)* Amur Falcon	Oostelike Rooipootvalkie	*Falco amurensis*
272.	*(181)* Rock Kestrel	Kransvalk	*Falco (tinnunculus) rupicolis*
273.	*(183)* Lesser Kestrel	Kleinrooivalk	*Falco naumanni*
274.	*(194)* Swainson's Spurfowl	Bosveldfisant	*Pternistes swainsonii*
275.	*(200)* Common Quail	Afrikaanse Kwartel	*Coturnix coturnix*
276.	*(203)* Helmeted Guineafowl	Gewone Tarentaal	*Numida meleagris*
277.	*(213)* Black Crake	Swartriethaan	*Amaurornis flavirostris*
278.	*(223)* African Purple Swamphen	Grootkoningriethaan	*Porphyrio madagascariensis*
279.	*(226)* Common Moorhen	Grootwaterhoender	*Gallinula chloropus*
280.	*(228)* Red-knobbed Coot	Bleshoender	*Fulica cristata*
281.	*(239b)* Northern Black Korhaan	Witvlerkswartkorhaan	*Eupodotis afraoides*
282.	*(245)* Common Ringed Plover	Ringnekstrandkiewiet	*Charadrius hiaticula*
283.	*(247)* Chestnut-banded		

	Plover	Rooibandstrandkiewiet	*Charadrius pallidus*
284.	*(248)* Kittlitz's Plover	Geelborsstrandkiewiet	*Charadrius pecuarius*
285.	*(249)* Three-banded Plover	Driebandstrandkiewiet	*Charadrius tricollaris*
286.	*(255)* Crowned Lapwing	Kroonkiewiet	*Vanellus coronatus*
287.	*(258)* Blacksmith Lapwing	Bontkiewiet	*Vanellus crassirostris*
288.	*(260)* African Wattled Lapwing	Lelkiewiet	*Vanellus senegallus*
289.	*(274)* Little Stint	Kleinstrandloper	*Calidris minuta*
290.	*(284)* Ruff	Kemphaan	*Philomachus pugnax*
291.	*(286)* African Snipe	Afrikaanse snip	*Gallinago nigripennis*
292.	*(289)* Eurasian Curlew	Grootwulp	*Numenius arquata*
293.	*(294)* Pied Avocet	Bontelsie	*Recurvirostra avosetta*
294.	*(295)* Black-winged Stilt	Rooipootelsie	*Himantopus himantopus*
295.	*(297)* Spotted Thick-knee	Gewone Dikkop	*Burhinus capensis*
296.	*(305)* Black-winged Pratincole	Swartvlerksprinkaanvoël	*Glareola nordmanni*
297.	*(315)* Grey-headed Gull	Gryskopmeeu	*Larus cirrocephalus*
298.	*(322)* Caspian Tern	Reusesterretjie	*Sterna caspia*
299.	*(338)* Whiskered Tern	Witbaardsterretjie	*Chlidonias hybridus*
300.	*(344)* Namaqua Sandgrouse	Kelkiewyn	*Pterocles namaqua*
301.	*(349)* Speckled Pigeon	Kransduif	*Columba guinea*
302.	*(352)* Red-eyed Dove	Grootringduif	*Streptopelia semitorquata*
303.	*(354)* Cape Turtle-dove	Gewone Tortelduif	*Streptopelia capicola*
304.	*(355)* Laughing Dove	Rooiborsduif	*Streptopelia senegalensis*
305.	*(356)* Namaqua Dove	Namakwaduifie	*Oena capensis*
306.	*(386)* Diderick Cuckoo	Diederikkie	*Chrysococcyx caprius*
307.	*(391)* Burchell's Coucal	Gewone Vleiloerie	*Centropus burchelli*
308.	*(395)* Marsh Owl	Vlei-uil	*Asio capensis*
309.	*(401)* Spotted Eagle-owl	Gevlekte Ooruil	*Bubo africanus*
310.	*(417)* Little Swift	Kleinwindswael	*Apus affinis*
311.	*(421)* African Palm-swift	Palmwindswael	*Cypsiurus parvus*
312.	*(424)* Speckled Mousebird	Gevlekte Muisvoël	*Colius striatus*
313.	*(425)* White-backed Mousebird	Witkruismuisvoël	*Colius colius*
314.	*(426)* Red-faced Mousebird	Rooiwangmuisvoël	*Urocolius indicus*
315.	*(428)* Pied Kingfisher	Bontvisvanger	*Ceryle rudis*

