A Geographical Information System for Fire Management by the Western Cape Nature Conservation Board

Francois Yorke Ford

Thesis presented in partial fulfilment of the requirements for the degree of Master of Economic and Management Sciences at the University of Stellenbosch.

Supervisor: Mr A van Niekerk

April 2006

Abstract

A multitude of unique fauna and flora exist within the Western Cape of South Africa. Fire plays an intricate role in the conservation and extinction of many of these species. It is therefore imperative to understand this delicate relationship in order to help preserve the province's uniquely balanced ecosystem.

The Western Cape Nature Conservation Board (WCNCB) expressed the need for a system that would allow reserve managers to produce basic fire frequency and veld age maps with considerable ease. These maps are needed for intelligent decision-making regarding the management of veldfires. Information concerning vegetation and historical veldfires in the Western Cape, collected over a period of 50 years exist in tabular format in databases of the WCNCB. Some of these tables contain spatial information elements, such as areas affected by fires. Tabular data with spatial elements can be converted to a geographical information system (GIS) format, extracting value previously shielded from the user. Using GIS techniques and the programming language Avenue, two tools with powerful decision-making qualities were created to extract value from these datasets.

One tool shows the fire history of a specified area as a digital map. This map shows areas with varying occurrences of fires over time, thereby highlighting hot spots within the specified location. The ability to view various fire scar datasets spatially over a specified period, as opposed to records in a table, enables the user to understand the extent to which areas have been repeatedly exposed to fire and quickly identify areas most affected.

The second tool shows vegetation age in a similar fashion, allowing the user to see the current spatial distribution of vegetation and its age. Knowledge about the age of indigenous vegetation, such as fynbos, in a predetermined area, facilitates the reserve manager in decisions related to block burning. This is an accepted practise in areas where vegetation requires fire to stimulate germination. Both tools provide decision-making support to reserve managers regarding the most suitable course of action in terms of the implementation of a proactive or passive approach towards fires.

This study satisfies the needs of the WCNCB by exploring the hidden value within their datasets. GIS supported by the programming language, Avenue, was successfully utilised in the development of a system capable of extracting information from current datasets to support reserve managers in their critical decision-making processes.

Opsomming

Die Wes-Kaap is wêreldwyd bekend vir sy magdom unieke plant- en dierspesies. Brande speel 'n belangrike rol in die bewaring en vernietiging van vele van dié spesies. Dit is van kardinale belang om die rol van vuur in die spesifieke omgewing te verstaan ter bewaring van die delikate ekostelsel.

Die Wes-Kaapse Natuurbewaringsraad het 'n behoefte daargestel aan 'n stelsel wat 'n reservaatbestuurder in staat sal stel om vinnig en maklik, basiese veldouderdom- en brand-frekwensiekaarte te genereer. Hierdie tipe kaarte word benodig as ‘n ondersteuningstelsel vir intelligente besluitneming aangaande die bestuur van veldbrande. In hierdie studie word dié behoefte bevredig met behulp van geografiese inligtingstelsels. Inligting oor plantegroei en historiese veldbrande in die Wes-Kaap, versamel oor ’n periode van ongeveer vyftig jaar, bestaan in tabelformaat in databasisse van die Wes-Kaapse Natuurbewaringsraad. Van dié inligting sluit ruimtelike informasie in wat na ‘n geografiese inligtingstelsel (GIS) formaat omskep kan word om sodoende waarde tot die datastel toe te voeg. Twee hulpmiddels met kragtige besluitnemings ondersteuningskwaliteite is ontwikkel met behulp van beide GIS tegnieke en die programmeringstaal, Avenue.

Die eerste hulpmiddel omskep die historiese veldbrand inligting in ‘n digitale kaart. Hierdie kaart vertoon die oorvleuling van die historiese veldbrande in ‘n bepaalde area. Sodoende word die identifisering van areas met herhaalde brandskade dus vergemaklik deur die gebruik van GIS tegnieke in plaas van getabuleerde data.

Die tweede hulpmiddel vertoon plantegroei-ouderdom op ‘n soortgelyke wyse. Dit vertoon die huidige verspreiding van plantegroei en gepaardgaande plantegroei-ouderdom op ‘n digitale kaart. Hierdie inligting kan die besluitnemingsproses rakende blokbrande ondersteun, ‘n aanvaarde praktyk vir plantegroei, soos fynbos, wat vuur benodig vir die stimulasie van ontkieming. Beide hulpmiddels bied besluitnemingsondersteuning aan reservaatbestuurders vir die mees sinvolle benadering, hetsy pro-aktief of passief, tot die bestuur van veldbrande.

Hierdie studie help die Wes-Kaapse Natuurbewaringsraad deur hul bestaande datastelle te ondersoek en waarde toe te voeg deur bruikbare informasie, wat voorheen versteek was, uit te lig. Met die gebruik van GIS en die programmeringstaal, Avenue, is ‘n program ontwikkel wat die proses aansienlik vergemaklik. Dit stel die reservaatbestuurder in staat om bruikbare inligting uit bestaande data te onttrek vir beluitneming tydens veldbrande en die hantering daarvan.

Acknowledgements

I would like to thank the following:

- Our Heavenly Father for without His grace this would not have been possible.
- The financial assistance of National Research Foundation (NRF) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the National Research Foundation.
- The staff of the Scientific Services Division of the Western Cape Nature Conservation Board at Jonkershoek, Mr Tim Sutton and the late Chris Burgers (1952-2002) in particular, who proved to be invaluable sources of information throughout this study.
- Dr Ernst Baard for providing me with accommodation on the reserve for the purposes of this study.
- Dr EPH Hees from the University of Stellenbosch for editing this report.
- Mrs CC Jooste for her preliminary efforts in editing this report.
- The University of Stellenbosch for their patience.
- My family for their motivation and support.
- Miss A Bailey for her editing.

CONTENTS

TABLES

FIGURES

CHAPTER 1: INTRODUCTION

One of the strengths of Geographical Information Systems (GIS) is the ability to manipulate spatial data. Existing tabular data with (apparently) little or no value can often yield very important information when exploring their spatial dimensions. Visualising tabular data can provide a fresh new perspective and assist humans in making better decisions. The potential advantages of linking spatial data with tabular data are not always realised, neither is the potential in using existing spatial elements in datasets. There is much scope for GIS in this type of application; as will be demonstrated in this study.

1.1 RESEARCH PROBLEM

In November 1998 a workshop held by the Western Cape Nature Conservation Board (WCNCB) identified needs and issues with the potential to be addressed using GIS technology. They expressed the need for, amongst other things, a system that will support them in their decision-making processes concerning effective management of fires. At a later stage a needs assessment was carried out to address this issue.

Even though the WCNCB does have a detailed database of veldfires in their reserves, it offers little in terms of spatial decision-making. The problem is to visualise the areas depicted in the database. If a reserve manager is fairly new in his/her position and not familiar with the fire history of an area, he/she would find it difficult to visualise a fire age map from the tabular data in the fire database. This can lead to wrong decisions being made with detrimental environmental effects. A graphical explanation of the problem is provided in Figure 1.1. This simplified hypothetical model shows four polygons that represent fires at various dates. The overlapping nature of these polygons results in 14 areas or polygons (A to N) that all represent areas that were subjected to different fire regimes. Area N, for example, had no fires during this period, whilst area K had been subjected to fires four times. This simple example demonstrates the complexity of fire management considering that tens and even hundreds of such polygons have to be taken into account in real-life situations.

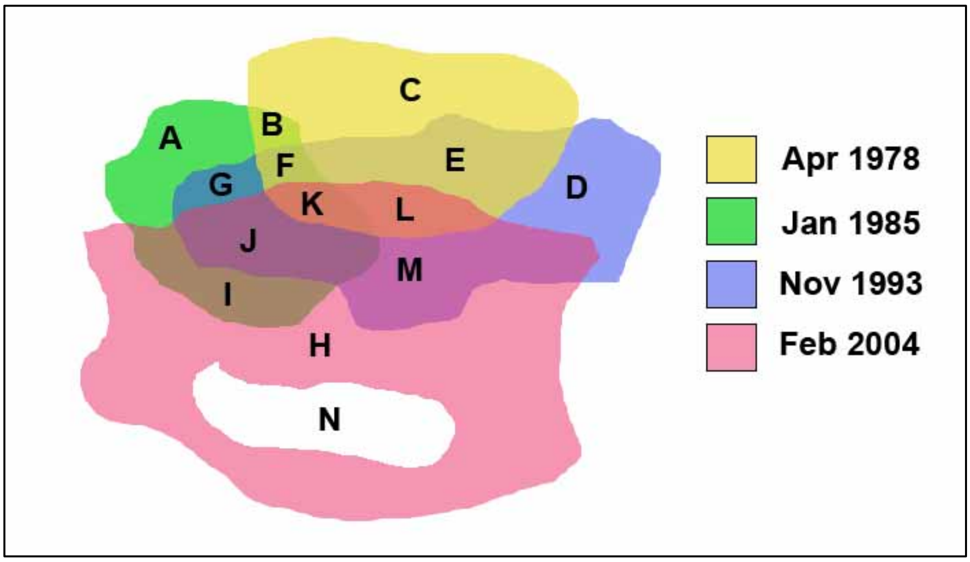

Figure 1.1 Visualising the problem of overlapping fire regimes; a simplified model

Being able to visualise this spatially, instead of in tabular format, will enable a reserve manager to decide more easily where a controlled fire should be started or an existing fire should be fought. The research problem lies within the fact that tabular data in its native form cannot be visualised. This study addresses that problem and shows that converting the WCNCB's tabular data with spatial elements, into a format that can be visualised, holds great power. This study takes up the challenge of solving this problem programmatically.

1.2 RESEARCH AIM AND GOAL

The aim of this research project is to prove that WCNCB's tabular fire data can be visualised using GIS techniques. This will satisfy the need of the Western Cape Nature Conservation Board for providing a decision support tool to reserve managers, by extracting information from their existing database that was previously shielded. This need is addressed by making use of GIS technology, specifically using the software program, ArcView and supporting programming language Avenue. An extension is developed that enables the user to visualise existing tabular, specifically historic veldfire data, spatially. The cognitive approach and research process are described in Figure 1.2.

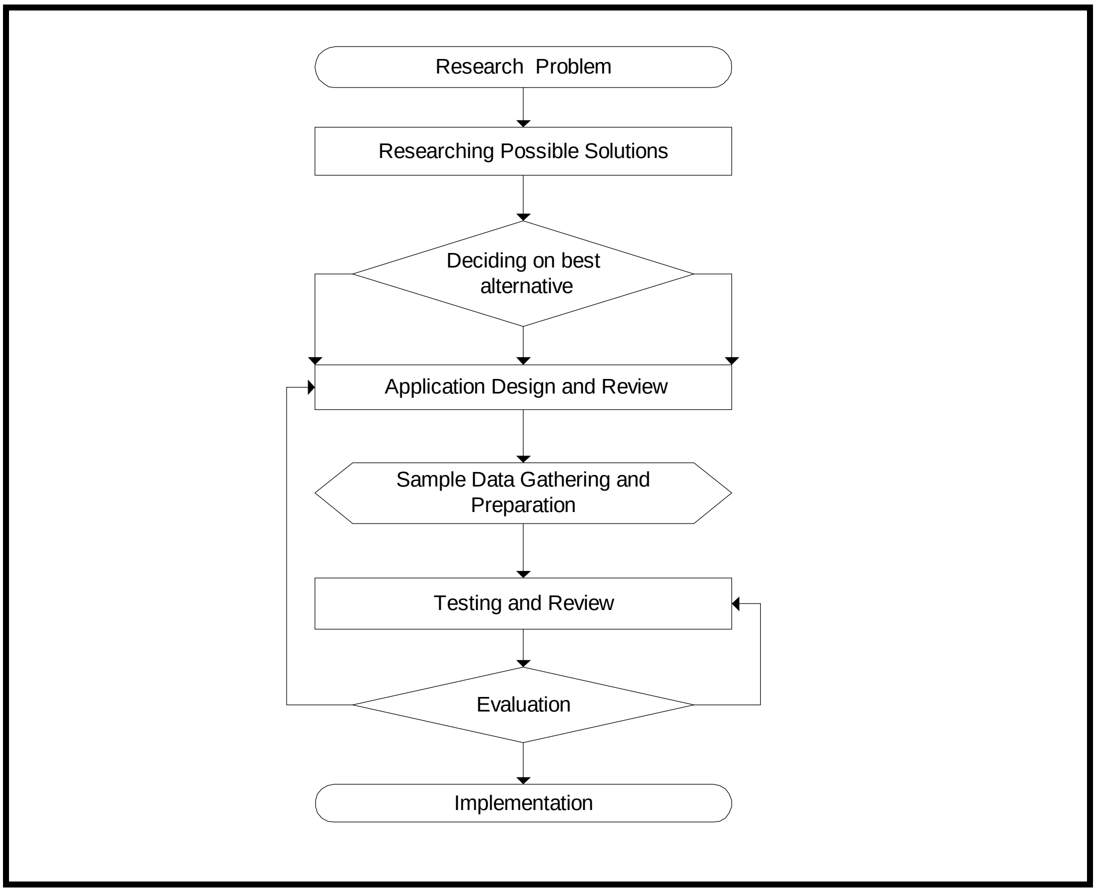

Figure 1.2 Research process flowchart

1.3 WESTERN CAPE NATURE CONSERVATION BOARD (WCNCB)

The Western Cape Nature Conservation Board's origins lie in the establishment of the Cape Department of Nature Conservation in 1952. After almost eight years of negotiations a statutory board was established on 1 April 2000.

Traditionally the nature conservation department relied entirely on the provincial government for its funding. The forming of an independent statutory board heralded a new period in which this organisation could take its rightful place, as a world-class conservation organisation, in mutually beneficial partnerships**.**

Today the WCNCB is a public institution with the statutory responsibility for biodiversity conservation in the Western Cape Province. Being the custodian of the Cape Floral Kingdom, the Board has a global responsibility for the conservation of biodiversity as well as natural systems and ecological processes in the Cape Floral Kingdom. It is the leading implementing agent for CAPE (Cape Action for People and the Environment), a 20-year strategy to secure the biodiversity of the Cape Floral Kingdom while delivering local social and economic benefits (see section 3.1.1). Through active partnerships with communities and development projects, they are a driving force of local rural economic development. The WCNCB is the largest implementing agent for Working for Water, an award-winning conservation and social development programme. The Board played a definitive role in the initiation of this national water conservation programme based on the removal of alien vegetation from water catchments. They act as conservation manager of more than 1.5 million hectares, or nine percent of the land surface of the Western Cape, one of the 11 provinces in South Africa. They are also the driver of partnership-based conservation initiatives and land management programmes. This totals more than 70 conservation areas or 700 000 hectares, and subscribe to more than fifty international environmental protocols and conventions. Furthermore they are a member of the IUCN – the World Conservation Union, committed to the World Conservation Strategy "Caring for the Earth". For the Western Cape Province and the country as a whole, they offer a wide range of accessible eco-tourism opportunities (De Klerk & Sutton 2000; De Klerk 2000, pers com).

The WCNCB's mission is the conservation of the Western Cape's unique natural heritage in partnership with all its people, for the welfare, advantage and enjoyment of present and future generations. Its vision is to strive to become a world leader in conservation. "We aim to instil in all our people a deep sense of ownership and pride in our unique natural heritage and a realisation of its intrinsic and economic value" (WCNCB 2002).

The WCNCB aims to:

- excel as a world leader in conservation;
- enthuse and involve all citizens, especially the youth, in environmental conservation;
- stimulate the economy through the sound and sustainable use of natural resources ;
- instil an enduring sense of ownership and pride in natural heritage;
- deliver significant benefits to the people of the region; and

- be a passionate custodian of a global natural treasure, the Cape Floral Kingdom (WCNCB 2002).

Its goals are to:

- maintain ecological systems and processes;
- conserve genetic diversity;
- conserve (and use) the natural heritage of the Western Cape Province; and
- ensure the sustainable utilisation of species and ecosystems (WCNCB 2002).

The Scientific Services Division (SSD) of the WCNCB has offices situated at the Assegaaibosch Nature Reserve in the Jonkershoek valley 6 kilometres from Stellenbosch.

The conservation scientists and technical assistants of the SSD aim to:

- provide an inventory and assist in the monitoring of the natural heritage of the Western Cape;
- do research or have research done to understand natural systems and processes;
- provide new and revise current policies; and
- ensure technology transfer and capacity building towards effective conservation management (WCNCB 2002).

Members of the SSD supply expert advice on indigenous aquatic systems, plants, invertebrates, freshwater fishes, amphibians, reptiles, birds and mammals to top management; they liaise with outside academic and non-governmental organisations, represent Cape Nature Conservation at corporate level and facilitate the flow of conservation biology information to and from the management division. Members of the SSD form part of the extensive regional management committee network and accept co-responsibility for management issues pertaining to the regions (Shaw 2001, pers com). In addition it gives input into the evaluation of impact assessments for new developments in the region and aims for a balanced approach towards conservation and development in the Western Cape (Sutton 2000, pers com).

In the SSD, the WCNCB has a strong GIS division. The GIS division's vision is to:

- provide all WCNCB personnel whose function necessitates the use of spatial data or spatial analyses with access to GIS data and facilities to aid said functions;
- provide data to internal parties to facilitate and promote environmentally sensitive and sustainable development within the Western Cape; and
- provide non-sensitive data to external parties to facilitate and promote environmentally sensitive and sustainable development within the Western Cape (WCNCB 2002).

The GIS division's goals are to:

- integrate geographically referenced data from all available sources;
- provide a tool for the visualisation of these data;
- improve access to critical management information;
- ensure continuity of management and information used for management;
- improve efficiency with which management and conservation activities are carried out;
- identify shortcomings in the conservation programme of the region; and
- provide a service to internal and external public (WCNCB 2002).

1.4 WCNCB RESERVES

There are 29 conservation areas that fall within the WCNCB's responsibility (WCNCB 2002).

1. Cederberg
2. Matjiesrivier
3. Bird Island
4. Verlorenvlei
5. Rocherpan
6. Groot Winterhoek
7. Kogelberg
8. Jonkershoek
9. Assegaaibosch
10. Limietberg
11. Hottentots Holland
12. Walker Bay
13. Salmonsdam
14. De Mond
15. De Hoop
16. Vrolijkheid
17. Marloth
18. Grootvadersbosch
19. Boosmansbos
20. Anysberg
21. Towerkop
22. Gamkapoort
23. Gamkaberg
24. Swartberg
25. Outeniqua
26. Goukamma
27. Kammanassie
28. Keurbooms
29. Robberg

A reserve manager manages each of the reserves, with a myriad tasks, duties and responsibilities. These include:

- staff management;
- monitoring;
- veld management including planning controlled 'block burns' and managing wildfires;
- planning programmes for upkeep of reserve infrastructure;
- law enforcement;
- management of alien fauna and flora; and
- financial management (Shaw 2001; Sutton 2001, pers com).

CHAPTER 2: THE ENVIRONMENT

For the purpose of this study it is necessary to understand the environmental aspects of vegetation and fire. The relationship between these two components is outlined below.

2.1 FYNBOS

Fires and fynbos have an important symbiosis, which is significant to the purposes of this study.

2.1.1 What is Fynbos?

Residents in the Cape region, a small area at the extreme south-west of the African subcontinent are privileged to live in one of the six richest temperate floras in the world. The Cape Floral Kingdom region covers less than 90 000 square kilometres with about 8 600 plant species (mostly fynbos) and represents more than one third of southern Africa’s flora. Even though the Cape Floral Kingdom is one of the smallest of these worldwide floras, representing only four percent of the total land surface of southern Africa, it has the greatest diversity of plant species. More plant species are found in the Cape Peninsula than in the whole of the United Kingdom and there are some botanists who are strongly of the opinion that there are species that have not yet been identified (Van Wilgen 1980; Van Wilgen 1981).

Lotriet (2003) of the World Wildlife Federation (WWF) states that, as the smallest yet richest of the world's six floral kingdoms, the sustained conservation of the Cape Floral Kingdom (or fynbos) is of critical global significance. According to him, a phenomenal 9 000 plant species make up this kingdom, 6 000 of which are found nowhere else on Earth (Lotriet 2003).

The six floral kingdoms of the world are proportionally:

1. Holarctic Kingdom: 42%
2. Paleotropic Kingdom: 35%
3. Neotropical Kingdom: 14%

4. Australian Kingdom: 8%
5. Holantarctic Kingdom: 1%
6. Capensis: 0.04%.

(Huguenot Memorial Museum 2003)

The word fynbos relates to a group of plants, dominated by shrubs and compromising species peculiar to the Cape Region. It is an Afrikaans word that means 'fine bush' and describes this distinctive vegetation. The Institute for Plant Conservation suggests that the word originated from the Dutch who, in the mid-seventeenth century used the term "fijnbosch" for the timber from this vegetation which was too slender for building purposes or manufacturing of furniture. It is also possible that it refers to the fine leaves of the shrubs. Today fynbos is the term used for the group of plants that is dominated by shrubs and comprises species specific to South Africa's South-western- and Southern Cape (Cowling & Richardson 1995).

According to Cowling & Richardson (1995), fynbos is characterised by four different growth forms: the proteoids- the larger protea shrubs with large leaves; the ericoids- heath-like shrubs; the restioids- wiry, reed-like plants and the geophytes; and the bulbous herbs. The restioids are the unique distinguishing feature of the fynbos as the presence of the others varies from area to area. Van Wilgen (1980) states that these 8 550 species are in 957 genera, of which 198 genera (6 252 species) are endemic. Goldblatt (1978) and Cowling & Richardson (1995) indicate that the following seven families are endemic to the Cape: Bruniaceae (except for one species which occurs in Pondoland and southern Kwa-Zulu Natal), Geissolomaceae, Grubbiaceae, Penaceae, Retziaceae, Roridulaceae, and Stilbaceae.

According to Van Wilgen (1980) the Fynbos biome extends from Nieuwoudtville in the north, following the eastern slopes of the Cedarberg, and east from Karoopoort along the north slope of the Witteberg, Swartberg, Baviaanskloof and Groot Winterhoek Mountains, ending at Port Elizabeth (see Figure 2.1). All territory south and west of this line to the coast forms the Cape Region.

Figure 2.1 **Map showing the extent of the fynbos biome in the Western Cape**

The distribution of fynbos follows a geological rather than climatic pattern, with most fynbos restricted to the sandstones of the Cape System (Van Wilgen, 1980). The Department of Water Affairs and Forestry is by far the largest controller of mountain land under natural vegetation in the Republic of South Africa.

