SATELLITE BASED LONG-TERM EVALUATION OF BUSH ENCROACHMENT ON SOURISH MIXED VELD AT THE TOWOOMBA RESEARCH STATION IN BELA BELA, LIMPOPO PROVINCE

by

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A MINI-DISSERTATION

Submitted in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE AGRICULTURE

In

REMOTE SENSING

in the

FACULTY OF SCIENCE AND AGRICULTURE

(School of Agricultural and Environmental Sciences)

at the

UNIVERSITY OF LIMPOPO

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2015

DECLARATION

I declare that the mini-dissertation hereby submitted to the University of Limpopo, for the degree of Master of Science Agriculture in Remote Sensing has not been previously by me for a degree at this or any other university; that it is my own work in design and in execution, and that all material contained herein has been duly acknowledged.

Mpati TM Date

DEDICATION

This study is dedicated to my daughter Mphoyarena Mmanakedi, my brothers Simon, Magnus and Khutjo and my niece Lehlogonolo who gave me extra strength in everything I do and my mother Cathrine, my younger sister Patricia and the special lady in my life Sandra Mashiloane who stood by me through thick and thin throughout this study.

ACKNOWLEDGEMENTS

I would like to thank God for the wisdom and strength granted to pursue the study. I sincerely pay my gratitude to my supervisor Dr BM Petja for his time, guidance and mentoring throughout the study and thank you Sir for acquiring satellite images. I would like to thank Richard Tswai of the Agricultural Research Council for his time and guidance in value adding to the image products. A special acknowledgement goes to Dr P Shaker for nominating me for an NRF grant through RVSC and the support I got in initiating this study. Also a special acknowledgement goes to Ms Suzan Mashego and Nomagugu Lukhele for guidance on my research proposal. Appreciation also goes to the Limpopo Department of Agriculture for sponsoring this study and for the use of its premises in undertaking this research. I would also like to thank Prof K Ayisi for motivation and courage he gave fueling me to the completion of this study. I would also like to thank the University of Limpopo and the School of Agricultural and Environmental Sciences for letting me pursue my studies in the institution. All friends and colleagues especially Mrs Wisani Mushadu your support meant a lot.

ABSTRACT

Savannas are the most important ecosystems for raising livestock in Africa. In the past 50 years, evidence has shown that savannas throughout the world are being altered by bush encroachment. This is an ecological succession process where perennial plants such as shrubs and trees replace annual vegetation. This reduces the amount of palatable fodder and directly threatens livestock productivity in many localities. This study evaluated long-term bush encroachment using multi-date Landsat Thematic Mapper (TM) images 1989, 1990, 1993, 1995, 1999, 2004 and 2008 to reconstruct changes in spatial distribution of trees and shrubs at the Towoomba Reseach Station over a period of 19 years, from 1989 to 2008. Grasses and woody species were classified using unsupervised classification and Normalised Difference Vegetation Index was used to assess forage productivity and change in vegetation with years. The study was carried out at Towoomba Research Station in Bela Bela, Limpopo Province, South Africa. The study revealed that bush encroachment is a natural process and is independent of the grazing patterns. The results show that if not monitored encroaching species will make it difficult for grazers to get underneath the trees and also disturb the photosynthetic process of grass thereby replacing the grass. The study further showed that satellite remote sensing has the potential for monitoring rangeland quality.

Keywords: Bush encroachment, remote sensing, classification and Normalised Difference Vegetation Index

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CHAPTER 1

BACKGROUND

1.1 Introduction

This chapter introduces the main aim of this research. Rangeland monitoring for bush encroachment is critical and therefore methods for rangeland monitoring have to be developed while taking into consideration the cost for monitoring. Bush encroachment is clearly defined in this chapter and satellite imagery has been accepted globally as a reliable tool for long-term determination of rangeland degradation. The problem statement, motivation for the study, aim and objective of the study and the hypothesis are outlined in this chapter.

Sourish Mixed Veld represents a great variety of plant communities, with many variations and transitions. The vegetation varies from a dense, short bushveld to a rather open tree, covering the greater part of Limpopo Province and the northern parts of North-West Province. The soil is mostly coarse, sandy and shallow, overlying granite, quartzite, sandstone or shale (Acocks, 1988). According to Ward (2005) bush encroachment is the suppression of palatable grasses and herbs by encroaching woody species often unpalatable to domestic livestock. Ahmed and Florian (2000) defined bush encroachment as the invasion of shrub and bushes/trees into former grassy rangelands.

An expansion of bushland, dominated by unpalatable thorny shrubs, is a common feature of overgrazed pastures in Africa (Rhiginos and Hoffman, 2003). Therefore, bush encroachment reduces the carrying capacity for livestock. The reduction in carrying capacity is of great significance because savannas in southern and central Africa contain a large and rapidly growing proportion of the world's human population, including many pastoralists whose livelihood is threatened by this process (Lamprey, 1983; Scholes and Archer, 1997).

Satellite images are used to determine long-term potential degradation over rangelands worldwide. Degradation and desertification are global environmental problems affecting inhabitants of semi-arid lands (Dregne, 2002). Under semi-arid conditions of naturally variable rainfall, increased human activities tend to stress land and vegetation resources leading to degradation and erosion particularly in Africa where about 20 million pastoralists depend on natural grazing land for their subsistence (McGraw and Tueller, 1983; Reynolds et al., 2003; Thomas, 1997). The main aim of this study is to assess the extent of bush encroachment and its effects on biomass productivity in a Sourish Mixed Veld at Towoomba Research station using satellite imagery.

1.2 Problem statement

Bush encroachment reduces the grazing capacity of the veld and this in turn results in reduced grazing area which leads to loss of profit by pastoralists and farmers. It often results in species with poor nutrition and low palatability for livestock. Monitoring and timely detection of bush encroachment in Limpopo Province has been ignored. Worldwide, there is more data on detection of bush encroachment whereas on monitoring it, is limited. Veld must be monitored for early detection and prevention of encroaching species in order to plan effective mitigation and control measures.

Developing approaches that advance rangeland monitoring and assessment with science and technology is critical. This is especially a concern for land managers responsible for very large areas. Since many of the rangelands that require monitoring are in remote places; safety, labour and travel costs present major challenges to managers. Having a sufficient and well trained work force is another need that is becoming crucial as many of the traditionally-trained rangeland scientists approach retirement age. Designing approaches for monitoring these large areas is vitally important to managers that need timely and legally defensible information to make decisions about the use and management of rangelands.

1.3 Motivation of the study

Sickelbush (*Dichrostachys cinerea)* is believed to be one of the main species causing bush encroachment in the rangelands of Limpopo Province. Monitoring bush encroachment using remote sensing has a potential to ease the task of monitoring range quality by range managers both for livestock and game species, both of which are important agricultural activities in the Limpopo Province. Therefore, this research is important in providing a methodology for rangeland quality assessment and monitoring adapted for Limpopo Province.

1.4 Aim and Objective of the study

1.4.1 Aim

The aim of the study is to assess the effect of bush encroachment on biomass productivity in sourish mixed veld at Towoomba Research Station using satellite imagery.

1.4.2 Objective

i. To use remote sensing techniques to assess and monitor bush encroachment in rangeland.

ii. To map the extent to which bush encroachment decreases rangeland productivity.

1.5 Hypothesis

Bush encroachment has no effect on the grazing capacity in the sourish mixed veld in Towoomba Research Station.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides a literature survey of the following topics: the impact of bush encroachment on rangeland, remote sensing and its application in rangeland systems, research done on bush encroachment using remote sensing, effect of growth determinants on bush encroachment, tree-grass competition and management approaches.

According to Ward (2005) bush encroachment has been found to affect the agricultural productivity and biodiversity of 10-20 million ha of South Africa. Bush encroachment involves the natural replacement of the herbaceous cover by an undesirable woody component. Savannas are the most important ecosystems for raising livestock in Africa (Lamprey, 1983). In the past 50 years, evidence has accumulated suggesting that savannas throughout the world are being altered by the phenomenon known as bush encroachment (Archer et al., 1995).

Although the causes of bush encroachment are still unknown (Ward, 2005), the general explanation for bush encroachment was derived from Walter‘s (1971) two-layer hypothesis for tree-grass coexistence (Noy-Meir, 1982). Walter (1971) explained the coexistence of these two different life forms in terms of root separation, viz. he assumed water to be the major limiting factor for both grassy and woody plants and hypothesized that grasses use only topsoil moisture, while woody plants mostly use subsoil moisture. The removal of grasses, e.g. by heavy grazing, allows more water to percolate into the sub-soil, where it is available for woody plant growth. Therefore a balance between grass and woody species must be maintained.