316.	*(438)*	European Bee-eater	Europese Byvreter	*Merops apiaster*
317.	*(445)*	Swallow-tailed Bee-eater	Swaelstertbyvreter	*Merops hirundineus*
318.	*(451)*	African Hoopoe	Hoephoep	*Upupa africana*
319.	*(457)*	African Grey Hornbill	Grysneushoringvoël	*Tockus nasutus*
320.	*(465)*	Acacia Pied Barbet	Bonthoutkapper	*Tricholaema leucomelas*
321.	*(473)*	Crested Barbet	Kuifkophoutkapper	*Trachyphonus vaillantii*
322.	*(474)*	Greater Honeyguide	Grootheuningwyser	*Indicator indicator*
323.		Eastern Clapper Lark	Hoëveldklappertjie	*Mirafra fasciolata*
324.	*(506)*	Spike-heeled Lark	Vlaktelewerik	*Chersomanes albofasciata*
325.	*(507)*	Red-capped Lark	Rooikoplewerik	*Calandrella cinerea*
326.	*(515)*	Chestnut-backed Sparrowlark	Rooiruglewerik	*Eremopterix leucotis*
327.	*(516)*	Grey-backed Sparrowlark	Grysruglewerik	*Eremopterix verticallis*
328.	*(518)*	Barn Swallow	Europese Swael	*Hirundo rustica*
329.	*(520)*	White-throated Swallow	Witkeelswael	*Hirundo albigularis*
330.	*(523)*	Pearl-breasted Swallow	Pêrelborsswael	*Hirundo dimidiata*
331.	*(524)*	Red-breasted Swallow	Rooiborsswael	*Hirundo semirufa*
332.	*(526)*	Greater Striped Swallow	Grootstreepswael	*Hirundo cucullata*
333.	*(528)*	South African Cliff-swallow	Familieswael	*Hirundo spilodera*
334.	*(530)*	Common House-martin	Huisswael	*Delichon urbica*
335.	*(538)*	Black Cuckooshrike	Swartkatakoeroe	*Campephaga flava*
336.	*(548)*	Pied Crow	Witborskraai	*Corvus capensis*
337.	*(567)*	African Red-eyed Bulbul	Rooioogtiptol	*Pycnonotus nigricans*
338.		Olive Thrush	Olyflyster	*Turdus olivaceus*
339.	*(587)*	Capped Wheatear	Hoëveldskaapwagter	*Oenanthe pileata*
340.	*(595)*	Ant-eating Chat	Swartpiek	*Myrmecocichla formicivora*
341.	*(596)*	African Stonechat	Gewone Bontrokkie	*Saxicola torquata*
342.	*(615)*	Kalahari Scrub-robin	Kalahariwipstert	*Cercotrichas paean*