2.1.2 The Origin of Fynbos

When the different continents or landmasses now known as Africa, South America, Antarctica, Australia, India, Madagascar, New Zealand and some Pacific Islands broke away from the giant super continent called Gondwanaland, about 140 million years ago, significant climatic changes occurred (Cowling & Richardson 1995). Cycles of sediment deposition, mountain building and erosion were instrumental in forming the sandstone mountain ranges with valleys and shale flats and limestone outcrops of the fynbos region, which is one of the explanations for the richness and diversity of the flora found in these areas. The soils on these mountain slopes are mainly weathered from sandstones and are, as a rule, acid, leached and low in fertility (nutrients).

The origins of fynbos date back millions of years. According to Cowling & Richardson (1995), the fossil evidence of protea pollen was dated to 95 million years ago during the Mesozoic period. The fynbos region started to resemble closely what we see today between five and two million years ago.

The region's climate changed mainly to a Mediterranean type, with rainfall ranging from 300 to 2 500 millimeters or more per annum. Towards the west, more than 50 per cent of the rainfall occurs in winter whilst further east the rainfall is more evenly distributed throughout the year. It is during this time that the importance of fire increased and played a crucial role in the evolution of fynbos species (Cowling & Richardson 1995).

Fynbos is, however, under very serious threat of extinction. Carefully managed conservation programmes are therefore of the utmost importance (Rebelo 1995).

2.1.3 The Role of Fire in Fynbos

Fire is one of the key factors in driving the fynbos system and maintaining its great diversity (Aupiais & Stammers 2000). Cowling & Richardson (1995:50) state that "Out of the ashes of the primeval rainforests, fynbos was born".

Early Greek philosophers ranked fire with air, water and earth as one of the four basic elements, according to Brown & Davis (1973). Throughout the history of the world fire has played an important role in the evolution of plant life and the changing of the "face" of the earth. Even today fire has an enormous impact on the survival or extinction of species and erosion of the topsoil. Photographs taken from space crafts clearly illustrate the effects of fire on the Amazonian rainforests. The efflux of topsoil into the ocean, where the Amazon River runs into the Atlantic Ocean, can be seen in Figure 2.2 (Burtt 1993).

(source: Jungle Photos 2003)

Figure 2.2 Fire promotes loss of topsoil as can be seen in the Amazon river mouth

According to Whelan (1998), new knowledge about the ecological influence of fire on vegetation has contributed to the notion that fire has broader significance, i.e. the ecological effects of fire, both wildfire and management burning, are fundamental to the conservation of plant and animal populations and representative communities in many areas.

In relation to the basic principles of combustion, one can recognise three stages in the combustion of vegetation. These are: (i) preheating, where the fuel just ahead of the fire front is heated, dried and partly pyrolysed; (ii) flaming combustion, which results from the ignition of the flammable hydrocarbon gases; and (iii) glowing combustion, during which the remaining charcoal burns as a solid, with oxidation taking place on the surface leaving a small amount of residual ash (Whelan 1998).

The amount of energy released during combustion is strongly influenced by the fire's intensity, which in turn is influenced by various factors. The presence of volatile oils and resins has high-energy contents. This together with the presence of water in the fuel will lead to heat loss. This is due to energy being required to raise the water content to 100ºC, then separating the bound water from the fuel, vaporising the water and then heating the water vapour to flame temperature.

Naveh (1990) believes that fire may be vital for the direct stimulation of germination, growth and regeneration of many species. This is true in particular for geophytes and hemicryptohytes, where fire aids the removal of heat unstable phytotoxic agents accumulating in the unburned litter, and efficient nutrient cycling.

Ecology cannot be studied without reference to fire. Nor can ecological principles be applied to ecosystem management without some understanding of the role of fire. After human urban and agricultural activities, fire is the most ubiquitous terrestrial disturbance. Fire is a very general and influential ecological phenomenon. Throughout the history of humankind terrestrial vegetation has changed drastically due to the influence of fire (Bond & Van Wilgen 1996).

According to Bond & Van Wilgen (1996), some fynbos plant species, such as the marsh rose (*Orothamus zeyheri*), were thought to be extinct until a forester noticed seedlings emerge in regularly burnt firebreaks. Cautious programmes of pre-planned burning were initiated to stimulate growth and subsequently more species that had been believed to be extinct have emerged.

Aupiais & Stammers (2000) claim that fynbos needs fire every 5 to 20 years and they base their statement on 50 years of research done by the CSIR. They explain that fynbos has some environmental barriers because it grows in nutrient-poor sandstone. Just dropping its seeds would mean that birds and rodents would consume them. For this reason, some fynbos species belong to a category called ‘re-sprouters’, having shoots or bulbs underground that can survive a fire.

Another group of fynbos belongs to a category called serotinous plants. These plants release their seeds only after they have died during a fire, seeing that birds and rodents would have been driven away at that stage. It takes about five years for a plant to produce seeds; hence the minimum requirement of a five-year window between fires. On the other hand, if the window between fires is too long, such as 20 years, then serotinus plants will release their seeds even if conditions are poor. Thus they are likely to become extinct over time (Aupiais & Stammers 2000).

A third group of fynbos belongs to the myrmehochorus plants. They produce seeds with a fatty food body irresistible to ants. The ants take the seeds underground and consume all except the seed section, which germinates after fires. Germination is triggered when diurnal underground temperatures fluctuate more strongly, as is typical after a fire when the isolating layer of vegetation has disappeared (Aupiais & Stammers 2000).

Research has shown that the dormant seeds of many fynbos species are stimulated to germinate by the chemical substances found in smoke. Substances leached from heated or charred wood can also stimulate germination (Rourke 1987). Many fynbos plants are killed by fire, and rely entirely on seeds for reproduction. Others survive fires and re-sprout from beneath fire-resistant bark or from below ground. A major explanation for the diversity of plant species in fynbos is to be found by exploring the many routes that different plant groups have followed in evolving adaptations to deal with fire (Rourke 1980). *Aulax umbellata* occurs in fire-prone vegetation, where natural fires occur every ten to thirty years. This 'Mediterranean' type of vegetation grows in soils with very low amounts of nutrients. These nutrients are used up by the plants during their lifetime and need to be returned to the soil to provide the food for a new generation of plants. Natural fires occur mainly in late summer or autumn and are followed by the first winter rains, which provide the moisture that the young seedlings need to grow to a size at which they can survive the long, hot summer. The fire itself, as well as the smoke it produces, is thought to play a role in damaging the thick seed coat of the small nuts, thereby stimulating the germination process (Rourke 1980). The heat shock of the fire causes desiccation of the seed coat in a fynbos *Leucospermum* species, which then cracks on moistening, initiating germination (Brits, Calitz, Brown & Manning 1993).

For the survival of various fynbos species, the actual timing of fire is important. Le Maitre & Brown (1992) showed through fire-stimulated flowering studies of the

Watsonia pyramidata in fynbos, that it flowered prolifically after autumn fires compared to sporadic flowering after spring fires.

Some fynbos species are dependent on fire to be able to release their seeds from cones, such as *Proteacea* and *Erica sessiflora*, according to Bond & Van Wilgen (1996). Due to this dependency, the concept of fire has been researched in more detail as is discussed below.

2.2 FIRE

In the simplest terms, fire is a chemical reaction. Fire is the naturally occurring companion of energy release in the form of heat and light when oxygen combines with a combustible, or burnable, material at a suitably high temperature (about 617°F, 325°C for wood to burn) (Lindley & Appleton 2003).

Figure 2.3 Fire triangle showing the elements needed to sustain fire

All three of these components are needed for fire. Simply stated combustible material is‘fuel’ and a suitably high temperature is ’heat’. Fuel, heat and oxygen are needed in the right combination to produce fire. Combined, they are called the "fire triangle" (Figure 2.3). By nature, a triangle needs three sides. Take away one of the sides and the triangle collapses. The same is true of fire. Take away any of the three components of fire- fuel, heat or oxygen- and the fire collapses, meaning that it can not burn (Lindley & Appleton 2003).

2.2.1 Wildfires / Veldfires

With a steady supply of oxygen (a fire needs air that contains at least 16% oxygen; the earth’s atmosphere contains 21%), fuel and temperature become critical to sustaining a fire once it’s ignited (Lindley & Appleton 2003). (Lightning ignites most wildfires internationally.)

Large fires can create their own winds, increasing their flow of oxygen. A really large fire can generate hurricane-force winds of up to 190 km/h. The high temperatures ‘preheat’ fuels in the fire’s path, preparing them to burn more readily. When fires reach this stage, there is little that fire-fighters can do (Lindley & Appleton 2003).

2.2.2 Wildfires in South Africa

South Africa has diverse vegetation and the wildfires, which occur throughout the country, have variable effects on the different vegetations.

2.2.2.1 Forest

Natural forests in South Africa cover less than one per cent of the country’s total area. Fire plays an important role on the edges of these forest communities and wildfires seldom penetrate the larger patches of mature forest. Charcoal present in the soil profiles of some forests indicates that fires may occur in natural forests at intervals of several hundreds of years (Huntley 1984).

The inherited role of fire in forestry plantations was not recognised before the 1980s, by which time serious wildfires occurred at an increased rate, threatening the sustainability of timber supplies. The "total protection policy" applied in these plantations, completely excluding fire from planted areas, increased the fire hazard steadily, as fuel accumulation increased out of control in many forest regions. It was only during the 1990s that fuel management was considered as a viable fuel level control technique, and that selective use of prescribed burning was accepted as an important long-term solution to combat the increased wildfire problem (De Ronde 1990, 1997; De Ronde, Goldammer , Wade & Soares 1990).

Industrial forests, such as even-aged Acacia, Eucalyptus and Pinus plantation stands, cover an area of approximately one and a half percent of South Africa and have mostly been established in the higher rainfall areas of the grassland biome of the summer rainfall region. These forests are regularly exposed to wildfire damage, because of the fire history of the host vegetation, and the fire history of the countries of tree origin. (Goldammer & De Ronde 2001).

2.2.2.2 Other wooded land

The fynbos biome falls under this category, where trees are rare, but the vegetation is dominated by evergreen sclerophyllous heathlands and shrublands (Huntley 1984). This biome covers approximately five per cent of the land area of the country. Fynbos communities generally require four to six years to accumulate sufficient fuel to burn and fires occur at random within six- to forty-year rotations (Goldammer & De Ronde 2001). Prescribed burning is applied in most fynbos communities, but during the 1990s prescribed burning programmes were reduced for various reasons, specifically, to allow more natural fire occurrence. Another reason for fewer prescribed fires is the reduction in the availability of experienced fire managers who can apply block-burning correctly (Goldammer & De Ronde 2001).

2.2.2.3 Remaining land

The remaining vegetated land of South Africa includes the following: grassland (24%), arid savanna biome (24%) and moist savanna biome (9%). These estimations have been rounded to make provision for plantation forests. As yearly biomass production differs significantly within these biomes, fire rotations vary likewise (from 1 to 15 years) and these rotations are also exposed to seasonal variation. Winter burns normally occur after moisture stress and frost set in during autumn (Goldammer & De Ronde 2001).

Fire is an infrequent, but significant phenomenon in the arid savanna biome, normally occurring after above-average rainfall has been recorded, and subsequently a higher biomass production being experienced. In the moist savanna biome, fire occurs more frequently at approximately five-year intervals, but can also occur as commonly as annually in places during some seasons (Huntley 1984).

Van Wilgen, Biggs, O'Regan & Mare (2000) analyse the fire history of the Kruger National Park (1.9 million hectares) for different periods in the park's history, where fire protection was followed by prescribed burning and a 'natural' (lightning) fire policy. Fires covering 16.79 million hectares occurred between 1941 and 1996 (16 per cent of the area burning each year on average). Of this area, 5.15 million hectares burnt between 1941 and 1957, during which period limited prescribed burning and protection from fire took place (16 per cent burning each year on average). Between 1957 and 1991, 2 213 prescribed burns covering 5.1 million hectares (46.3 percent of the 10.98 million hectares burnt during that period) were carried out (Van Wilgen et al. 2000).

Lightning fires burnt 2.5 million hectares between 1957 and 1996, or 21.6 per cent of the area in the Kruger National Park. The mean fire return period was four and a half years, with intervals between fires of one to 34 years. The distribution around the mean was not symmetrical and the median fire interval was 3.1 years. Some areas burnt more often than others, and mean fire return periods ranged from 2.7 to 7.1 years in the eleven major land systems of the park. Fires occurred in all months, but 59 percent of all fires took place between September and November. Prescribed burns were concentrated late in the dry season (September to November). Lightning fires were later, with 84.7 per cent of the area burning between September and January (Brockett, Biggs & van Wilgen 2000,Van Wilgen et al. 2000).

2.2.2.4 Major wildfires experienced in South Africa during 1990 - 2000 and their impacts

Major wildfires, their location and their biggest impacts are summarised in Table 2-1. As a visual example Figure 2-4 shows the extent of the fire in the Cape Peninsula during the year 2000.

Table 2-1 Major wildfires in the South Africa and their impacts 1990 - 2000

Year	Major wildfires experienced during 1990 - 2000 and their impacts
1990/1991	• In Kwazulu-Natal the number of wildfires increased from 210 during 1989, to 350 during 1990 and to 510 during 1991.
1992/1993	• 1992 - serious drought in most of the summer rainfall regions in the north and east of South Africa. The number of fires in these provinces increased to 792, but surprisingly losses from wildfires were less than during 1991, and only 9 333 ha of industrial forests were lost. • 1993 - no major fire events were recorded
1994	• Mpumalanga and Kwazulu-Natal - few serious wildfires in industrial forests and in surrounding grasslands • October 1994, Sabie district - three major plantation wildfires destroying more than 1 000 ha in each case. Ten fire-fighters lost their lives, two fire-fighting vehicles were lost. Damages exceeded US$1 million.
1995	• Winter season, eastern Free State,- some serious grassland wildfires ; in Kwazulu-Natal, one fire destroyed 5 500 ha of timber plantations in the Melmoth district. No lives were lost. • December - a bushfire lit 15 000 tons of sulphur at an explosives and

	chemical company near Cape Town, covering the local community with toxic fumes. Two thousand five hundred people had to be evacuated, and 500 patients had to be treated in hospital. Two people died.
1996/1997	• Numerous grassland fires in the summer rainfall regions, but higher than average rainfall prevented serious moisture deficiencies from occurring, subsequently little damage was caused. During both years rainfall days extended well into the June/July period avoiding a long seasonal drought.
1998	• Cape regions - hot mountain wind conditions during March/April caused extreme fire weather conditions in the fynbos biome, and in some adjoining industrial forests. • Two serious fires occurred in the Tsitsikamma region. In one of them 60 000 ha of fynbos were burned and 4 000 ha of industrial forests were destroyed. Six people lost their lives, 250 were left homeless. Damage exceeded US$1 million. The ecological impact of this fire was limited to localised erosion problems on steep slopes. • In the summer rainfall area the fire season started early in April. • May, eastern Free State - 30 000 ha of grassland grazing areas were lost in wildfires, one fire destroyed 20 000 ha of a nature reserve. • June, Gauteng Province - loss of lives occurred indirectly as a result of a grassland fire when twenty people lost their lives in a traffic pile up caused by thick smoke. • Summer rainfall areas - four people lost their lives in one of the numerous grassland wildfires in Mpumalanga. Wildfires in industrial forests resulted in losses exceeding 1 000 ha of standing timber in the Northern Cape, Mpumalanga and in Swaziland. • In the North West province, a grassland fire burned down some farms and homesteads, two policemen died in the incident.
1999	• Southern Cape and Tsitsikamma regions - wildfires burned through thousands of hectares of fynbos vegetation, burning down homesteads in the Plettenberg Bay area, as well as a few thousand hectares of timber plantations and farmland. These fires occurred during extremely dry mountain-wind conditions. • Swaziland experienced most wildfire damage (in the form of grazing area lost and timber plantations damaged) of summer rainfall areas.
2000	• January - the Cape Peninsula was devastated by a serious fynbos wildfire, which burned 8 000 ha of fynbos vegetation (see Figure 2-4). Elsewhere in the Western Cape an additional 10 000 ha of fynbos burned. In the Cape Metropolitan area 70 houses were damaged or destroyed by the fire and 200 shacks of an informal settlement were also destroyed. Total fire suppression costs exceeded R30 million, while insurance claims were expected to exceed R5 billion. No lives were lost.

Source: Adapted from Aupiais & Stammers (2000) and. Goldammer & De Ronde (2001)

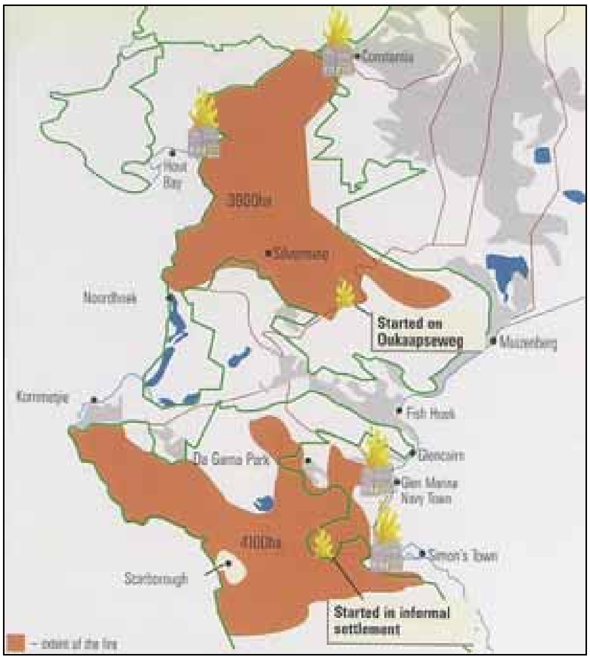

Figure 2.4 **Map detailing the area affected by the 2000 Cape Peninsula fire**

Source: Aupiais & Stammers (2000)

2.2.2.5 Laws and policies concerning fire

(a) Legislation directing regulating fires and fire management (within a mostly emergency management context):

- Forest Act
- Fire Brigade Services Act
- National Environmental Management Act
- Mountain Catchment's Areas Act

(b) Towards integrated disaster management regulation:

- Disaster Management Bill (in preparation)
- Veld and Forest Fires Act

(c) Resource management regulation:

- National Parks Act
- Cape Nature Conservation Ordinance
- Conservation of Agricultural Resources Act

(d) Land use planning legislation:

- Physical Planning
- Development Facilitation Act

- Local Government Transition Act 209 of 1993
- Environment Conservation Act 73 of 1989
- National Environmental Management Act

(e) Air quality control legislation:

- Atmospheric Pollution Prevent Act
- Local Authority Legislation

(f) General environmental management:

- National Environmental Management Act

The Department of Water Affairs and Forestry (DWAF) is responsible for the provision, management and administration of the 1998 National Veld and Forest Fire Act, and the support of Fire Protection Associations (FPA). The key principle of the National Veld and Forest Fire Act is that the landowner is the main player in controlling wildfires. The state is going to assist to a greater extent than in the past, having taken upon itself the task of applying a system of fire danger rating. It must also devise, together with all the role players, an information system to raise the awareness level about wildfires among the public at large, especially among landowners (Goldammer & De Ronde 2001; Von Krosigk 1999).

2.2.2.6 Fire-fighting bodies

Fire prevention is normally regarded as the responsibility of the landowners, guided by DWAF and the National Veld and Forest Fire Act. However, there is a lack of regional co-ordination in this field. There are certain exceptions where integrated regional fire protection plans have been implemented: the Mpumalanga Highveld, in the Melmoth district of the Kwazulu-Natal region, and in the north-eastern Cape. Local (private and state) fire management bodies in industrial forests, agricultural regions and nature reserves are normally responsible for their own fire-prevention measures.

In most provinces the fire-fighting role is conducted and controlled by the Regional Services fire brigades in rural areas, assisted by Municipal fire-fighting units in metropolitan districts. In some areas certain central government bodies, such as the defence forces, assist these efforts, particularly when wildfires expand to disastrous dimensions. Local forestry organisations and agricultural bodies also assist in fighting fires in certain regions, depending on the dominant land use of these regions (Goldammer & De Ronde 2001).Some of the most important forestry fire-fighting organisations in South Africa are the Forest Fire Association (FFA) based in Nelspruit, the Zululand Fire Protection Association (ZFPA) and the Natal Fire Protection Association (NFPA).Although spontaneous fire-fighting support from local communities has been recorded during some wildfires, no major voluntary fire-fighting organisations exist in South Africa, compared to countries such as the United Kingdom, Australia and New Zealand (see section 2.2.3.1).

2.2.2.7 Finances for fire control

Although adapted to fire, the fauna and flora of the Cape floristic region can be adversely affected by too frequent human-induced fire. This can be the result of inappropriate fire regimes on agricultural and conservation land as well as through accidental fires. Fire regimes that maintain biological diversity (high-intensity summer burns) can conflict with fire regimes that ensure safety (low-intensity, short rotation, spring or winter burns). Fire control can have significant budgetary implications for conservation agencies. For example, in the Cape Peninsula National Park, R2.44 million, or 13.25 per cent of the total park budget was allocated for fire control during the 1999/2000 year (Fowkes 1999).

The costs of fire-prevention in the cape floral kingdom falls upon a number of agencies, from national government, through provincial to local government levels and the private sector.As an indicator of fire prevention costs, however, the South African National Parks (SANP) budgeted R2.44 million for fire prevention in the Cape Peninsula National Park (CPNP) alone, for the 99/00 financial year (Fowkes 1999). The actual cost of fire fighting to WCNCB between the years 1994-2000 is summarised in Table 2-2, as an indication of the costs involved and the escalation in these costs as a percentage of the board’s total budget

Table 2-2 Costs and budget percentage of fire management to the WCNCB

Year	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00
As a percentage of total budget	N/A	N/A	1.9%	5.99%	9,2%	13,25%
Cost	R780 000	R572 000	R970 000	R2 712 000	R3 616 000	R4 513 000

This is an increase in the cost of nearly 750per cent in six years. With the serious fires that have already occurred during the 1999/00 financial year, it was expected that actual expenditure on fighting fires and fire control may reach R5 500 000 during that period (Fowkes 1999; Burgers 2000, pers com).

According to Spence (2003) the total national loss and number of fires for the years 2002 and 2001, as determined by the Fire Protection Agency of South Africa (FPASA), are compared in Table 2-3. These statistics are for fire and emergency services rendered and do not reflect damages suffered by nature reserves and private landowners, where fire and emergency services were not involved. (See section 2.2.2.5 for the National Veld and Forest Act regarding responsibilities with respect to fires of this nature). For 2002 only two deaths linked to rubbish-, grass- and bush fires were recorded. Fynbos falls under this category at the FPASA.