2.2 Impact of bush encroachment on rangeland

Bush encroachment has an adverse effect on the ecosystem and the environment. Herbaceous biomass production and bush encroachment are negatively correlated (Gemedo et al., 2006). The expansion of unpalatable woody species significantly reduced the rangeland size and availability of grasses. The consequence of the decrease in herbaceous biomass could result in high risk of food insecurity in the area. In addition, the bush prohibits access of livestock to the underlying grass and as the canopy closes the grasses and herbs disappear rendering the ground susceptible to water erosion (Belsky, 1994).

Bush encroachment involves the natural replacement of the herbaceous cover by an undesirable woody component (Bester and Reed, 1997). This has become a big concern for farmers throughout the whole of southern Africa. Indigenous woody species such as *Acacia mellifera, Dichrostachys cinerea* and *Colophospermum mopane* tend to become invasive, causing a decrease in herbaceous cover and carrying capacity of rangeland, as well as an increase in the erosion potential, thus negatively impacting optimal animal production. Within the affected areas, the woody plant component shows a substantial increase in density resulting in a decrease in rangeland productivity. Most notable is the decline in grass production (Scholes and Archer, 1997), which is associated with reduction in livestock carrying capacity (Moleele et al., 2002). Jordaan (2004) stated that overgrazing, low and uncertain rainfalls, as well as fire regime changes are the main factors believed to be responsible for the development of shrubs.

2.3 Remote sensing and its application in rangelands

Remote sensing is a science and an art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon (Lillesand and Keifer, 1994). It utilizes the electromagnetic radiation emitted from objects when natural or artificial radiation strike them. Remote sensing evolved as the ability of man to observe in regions of electromagnetic spectrum, beyond the range of human vision (Mintesnot, 2009).

Satellite remote sensing was introduced as an important tool in understanding and monitoring various components of rangeland function and health (McGraw and

Tueller, 1983; Tueller, 1991; Soshany, 2000; Palmer and Fortescue, 2003). Keeping the limits imposed by scale and image resolution, remote sensing application in rangeland management received wide acceptance. One of the primary applications of remote sensing in the rangelands is prediction of production potential of a ranch (Palmer and Fortescue, 2003). Using different imageries that have varying spatial and temporal resolution, it is possible to estimate grass biomass (Mintesnot, 2009).

2.4 Research done on bush encroachment using remote sensing

Most studies showed that there is an increasing trend in bush coverage. A study, undertaken at Mokopane Biodiversity Conservation Centre in Limpopo Province South Africa to monitor rangeland deterioration through woody plant proliferation showed that the heavily grazed and relatively lightly grazed wild game-utilise rangelands under a fire suppression rangeland management regime had rates of bush encroachment of about 56% and 34%, respectively, in 6 years (Munyati et al., 2009). According to Myburgh et al. (2008) *Acacia tortilis*, *Dactyloctenium aegyptium, Dichrostachys cinerea, Panicum maximum, Combretum apiculatum, Sporobolus panicoides, Grewia vernicosa, Enneapogon cenchroides, Gymnosporia maranguensis and Cymbopogon pospischillia* are the dominant species that make up major plant communities of the area.

2.5 Effect of growth determinants on bush encroachment

Smit (2004) hypothesised that a more stable environment can be created by maintaining or restoring savanna structure. In a structured savanna, large trees are able to suppress the establishment of new seedlings, while maintaining the other benefits of woody plants such as soil enrichment and the provision of food to browsing herbivore species.

The presence of woody plants can alter the composition, spatial distribution, and productivity of grasses in savannas. According to Scholes and Archer (1997) the effect of trees on grasses could be positive, neutral to negative, and these may depend on a number of factors including the following:

a) The ecophysiological or specific characteristics of the tree and grass growth forms: canopy architecture, rooting patterns, photosynthetic pathway C3, C4, CAM, photosynthetic habit: evergreen, deciduous, and resource requirements: light, water, nutrients.

b) The availability of resources as influenced by interannual variability in the amount and seasonality of precipitation and topoedaphic properties.

c) The extent of selective grazing, browsing, or granivory.

d) The frequency, intensity, and extent of disturbances such as fire. Though not well quantified, the nature of tree-grass interactions can change with time. At decadal time scales, tree aging and factors that influence tree size and density must be considered.

2.6 Tree-grass competition

A high density of trees and shrubs, however, can have strong negative effects on grasses, rangeland productivity, and wild herbivores (Scholes and Archer, 1997, Riginos and Grace, 2008). Savanna systems all over the world are threatened by increasing densities of woody plants (Archer, 1995, van Auken, 2000, Roques et al., 2001, Moleele et al. 2002), which can, in extreme cases, lead to ranch failure and apparently irreversible landscape degradation (Scheffer et al., 2001;Tobler et al., 2003). In a subsequent study, Smit and Rethman, (2000) presented evidence that the roots of the *Colophospermum mopane* are able to utilise soil water at a matric potential lower than that of grasses. This enables the *C.mopane* trees to compete successfully with herbaceous plants and to prevent their establishment at high tree densities.

2.7 Management approaches

Smit et al. (1996) stated that the main purpose of bush control is not the total removal of trees, but the reduction of tree numbers to an optimum level, thereby restoring the veld to a state of optimum grazing and browsing production together with ecological stability. There are three methods that can be used to control bush encroachment as discussed in Hoffman and Todd (1999)**:** mechanical, chemical and biological control.

2.7.1 Mechanical control

The mechanical clearing of trees form is the most expensive methodology and is normally used as an adjunct to other forms of control. The methods range from simply cutting down trees and shrubs by hand to stumping, "holting" and using the ball and chain drag method with the employment of specialised equipment including heavy machinery such as tractors and bulldozers. Such high cost intervention is only recommended when thickets are to be replaced with cash crops or planted pastures. Due to the high cost involved, mechanical methods of controlling bush encroachment play only a limited role in most problem areas (Hoffman and Todd, 1999).

2.7.2 Chemical control

The control of bushes and trees through chemical methods can be carried out on a large scale and with quick results especially if chemicals are sprayed aerially. Guidelines for chemical spraying were developed at the 1980 bush encroachment workshop (Hoffman and Todd, 1999). Chemical spraying is only recommended when it complements the use of fire and browsers and when a known, registered and selective poison is available for the control of one or more specific species (Hoffman and Todd, 1999).

A wide range of chemicals have been used in the past including brand names such as Hyvar X, Tordon 225, Tordon Super, Garlon, Ustilan, Graslan, Grazer and Reclaim. Most act by inhibiting respiration, photosynthesis and the synthesis of nucleic acids of selected tree species either through uptake via the leaves or root systems and can remain active for up to four years in the environment. Soil applications appear particularly effective only on non-sour soils with a low clay content (<20 % clay) (Hoffman and Todd, 1999).

Costs of chemical spraying in 1980, ranged from R22- R32 per ha. A number of extensive bush eradication trials, which have tested the efficacy and economic viability of chemical eradication, have been carried out in southern Africa over the last several decades. A well-replicated experiment, carried out in Namibia in 1976 showed that the application of one, two and three litres of Tordon 225 per ha applied to woody species kills 45, 55 and 67 % respectively. Grass production is also increased by 100-300 % after the second year, mainly as a result of the increase in perennial species. Livestock production doubled in the replicates where 3 litres/ha Tordon 225 were used, largely as a result of increased grass production. Research has shown that chemical eradication is a viable economic option (Hoffman and Todd, 1999).

2.7.3 Biological control

The biological control of bush encroachment usually incorporates the role of browsers and fire. Some researchers however feel that domestic browsers are unlikely to significantly reduce bush densities. Goats and indigenous breeds such as Damara sheep have been used successfully to browse trees and shrubs, thereby allowing cattle to get in underneath and to utilize some of the ground layer which was previously protected by the trees. It is also worth noting that the generally low incidence of bush encroachment in communal areas may be attributed in part to the usually high number of goats in these areas (Hoffman and Todd, 1999).

Goats are thought to keep invading trees short and utilizable and the role of browsers may therefore be very important in preventing and managing bush encroachment. Finally, the call for a breeding and domestication programme of indigenous large browsers such as giraffe, which could then be used to control bush encroachment under normal ranching conditions has not been explored. Generally it is advocated that fire and browsers be used in an integrated way to control bush encroachment, although fire is probably only effective where encroachment is not too dense and where there is a fuel load capable of burning (Hoffman and Todd, 1999).

The older the tree the more resistant it is to fire although this is not the case in some species such as *Acacia erioloba*. Good guidelines for burning practices in savannas have been established. For example, in the higher rainfall areas (>650 mm) where enough biomass accumulates, a fire of about 2 000 – 3 000 kJ/s/m is needed every 3-4 years to be an effective tool for controlling bush encroachment through the control of tree regrowth and seedling establishment. For lower rainfall areas, one needs the addition of browsers to control bush encroachment and in this situation, burning is only necessary every 10-15 years (Hoffman and Todd, 1999).