343.	*(621)* Chestnut-vented Tit-babbler	Bosveldtjeriktik	*Parisoma subcaeruleum*
344.	*(634)* Sedge Warbler	Europese Vleisanger	*Acrocephalus schoenobaenus*
345.	*(635)* Lesser Swamp-warbler	Kaapse Rietsanger	*Acrocephalus gracilirostris*
346.	*(643)* Willow Warbler	Hofsanger	*Phylloscopus trochilus*
347.	*(664)* Zitting Cisticola	Landeryklopkloppie	*Cisticola juncidis*
348.	*(665)* Desert Cisticola	Woestynklopkloppie	*Cisticola aridulus*
349.	*(667)* Wing-snapping Cisticola	Kleinste Klopkloppie	*Cisticola ayresii*
350.	*(672)* Rattling Cisticola	Bosveldtinktinkie	*Cisticola chinianus*
351.	*(677)* Levaillant's Cisticola	Vleitinktinkie	*Cisticola tinniens*
352.	*(681)* Neddicky	Neddikkie	*Cisticola fulvicapillus*
353.	*(685)* Black-chested Prinia	Swartbandlangstertjie	*Prinia flavicans*
354.	*(689)* Spotted Flycatcher	Europese Vlieëvanger	*Muscicapa striata*
355.	*(695)* Marico Flycatcher	Maricovlieëvanger	*Bradornis mariquensis*
356.	*(698)* Fiscal Flycatcher	Fiskaalvlieëvanger	*Sigelus silnes*
357.	*(706)* Fairy Flycatcher	Feevlieëvanger	*Stenostira scita*
358.	*(710)* African Paradise-flycatcher	Paradysvlieëvanger	*Terpsiphone viridis*
359.	*(713)* Cape Wagtail	Gewone Kwikkie	*Motacilla capensis*
360.	*(714)* Yellow Wagtail	Geelkwikkie	*Motacilla flava*
361.	*(716)* African Pipit	Gewone Koester	*Anthus leucophrys*
362.	*(719)* Buffy Pipit	Vaalkoester	*Anthus vaalensis*
363.	*(727)* Cape Longclaw	Oranjekeelkalkoentjie	*Macronyx capensis*
364.	*(732)* Common Fiscal	Fiskaallaksman	*Lanius collaris*
365.	*(733)* Red-backed Shrike	Rooiruglaksman	*Lanius collurio*
366.	*(739)* Crimson-breasted Shrike	Rooiborslaksman	*Laniarius atrococcineus*
367.	*(741)* Brubru	Bontroklaksman	*Nilaus afer*
368.	*(746)* Bokmakierie	Bokmakierie	*Telophorus zeylonus*
369.	*(760)* Wattled Starling	Lelspreeu	*Creatophora cinerea*
370.	*(764)* Cape Glossy Starling	Kleinglansspreeu	*Lamprotornis nitens*
371.	*(796)* Cape White-eye	Kaapse Glasogie	*Zosterops virens*
372.	*(799)* White-browed Sparrow-weaver	Koringvoël	*Plocepasser mahali*

373.	*(801)* House Sparrow	Huismossie	*Passer domesticus*
374.	*(803)* Cape Sparrow	Gewone Mossie	*Passer melanurus*
375.	*(804)* Southern Grey-headed Sparrow	Gryskopmossie	*Passer diffuses*
376.	*(814)* Southern Masked-weaver	Swartkeelgeelvink	*Ploceus velatus*
377.	*(821)* Red-billed Quelea	Rooibekkwelea	*Quelea quelea*
378.	*(824)* Southern Red Bishop	Rooivink	*Euplectes orix*
379.	*(826)* Yellow-crowned Bishop	Goudgeelvink	*Euplectes afer*
380.	*(828)* Fan-tailed Widowbird	Kortstertflap	*Euplectes axillaris*
381.	*(829)* White-winged Widowbird	Witvlerkflap	*Euplectes albonotatus*
382.	*(832)* Long-tailed Widowbird	Langstertflap	*Euplectes progne*
383.	*(846)* Common Waxbill	Rooibeksysie	*Estrilda astrild*
384.	*(852)* African Quailfinch	Gewone Kwartelvinkie	*Ortygospiza atricollis*
385.	*(856)* Red-headed Finch	Rooikopvink	*Amadina erythrocephala*
386.	*(860)* Pin-tailed Whydah	Koningrooibekkie	*Vidua macroura*
387.	*(861)* Shaft-tailed Whydah	Pylstertrooibekkie	*Vidua regia*
388.	*(867)* Village Indigobird	Staalblouvinkie	*Vidua chalybeata*
389.	*(870)* Black-throated Canary	Bergkanarie	*Serinus atrogularis*
390.	*(878)* Yellow Canary	Geelkanarie	*Serinus flaviventris*