Table 2-3 Fire Protection Agency of South Africa (FPASA) fire statistics

Description of fire type	Total number of fires in the database	Damage amount in Rand	Total number of fires in the database	Damage amount in Rand
Year	**2002**		**2001**	
Rubbish, Grass and Bush	33607	2995761	26402	4753255
Plantations and Forest	200	70000	104	1819800

Source: Spence (2003)

2.2.3 Wildfires Internationally

Veldfires, more commonly known as ‘wildfires’ or ‘wildland fires’ internationally, are a common phenomenon worldwide. Big fire disasters are frequently in the news, especially those in recent years in Australia and the USA. Wildfires are in no sense limited to what we see in the media.

In October 2003 the third International Wildland Fire Conference and Exhibition held in Sydney, Australia, brought together representatives of 71 countries that have experienced the impact of forest fires most severely, as well as international agencies that are in a position to assist, either because of their charter or because they have both the resources and the will. All these countries are searching for pragmatic and sustainable answers for the mitigation of risks to the health and safety of communities, as well as the environmental, ecological and economic damage caused by uncontrolled wildfires. Each country made valuable contributions towards providing synergistic solutions. Many countries and international agencies, especially those with well-developed wild fire management systems or with available resources to share, are in a position to assist others in need of help.

The participants at the summit had an opportunity to consider the key issues and to help identify solutions and ways to commit to global action. All communities around the world afflicted by wildfires can benefit from initiatives taken at the gathering.

The list of participating countries (see Appendix E) gives a good idea of the international magnitude of wildfires. Wildfires and wildfire management in a few countries are discussed below.

2.2.3.1 Australia

Australia is relatively flat, dry and warm although it also has mountains of moderate height (particularly along the eastern seaboard), rainforests and ski-fields, as well as a large arid and semi-arid zone. Australia is 6.6 times larger than SA. (Gill & Moore 2002).

Across the tropical north is a large savanna region with a monsoonal (wet-dry) climate. In the southwest is a region of eucalypt forests, woodlands and shrub-lands with a largely Mediterranean climate. In the southeast, including Tasmania, there are forests and woodlands, but the climate there is quasi-Mediterranean with dry summer conditions due to high evaporation rather than low rainfall. A large area of the continent is arid and semi-arid, both tropical and temperate, and is dominated by hummock grasslands and Acacia shrublands. Prominent, species-rich woody plant genera in Australia are Acacia and Eucalyptus. Among the vertebrate animals, marsupials are particularly noteworthy. Australia is a fire-prone continent. Fires occur in rainforests and in deserts (Gill & Moore 2002; Russell-Smith 1998; Benneton 1998).

In Australia, communities have suppressed wildfires together at least since the English settled there. Until recently, the 200 000 volunteers that make up the rural fire brigades have acted semi-independently. Some brigades have modern equipment and training, while others such as the Coal and Candle brigade work with gear that dates back to the Second World War. Similarly, while some brigades participate in prescribed burns, others respond only to ignitions.

The Commonwealth Scientific and Industrial Research Organisation launched a project called Vesta (after the Roman goddess of the hearth) in conjunction with Western Australia's Department of Conservation and Land Management. This project aims to improve Australia’s approach to fire management by means of experimenting and investigating the behaviour of high-intensity fires. The main goal is to improve ways to predict bushfire spread (Cheney 1997; Cheney 1999; Knight & Sullivan 2000).

2.2.3.2 France

Wildfire management in France is an example of efficient, streamlined fire management. Officials realise exactly how precious their forests are and are very stringent in their supervision through a state-of-the-art meteorological prediction system. In 1994, with assistance from the Conservatoire de la Forêt Méditerranéenne, French fire-management officials kept 95% of all fires from exceeding 12.5 acres. France is experiencing changes as the European Union (EU) works to standardise wildfire management (Alexandrian, Esnault & Calabri 1999; Teusan 1995).

2.2.4 Prescribed Burning

Prescribed burning (also known as block burning) is practiced internationally for various reasons as discussed below.

2.2.4.1 Internationally

Prescribed burning is used widely in **Australia**. In forestry it is used primarily for crop protection, disposal of debris, and for the protection of human lives. In Western Australia, the extent of prescribed burning has been in gradual decline for many years, possibly because of reactions by the public to smoke (Gill & Moore 2002).

For land uses outside of forestry there are many reasons for prescribed burning. For the pastoral areas Leigh & Noble (1981) list among other reasons, removal of top hamper (dead grass), extension of the growing season, control of woody weeds, and assistance with the establishment of improved pasture species, fuel reduction and nutrient release.

In conservation areas, fires may be prescribed for the maintenance of natural values. In agricultural areas, fires may be used just before the harvest of sugar-cane and just after the harvest of cereal crops, although such practices have often been criticised in recent decades. In most land uses where native vegetation is predominant there will often be some burning designated for the protection of human life and property (Gill & Moore 2002).

According to Bruce (2002), in the **United Kingdom** prescribed burning is used extensively for habitat management for Red Grouse, an upland game bird that lives in heather (*Calluna vulgaris*). Fire is also used extensively to regenerate grazing land for cattle, sheep and deer. In forests fire is used to clear branches or heather from sites as a ground preparation tool prior to forest establishment by planting or natural regeneration. Firebreaks are also sometimes created alongside forests by burning. Fire is used occasionally on farmland in Scotland to burn straw, a practice that has been stopped in England and Wales. Prescribed burning is used more frequently on private land than on publicly owned land.

Craig (2002) states that in **New Zealand** prescribed burning in forests has been rare. Agricultural maintenance burning, however, is still used quite extensively in the high country areas of New Zealand as a land management tool, predominantly in tussock areas to encourage new growth and enable over-sowing with grass species in an effort to improve the pasture. Burning is also carried out to remove weed species. Access by stock is also improved after burning. Most high country burning is carried out in the spring, when soil and moisture levels are generally high. In general the policy is to extinguish fires rather than leaving them to burn (Craig 2002).

2.2.4.2 South Africa

According to Brown (1993), it seems as if prescribed burning could lessen the incidence of wildfires, provided that it occurs during the natural fire season of November to April, with a peak between November and February and at intervals of 15 to 25 years. Shorter intervals reduce plantcover, height, biomass and aid the elimination of the longer living, seed-regenerating shrubs. Fire frequency should thus emulate the natural disturbance regime under which species evolved. The ecological role of fire in an ecosystem managed by burning must be understood in terms of its regime, i.e. the frequency, seasonality, intensity and size of the fires. Kruger & Bigalke (1984) state the main objectives of managing fynbos by burning are to ensure the maximum sustained yield of silt-free water, maintaining species diversity, and controlling alien invasive plants and wildfires.

Fire is a natural agent of regeneration in fynbos. However the correct management of fire frequency in prescribed burning would be necessary to maintain the rich diversity of species, community structure and processes. Fire acts as a marked disturbance to prevent the competitive exclusion of species that would operate if the environment reached equilibrium (Kruger & Bigalke 1984). In forestry, more recently, burning after clear-felling and prescribed burning under trees for fuel reduction purposes are now established management processes. These prescribed fires are being applied at a limited but increasing scale, according to Goldammer & De Ronde (2001).

2.2.5 Fire Frequency

Research achievements in the past now make it possible to determine optimum fire frequencies with an acceptable degree of accuracy, not only considering fuel dynamics, but also maintaining species diversity in the process. The optimum fire frequency for fynbos is 10 to 15 years, but fire intensity and season of burn also play an important role in fulfilling ecological requirements in the fynbos biome. These requirements vary from region to region and also with topographical and climate variation (Bond & Goldblatt 1984).

As a result of delays in the prescribed burning programme due to public pressure, staff shortages, a high staff turnover, lack of staff with prescribed burning experience, weed infestation and urban expansion, fynbos in certain catchments is sometimes allowed to become too old. It is therefore impossible to apply fuel reduction by means of prescribed burning, because this would be too hazardous. The accumulation of fuels is further increased through the spread of alien weeds such as *Hakea sericea*, *Acacia longifolia* and *Pinus pinaster*, until a situation is reached where serious wildfires can not be avoided, particularly during abnormal weather conditions as experienced in southern Africa during recent years (De Ronde 2000).

Students and organisations are researching the possibilities of modelling fire frequency, both in general and specifically within fynbos. Some well-known methods and models used to estimate and model fire frequency are the:

- Natural Fire Rotation Method;
- Poisson Model for Fire Frequency;
- Fire Return Interval Method for Estimating Fire Frequency;
- Negative Exponential Model;
- Weibull Fire Frequency Model; and
- Fire Cycle Method (Bond, Vlok & Viviers 1984; De Ronde 2000).

2.2.6 Veld Age

The term ‘veld age’ refers to the age of vegetation. In nature, mainly fires determine this - thus the age of vegetation covering an area since the last fire. Knowing the age of vegetation is extremely important to a reserve manager, especially when decisions concerning block burning (also known as prescribed burning) are to be made (Burgers 2001, pers com).

CHAPTER 3: WORKING TOWARDS A SOLUTION

Various projects and methodologies were explored to provide a foundation for working towards a feasible solution.

3.1 FIRE- AND ENVIRONMENT PROJECTS IN THE WESTERN CAPE AND ELSEWHERE

Some of the projects addressing the problems associated with wild fires are discussed below.

3.1.1 The Cape Action Plan for the Environment (CAPE)

CAPE (see also section 1.3) was funded by the Global Environment Facility and co-ordinated by the World Wide Fund for Nature South Africa (WWF-SA) in partnership with government, communities and the private sector. Its aim is to develop a strategy and action plan to protect biodiversity in one of earth's richest but severely threatened biological regions, the Cape Floral Kingdom and its associated marine and coastal environments. Major threats include loss of habitat to agriculture, rapid and insensitive development, the overexploitation of marine resources and wild flowers, and the spread of alien species. Underlying causes include lack of capacity and poor co-ordination between bodies responsible for management of natural resources, lack of awareness of the importance of biodiversity and a short-term focus on meeting needs (Young & Fowkes 2003).

3.1.2 Ukuvuka

The Ukuvuka-Firestop campaign was set up following the huge fires in the southern Peninsula in January “Ukuvuka" is Xhosa for "wake up", and the campaign was initiated to reduce the risk of wildfires by clearing invading alien vegetation from the Peninsula's natural areas. It also aims to rehabilitate ecologically damaged areas, to promote employment opportunities and to reduce the fire risk in disadvantaged areas; as, for example, is happening in the Noordhoek/Kommetjie wetlands project (Yeld 2002; Aupiais & Stammers 2000).

The Ukuvuka objectives are to:

- control invading alien plants;
- rehabilitate fire-damaged areas;
- create employment, training and poverty relief for disadvantages people;
- promote co-operation and social cohesion between communities;
- implement integrated fire management plans; and
- manage the urban edge (Aupiais & Stammers 2000).

The campaign has a four-year mandate to achieve these goals, starting in 2000 (Aupiais & Stammers 2000).

Ukuvuka-Operation Firestop is making a significant contribution to the lives of people in the city. There has been a significant reduction in the number of fires in the Joe Slovo area (at Langa) and there has been an increase in employment, economic opportunities and the development of entrepreneurship in five areas around the peninsula (Yeld 2002). The Ukuvuka-Operation Firestop partnership is also creating real economic benefits for the city as a whole, through helping SANP rehabilitate more areas in the CPNP, which in turn creates more opportunities for visitors and tourists.

The core sponsors of Ukuvuka-Operation Firestop are the *Cape Argus* and Santam. The *Cape Times* and the 14 cape community newspapers support the initiative. Other sponsors are the Working for Water Programme of the DWAF, SANP, Total SA, Nedbank, and the City of Cape Town (Aupiais & Stammers 2000; The CPNP Official News Letter 2002; Yeld 2002).

3.1.3 The Southern African Regional Science Initiative - SAFARI 2000

The Southern African Regional Science Initiative - SAFARI 2000 - is an international collaborative science initiative. It aims to develop an integrated understanding of selected aspects of the southern African earth-atmosphere-human system. Although limited, their interests lie with fires, amongst other things, but mainly the polluting aspects of fire (Swap 2002).

The foundations of the study were laid during June and July 1998 at a series of stakeholder workshops involving scientists from southern Africa, the United States and Europe. The goal of SAFARI 2000 is to identify and understand the key linkages among the physical, chemical, biological and anthropogenic processes underpinning the functioning of the bio-geophysical and bio-geochemical systems of southern Africa (Swap 2002).

3.1.4 Other Initiatives worth mentioning

- SAFNet: The southern African Fire Network is a regional network that fosters collaborative efforts in fire monitoring and management in southern Africa.
- Afrifirenet: Regional Subsahara Wildland Fire Network

3.2 USER REQUIREMENTS OF THE WCNCB

A needs assessment was performed over a series of informal meetings. As a result of these meetings the following was made clear:

- The WCNCB have detailed datasets that can be better utilised using GIS;
- from these datasets they would like to extract information about the spatial distribution of vegetation and its age / time since it last suffered from fire;
- furthermore they would like to be able to see areas that has suffered from repeated burns, these were to be visualised in a way that areas most affected by fire over time were clearly highlighted;
- managers and scientists at the WCNCB does not necessarily have the knowledge or time to convert their tablular data into a visual context; and
- a system that will allow non-GIS users to perform these tasks easily and automatically was needed;

It was evident that the optimum solution would be to use the ESRI product, ArcView. The Western Cape Nature Conservation Board makes wide use of the GIS software program, ArcView. This is a very versatile and customisable GIS, which provided a suitable platform to implement in this study. This was also suggested by the WCNCB (De Klerk & Sutton 2000; Burgers 2000, pers com; Sutton 2000, pers com). The idea is to provide a reserve manager with a computer-based ‘point and click’ graphical user interface (GUI) application. He/she should be able to produce up-to-date fire history and veld age maps merely with the press of a few buttons. This will enable a manager to decide whether a controlled fire should be started in a certain region or whether an existing fire should be allowed to prevail.

ArcView is an affordable, easy-to-learn desktop mapping tool developed by the Environmental Systems Research Institute (ESRI). ArcView enables the user to visualize, explore, query and analyse data spatially. ArcView scripts are macros written in Avenue, ArcView's programming language and development environment. With Avenue one can customise almost every aspect of ArcView, from adding a new button to running a self-written script to creating an entire customised application that can be distributed, as in the case of this study (ESRI 2003).

3.3 PROGRAMMING

Customising any GIS system involves programming. Various alternatives exist with the number of programming languages ever increasing.

3.3.1 Object-Orientated Programming (OOP)

Although ArcView's Avenue is not a truly object-orientated programming language, it tends towards being one and has many similarities such as having a class structure that supports inheritance down the hierarchy. Unlike true object-orientated languages Avenue does not allow the user to subclass existing classes or even define new classes (ESRI 1997).

Object-orientated programming is organised around "objects" rather than "actions" and data rather than logic, according to Fowler (2003). Historically, a program has been viewed as a logical procedure that takes input data, processes it and produces output data. The programming challenge is how to write the logic, not how to define the data. OOP is concerned with the objects that need manipulating rather than the logic required in manipulating them. Examples of objects range from human beings (described by name, address and so forth) to buildings and floors (whose properties can be described and managed) to the little widgets on one's computer desktop (such as buttons and scroll bars) (Fowler 2003).

The first step in OOP is to identify all the objects one wants to manipulate and how they relate to one another, an exercise often known as data modelling. Once an object has been identified, it is generalized as a class of objects and the kind of data it contains is defined along with any logic sequences that can manipulate it. Each distinct logic sequence is known as a method. A real instance of a class is called an "object" or, in some environments, an "instance of a class." The object or class instance is what is run in a computer. Its methods provide computer instructions and the class object characteristics provide relevant data (Coad & Nicola 1993, Fowler 2003).

The concepts and rules used in object-orientated programming provide the following important benefits:

- The concept of a data class makes it possible to define subclasses of data objects that share some or all of the main class characteristics. Called inheritance, this property of OOP forces a more thorough data analysis, reduces development time, and ensures more accurate coding.
- Since a class defines only the data it needs to be concerned with, when an instance of that class (an object) is run, the code will not be able to accidentally access other program data. This characteristic of data hiding provides greater system security and avoids data corruption.
- The definition of a class is reusable not only by the program, for which it is initially created, but also by other object-orientated programs (and, for this reason, can be more easily distributed for use in networks).
- The concept of data classes allows a programmer to create any new data type that is not already defined in the language itself.

One of the first object-orientated computer languages was called Smalltalk, while C++ and Java are the most popular object-orientated languages today. Visual Basic is a widely used program language but is also not a true OOP language as it lacks some essential OOP features, such as inheritance (Barnes & Kolling 2002; Fowler 2003).

3.3.2 Artificial Intelligence

Although the software program developed during this study did not produce a pure product of artificial intelligence (AI), it is still a noteworthy subject that needed some exploration.

Bellman (1978) describes AI as the automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning, etc. An Artificial Intelligence (AI) is an experimental science whose goal is to understand the nature of intelligent thought and action (Howe 1994).

The popular view of intelligence is that it is associated with high-level problem solving, i.e. people who can play chess, solve mathematical problems, make complex financial decisions, and so on, are regarded as intelligent. According to Howe (1994), intelligence is like an iceberg - a small amount of processing activity relates to high-level problem solving. This is the part that we can reason about and introspect, but much of it is devoted to our interaction with the physical environment. It is in this environment where we are dealing with information from a range of senses, visual, auditory and tactile, and coupling sensing to action, including the use of language, in an appropriate reactive fashion, which is not accessible to reasoning and introspection.

For the purpose of this study the focus was on the visual element of AI, understanding of the increased ability to perform when more information is available, especially visual information.

3.4 DECISION-SUPPORT SYSTEMS (DSS), SPATIAL DECISION SUPPORT SYSTEMS (SDSS) AND GEOGRAPHICAL INFORMATION SYSTEMS (GIS)

DSS is defined as knowledge management technology that uses reasoning software to advise the user. DSS are a specific class of computerised information systems that support business and organisational decision-making activities. Properly designed DSS are interactive software-based systems intended to help decision-makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions (Bonczek, Holsapple & Whinston 1991).

Holsapple & Whinston (1996) states that advances in the 1960s, such as the IBM 360 and other mainframe technologies, laid the foundation for DSS. During the 1970s DSS took off with the arrival of query systems, what-if spreadsheets, rules-based software development and packaged algorithms from companies such as Chicago-based SPSS Inc. and Cary, N.C.-based SAS Institute Inc.

One of the most common DSS used in business today is the spreadsheet. Also most executives use corporate planning tools with DSS capabilities in them. DSS analytics has become successfully entrenched in people's lives. This is demonstrated by the wide range of DSS tools available online. Despite this Holsapple & Whinston (1996) believes that more improvement is possible, especially with application data integration.

This study focuses on the spatial element of decision-support systems, namely spatial-decision-support systems (SDSS). SDSS are not uncommon and some of the better-known vendors who offer SDSS software include ESRI, MapInfo, Autodesk, Caliper Corp, Tactician, ESS, Facet Decision Systems, Geosoft, Nobility, RT Soft, Routesmart and Sylvan Maps. This study makes use of software components developed by ESRI for its SDSS.

According to Maguire, Goodchild & Rhind (1991) these SDSS evolved in parallel with DSS developed for business applications, but only much later, allowing the use of DSS literature for the design of SDSS. The differences between DSS, SDSS and GIS are explained in Table 3-1.

Table 3-1 Properties of DSS, SDSS and GIS

DSS, SDSS	SDSS	GIS
Designed to solve ill-structured problems where the objectives of the decision maker and the problem itself cannot be fully or precisely defined.	Provide mechanisms for the input of spatial data.	Whereas a SDSS is usually limited to a specific problem domain, GIS are usually generic over a wide range of problem domains.
Has a user interface that is both powerful and easy to use.	Allow representation of the complex spatial relations and structures that are common in spatial data.	Fail to allow for large variations in context or spatial decision-making.

Help the user to explore various solutions by using different models in the systems to generate a series of feasible alternatives.	Include analytical techniques that are unique to both spatial and geographic analysis – including statistics.	Do not always provide flexible mechanisms for communicating information to the user.
Support a variety of decision-making styles and is easily adapted to provide new capabilities as the needs of the user evolve.	Provide output in a variety of spatial forms including maps and other more specialised types.	Databases have traditionally been designed to support only cartographic display. Current database trends are to incorporate GIS functionality within the database as with Oracle Spatial and PostgresSQL's PostGIS extensions.
Allow problem solving to be both interactive and recursive.		Have weak support for analytical modelling

Source: Adapted from Maguire, Goodchild & Rhind (1991).

3.5 GRAPHICAL USER INTERFACE (GUI)

Within the WCNCB's GIS department there are loose standards concerning GUI's for in-house software. These standards have been adopted and were useful for the purposes of this study. Figure 3.1 illustrates some aspects.. The standard WCNCB logo in the top left corner (1) of a green block (2) down the left side of the GUI is to be found in most of their custom applications. The command buttons (3) are to be placed on the left and not at the bottom like most programs. Standard font and colour (HEX code: #E7F7C6) are to be used for headings (4). A khaki background is used for any sub-forms within a form (5). A navigational bar is to be placed at the bottom of the form it belongs to (6) and the standard Windows grey is to be used for the rest (7).