2.8 Summary

The causes of bush encroachment are outlined on this chapter. Bush encroachment affects both the environment and ecosystem. Satellite remote sensing was introduced as an important tool in understanding and monitoring various components of rangeland function and health. Most studies show that there is an increased trend in bush coverage and less on monitoring. Management approaches outlined in this chapter can be applied in real life situation according to the extent in which the rangeland is encroached.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter clearly explains the study location. This chapter also explains the method used to assess bush encroachment in the grazing camps in Towoomba Research Station. The Earth Resource Data Analysis System (ERDAS) imagine 10.0 was the software used for image processing, radiometric correction, geometric correction and data analysis.

3.2 Study location

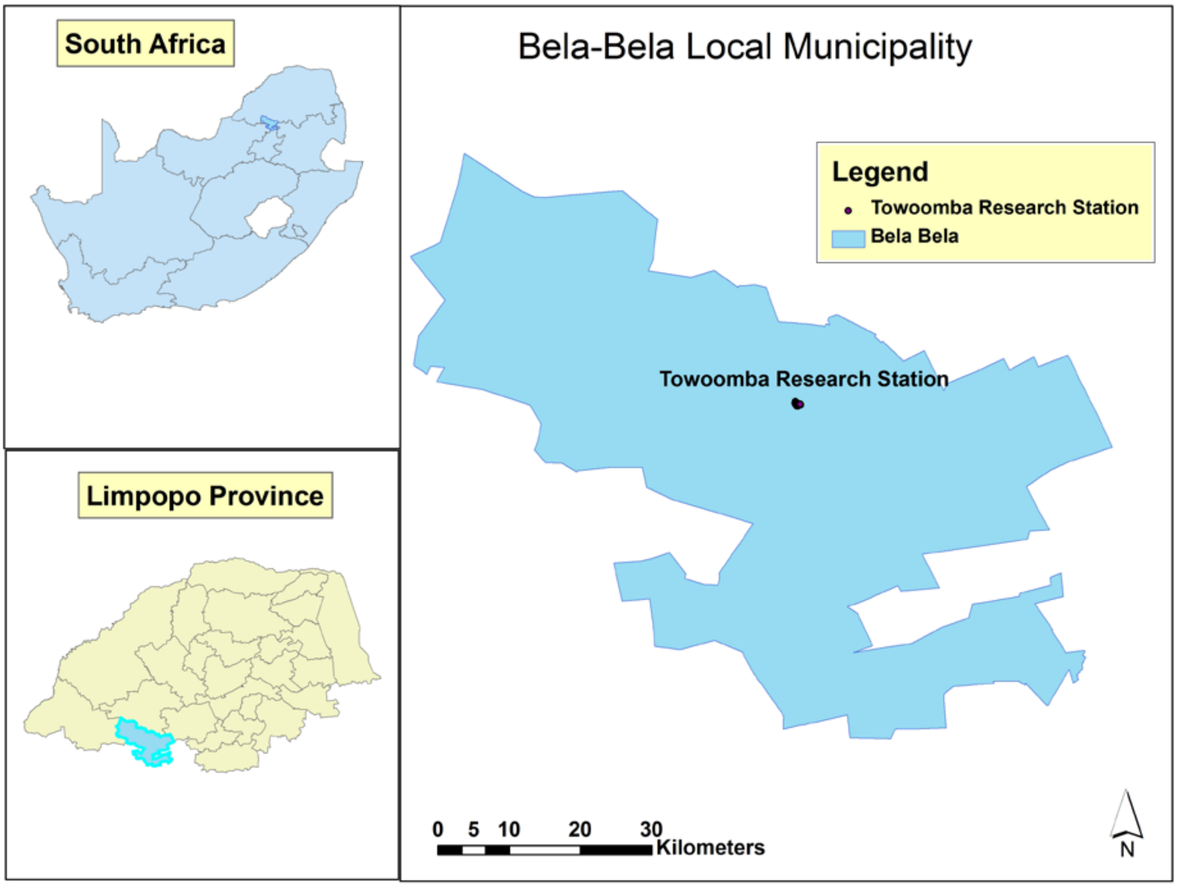


Fig 3.1 Locality map of the study area

The study was conducted at Toowoomba Research Station (28°19'26.69 S, -24°53'53.61E; 1 184m elevation) at Bela Bela, in Limpopo Province of South Africa. Bela Bela is a town in the Limpopo Province of South Africa. Deriving its name from the geothermal hot springs around which the town was built, it is widely known by the name Warmbaths but this officially changed to the current name (Bela Bela) in 2002. The town is situated in the Waterberg District of the Limpopo Province. It lies off the N1 road between Pretoria and Polokwane (Marula Markerting, 2009).

Towoomba Research Station was one of the first three Pasture Research Stations established in South Africa, founded in 1934. It serves the Turf Thornveld of the Springbok Flats as well as other adjoining bushveld areas of the Limpopo Province. It is situated on the southern part of the Springbok flats, approximately 4 km southeast of Bela Bela in the Limpopo Province. Towoomba is 1026 ha in size, occupying parts of the farms Roodekuil (600 ha), Turfbult (400 ha) and Hetbad (26 ha). Veld types vary from Turf Thornveld (on the typical black Arcadia family soils on the south-eastern part of Towoomba, to Mixed Bushveld and Sourish Mixed Bushveld on red loam soils, mostly of the Hutton form, in the north and north-western parts (Jordaan, 2004). Towoomba is flat with a 0.6% fall from the north-west in a south-eastern direction. It is currently a research station of the Limpopo Department of Agriculture.

3.3 Data Collection

Four grazing systems at Towoomba Research Station were used in this study (Fig. 3.2): System 1 camp 1 is used for continuous grazing, System 2 is divided into two parts (camp 2 and 3) camp 2 is for winter grazing and camp 3 is for spring, summer and autumn grazing. System 3 is also divided into two camps (camp 4 and 5) where camp 4 is used for mid-winter to mid-summer grazing and camp 5 is used for mid-summer to mid-winter grazing. System 4 is divided into three camps (camp 6, 7 and 8). Each system occupies the area of 7.5 ha. Co-ordinates of the camps were recorded on transect walk survey on four sampling points in each camp using a hand-held Trimble GPS.

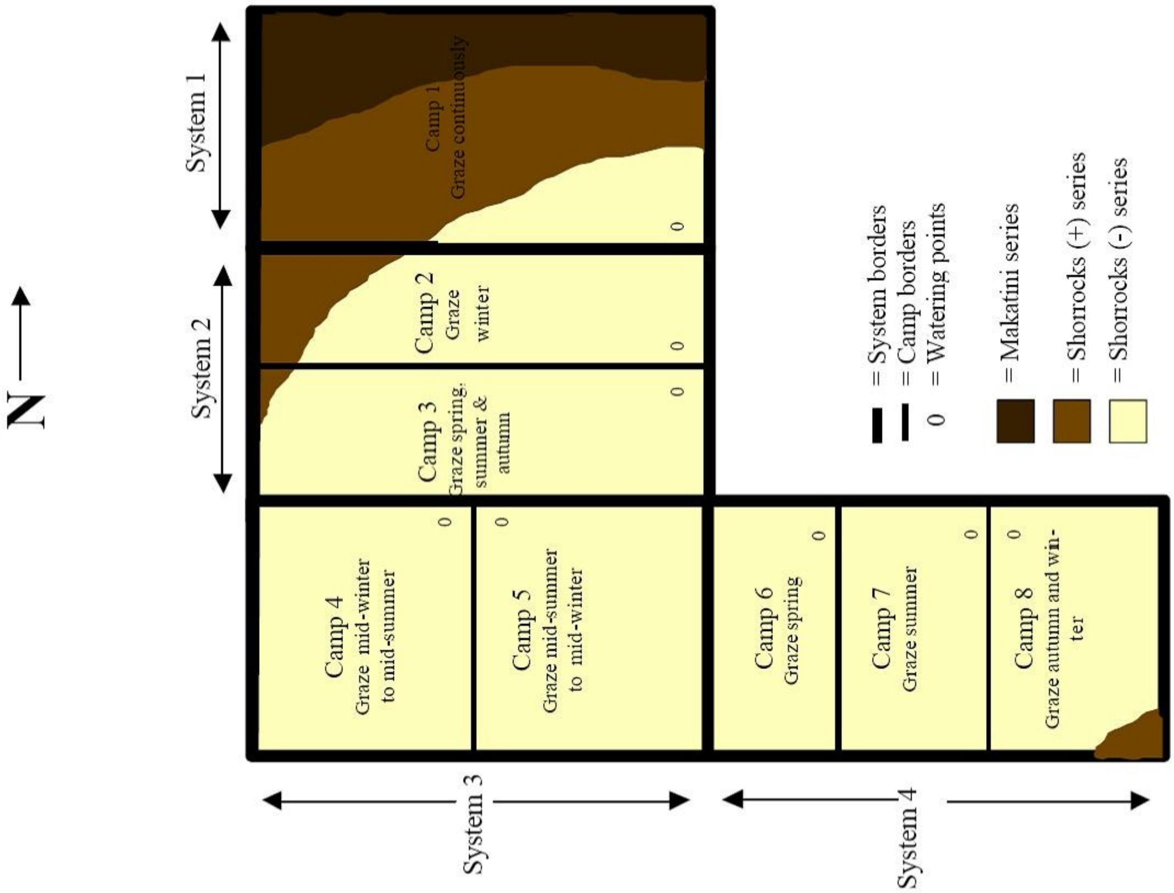


Fig 3.2 Experimental layout and soil types of the Irvine System (Jordaan, 2004)