Appendix C:

Other animals seen at Barberspan

English	*Afrikaans*	*Scientific*
Bat-eared Fox	Bakoorjakkals	*Otocyon megalotis*
Black-backed Jackal	Rooijakkals	*Canis mesomelas*
Cape Hare	Vlakhaas	*Lepus capensis*
Common Duiker	Duiker	*Sylvicapra grimmia*
Ground Squirrel	Waaierstert-grondeekhoring	*Xerus inauris*
Rinkhals	Rinkhals	*Hemachatus haemachatus*
Slender Mongoose	Swartkwasmuishond	*Galerella sanguinea*
Springhare	Springhaas	*Pedetes capensis*
Steenbok	Steenbok	*Raphicerus campestris*
Suricate	Stokstertmeerkat	*Suricata suricatta*
Yellow Mongoose	Witkwasmuishond	*Cynictus penicillata*
Bats		
Several species of spiders and insects		

Appendix D:

Species before and after the fire

Table 1: Species list for Burn 1: Control Site

Before Fire	After Fire
African Pipit	African Palm-swift
African Quailfinch	African Pipit
African Stonechat	African Stonechat
Ant-eating Chat	Ant-eating Chat
Black-chested Prinia	Barn Swallow
Cape Longclaw	Black-chested Prinia
Chestnut-backed Sparrowlark	Black-shouldered Kite
Common House-martin	Cape Longclaw
Desert Cisticola	Chestnut-backed Sparrowlark
Grey-backed Sparrowlark	Desert Cisticola
Helmeted Guineafowl	Greater Striped Swallow
Levaillant's Cisticola	Helmeted Guineafowl
Long-tailed Widowbird	Levaillant's Cisticola
Pied Crow	Little Swift
South African Cliff-swallow	Long-tailed Widowbird
Spike-heeled Lark	Marsh Owl
Swainson's Spurfowl	Namaqua Sandgrouse
Wing-snapping Cisticola	Northern Black Korhaan
Zitting Cisticola	Pied Crow
	Red-capped Lark
	Sabota Lark
	South African Cliff-swallow
	Spike-heeled Lark
	Spotted Thick-knee
	Swainson's Spurfowl
	Wing-snapping Cisticola
	Zitting Cisticola

Table 2: Species list for Burn 1: Burn Site

Before Fire	After Fire
African Stonechat	African Palm-swift
Ant-eating Chat	African Pipit
Barn Swallow	African Stonechat
Black-chested Prinia	Ant-eating Chat
Black-shouldered Kite	Barn Swallow
Cape Longclaw	Black-chested Prinia
Chestnut-backed Sparrowlark	Black-headed Heron
Crowned Lapwing	Black-shouldered Kite
Desert Cisticola	Blacksmith Lapwing
Grey-backed Sparrowlark	Cape Longclaw
Helmeted Guineafowl	Cape Sparrow
Levaillant's Cisticola	Capped Wheatear
Little Swift	Cattle Egret
Long-tailed Widowbird	Chestnut-backed Sparrowlark
Marsh Owl	Common Ringed Plover
Northern Black Korhaan	Crowned Lapwing
Pied Crow	Desert Cisticola
Red-capped Lark	Eastern Clapper Lark
South African Cliff-swallow	Egyptian Goose
Spike-heeled Lark	Goliath Heron
Swainson’s Spurfowl	Grey Heron
White-winged Widowbird	Grey-backed Sparrowlark
Zitting Cisticola	Helmeted Guineafowl
	Kittlitz's Plover
	Levaillant’s Cisticola
	Little Swift
	Long-tailed Widowbird
	Marsh Owl
	Namaqua Sandgrouse
	Northern Black Korhaan
	Pearl-breasted Swallow
	Pied Crow
	Red-billed Quelea
	Red-capped Lark
	Secretarybird
	South African Cliff-swallow
	Southern Grey-headed Sparrow
	Speckled Pigeon
	Spike-heeled Lark
	Spotted Thick-knee
	Swainson’s Spurfowl
	Three-banded Plover
	White-browed Sparrow-weaver
	White-throated Swallow
	Wing-snapping Cisticola
	Zitting Cisticola