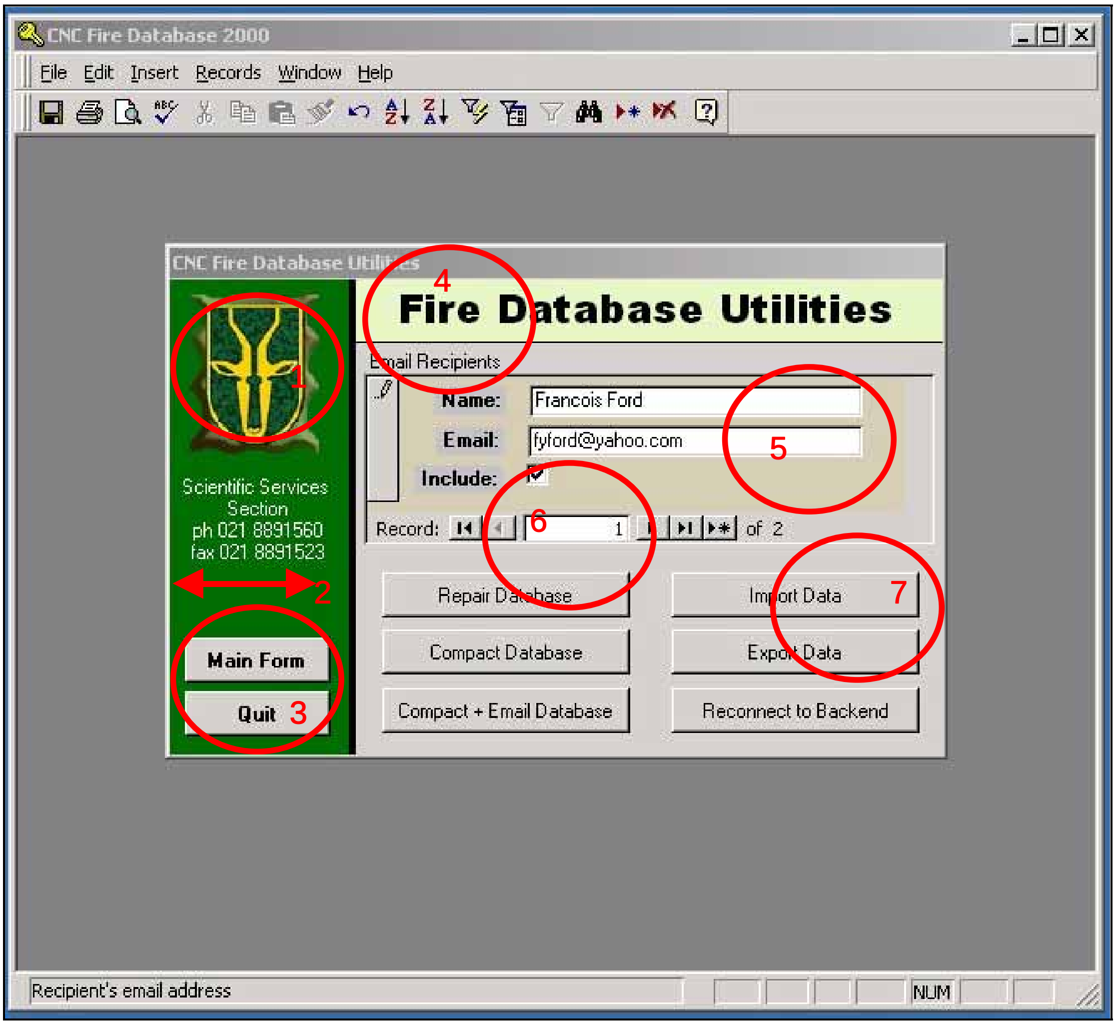

Figure 3.1 A typical graphical user interface as used by the Westen Cape Nature Conservation Board

GUI design is easier said than done. Some of the main design principles are:

- Avoid making the user feel incapable.
- Give the user control.
- Avoid too many features at top level.
- Understand people.
- Design for clarity.
- Design for consistency.
- Provide visual feedback.
- Speed.
- Keep text clear.

- Provide traceable paths.
- Provide keyboard support.

(Nielsen 1990; Arlov 1997; Hobart 2003)

Arlov (1997) states that successful GUIs share many common characteristics. Most importantly, good GUIs are more intuitive than their character-based counterparts. This can be achieved by using real-world metaphors whenever possible. Another important characteristic of good GUIs is speed, or more specifically, responsiveness. Most speed issues are handled via the design of the GUI, not the hardware. Depending on the type of application, speed can be the make-or-break factor in determining an application's acceptability in the user community. For example, if your application is orientated toward online transaction processing (OLTP), slow performance will quickly result in users wanting to abandon the system (Arlov 1997; Hobart 2003).

According to Hobart (2003) you can give a GUI the appearance of speed in several ways:

- Avoid repainting the screen unless it is absolutely necessary.
- Have all field validations occur on a whole-screen basis instead of on a field-by-field basis.
- Depending upon the skills of the user, it may be possible to design features into a GUI that give the user the capability to enter each field of each data record rapidly. Such features include mnemonics, accelerator keys, and toolbar buttons with meaningful icons, all of which would allow the speed user to control the GUI and rate of data entry.

Applications must reflect the perspectives and behaviours of their users. To understand users fully, developers must first understand people, because we all share common characteristics. People learn more easily by recognition than by recall. Always attempt to provide a list of data values to select from rather than have the users key in values from memory. The average person can recall about 2 000 to 3 000 words, yet can recognise more than 50 000 words (Hobart 2003).

GUI applications often are not clear to end-users. One effective way to increase the clarity of applications is to develop and use a list of reserved words. Hobart’s (2003) research shows that a common complaint among users is that certain terms are not clear or consistent. When the application is released, one screen may say "Item," while the next screen says "Product," and a third says, "Merchandise", when all three terms denote the same thing. This lack of consistency ultimately leads to confusion and frustration for users.

Good GUIs apply consistent behaviour throughout the application and build upon a user's prior knowledge of other successful applications. When writing software for business applications, it is advisable to provide the user with as much consistent behaviour as possible (Hobart 2003). Each new and exciting experience provided in the software can become an anxiety-inducing experience or an expensive call to the help desk.

Users greatly appreciate knowing how much longer a given operation will take before they can enjoy the fruits of their patience. As a general rule, most users like to have a message dialog box with a progress indicator displayed when operations are going to take longer than seven to ten seconds. This figure is highly variable, depending on the type of user and overall characteristics of the application (Hobart 2003; Arlov 1997).

Developers often try to make textual feedback clear by adding a lot of words. However, they ultimately make the message less clear. Concise wording of text labels, user error messages, and one-line help messages are challenging. Textual feedback can be handled most effectively by assigning these tasks to experienced technical writers (Hobart 2003; Arlov 1997).

According to Hobart (2003) areas where the menu structure can be flattened should be identified, thereby avoiding more than two levels of cascading menus. Providing a descriptive title bar within each dialog box will help greatly to remind the user what menu items or buttons were pressed to bring them to the window currently in focus.

Keyboards are a common fixture on users' desktops and provide an efficient means to enter text and data. With the introduction of GUI applications, assumptions are often made that users will embrace a mouse as the primary interactive device. This can become time-consuming and inefficient for the touch typist or frequent users of the application.

Keyboard accelerators can provide an efficient way for users to access specific menu items or controls within a window. The accelerators used should be easy to access and limited to one or two keys (such as F3 or Ctrl-P). Keyboards have limitations in the GUI world, such as when trying to implement direct-manipulation tasks like drag and drop, pointing, and resizing.

In contrast, one will always find a smaller set of users who are not touch typists and hence embrace the mouse as a point-and-click tool. The result is that one needs to provide complete and equal keyboard and mouse support for all menu and window operations (Hobart 2003; Arlov 1997).

Having access to the developers and existing in-house GUIs at the WCNCB proved to aid as a strong foundation for the development of this software. Not only did it serve as a starting point, but also provided insight in tried and tested methods regarding GIS development, ranging from GUIs and coding to database development.

3.6 DATABASES

A database is defined as “an organised body of related information” (Pfaffenberger 2000). A database is a collection of data that is organised so that its contents can easily be accessed, managed and updated. The most used type of database is the relational database, a tabular database in which data is defined so that it can be reorganised and accessed in a number of different ways. Other types of databases include distributed databases and object-orientated databases.

Databases contain aggregations of data records or files, such as sales transactions, product catalogues and inventories, and customer profiles. Examples of database software are: IBM's DB2, Microsoft's Access and database products from Oracle, Sybase, and Computer Associates (Pfaffenberger 2000).

3.6.1 Relational Databases

The relational database was invented by EF Codd at IBM in 1970 who describes it as a collection of data items organised as a set of formally described tables from which data can be accessed or reassembled in many different ways without having to reorganise the database tables (Pfaffenberger 2000; Stanczyk, Champion & Leyton 2001).

The standard user and application program interface to a relational database is the structured query language (SQL). SQL statements are used both for interactive queries for information from a relational database and for gathering data for reports. In addition to being relatively easy to create and access, a relational database has the important advantage of being easy to extend. After the original database creation, a new data category can be added without requiring that all existing applications be modified (Pfaffenberger 2000; Stanczyk, Champion & Leyton 2001).

A relational database can also be described as a set of tables containing data fitted into predefined categories. Each table contains one or more data categories in columns. Each row contains a unique instance of data for the categories defined by the columns. For example, a typical business-order entry database would include a table that describes a customer with columns for name, address, telephone number and so forth. Another table would describe an order: product, customer, date, sales price and so forth. A user of the database could obtain a view of the database that fitted the user's needs. For example, a branch office manager might like a view or report on all customers who had bought products after a certain date. A financial services manager in the same company could, from the same tables, obtain a report on accounts that needed to be paid.

When creating a relational database, one can define the domain of possible values in a data column and further constraints that may apply to that data value. For example, a domain of possible customers could allow up to ten possible customer names, but be constrained in one table to allowing only three of these customer names to be specifiable (Pfaffenberger 2000; Stanczyk, Champion & Leyton 2001). The definition of a relational database results in a table of metadata or formal descriptions of the tables, columns, domains, and constraints (Pfaffenberger 2000; Stanczyk, Champion & Leyton 2001).

3.6.2 The WCNCB Fire Database

The WCNCB uses Microsoft's software package, Access97, to design and maintain their relational database to store all their fire data. The technical side of this database is principally handled by staff members in the GIS division (Sutton 2000, pers com; Turner 2000, pers com).

Note the table, 'Fire'. Mainly many-to-one relations link this to other tables as shown in Figure 3.2. An example of how a table like the 'Fire' table is designed and set-up is seen in Figure 3.3. Of importance for this study are the main 'Fire' table and the table called 'tblPolygon'. It is in the tblPolygon table that the spatial data are stored. These data are gathered from aerial photography and maps, some dating back 50 years.

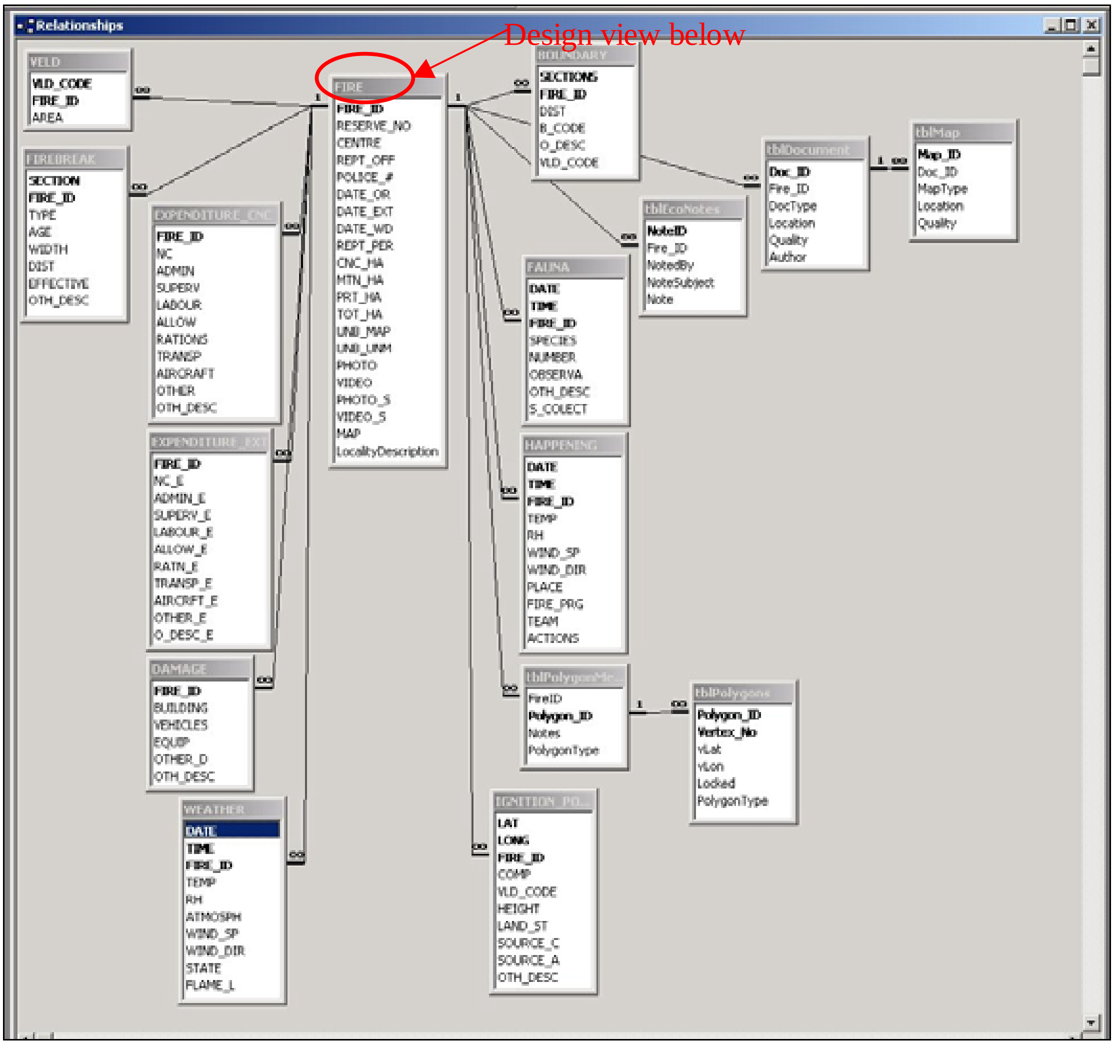

Figure 3.2 A Schematic explaining the WCNCB Fire Database Relationships

FIRE : Table

Field Name	Data Type	Description
FIRE_ID	Text	Fire Identification number
RESERVE_NO	Number	Reserve number to link with other DBases
CENTRE	Text	Centre name
REPT_OFF	Text	Reporting Officer
POLICE_#	Text	Case number of Police
DATE_OR	Date/Time	Date of origin of fire
DATE_EXT	Date/Time	Date when fire was extinguished
DATE_WD	Date/Time	Date when management control was withdrawn
REPT_PER	Text	Reporting person - choose from group
CNC_HA	Number	Size of burnt area on CNC property
MTN_HA	Number	Size of burnt area on declared Mountain Catchment area
PRT_HA	Number	Size of burnt area on other private land
TOT_HA	Number	Total ha of burnt area
UNB_MAP	Yes/No	Are their unburnt areas within the fire area that are mapped
UNB_UNM	Yes/No	Are their unburnt areas within the fire area that are unmapped
PHOTO	Yes/No	Are their photo's of the fire area
VIDEO	Yes/No	Are their video's of the fire area
PHOTO_S	Memo	Notes about the photo's
VIDEO_S	Memo	Notes about the video
MAP	OLE Object	A scanned map of the fire area
LocalityDescription	Text	A description of the locality - Essential if fire not in reserve!

Figure 3.3 Design layout of the fire table in the database

To populate the above database an easy to use front-end (i.e. the GUI or interface the user sees) had to be developed to facilitate data entry even by a person not familiar with the system. It is important to note that brainstorming sessions helped the designers to come up with an extensive list of possible metadata. Anything of possible value is to be added to the database. The database details are available in Appendix A. It must be noted that this database contains some privileged data so no actual data are displayed.

3.7 SCIENTIFIC INFORMATION SYSTEMS

Strebel, Meeson & Nelson (1994) have developed a conceptual framework for the design, implementation and operation of scientific information systems. According to them it has been found that the structured engineering approach applied in business applications usually fails in the science arena. The dogmatic application of structured methodologies to information systems for exploratory science, in which all relations are seldom known, guarantees such failure. This is particularly problematic in the environmental sciences, which often deal with data from monitoring programs with rapidly changing instrumentation or from one-time field experiments with varying degrees of structures. Integrating such disparate datasets and preserving them for later use are major challenges.

The fundamental role of scientific information systems is to publish data in a manner analogous to publication research results. An established conceptual framework for key components of successful scientific information systems is:

- Management and Organisation;
- Science requirements;
- Data flow;
- Resources.

In each component there are basic principles of design, implementation and operations. Ignoring these principles greatly increases the chances of failure of the system. The principles address many aspects of scientific information systems, including data quality, data retrievability, data distribution, data system usability, data system continuity and responsiveness of data system management (Strebel, Meeson & Nelson 1994).

Strebel, Meeson & Nelson (1994) further agree that management and organisation can either assist or impede the services that it renders. It is important that the systems and the data are reviewed and organised as well as the information management staff that handle it. Such a partnership will enable the creation of a highly flexible system necessary to cope with the inherently exploratory nature of scientific research.

The resources necessary to support a maturing dataset from field data collection to a final mature archival publication are appreciable. The unavailability of sufficient staff to handle peak periods of intensive data collection will delay data maturation and archiving, resulting in the loss of vital information and render a dataset far less valuable than it might have been.

CHAPTER 4: THE END PRODUCT – THE CNCFIREMANAGER.AVX EXTENSION

The end product is a carefully designed extension to ArcView. This was done using the programming language Avenue. The actual coding took several months to complete due to the complex nature of the package.

4.1 THE DESIGN

The design stage of software application is crucial to meeting deadlines and avoiding unexpected surprises. In the development of this software extension, great care was taken in the design. Although this careful approach proved to be of great value in later phases, some parts of the application had to be redesigned after testing.

The earlier versions of the application and design followed a multiple-stage wizard-like approach for both the VeldAge and FireFrequency options. This was removed after testing and evaluation; it was decided that speed was more important than ease of use.

4.2 THE APPLICATION

The main purpose of the research is to provide the user with accurate and up to date veld age and fire frequency maps. This was orchestrated by developing an automated ArcView extension, called 'CNCFIREMANAGER.AVX'. The WCNCB was formerly known as Cape Nature Conservation (CNC) and all their ArcView extensions start with CNC, hence the 'CNC'; all ArcView extensions end in '.avx', hence the '.avx'.

The extension is available on compact disk (CD) (see appendix) and the installation instructions are to be found in a text file called, 'readme.txt'. CNCFIREMANAGER.AVX needs to be copied to the ArcView EXT32 directory where all the ArcView extensions are held.

To activate the extension it must be selected from within ArcView. This can be done from the 'Extensions…' option under 'File', see Figure 4.1

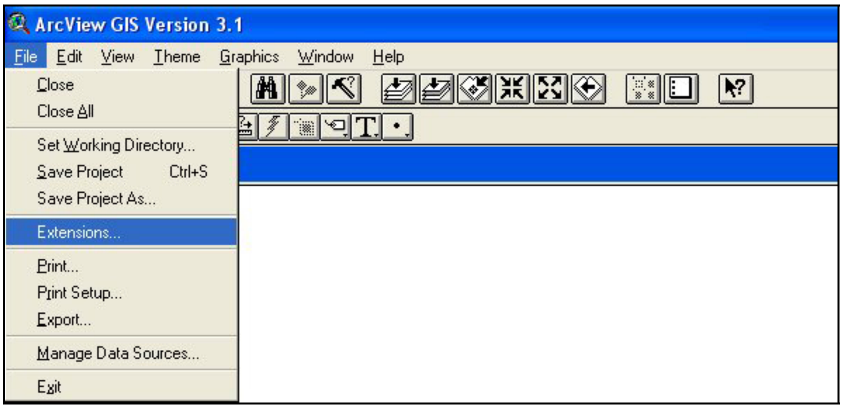

Figure 4.1 Graphical example of the 'extensions' option in ArcView

Choosing the Extensions option will open a list of available extensions, see Figure 4.2. Tick the CNCFireManager option to load the fire management extension.

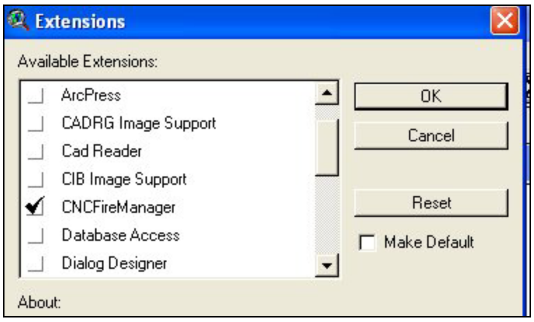

Figure 4.2 The extension list in ArcView, where the new extension needs to be selected, is indicated

Once the extension is loaded a new tab in the normal ArcView top-level menu bar, called, 'FireManagement', will appear (see Figure 4.3).

Figure 4.3 ArcView top-level menu, showing the fire management options

Clicking on the FireManagement option then provides the user with the choice of producing either a veld age map or fire-frequency map, as can be seen on Figure 4.3.

4.2.1 The VeldAge Option

Choosing the VeldAge option will open up a window as in the example in Figure 4.4. (Note the GUI design following the WCNCB standard - section 3.5). For a user to be able to use this section of the extension he/she must at least have data containing fire-polygons loaded in ArcView. Optionally, a layer with a constraining boundary such as a nature reserve's or a farm's boundary can be loaded. If a user wishes to focus his/her resulting map on a constraining boundary and chooses the bounding theme option, the screen will appear as in Figure 4.4.

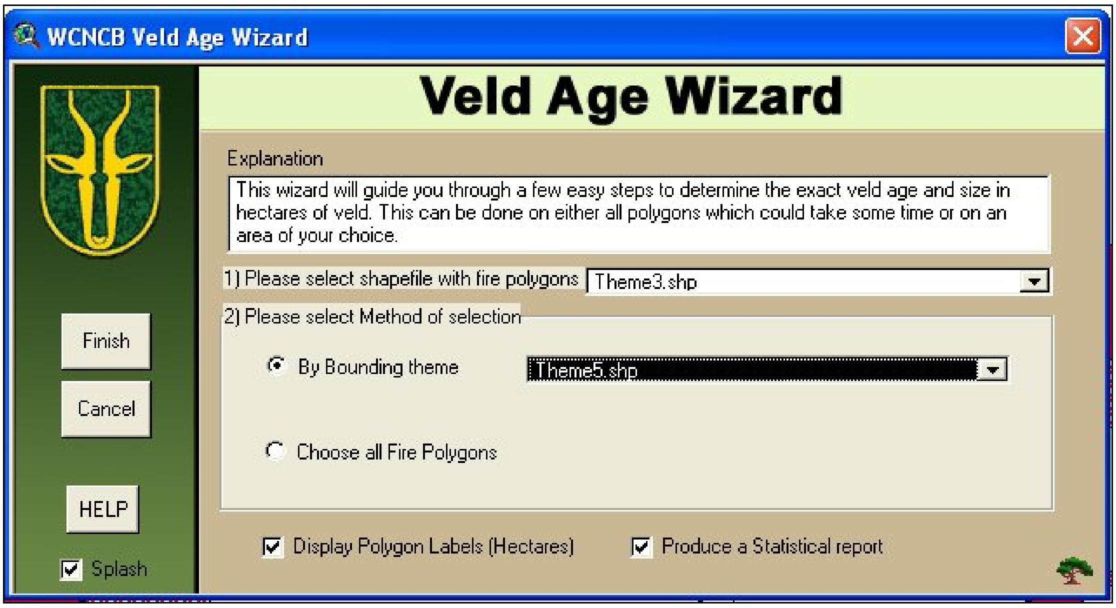

Figure 4.4 Veld Age Wizard with the bounding theme selected

If a user chooses to have a resulting map showing veld age for all available data, then the bounding theme option gets greyed out automatically, as can be seen in Figure 4.5 (Red arrow No. 1 indicates greyed out area).