Satellite data was collected from the South African National Space Agency (SANSA) through the Department of Science and Technology (DST) and Limpopo Department of Agriculture. The following species were found in the grazing system: woody species include *Acacia karroo*, *Sclerocarya birrea*, *Acacia mellifera* , *Dichrostachys cinerea, Miconia calvescens*, *Grewia bicolour*, *Acacia tortolis, Ziziphus mucronata and Other Acacia spp* whereas grass species include: *Cymbopogon plurinodes*, *Chloris gayana*, *Thermeda triandra*, *Panicum maximum*, *Eragrostis rigidior*, *Enneapogon spp*, *Eragrostis lehmanniana*, *Melinis repens*, *Aristida conjesta*, *Pogonarthria squarroza* and *Heteropogon contortus*

3.4 Image processing

The first step in image processing using ERDAS is to import the raw data into the system before processing the images. The images were imported into ERDAS using National Land Archive Production System (NLAPS) importing format. Two steps were taken to process the data. In the first step, the images were imported into ERDAS Imagine's standard image format (.img). A subset of the images was obtained from the scene to identify the study area. In order to assure the map accuracy in terms of the relationship between specific pixels and map co-ordinates, the images were geometrically corrected using first order polynomial transformation. The "mapping polynomial" function is denoted by Equations 1 and 2.

$$X' = a0 + a1X + a2Y + a3XY + a4X2 + a5Y2 \quad (1)$$

$$Y' = b0 + b1X + b2Y + b3XY + b4X2 + b5Y2 \quad (2)$$

The final positional accuracy (root mean square error) for the transformation was within 1.00 pixel. The images were later resampled using the nearest neighbour techniques in order to preserve as much of the original details in the images as possible. The images were later classified using an unsupervised classification technique to identify land cover features within the study area.

3.4.1 Radiometric correction

Radiometric correction is important to ensure that terrestrial variables retrieved from optical satellite sensor systems are calibrated to a common physical scale. Radiometric correction is one of several corrections performed on satellite image data prior to the retrieval of land, atmosphere, and ocean information. These preprocessing procedures are essential for ensuring high-quality information from remote sensors. Radiometric correction ensures that measurements and methods yield self-consistent and accurate geophysical and biophysical data, even though the measurements are made with a variety of different satellite sensors under different observational conditions and the parameter retrieval methodologies vary. Radiometric correction was performed to remove noise and haze on the images.

3.4.2 Geometric correction

Geometric correction is to correct the geometric distortions; internal and external distortions. Raw digital images usually contain geometric distortions so that they cannot be used as maps. The sources of these distortions range from variations in the altitude, velocity of the sensor platform, to factors such as panoramic distortion, earth curvature, and atmospheric refraction and relief displacements. The intent of geometric correction is to compensate for the distortions introduced by these factors so that the corrected image will have the geometric integrity of a map (Lillesand and Keifer, 1994).

Common way of creating a geometrically correct image of XY coordinates. The least square regression method is applied to establish the relationship between two or more sets of variables. That's basically using ground control points (GCPs) and a computation of Root Mean Square (RMS). The roads, waterbodies and vegetation were used as ground control points to geometrically correct images.

The images were taken at scene 170/077 for 19890308, 19900303, 19930327, 19950808, 19990312, 20040309 and 20080827. The corrected images were then resampled using the nearest neighbour approach. Pre-processing of data was done based on World Geodetic System (WGS) 84 projection using Landsat TM scene taken in 20020317 of the same area to correct the images in ERDAS imagine.

3.4.3 Interactive Self-Organizing Data Analysis (ISODATA) algorithm

The objective of K-means clustering is to group a number of data vectors into a predefined number of clusters. The centroid vector of each of these clusters is initialized to arbitrary vectors. Each centroid vector represents the mean of the data vectors associated with the corresponding cluster. For image classification, a data vector represents a pixel of the image. Each pixel is then assigned to the closest mean, or cluster centroid. After all pixels have been clustered, the mean of each cluster is recalculated based on the pixels associated with that cluster. This process is repeated until no significant changes result for each cluster mean.

The ISODATA algorithm is an implementation of the K-means approach, which uses Euclidean distance as the similarity measure to cluster pixels into different spectral classes. The raster recode function in ERDAS was applied to combine the 36 classes generated into 4 then 2 classes and assigned the informational classes based on the *in situ* knowledge acquired during field validation. The image were classified using the ISODATA algorithm in unsupervised classification in ERDAS imagine to classify the woody species and the grass.

3.4.3 Normalised Difference Vegetation Index

Remote sensing studies monitor vegetation cover and the changes depending on the properties of chlorophyll and electromagnetic spectrum using satellite images. The NDVI shows the biomass and is calculated by this formula:

NDVI = (NIR-R) \ (NIR + R)

Where:

NIR is the value of digital number in Near-Infrared channel.

R is the value of digital number in red channel.

The value of NDVI changes from -1 to +1. When the vegetation cover is denser the absorption of radiation in red channel is more and the reflectance is low, so the value of NDVI will be close to +1. When the vegetation cover is degraded, bare soil will appear and the absorption in red channel is low and reflectance is high, so the value of NDVI will be close to -1 (Rouse et al. 1973) . NDVI images were produced in ERDAS and a subset of the study area was created using coordinates to the area.

3.5 Data analysis

Zonal statistics was created in ArcGIS 10.1 from the spatial analyst tool for both classified and NDVI images. The camp coordinates were imported into ArcGIS 10.1 from excel and saved as Text (Tab delimited). The spatial analyst tool in ArcGIS was used to extract the zonal statistics for both classified and NDVI images. The zonal statistics was created as a table showing: the mean, range, median and standard deviation in an excel sheet. These data in excel format was used to produce graphs showing mean biomass per camp (Fig 4.10) and NDVI per camp of woody species over the years. Change detection was done in ERDAS imagine and was mapped in decrease and increase by 10%.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents and discusses the results generated from the study. Seven Landsat 5 Thematic Mapper images were used. The images were taken in 1989, 1990, 1993,1995,1999,2004 and 2008 respectively. Field survey was done to identify what was present the camps. There are two classes in the classified images namely: grass and woody species. The green colour represents the grassland while the dark green represents the encroaching woody species. Normalised Difference Vegetation Index (NDVI), change detection and the means for classified images and NDVI are also presented.

4.2 Classified Images

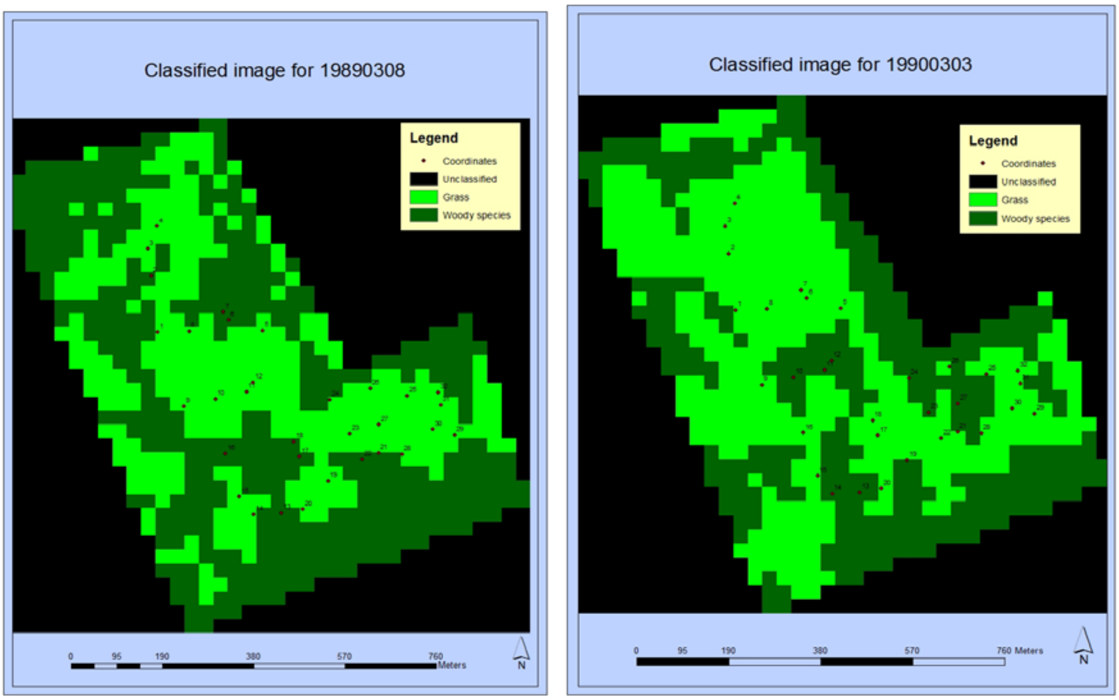


Fig 4.1 Classified images for 1989 and 1990.