Table 3: Species list for Burn 2: Control Site

Before Fire	After Fire
African Quailfinch	African Quailfinch
African Stonechat	Ant-eating Chat
Ant-eating Chat	Black-chested Prinia
Black-chested Prinia	Black-shouldered Kite
Black-shouldered Kite	Cape Longclaw
Cape Longclaw	Desert Cisticola
Crowned Lapwing	Helmeted Guineafowl
Egyptian Goose	Long-tailed Widowbird
Helmeted Guineafowl	Northern Black Korhaan
Long-tailed Widowbird	Pied Crow
Northern Black Korhaan	Swainson's Spurfowl
Pied Crow	Zitting Cisticola
Swainson's Spurfowl	
Zitting Cisticola	

Table 4: Species list for Burn 2: Burn Site

Before Fire	After Fire
African Quailfinch	African Pipit
Ant-eating Chat	African Quailfinch
Black-chested Prinia	African Stonechat
Blacksmith Lapwing	Ant-eating Chat
Cape Longclaw	Black-headed Heron
Crowned Lapwing	Blacksmith Lapwing
Desert Cisticola	Cape Longclaw
Greater Striped Swallow	Cattle Egret
Helmeted Guineafowl	Chestnut-backed Sparrowlark
Long-tailed Widowbird	Crowned Lapwing
Marsh Owl	Greater Kestrel
Northern Black Korhaan	Helmeted Guineafowl
Spike-heeled Lark	Laughing Dove
Zitting Cisticola	Long-tailed Widowbird
	Northern Black Korhaan
	Pied Crow
	Red-billed Quelea
	Red-capped Lark
	Southern Pale Chanting Goshawk
	Speckled Pigeon
	Spotted Thick-knee
	Swainson's Spurfowl

Table 5: Species list for Burn 3: Control and Burn Site after fire

Control	Burn
African Quailfinch	African Hoopoe
African Stonechat	African Pipit
Ant-eating Chat	African Quailfinch
Black-chested Prinia	African Stonechat
Black-shouldered Kite	Ant-eating Chat
Cape Longclaw	Black-chested Prinia
Desert Cisticola	Black-headed Heron
Helmeted Guineafowl	Blacksmith Lapwing
Levaillant's Cisticola	Black-throated Canary
Little Swift	Cape Longclaw
Long-tailed Widowbird	Cape Sparrow
Northern Black Korhaan	Capped Wheatear
South African Cliff-swallow	Chestnut-backed Sparrowlark
Spike-heeled Lark	Common Fiscal
Spur-winged Goose	Crowned Lapwing
Wing-snapping Cisticola	Desert Cisticola
Zitting Cisticola	Egyptian Goose
	Goliath Heron
	Greater Striped Swallow
	Helmeted Guineafowl
	Kittlitz's Plover
	Laughing Dove
	Lesser Kestrel
	Long-tailed Widowbird
	Northern Black Korhaan
	Pied Crow
	Red-billed Quelea
	Red-breasted Swallow
	Red-capped Lark
	Red-headed Finch
	South African Cliff-swallow
	Southern Red Bishop
	Spike-heeled Lark
	Spotted Thick-knee
	Swainson's Spurfowl
	Wattled Starling
	White Stork
	White-browed Sparrow-weaver
	Wing-snapping Cisticola
	Yellow Canary
	Zitting Cisticola