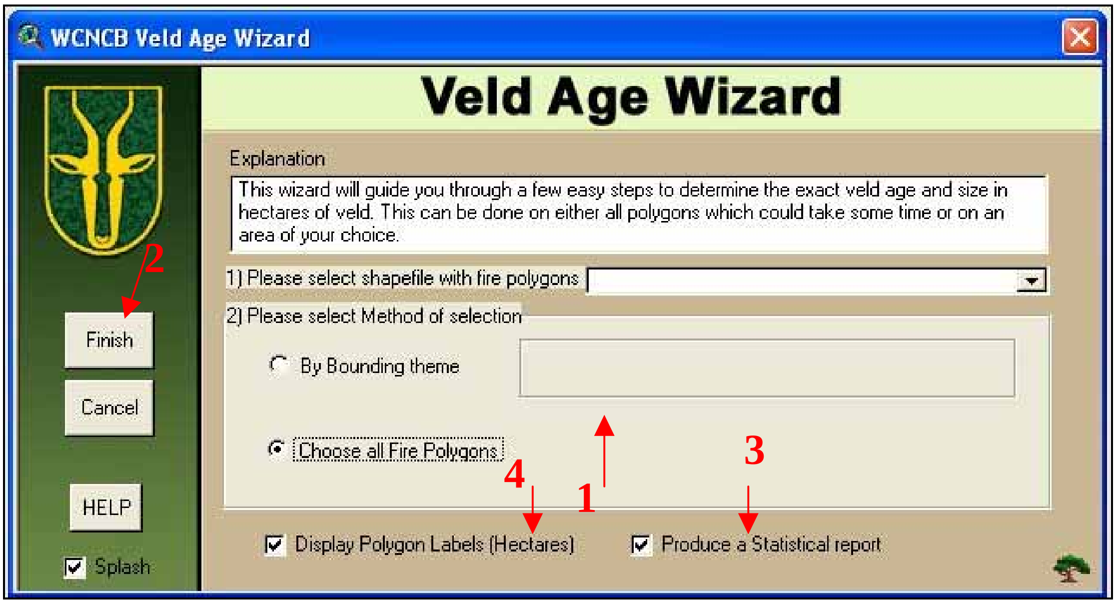

Figure 4.5 Veld Age Wizard with the bounding theme greyed out

It was decided that the resulting theme would be a new theme. When the themes are selected and the Finish button is clicked (Figure 4.5 arrow No. 2), the user is asked to provide a name for the output theme. Depending on whether the user chose to use a bounding theme, the user will be reminded of the type of output theme (clipped or not).

In the main Veld Age Wizard screen (Figure 4.5) there are two more options. Namely the option to display polygon labels and the option to produce a statistical report (see arrows 3 and 4). If the option for statistics is chosen, then reports such as the examples in Figure 4.6 and Figure 4.7 are generated. The two reports give information on the mean veld age, the minimum and maximum veld age in question, the range, variance and standard deviation of the veld age and the percentage of surface area having which have age allocated.

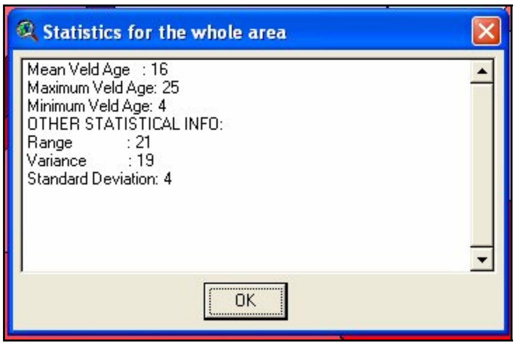

Figure 4.6 Veld age statistics are calculated automatically as seen in this example

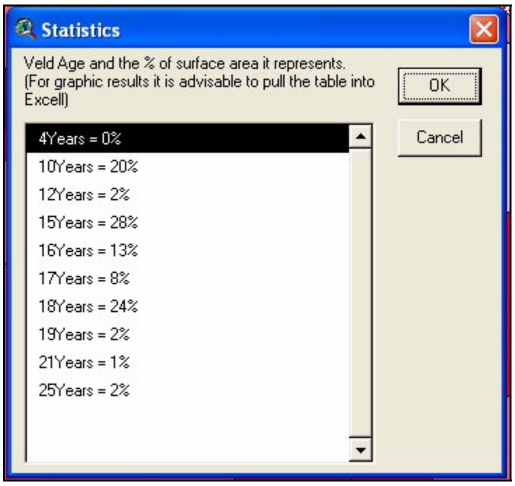

Figure 4.7 Veld age surface statistics are calculated automatically as seen in this example

For this example, fire data for the Rooiberg Nature Reserve in the Klein Karoo district was used. This is typically the type of data supplied by the WCNCB and that which the reserve manager will have access to (see Figure 4.8).

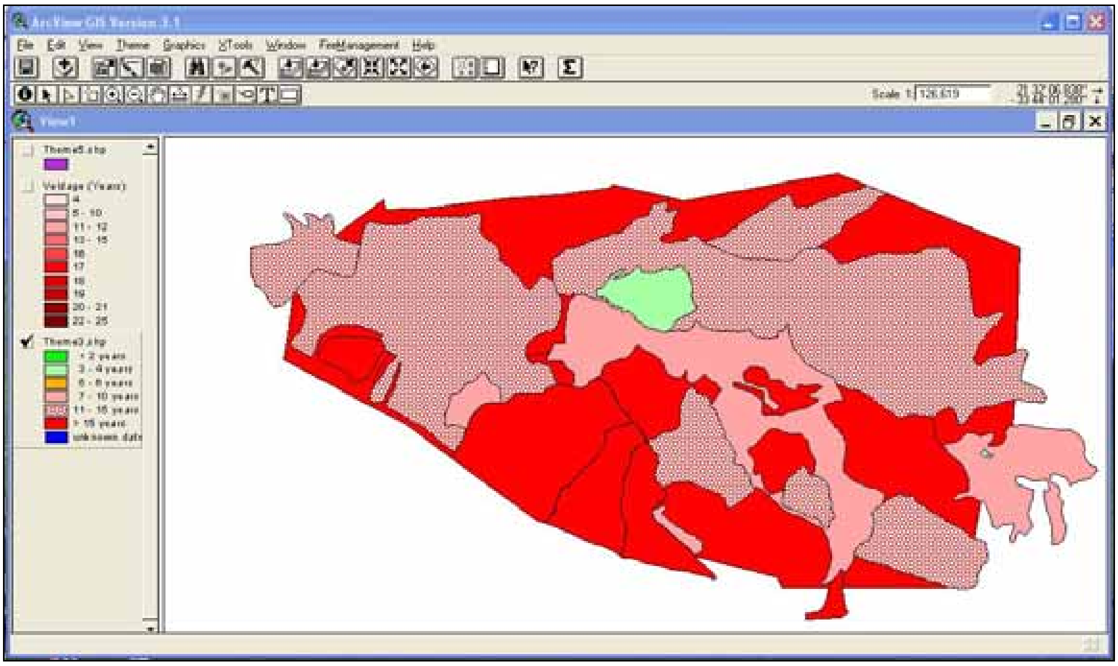

Figure 4.8 Example of fire data: Fires in the area of the Rooiberg Nature Reserve in the Klein Karoo district

The bounding theme used was that of the Rooiberg Nature reserve, as can be seen in Figure 4.9. This produced a final map showing the veld age in grades of age with sizes in hectares, as can be seen in Figure 4.10, where the darkest polygons show vegetation aged 22 – 25 years.

The overlapping nature of the polygons proved to be the main problem from a programming perspective. Various attempts to produce code to extract the needed data through the polygon layers resulted in the code called 'cnc.firefreq.drilldown' (see Appendix C). This code snippet was then recycled where needed in the matrix options and the fire frequency options.

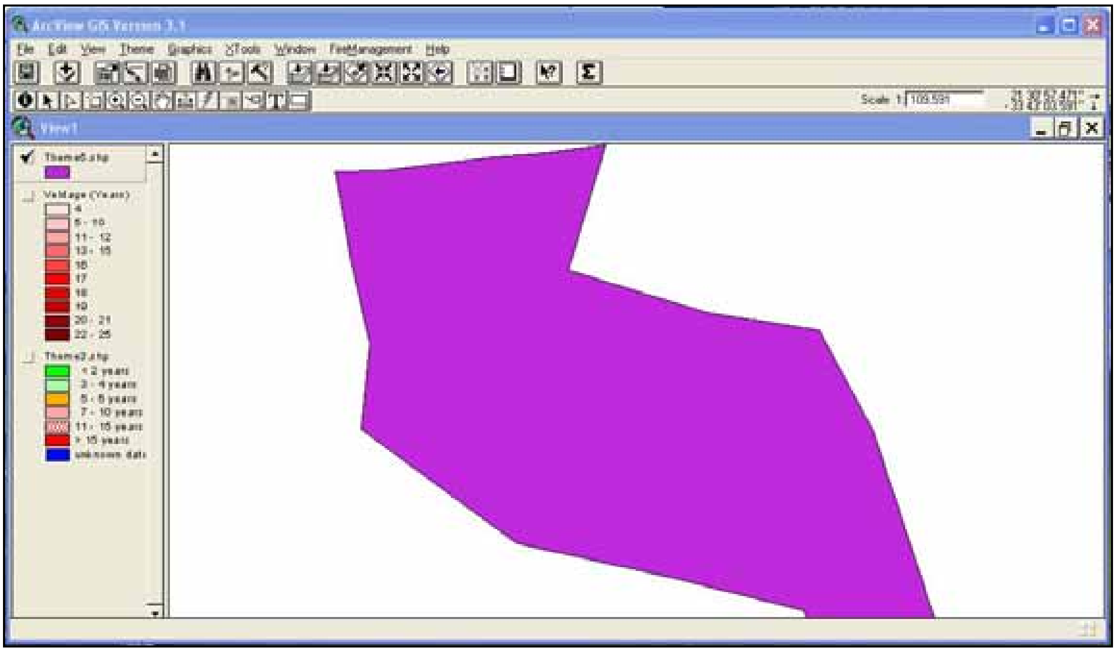

Figure 4.9 **A graphical example of the Rooiberg Nature Reserve's boundary**

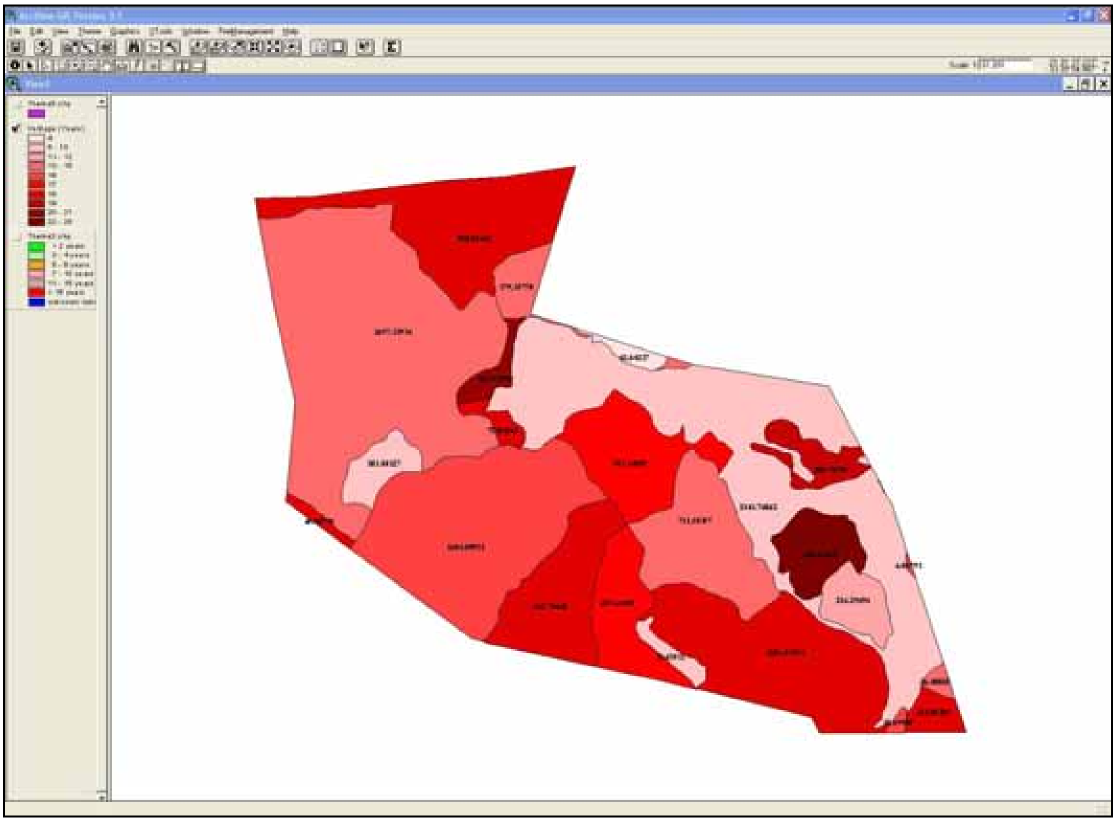

Figure 4.10 **Veld age map of the Rooiberg Nature Reserve as generated and presented by the application, clearly showing the age distribution of vegetation**

4.2.2 The FireFrequency Option

Clicking on the FireFrequency option opens a dialogue box as can be seen in Figure 4.11. Note the adherence to the WCNCB's GUI guidelines (see section 3.5). Here the user will find the option to select the theme containing the fire data from the themes loaded in ArcView (see option 1 in Figure 4.11). Once the theme is selected the user has the opportunity to either produce a map by 'regular matrix' or by 'fire scar polygon' (see option 2 in Figure 4.11).

Figure 4.13 shows the result by fire scar polygons. Once again the functionality to constrain the map to a boundary (see option 3 in Figure 4.11) such as that of a reserve or a farm (the Towerkop Nature Reserve boundary, Figure 4.12, was used for this example) is available. This follows the same design as with the veld-age map and includes the functionality to produce a statistical report (see option 4 in Figure 4.11). When the user clicks on the 'Next' button, he/she is prompted to provide a filename and location for the new theme, containing the resulting map.

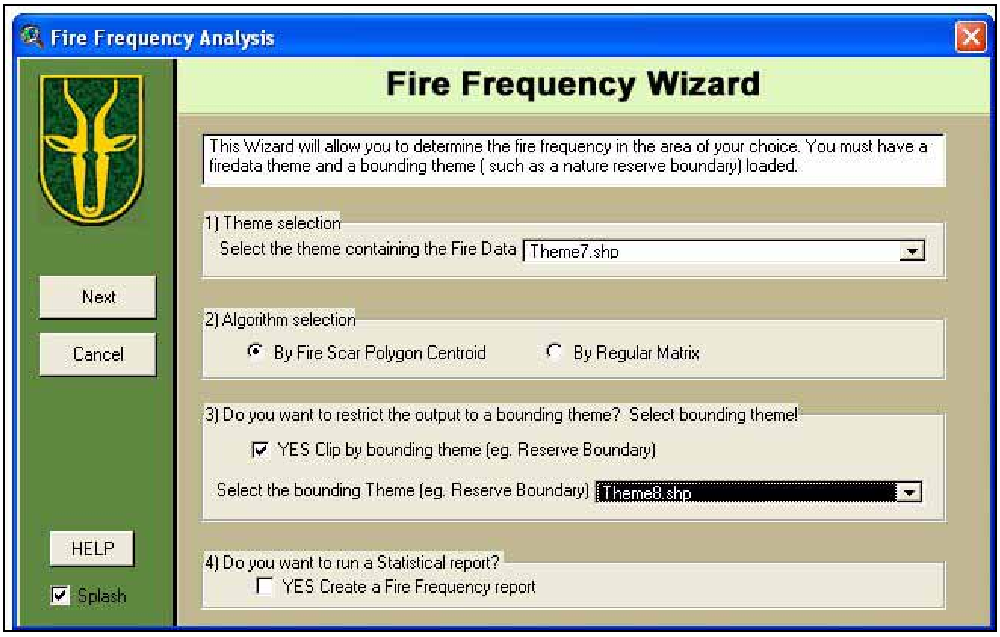

Figure 4.11 The Fire Frequency Wizard assist users to determine fire frequency in the area of their choice

If the options were chosen as in the example above shown in Figure 4.11, a map such as
Figure 4.13 will be produced. This is a map showing the fire frequency for the Towerkop Nature Reserve in the Klein Karoo, with lighter shades indicating low fire frequency and darker shades indicating higher fire frequency.

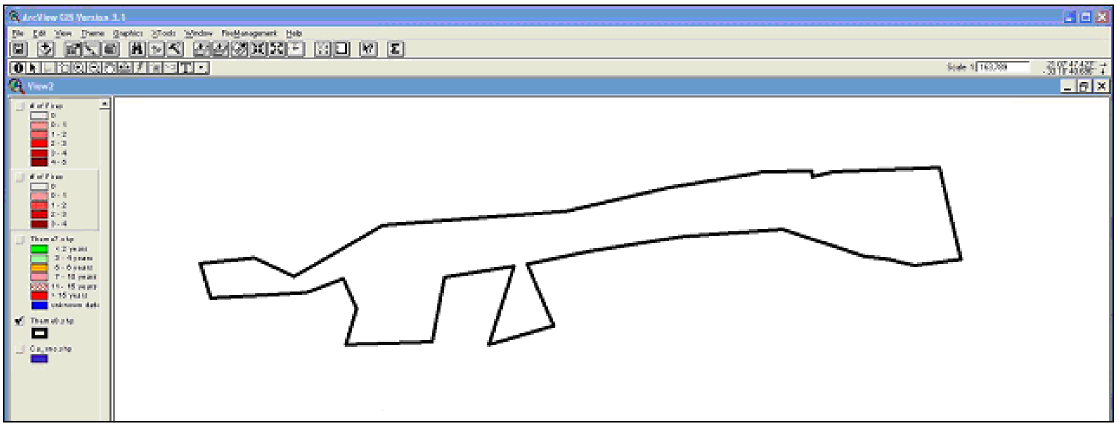

Figure 4.12 Towerkop Nature Reserve boundary represented graphically

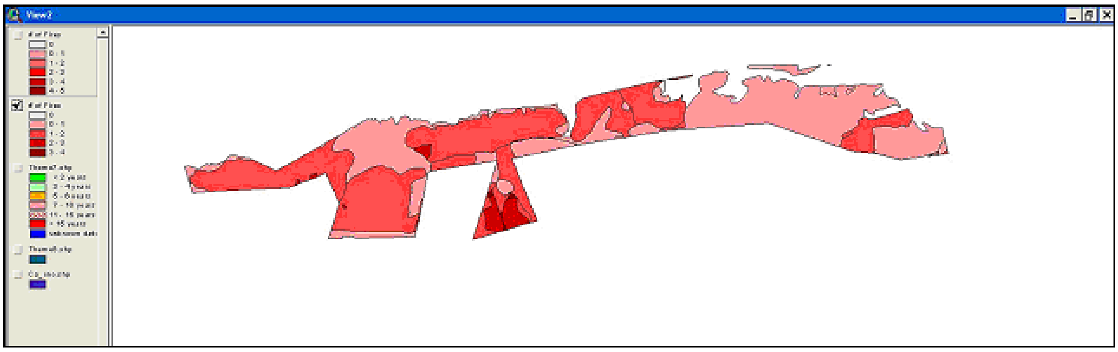

Figure 4.13 Fire Frequency in the Towerkop Nature Reserve as generated and presented by the application, clearly highlighting areas suffered from repeated scarring in dark red

Staff members involved in the project requested the inclusion of a ‘regular matrix’ option (see Figure 4.14 and Figure 4.17), during a meeting in 2000, as it is a familiar approach, especially in hotspot analysis within the WCNCB. It produces a matrix to the grain/resolution the user chooses (see Figure 4.15). This is a very processor-intensive procedure and, if done in high resolution, can take a very long time depending on the performance of the computer used. The application will warn the user (see Figure 4.16) that a long waiting time is likely if a high resolution is chosen. It also keeps the user informed of what the algorithm is doing, as in the example in Figure 4.17, and the stage of the process.

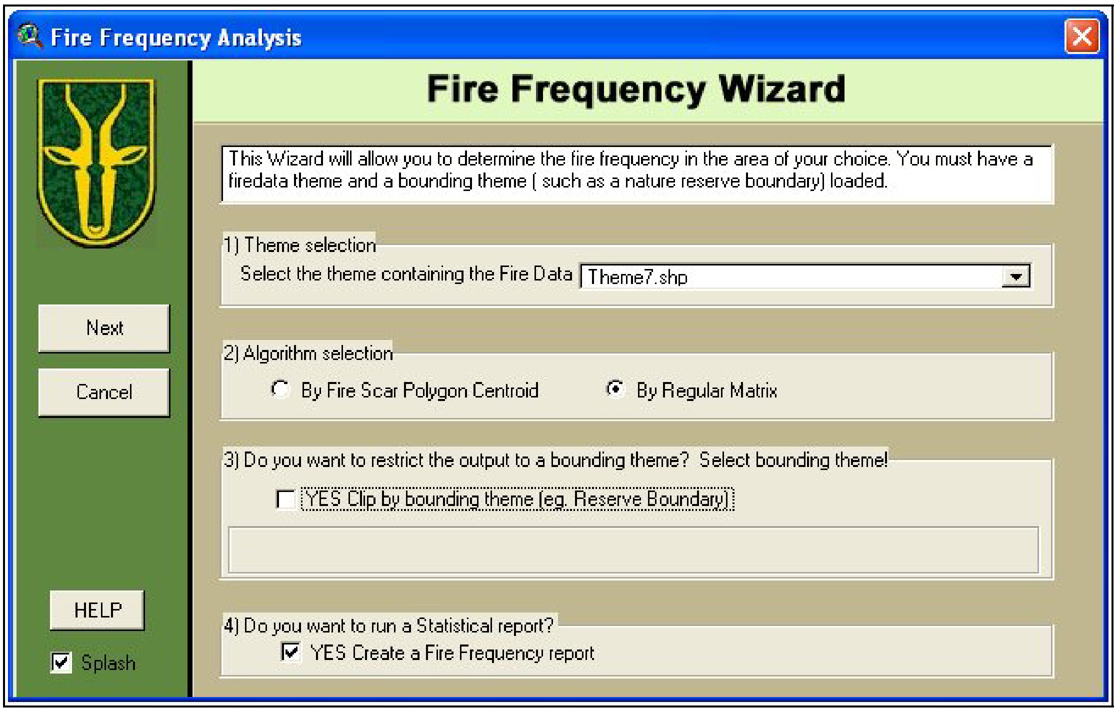

Figure 4.14 The Fire Frequency Wizard with the Regular Matrix option selected, this allows the user to present fire frequency in a regular matrix

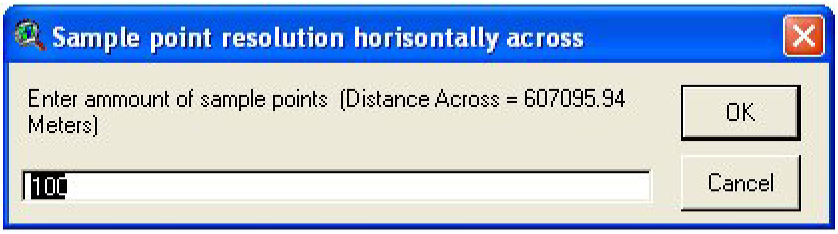

Figure 4.15 The application allows the user to enter any resolution for the Regular Matrix, to be used for presenting fire frequency

Figure 4.16 Users are warned of long processing time when a fine matrix is selected

The Regular Matrix option is very much the same algorithm as the normal fire scar polygon algorithm. It differs in that it produces an indicator of fire frequency by a user-selectable size square, rather than by a whole polygon. The resulting map looks like the example in Figure 4.17. Although this is less accurate than the direct fire scar method, the reserve manager might want to see an estimated fire frequency per hectare for example. Once again this allows the user to identify areas with repeated fire scarring with ease, as the darker colours that flag up hotspots indicate this.