Healthy green vegetation reflects greener in the visible portion (0.45 and 0.67 µm) of the spectrum (Lillesand and Keifer, 1994). Fig 4.1 shows an increasing trend of the woody species in the study site. A healthy green vegetation can be seen as this confirmed by Fig 4.5. In 1989 there was increase in the density of woody species;

the veld had a healthy balanced savanna, the encroaching species could clearly be seen in 1990 towards the edges of the fences of the study area. Patterns of bush and grass cover are determined mostly by grazing, fire and rainfall regimes, in addition to competition for soil water and nutrient resources.

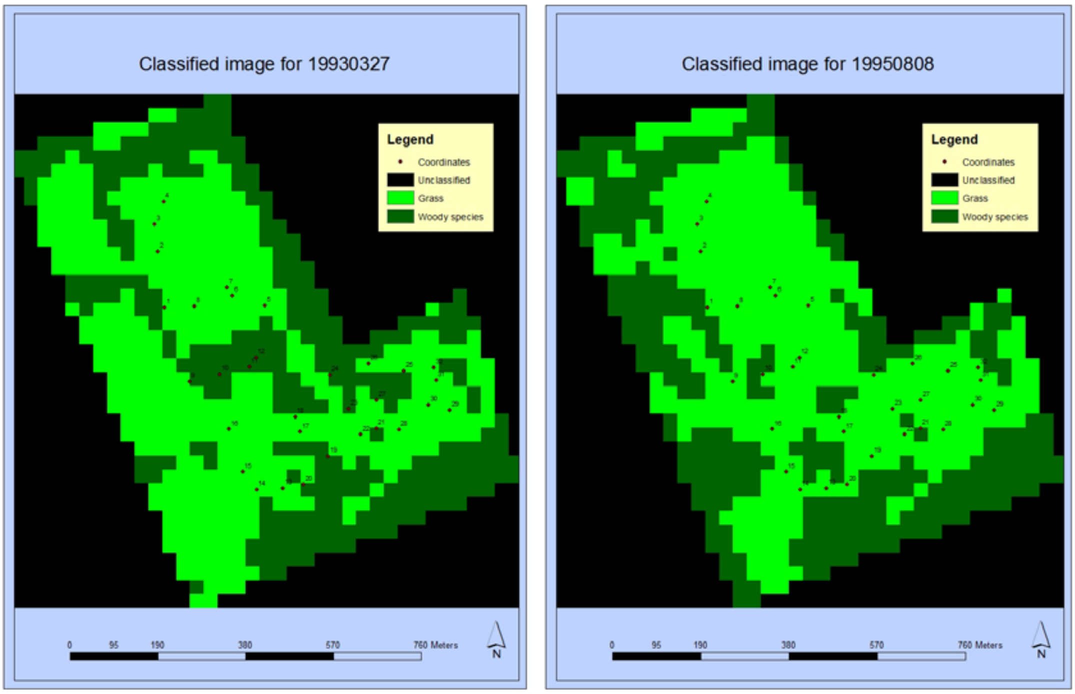


Fig 4.2 Classified images for 1993 and 1995

Fig 4.2 shows stability on the woody species between 1993 and 1995. The grazing capacity of the veld slightly increased and the density of the woody components decreased.

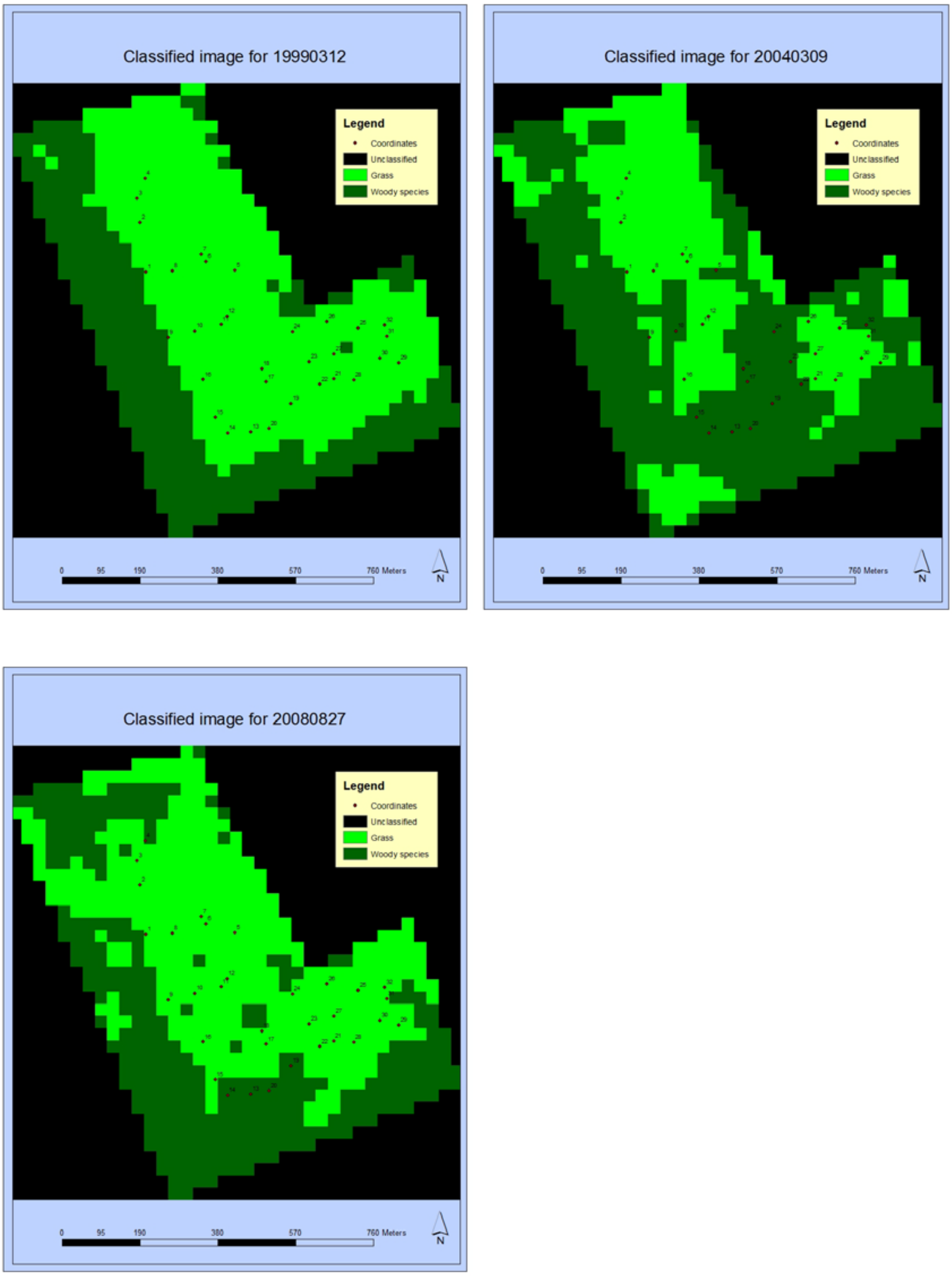


Fig 4.3 Classified images for 1999, 2004 and 2008

Fig 4.3 shows a more increasing trend between 1999 and 2004, there has been a severe increase in the density of woody components in the study area. It is reported in Jordaan (2004) that there was chemical control using Tebuthiuron in 1995 on these camps that led to regrowth of grasses between 1995 and 1999. The density of the woody components peaked up significantly in 2004. In 2008 there was a decline in the denisity of woody components, this is suspected to be due to increased human activities in the camp e.g. cutting of woody plant for fire wood.

4.3 Change detection

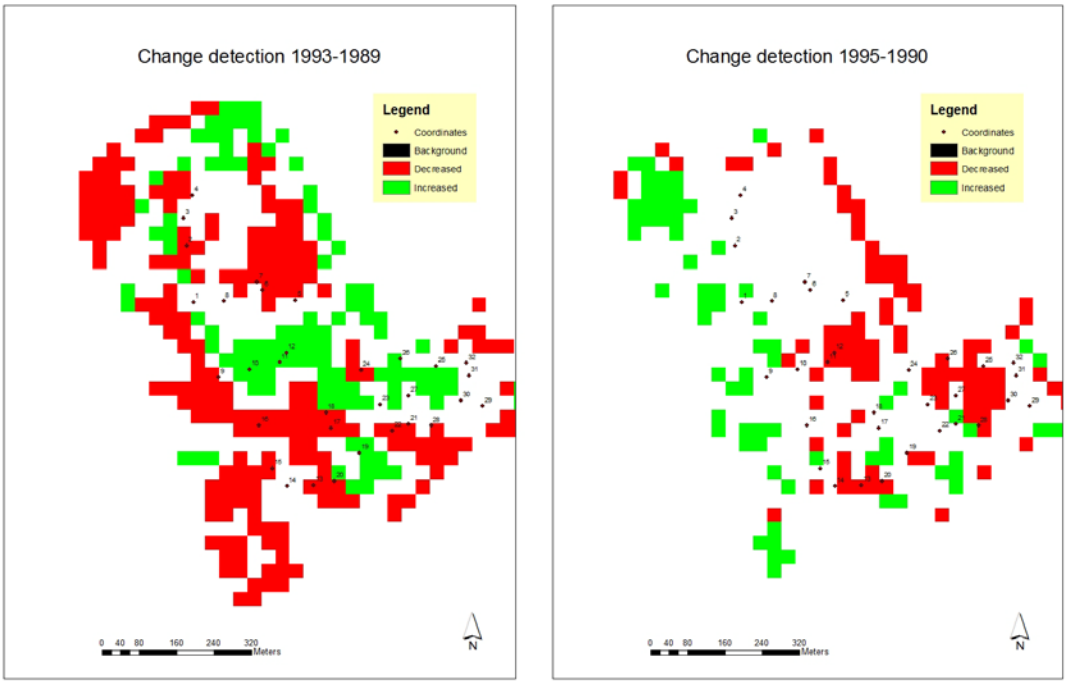


Fig 4.4 Change detected between 1993 and 1989 and 1995 and 1990.

Fig 4.4 shows an increasing trend on the decrease in the grass component of the study area, there was a high decrease in grass between 1989 and 1993. A low decrease in grass can be seen between 1990 and 1995.

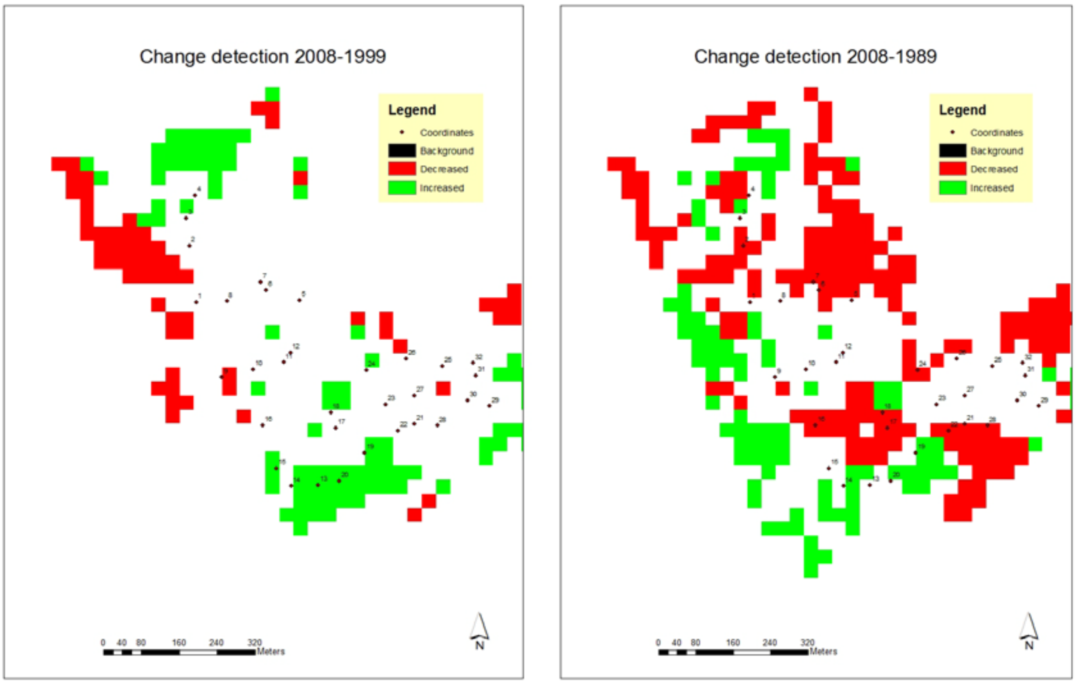
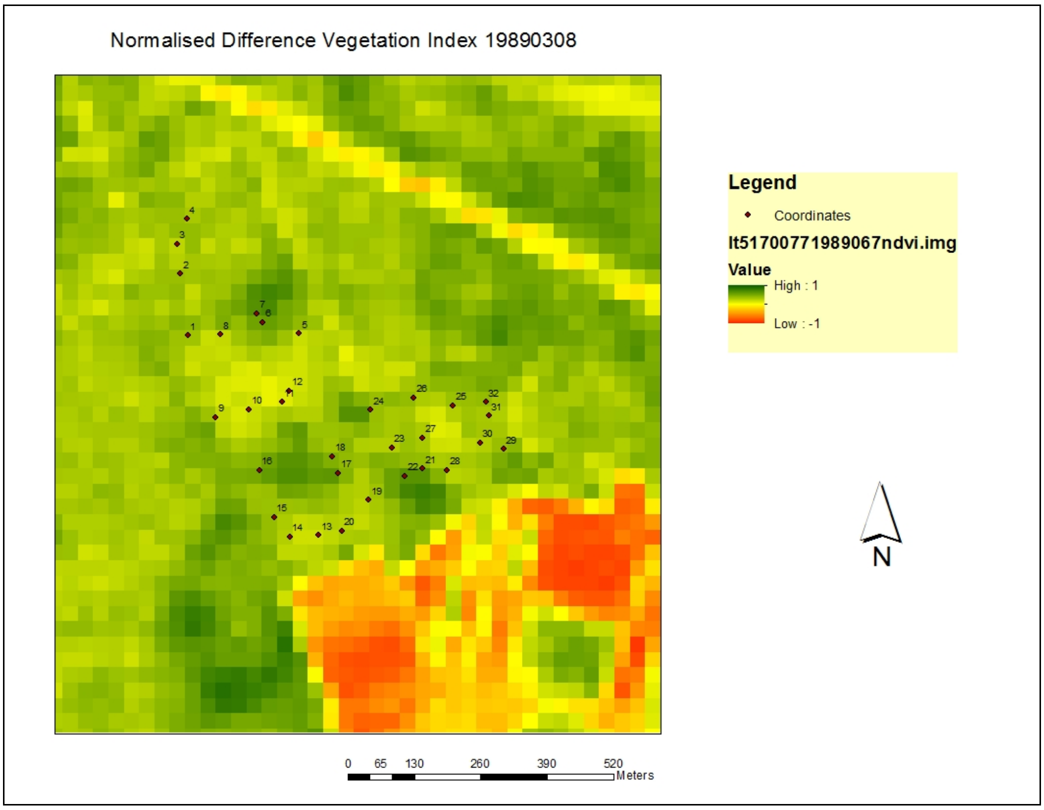


Fig 4.5 Change detected between 2008 and 1999 and 2008 and 1989.

Fig 4.5 also shows a low decrease in the woody specie component between 1999 and 2008. This is suspected to be due to increased human activities in the study area. A high decrease in grass was also seen in system 4 which is camp 6, 7 and 8. This corresponds to the findings in figures 4.1, 4.2 and 4.3. An overall change detection between 1989 and 2008 shows a high decrease in the grazing component of the study area. The field survey has confirmed most part of the camp as being heavily encroached.