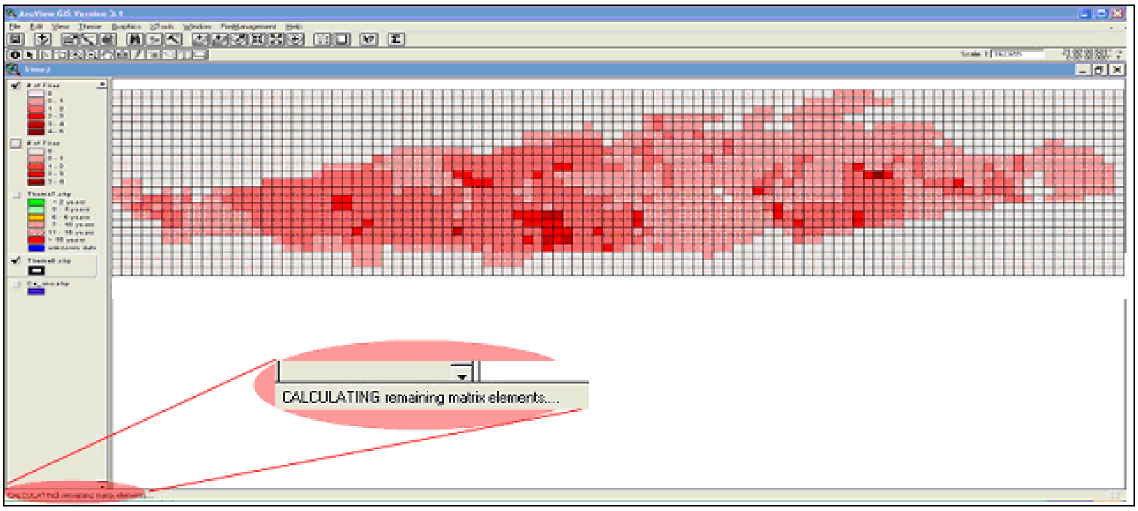

Figure 4.17 The application keeps the user informed of the process stage and the final map.

As can be seen in Figure 4.11 and Figure 4.14 there is the option to produce a statistical report. ArcView's chart and graphing functionalities are below average and not recommended. Figure 4.18 demonstrates the Fire Frequency Chart that is produced when the statistical option is selected. It shows the number of polygons/grid cells on the vertical axis and number of fire recurrence on the horizontal axes.

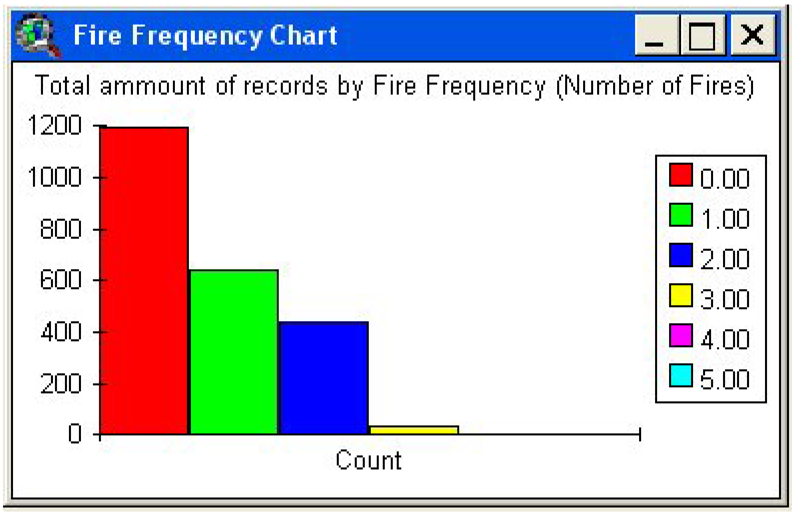

Figure 4.18 A Fire Frequency Chart is generated

The window with statistics resembles Figure 4.19 and shows the number of cells in the matrix, the year range, mean fire frequency, minimum and maximum fire frequency, as well as the fire frequency range, variance and standard deviation.

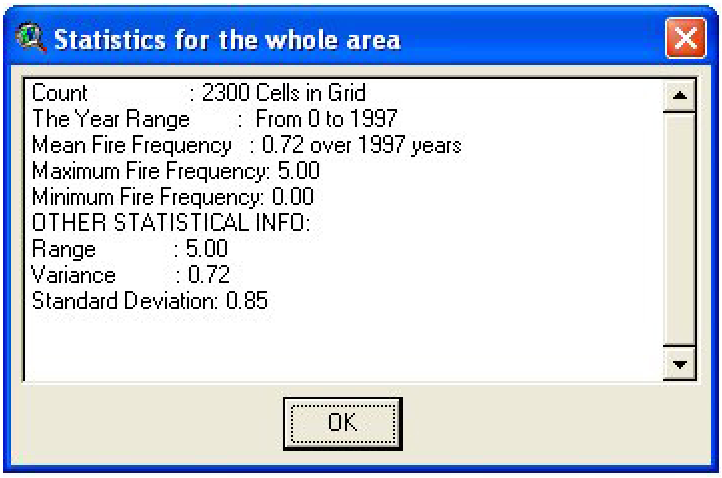

Figure 4.19 Fire frequency statistics as generated by the application

Figure 4.20 shows the original fire scar data of the Towerkop Nature Reserve that was used to produce the previous fire frequency maps.

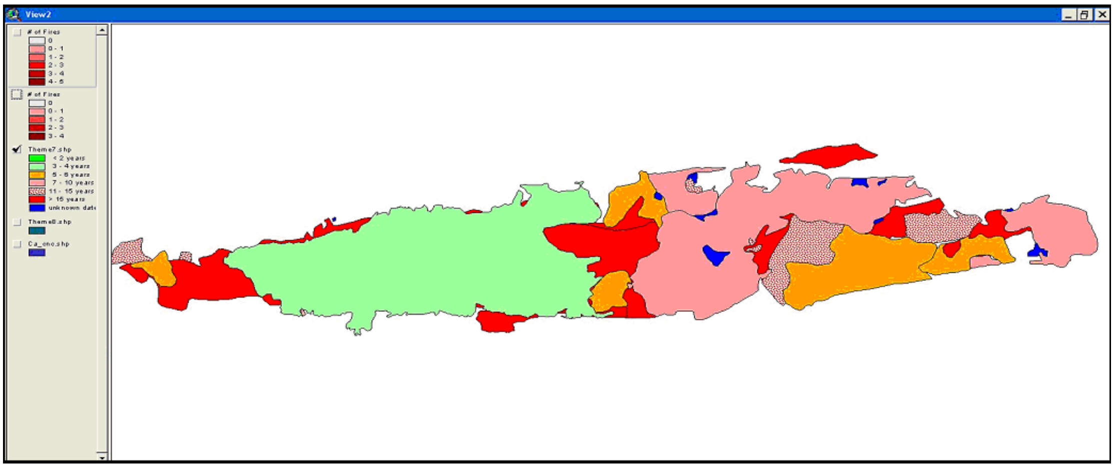

Figure 4.20 A graphical representation of the fire scar data for the Towerkop Nature Reserve

4.3 THE DATASET

The sample dataset for this study was provided by the WCNCB and can be seen in Figures 3-24 & 3-25. It covers most nature reserves from the Cederberg Nature Reserve in the north-western Cape to the Baviaanskloof Nature Reserve in the east of the Western Cape.

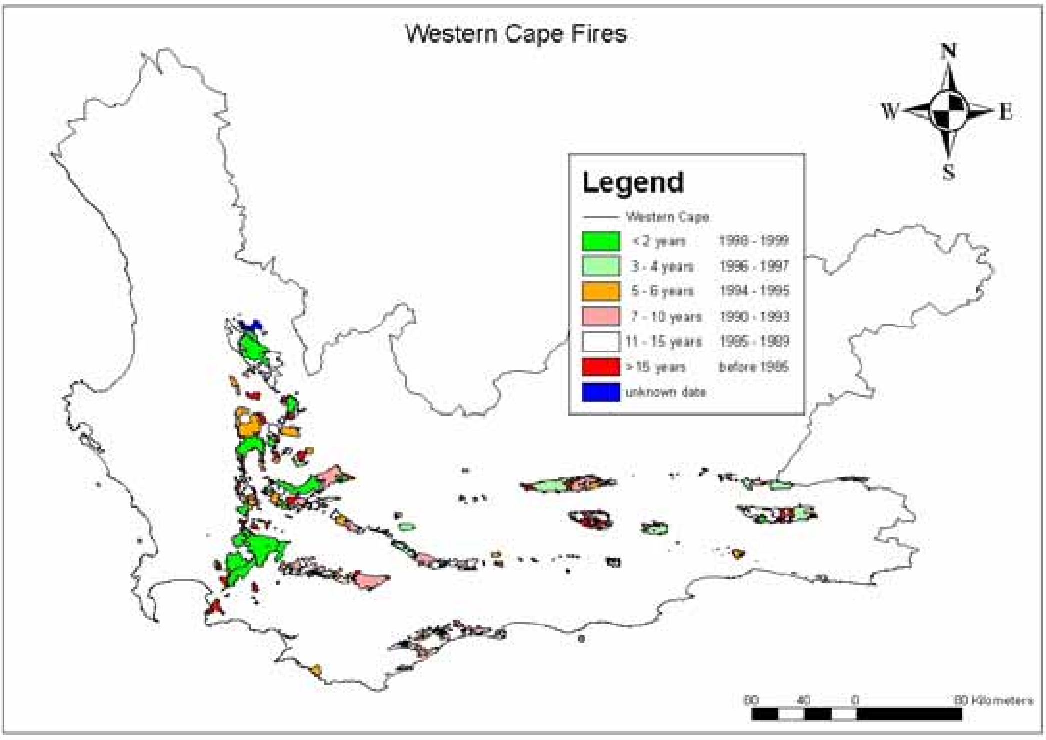

Figure 4.21 **The extent of WCNCB fire data shown graphically**

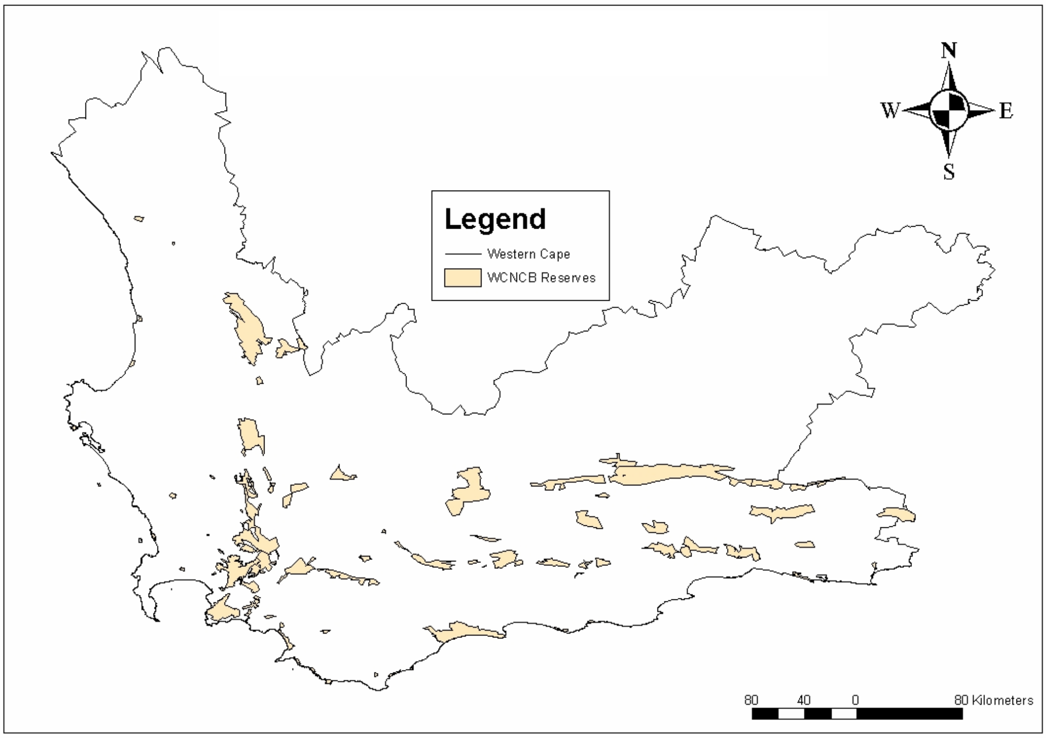

Figure 4.22 **WCNCB reserve boundaries map**

4.4 TESTING AND TRAINING

Over the duration of this study this software was tested on various operating systems, including, Windows 98, Windows NT and Windows 2000 (but not XP). It was also tested on machines with various levels of performance ranging from Pentium II, 266mhz to Pentium IV, 2ghz processors. Various amounts of random access memory (RAM) from 64 megabytes to 512 megabytes were used and hard disk drives with speeds ranging from 5 200 revolutions per minute to 7 400 revolutions per minute were used for testing. It was concluded that the software did perform better on machines with higher specifications. Hard drive speed had a greater effect on performance than expected; this suggested that ArcView writes more data directly to the hard drive than it did to RAM. The software had no problems working within the performance ranges within which it was tested.

ArcView 3.1 was used throughout the testing and development, as this was the WCNCB’s product of choice and the only version accessible. This version of ArcView proved to be rather unstable, but that was beyond the researcher’s control. It seemed to crash frequently, mostly providing the error message ‘segmentation violation’. This was subsequently overcome through extensive revisions of the code and patches provided by the software provider.

Frequent testing also involved testing by WCNCB staff members. The WCNCB’s scientific division’s GIS personnel were involved in testing and training throughout the development of the software. Testing took the user through all the steps of the software, and evaluated the user-friendliness and functionality of the software. Quite often this resulted in crucial and dramatic changes to the software (such as moving away from multiple screen wizards to single screen wizards). Once the software was finalised and it was agreed not to expand it any further, staff members were trained to the level where they were confident to install the software and train reserve managers in other areas.

.

CHAPTER 5: SUMMARY, CONCLUSION, RECOMMENDATION AND FURTHER STUDIES

5.1 SUMMARY

A need expressed by the WCNCB, formed the basis of this study. This need was to produce a decision-support tool for reserve managers, specifically a user-friendly software application that would enable a reserve manager to produce basic veld age and fire frequency maps.

This study explored the possibilities of solving a cognitively demanding problem. The difficulty lay in processing complicated tabular data with confidence and ease. This tabular data had a spatial element, which made it a suitable candidate for focusing on GIS as a solution. GIS provided the foundation for simplifying the data by providing visual feedback to the user, making it easier to understand and subsequently enabling efficient and effective decision-making.

A big challenge of this study was to gain comprehensive insight into the environment, the people involved and their abilities. The field covers a wide spectrum of study areas from physics, botany, mathematics and programming to wildfires, which is a very broad and interesting field of study in itself. This was facilitated by the generosity of the WCNCB by providing accommodation and access to their premises over an extended period of time.

Part of the challenge was to master the art of programming. This is by no means limited to mastering a programming language to the extent that it could be used successfully for this study, but also the plethora of disciplines going hand-in-hand with programming. The most important of these were the maintenance of code, version checking and pseudo-coding. The management of the ‘client’ who added more complex demands and ever extended the functionality of the code outside of the extent of the study, was a testing problem. Careful planning and bookkeeping was needed to overcome these issues.

The research problem seems simplistic, but resolving it proved to be a highly complex procedure, involving many months spent on automating a series of GIS techniques.

5.2 CONCLUSION

The study researched possible methods of visualising tabular data. GIS provides a powerful combination of advanced cartography, database integration, and spatial analysis and manipulation. This combination made it an ideal and effective platform for building a solution for the research problem. A rich new dimension is opened when the user is able to visualise tabular data; this dimension often simplifies complex problems and makes it easier for the decision-maker to digest.

The automated ArcView extension (cncfiremanager.avx), developed using the programming language Avenue, is the product of this study. It enables reserve managers to identify areas where prompt action is required in order to prevent the further destruction by fire of sensitive areas. It allows for interactive input with visual output as the result. This transformation of tabular data into visual data is shown to be of great value for the reserve manager, especially in cases where the manager has little knowledge of the area in question. Being able to view historic fire data cartographically, and to compare the net effect over time on a digital platform merely by pressing a few buttons, provides invaluable timesaving support unavailable in the past within the realms of the WCNCB.

In concluding this study, the following important points can be noted:

1. On GIS

- GIS is an excellent tool for visualising data and extracting hidden values within existing tabular data, as demonstrated in this project.
- GIS is only as accurate as the data that are used.
- GIS is a powerful decision-support tool if used correctly and an even better spatial decision-support tool.
- It is possible to build a customised GIS to be used effectively by GIS-illiterate people.

- Avenue and ArcView 3.1 are a good combination for developing customised applications. It is believed, however, that better platforms exist, as is evident in ESRI's latest software, ArcGIS 9, which uses Visual Basic as basis for customisation. It also provides an interface for a variety of industry standard programming languages including object-orientated programming languages such as such as C++, .NET, or VB.

2. On programming
    - Programming is a full-blown language like any linguistic language, and object-orientated programming is neither an easy nor a fast language to learn - especially Avenue. Avenue is not as widely supported as other object-orientated languages such as C++. The biggest obstacle in coding using Avenue is its poor error-trapping capabilities. The user is often forced to find creative ways to trap errors, which waste valuable time.
    - Programming is a study in its own, hence it being a full time career to some. It is important to understand that coding is only one element of the equation when it comes to writing software. Other elements include design, versioning, system specification, error checking, documentation and training.
    - Programming can be a time-consuming and frustrating activity and should not be taken lightly if never attempted before.
    - Programmers ought to adhere to extremely strict end-product specifications. Any program can be modified, expanded and improved to great lengths. If a software program is not developed according to a strict specification, it is likely that the developer may get trapped in an ever-expanding project and altering his/her product as new development demands are made.

The final conclusion is that GIS proved a suitable candidate for successfully solving the research problem at hand and resulted in a tool, which aids the WCNCB in the decision-making processes involved with fire management.

5.3 RECOMMENDATION AND FURTHER STUDIES

The application satisfies the initial basic needs, but there is scope for further studies. A considerable amount of research has been carried out on an international scale, specifically in the modelling of fire frequency. Hence the development of a customised software fire frequency-modelling tool for the WCNCB could be of interest. This would allow managers to be proactive in researching possible scenarios. Critical scenarios would easily be highlighted and contingency plans drawn up, should such a scenario become a real life threat. Such a modelling tool would tie in neatly with the research project.

The fire frequency tool that was developed had only basic functionality in mind, allowing the user to identify areas frequented by fire over a period of time, quickly and easily. Further development of this into a more complex tool, allowing detailed analysis can be considered. This could include functionality that allows comparisons between seasons or predefined periods to see if there is a change or trend in the fire frequency over time.

The effects of fire on fynbos and vegetation are a well-studied topic, but there is scope for more research in this area. The relationship between specie modelling and fire scar history is one example. Specific species can be mapped against fire-scar maps produced by this software, possibly yielding new trends and information on the effects of fire over time. This might be instrumental in the preservation of the unique vegetation in this area.

The application as it stands does not allow for automated importation of vegetation cover layers. This can easily be done using the normal ArcView tools, but some knowledge of ArcView will be required, particularly in cases where projections are an issue. By comparing different vegetation types with the underlying fire scar data as provided by the research project, possible new trends could come to light. For instance this could highlight types of vegetation that are more susceptible to fire or whose germination period is longer than previously thought. This opens up possibilities for future studies to students with a botany background.

The application is modelled to fit the strict WCNCB standards. This allows for uniformity within the organisation, but hampers the possibility of transferring the system to another company. Recoding the whole system using the same algorithms and logic into a viable commercial application is an avenue worth considering. This could be done either for the love of the cause, possibly on an open source basis as a programming project, or for monetary purposes.

With advances in technology it is likely that the WCNCB will move to different software environments in the future. Better coding platforms will be available and the porting of this code to the next generation will be needed when this takes effect. Trends in programming languages indicate easier integration between platforms in the future, which would probably make the updating of code easier as languages merge. This tendency is evident in examples such as JAVA, GML and XML. It is inevitable that internal re-coding of this application will become an internal project of the WCNCB in the future.

The concepts of this study are not limited to fire scarring and veld age. Various projects could be considered where the cumulative effect of random spatial occurrences needs to be investigated. A couple of examples could be the cumulative effect of:

- ground pollution, caused by industrial use, on vegetation over time;
- flooding on agriculture in a specific area prone to flooding; and
- urbanisation on rural economies.

This list of possible applications is not exhaustive. Researchers may find further ways of adapting this study for other purposes.

REFERENCES

Alexandrian D, Esnault F & Calabri G 1999. Forest fires in the Mediterranean. *Unasylva* 197, 50: 35-44.

Arlov L 1997. *GUI design for dummies*. Montreal: Wiley Publishing & IDG Books.

Aupiais L & Stammers R 2000. *The Cape of flames.* Kenilworth: Inyati Publishing.

Barnes DJ & Kolling M 2002. *An introduction to object-oriented programming.* Upper Saddle River: Prentice Hall.

Bellman RE 1978. *An introduction to artificial intelligence: Can computers think?* San Francisco: Boyd & Fraser Publishing Company.

Benneton J, Cashin P, Jones D & Soligo J 1998. An economic evaluation of bushfire prevention and suppression. *The Australian Journal of Agricultural Resource Economics* 42: 149-175.

Bonczek RH, Holsapple CW & Whinston AB 1991. *Foundations of decision support systems.* Orlando: Academic Press.

Bond P & Goldblatt B 1984. Plants of the Cape Flora – A descriptive catalogue. *Journal of South African Botany* 13. Cape Town: National Botanic Gardens of South Africa.

Bond WJ, Vlok J & Viviers M 1984. Variation in seedling recruitment of Cape Proteaceae after fire. *Journal of Ecology* 72: 209–221.

Bond WJ & Van Wilgen BW 1996. *Fire and plants*. London: Chapman & Hall.

Brits GJ, Calitz FJ, Brown NAC & Manning JC 1993. Desiccation as the active principle in heat-stimulated seed germination of Leucospermum R. (Proteaceae) in fynbos. *New Phytology* 125: 397–403.

Brockett BH, Biggs HC & Van Wilgen BW 2000. A patch mosaic burning system for conservation areas in southern Africa. *International Journal of Wildland Fire* 10, 2: 169–183.

Brown AA & Davis KP 1973. Man, fire, and forests. In Fankel WP, Langman N, (eds) *Forest Fire*: *Control and use*. 2nd ed. McGraw-Hill Series in forest resources. New York: McGraw-Hill Book Company.

Brown NAC 1993. Promotion of germination of fynbos seeds by plant-derived smoke. *New Phytolology* 123: 575–584.

Bruce M 2002. Country report for the United Kingdom. *International Forest Fire News* 27: 68-76.

Burtt B (Director and Producer) 1993. *Blue Planet.* Imax Studios (film).

Cheney P 1997. Towards better bushfire predictions. *Onwood* 18: 1-2.

Cheney P 1999. Bushfire behaviour experiment continues. *Onwood* 23: 2.

Coad P & Nicola J 1993. *Object-oriented programming.* Upper Saddle River : Prentice Hall.

Cowling R & Richardson D 1995. South Africa’s unique floral kingdom. In Martin L (ed.) *Fynbos.* Cape Town: University of Cape Town Press.

Craig A 2002. Wildland fires in New Zealand in the 1990s: Retrospective and challenges. *International Forest Fire News* 26: 87-91.

De Klerk HM & Sutton T 2000. *A strategy for the implementation of a Geographical Information System for Western Cape Nature Conservation*. Jonkershoek: Scientific Services Division.

De Ronde C 1990. How to use forest floor characteristics to determine litter reduction priorities, rate of fire hazard and feasibility of controlled burning. Paper read at the 1st International Conference on Forest Fire Research, Coimbra, Portugal.

De Ronde C 1997. Dynamic fire protection in Southern African plantations. 2nd International Wildland fire conference, Canada: Vancouver.

De Ronde C, Goldammer JG, Wade DD & Soares RV 1990. Prescribed burning in industrial plantations. *Ecological Studies* 84: 216–272.

De Ronde C 2000. Ecological requirements for the maintenance of Western Cape Fynbos Biodiversity and compromises recommended to meet metropolitan pressure. *International Forest Fire News* 22: 76-78.

ESRI 1997. *Arcview dialog designer*. USA: ESRI.

ESRI 2003. *ESRI History* [online]. Available from: http://www.esri.com/company/about/history.html [Accessed 12 December 2003].

Fowkes S 1999. *Public involvement programme for phase 1: Situation assessment and review*. (Report No. P-1). Prepared for WWF-SA.

Fowler M 2003. *UML distilled: A brief guide to the standard object modeling language.* Boston: Addison Wesley.

Gill M & Moore HR 2002. Fire situation in Australia. *International Forest Fire News* 26: 2-8.

Goldammer JG & De Ronde C 2001. Fire situation in South Africa. *International Forest Fire News* 25: 105-111.

Goldblatt P 1978. An analysis of the flora of Southern Africa: It's characteristics, relationships and origins. *Annual Missouri Botanical Gardens* 65: 369-436

Hobart J 2003. Software development. The SD best practices 2003 Conference, Boston.

Holsapple CW & Whinston WB 1996. *Decision support systems: A knowledge-based approach.* USA: West Publishing Company.

Howe J 1994. Artificial intelligence at Edinburgh University: a Perspective. Unpublished Manuscript. Cambridge: University of Cambridge, Division of Informatics.

Huguenot Memorial Museum 2003. The floral kingdoms of the world [online]. Available from: http://www.museum.co.za/fynbos.htm. [Accessed 02 March 2003].

Huntley BJ 1984. Ecological effects of fire in South African ecosystems. In De Booysen P & Tainton NM (eds) *Ecological Studies,* 48: 1-18. Berlin: Springer -Verlag.

Jungle Photos 2003. Amazon mouth [online]. Available from: www.junglephotos.com/satimages/amazmouth.html [Accessed 10 October 2003].

Knight I & Sullivan A 2000. Fire and wind – the need for caution. *Onwood* 28: 2

Kruger FJ & Bigalke RC 1984. Fire in fynbos. In De Booysen P & Tainton NM (eds) Ecological effects of fire in South African ecosystems. *Ecological Studies*, 48: 67-114. Berlin: Springer -Verlag.

Le Maitre DC & Brown PJ 1992. Life cycles and fire-stimulated flowering in geophytes. In Van Wilgen BW, Richardson M, Kruger FJ & Van Hensbergen HJ (eds), *Fire in South African mountain fynbos*, 145–160. Berlin: Springer-Verlag.

Leigh JH & Noble JC 1981. The role of fire in the management of rangelands in Australia. In Gill AM, Groves RH & Noble IR (eds) *Fire and the Australian biota*, 38-55. Canberra: Australian Academy of Science.

Lindley BM & Appleton WC 2003. *Street smart chemistry*. New York: Dupont Denemours & Co.

Lotriet C 2003. *WWF South Africa: Fynbos programme* [online]. Available from http://www.panda.org.za/fynbos.htm [Accessed 10 October 2003].

Maguire DJ, Goodchild MF & Rhind DW 1991. *Geographical information systems.* New York: John Wiley and Sons.

Naveh Z 1990. Fire in the Mediterranean – A landscape ecological perspective. In Goldammer JG & Jenkins MJ (eds) *Fire in ecosystem dynamics: Mediterranean and Northern perspectives: Third International Symposium on Fire Ecology, Freiburg, FRG, May 1989.* The Hague: SPB Academic Publishing.

Nielsen J 1990. *Designing user interfaces for international use*. Elsevier: Elsevier Science Publishers.

Pfaffenberger B 2000. *Webster's new world dictionary of computer terms.* USA: Hungry Minds Inc..

Rebelo T 1995. *Proteas. A field guide to the Proteas of Southern Africa.* Cape Town: Fernwood Press.

Rourke JP 1980. *The Proteas of Southern Africa by J.P. Rourke*. Cape Town: Purnell

Rourke JP 1987**.** The inflorescence morphology and systematics of Aulax (Proteaceae). *Journal of South African Botany* 53: 464 – 480.

Russell-Smith J, Ryan PG, Klessa D, Waights G & Harwood R 1998. Fire regimes, fire-sensitive vegetation and fire management of the sandstone Arnhem Plateu, monsoonal northen Australia. *Journal of Applied Ecology 6,*35: 829-846.

Spence B 2003. SA national fire statistics 2002. *Fire Protection* 1,30 13-26.

Stanczyk S, Champion B & Leyton R 2001. *Theory and practice of relational databases.* London: Routledge.

Strebel DE, Meeson BW & Nelson AK 1994. Scientific information systems: A conceptual framework. In Michener WK, Brunt JW & Stafford SG (eds) *Environmental information management and analysis,* 58-85. London: Taylor & Francis.

Swap JR 2002. Update on the Southern African regional science initiative - SAFARI 2000. *International Forest Fire News* 21: 28-34.

Teusan S 1995. France: Forest fire profile. *International Forest Fire News* 13: 10-11.

The Cape Peninsula National Park's Official News Letter 2002. Ukuvuka-Operation Firestop. 7 October: 7.

Van Wilgen BW 1980. Some effects of fire frequency on fynbos at Jonkershoek, South Africa. Masters thesis. Cape Town: University of Cape Town.

Van Wilgen BW 1981. Some effects of fire frequency on fynbos plant community composition and structure at Jonkershoek, Stellenbosch. *South African Forestry Journal* 118: 42-55.

Van Wilgen BW, Biggs HC, O'Regan S & Mare N 2000. A fire history of the savanna ecosystems in the Kruger National Park, South Africa, between 1941 and 1996. *South African Journal of Science* 96: 167-178.

Von Krosigk, FK 1999. The National Veld and Forest Fire Act: Act 101 of 1998 of the Republic of South Africa. *International Forest Fire News* 21:15-16.

Western Cape Nature Conservation Board (WCNCB) 2002 [online]. Cape Nature Conservation. Available from http://www.capenature.org.za/About_us/html/parent_template.html. [Accessed 10 March 2002].

Whelan RJ 1998. *More questions than answers: The ecology of fire*. Cambridge: Cambridge University Press.

Yeld J 2002. Ukuvuka. *The Independent.* 8 February: 7.

Young A & Fowkes S. The Cape Action Plan for the Environment: Overview of an ecoregional planning process. *Biological Conservation*. 1,112: 15-28.

PERSONAL COMMUNICATIONS

Burgers CJ 2000. Information given to FY Ford during personal communications in connection with the WCNCB, fire management, wild fires and the development of the CNCFIREMANAGER extension in 2000.

Burgers CJ 2001. Information given to FY Ford during personal communications in connection with the WCNCB, fire management, wild fires and the development of the CNCFIREMANAGER extension in 2001.

De Klerk HM 2000. Information given to FY Ford during personal communications in connection with the WCNCB and the development of the CNCFIREMANAGER extension in 2000.

Shaw K 2001. Information given to FY Ford during a personal communication in connection with management in WCNCB.

Sutton T 2000. Information given to FY Ford during personal communications in connection with development of the CNCFIREMANAGER extension in 2000.

Sutton T 2001. Information given to FY Ford during personal communications in connection with development of the CNCFIREMANAGER extension in 2001.

Turner AA 2000. Information given to FY Ford during personal communications in connection with development of the CNCFIREMANAGER extension and WCNCB databases in 2000

Turner AA 2001. Information given to FY Ford during personal communications in connection with development of the CNCFIREMANAGER extension and WCNCB databases in 2001.

APPENDICES

Appendix A: The WCNCB's Fire Database

When the user starts the database application, it starts with a splash screen (Figure A-1), which allows the user to either start the data entry process or go to a page called 'Utilities'.

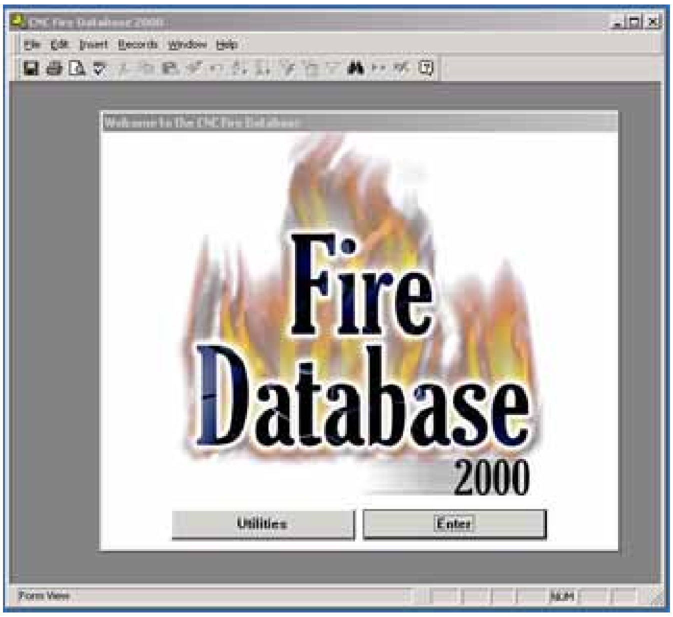

Figure A-1 Fire Database Splash Screen

The Utility option allows the user to perform various maintenance procedures on the database. Most of these procedures are standard Access97 procedures. These have been automated to make the application user-friendly for users with no or little experience with Access97.

Figure A-2 **Fire Database Utilities**

If the user chose the other option on the Splash screen, namely, 'Enter', he would get to the fire data entry form as seen in Figure A-2

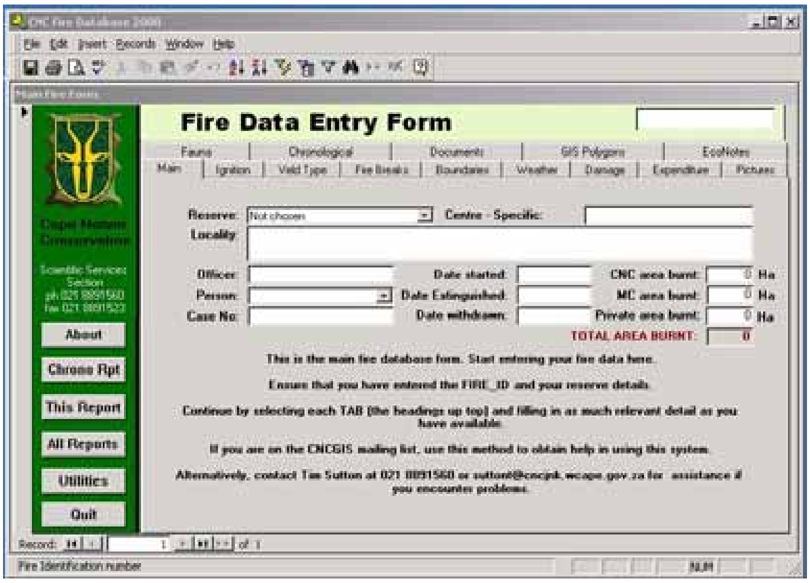

Figure A-3 **Main Data Entry Form**

This form is a good example of the WCNCB GUI standard. Note the logo in the top left corner, a green bar running down the left encapsulating the logo. Higher-level buttons are to be found on the green bar. The title appears at the top and the data manipulation is done on the rest of the screen in grey.

The form allows 14 data entry categories, all divided by tabs. The form starts on the 'Main' Tab as in Figure A-3. Here the user enters the main and most important data, such as the name of the reserve, the area, the name of the Officer involved, the dates involved, the case number and the area burnt in hectares. From here the user can enter any other available data. Below are some screenshots of the other tabs.

In the fire ignition entry the user can enter any available data concerning the ignition, such as the exact co-ordinates, the source and the veld type in which the fire was started. Adding the co-ordinates is a very good example of creating a database that contains spatial data in tabular form. This can easily be converted to visual data using GIS technology, which in turn can provide valuable information overlooked if it is simply stored in tabular form.

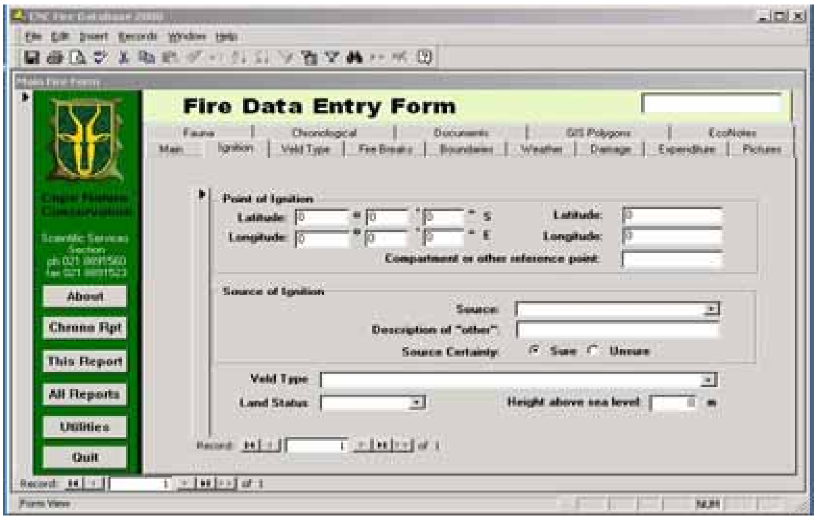

Figure A-4 **Fire Ignition Tab**

In the Veld Type tab (Figure A-4) there is provision for entering the type of veld or selecting it from a list, as well as for entering the areas burnt.

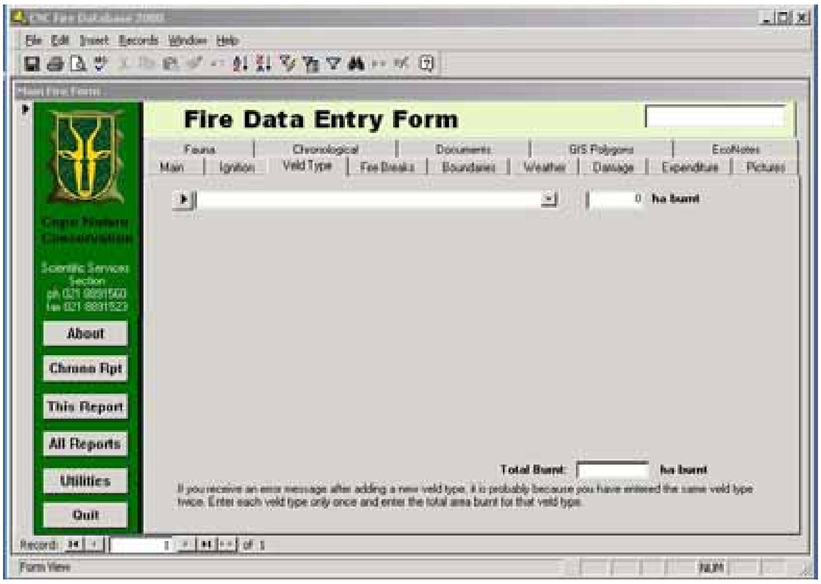

Figure A-5 Veld Type Tab

In the Fire Breaks Tab there is provision for adding the type of fire break and its dimensions. It also allows data entry for more than one fire break per burn.

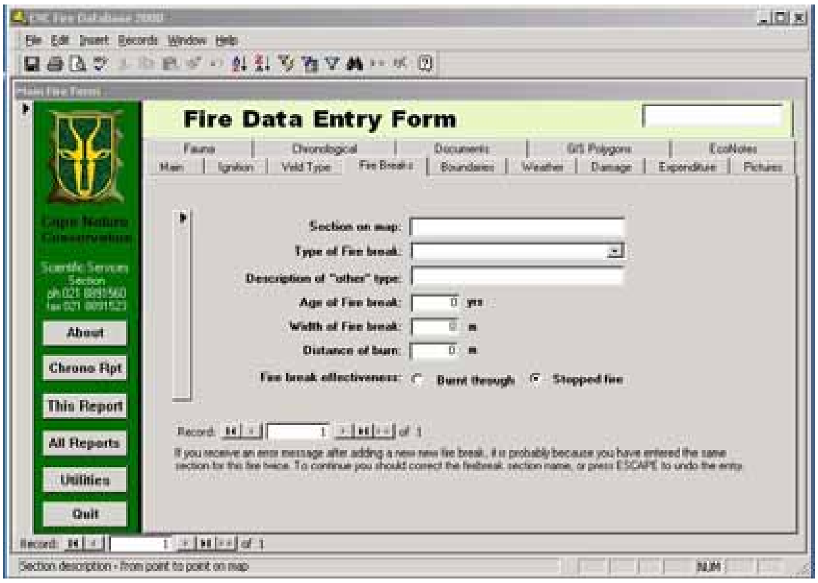

Figure A-5 Fire Breaks Tab

Under the boundaries tab provision is made for data about the boundary types and dimensions.

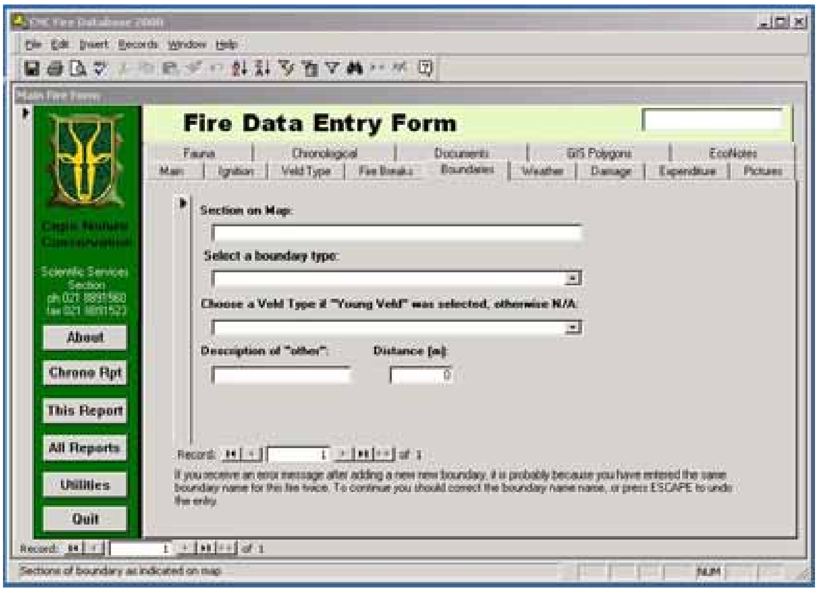

Figure A-6 Boundaries Tab

As the heading indicates, the weather tab is for data about the weather conditions at the time of the fire.

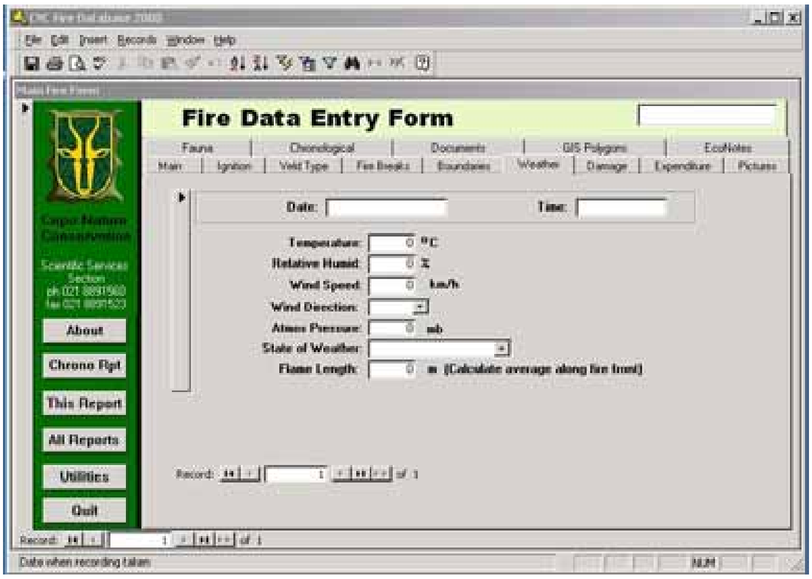

Figure A-7 Weather tab

The damage tab is for data entry on damage occurred to buildings, vehicles and equipment as well as any generic item with the option to describe this/these item/s.