4.4 Normalised Difference Vegetation Index (NDVI)



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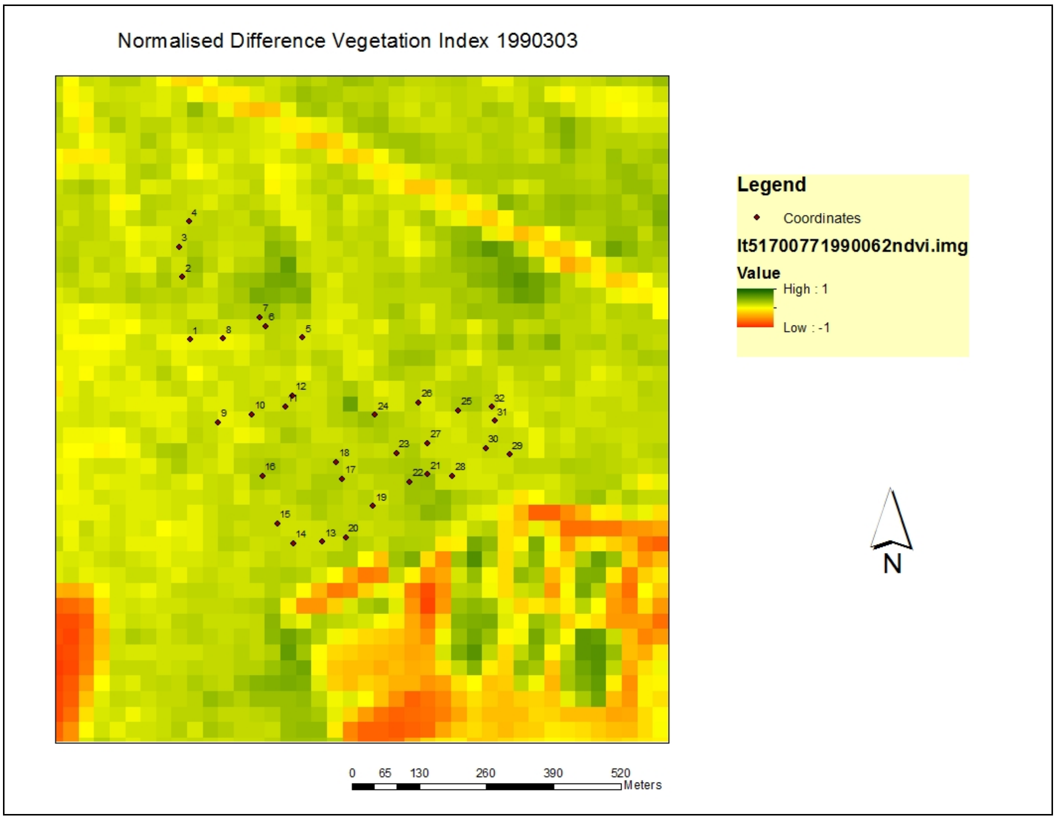
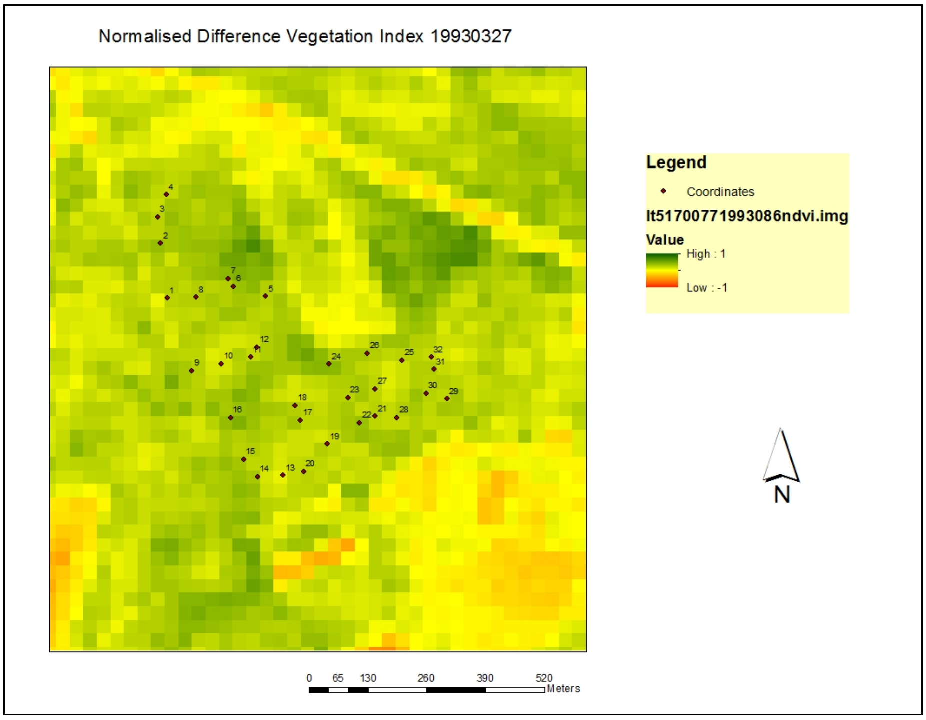


Fig 4.6 NDVI for 1989 and 1990

Fig 4.6 shows a healthy green land cover in 1989 indicating high photosynthetic activities in all the camps. It also shows a slight decline in the photosynthetic activities in 1990.



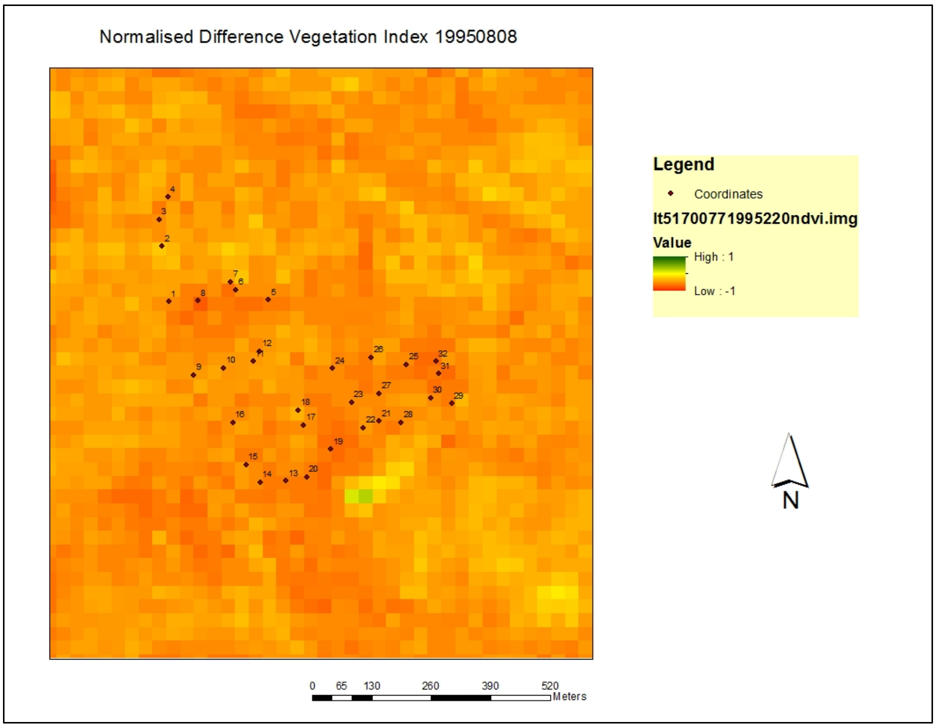
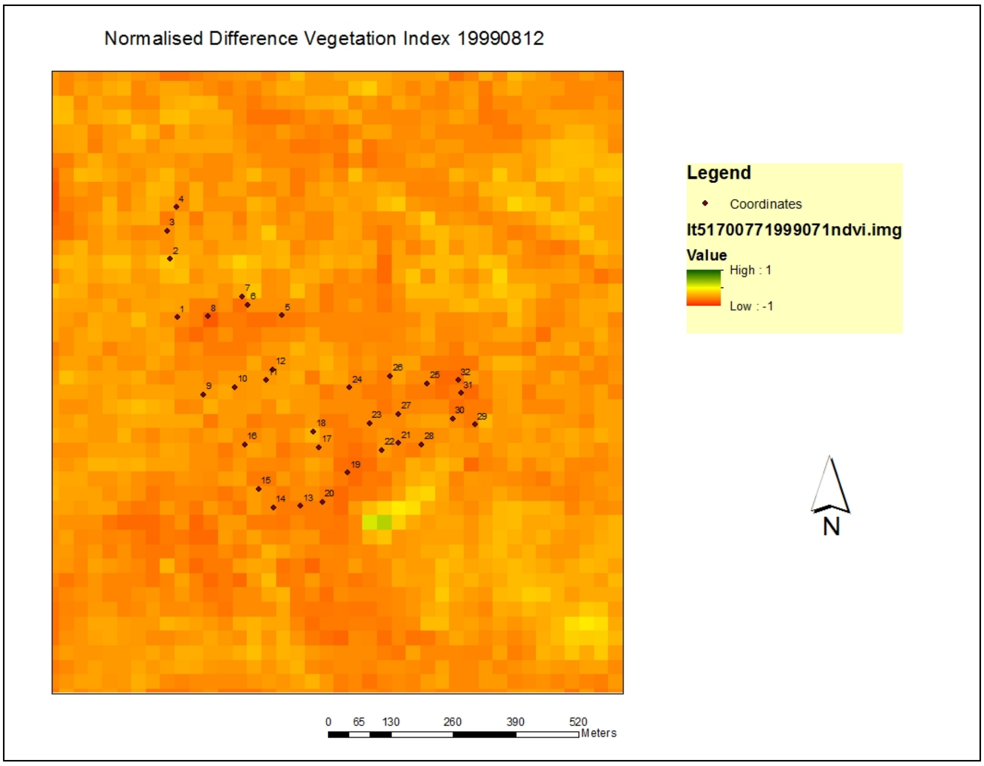


Fig 4.7 NDVI for 1993 and 1995

Fig 4.7 shows a decline in the photosynthetic activities of the vegetation in 1993 and high decline in 1995. This is because the image was taken in winter when the vegetation was dormant.