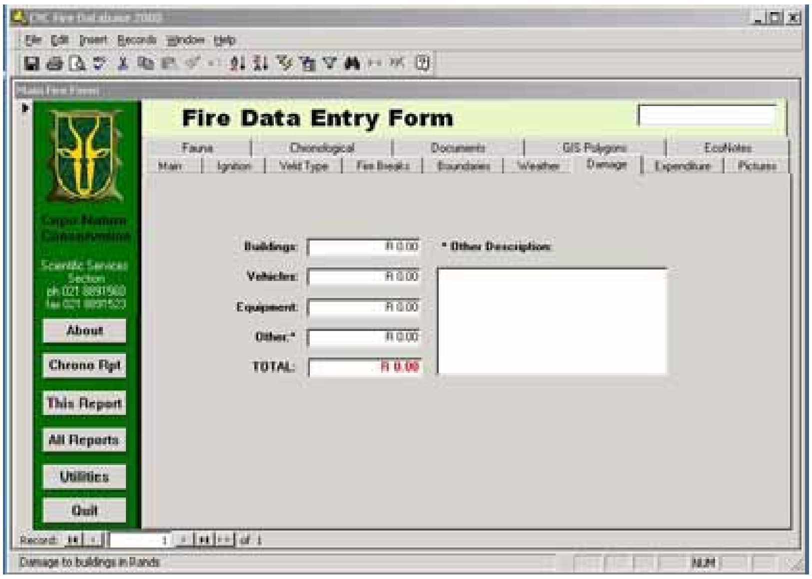

Figure A-8　　Damage Tab

The expenditure tab allows data gathering concerned with any expenses resulting from the fire.

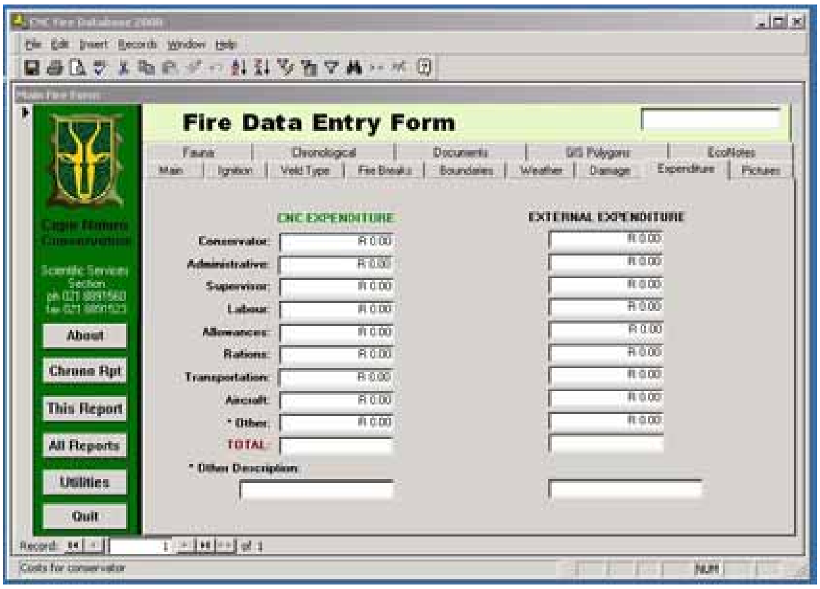

Figure A-9　　Expenditure Tab

Under Pictures data can be gathered about any photos (aerial or standard), video footage or even maps of the event.

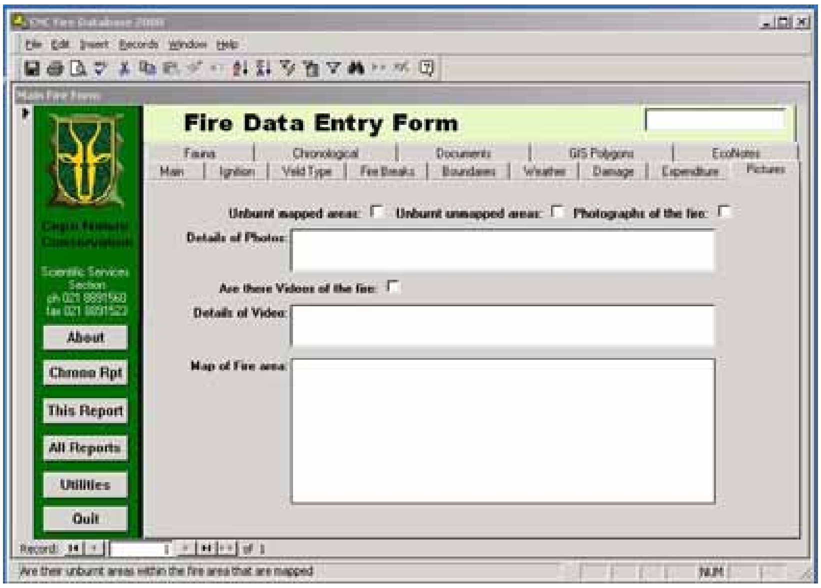

Figure A-10 Pictures Tab

Any fauna found charred or alive is noted under the Fauna tab.

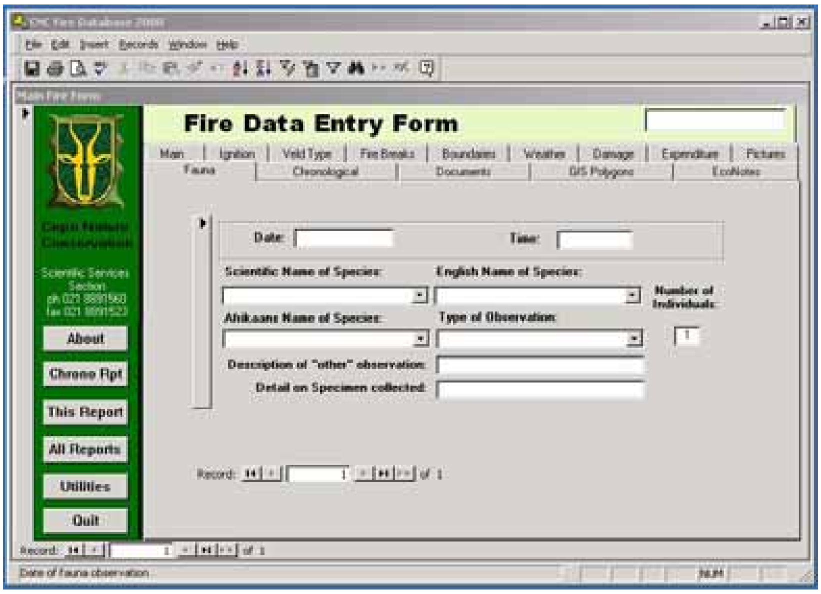

Figure A-11 Fauna Tab

Under the Chronological tab data describing the fire chronologically can be added to sketch a picture of the fire event from the moment it was first observed. Multiple records will be assigned to a single event on one form to make this possible.

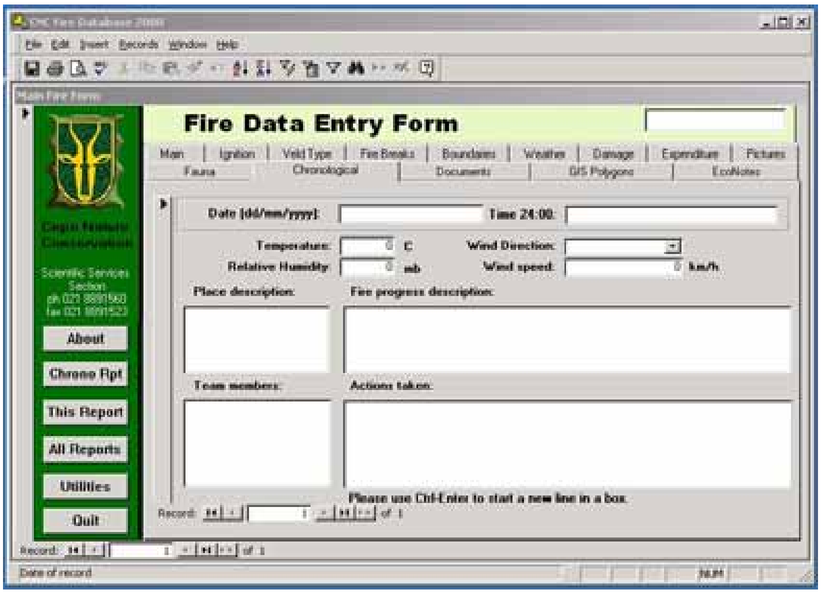

Figure A-12 Chronological Tab

The Documents tab keeps data of any documentation filed on a specific fire event to make referencing easier at a later stage.

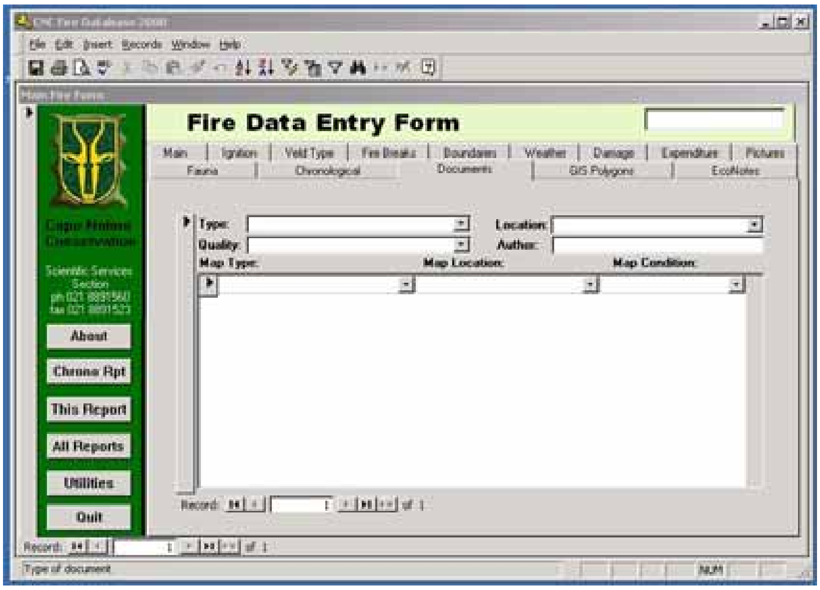

Figure A-13 Documents Tab

The GIS Polygons tab is the one section of the database that is very important for this study. The gathering of spatial data and converting them to GIS readable formats at this early stage will make the integration of this ArcView extension an easy task. The software developed can only produce results as accurate as the data that are available. The ArcView Extension and the scope of this study are not concerned with the data-gathering process as this is in place already at the WCNCB.

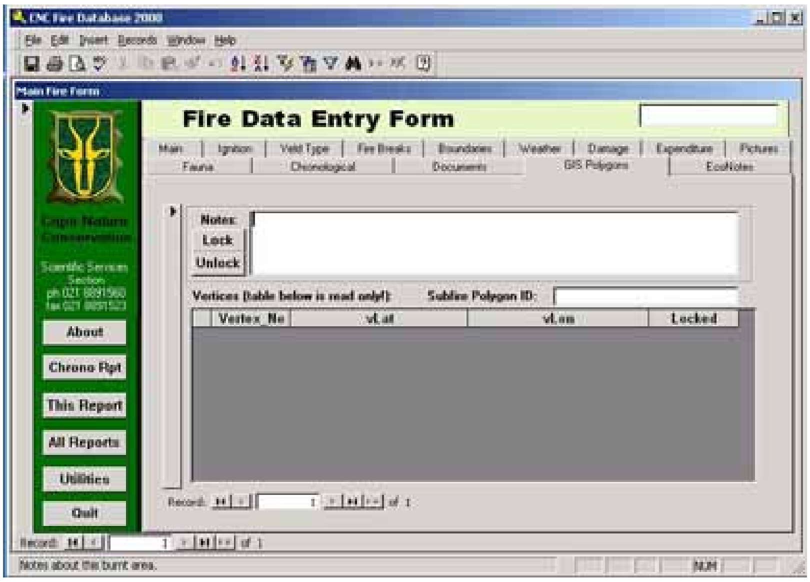

Figure A-14 GIS Polygons Tab

Any ecological notes are to be entered under EcoNotes.

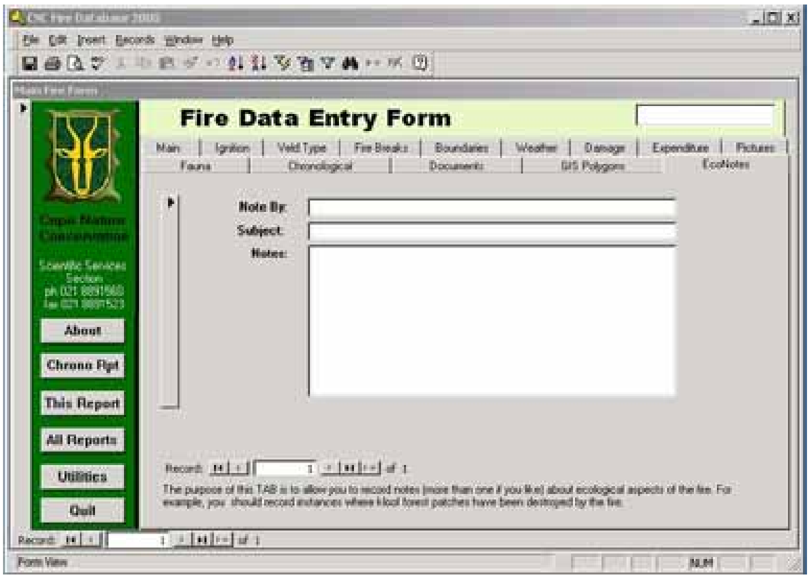

Figure A-15 EcoNotes Tab

Appendix B: Examples of the Veldage option's file creation dialogues

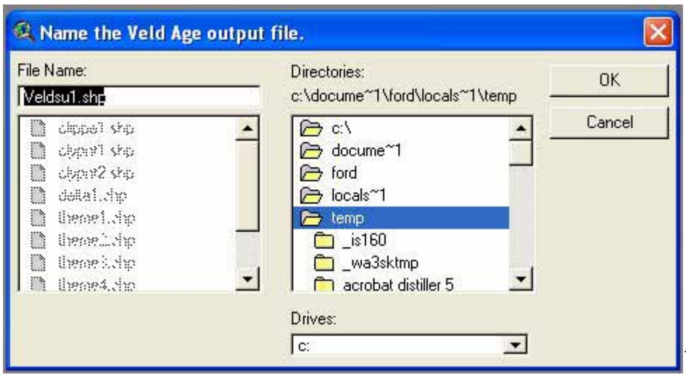

Figure B-1 Veld Age output filename screen.

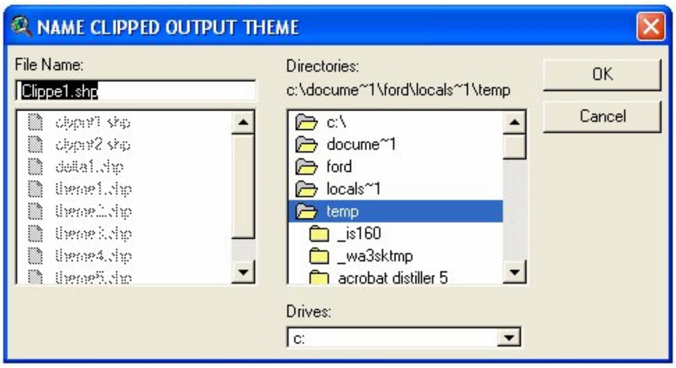

Figure B-2 Clipped Veld Age output filename screen

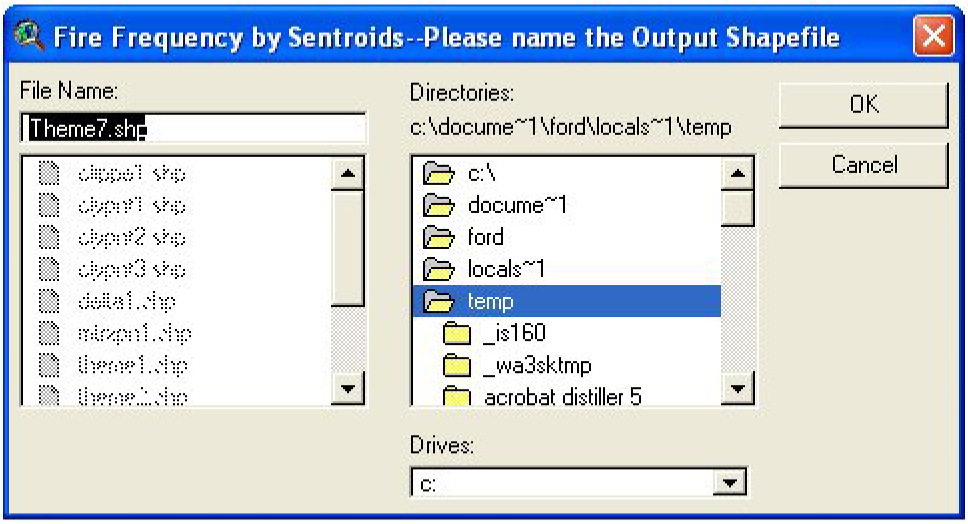

Figure B-3 Prompt to save the output

Appendix C: Avenue Code example for drilling through layers

```
'*****************************************************************************
************************
'cnc.firefreq.drilldown
'F.Y.Ford 2000
'University of Stellenbosch
'NSIF funded
'
' This script will 'drill' through a selected set of layers
' and produce a frequency table for a field common to
' each layer. For example if you have three layers
' containing fire polygons, the script will
' query either a user defined or self generated point layer at each polygon
' to determine the year that the fire burnt through
' each point for each theme:
'
'         \/        point is here
'   --------------- 1996 Fire
'   ============== 1994 Fire
'   *************** 1990 Fire
'
'
'*****************************************************************************
*************************

myView = av.GetActiveDoc
myDisplay = av.GetActiveDoc.GetDisplay
mydisplay.flush
    'self(0) = pointlocality        |_  see script Matrix drilldown section
    'self(1) = theme to drill into  |
  '
   pnt = self.get(0)
   'myTheme = self.get(1)
   myTheme = _FireDataThm
   myProj = _myView.getProjection
   ' myProj = myView.getProjection
   'pnt.returnUnprojected(myProj)
   pnt.returnProjected(myProj)
```

```
 'msgbox.info("debug", pnt.asstring)
 'msgbox.info(pnt.getX.asstring, pnt.gety.asstring)
  if (myTheme.CanSelect) then
     myTheme.SelectByPoint(pnt, #VTAB_SELTYPE_NEW)
  else
      msgbox.error("Error","CANSELECT not possible!")
     return nil
  end

'-------------------------------------
'Select by year
'-------------------------------------



myFtab = myTheme.getFtab
myBitmap = myTheme.getFtab.getSelection
'msgbox.info("debug", myTheme.getFtab.asstring)
'check that at least 1 record is selected
  'msgbox.info(myBitmap.count.asstring,"Bitmap Count should be more than ONE!!!")
if (myBitmap.count > 0) then

    myFld = myTheme.getFtab.findField("Year")
    tempYear = Date.Now
    tempYear.SetFormat( "yyyy" )

    myYearList = {}

        For each myRecNo in myBitmap
            'return the current record
            myYear = myTheme.getFtab.
            returnValue(myFld,myRecNo)
                  if ((myYear.asstring.isnumber=false) or (myYear = 0)) then
                 'msgbox.info("HIert","blerrie ding se fout is hier")

                   continue

                  else
                   myYearList.add(myYear)
                   myFireID      =      myTheme.getFtab.returnValue(myTheme.getFtab.FindField("Fire_no"),
myRecNo)
```

```
          end


               'tempYear.asstring.asNumber -
   end
 'msgbox.listasstring(myYearList,"Debug","Debug")

   myYearList.sort(false)
        '       myAgeList = {}
        '       tempYear = Date.Now
        '       tempYear.SetFormat( "yyyy" )
        '       myRunTot = 0
'-------------------------------------------------------------------------------
'Do a Sanity Check on myMaxAge ie error checking in case of wrong year in database
'-------------------------------------------------------------------------------

   myMaxAge = 0

   if (myYearList.count = 0) then
   'msgbox.info("HIert","blerrie ding is leeg")
     return nil
   end

   myNewestYear = myYearList.get(0)

            'msgbox.info (myNewestYear.asstring, "Newestyear")
            'msgbox.info (myYearList.count.asstring, "yearlistcount")
            'msgbox.listasstring(myYearList,"yearlist","Debug")

   myLastYear = myYearList.get((myYearList.count) - 1)

            'msgbox.info (myLastYear.asstring, "Oldestyear")

   myNumFires = myYearList.count
            'msgbox.info (myNumFires.asstring, "NumFires")

   if ((myNewestYear = 0) or (myLastYear = 0)) then
     myAvInt = 0 else
     myAvInt = ((myNewestYear - MyLastYear )  / myNumFires)
   end
           ' msgbox.info(myavint.asstring,"Debug")
```

```
    return myNumFires
end
```

```
'*************************************************************
```

Appendix D: The contents of the Readme.txt file accompanying the CNCFireManager.AVX extension

****

The CNCFireManager.AVX extension's installation instructions. This extension has been developed for the Western Cape Nature Conservation Board by Francois Ford.

****

First load the .avx file into your extensions directory (…/ARCVIEW/EXT32/)

Load the help-files and image-files in your extensions directory if the structure is the same as (c:\program files\ESRI\AV_GIS30\ARCVIEW\EXT32\frequency2.gif), else create a dummy directory with the splash and help files to activate those facilities.

To prevent the splash screens, don't copy the image files

Appendix E: Participant Countries at the Conference International Wildland fire Summit 2003:

Albania
Argentina
Australia
Belarus
Bolivia
Brazil
Brunei
Darussalam
Bulgaria
Cambodia
Cameroon
Canada
Central African
Republic,
Chile
China
Colombia
Croatia
Dem Rep of
Congo
East Timor
Ecuador
Ethiopia
Finland
France
Germany
Ghana
Greece
Honduras
India
Indonesia
Iran
Italy
Japan
Kazakhstan
Kenya.
Korea
Malaysia
Mexico
Mongolia
Myanmar
New Zealand
Papua New
Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Republic of
Cameroon,
Republic of
Congo,
Republic of
Panama
Russian
Federation
Scotland
Singapore
Slovakia
South Africa
Spain
Sudan
Switzerland
Syria
Thailand
Gambia
The Philippines
Turkmenistan
UK
Ukraine
Uruguay.
USA
Uzbekistan
Venezuela.
Vietnam
Zimbabwe

Appendix F: CD-Rom containing full application code The remainder of code is available on the accompanying CD due to the high volume of pages it consumes (95 pages).