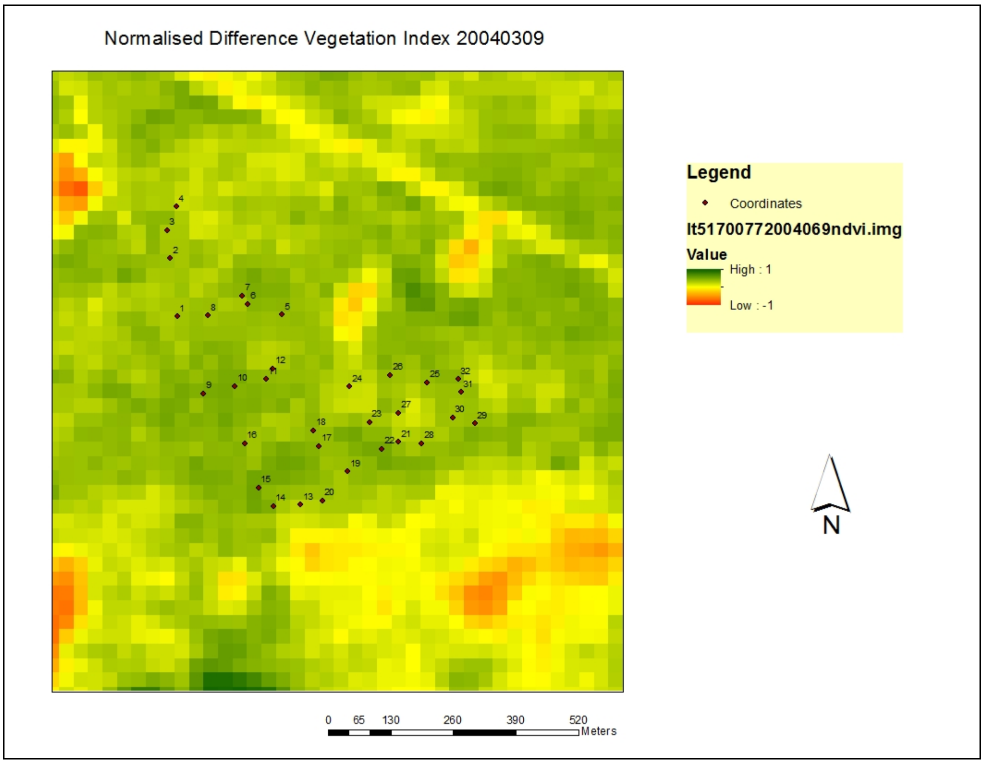


Fig 4.8 NDVI for 1999 and 2004

Fig 4.8 shows the red colour in 1999 and this indicates that the photosynthetic activities of the land cover has been disturbed as compared to 1989 and 1990 where the land cover was green, indicating healthy vegetation. This is in agreement with fig 4.1 and 4.2. There were high photosynthetic activities in 2004.

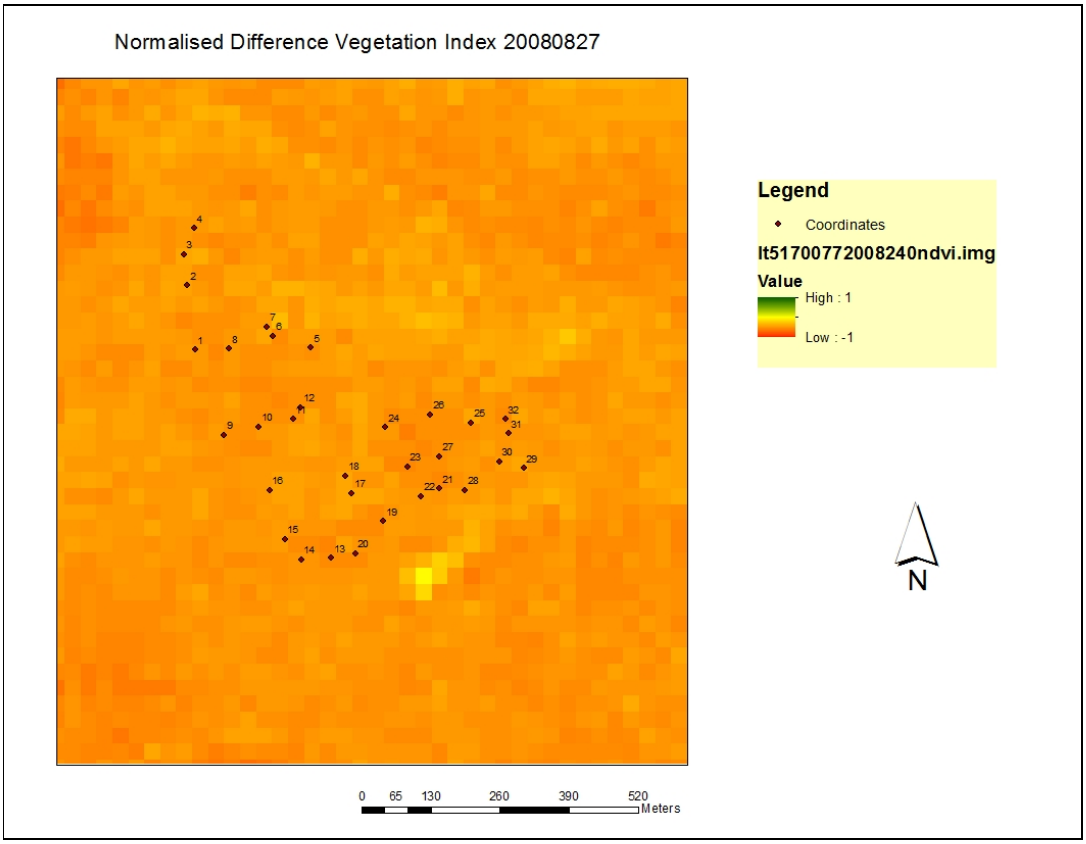


Fig 4.9 NDVI for 2008

Fig 4.9 shows that was a decline in photosynthetic activities of the land covers in 2008. This was because the image was taken in winter when most plant species shed their leaves.

4.5 Change detection as observed from classified images and NDVI

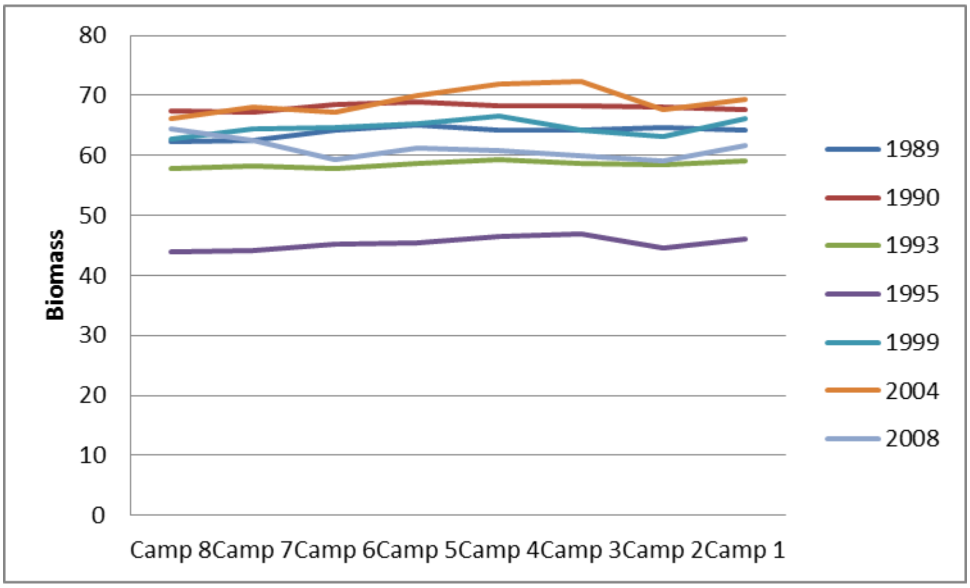


Fig 4.10 Mean biomass per camp over the years.

Fig 4.10 shows a high woody species density in 1989, 1990, 1999 and 2004. A decline in woody species density was seen in 1993 and 2008. A relatively lower woody species density was seen in 1995 and this is because there was chemical control in the camps. The average woody species density of all the camps was calculated and presented as a graph, fig 4.10.

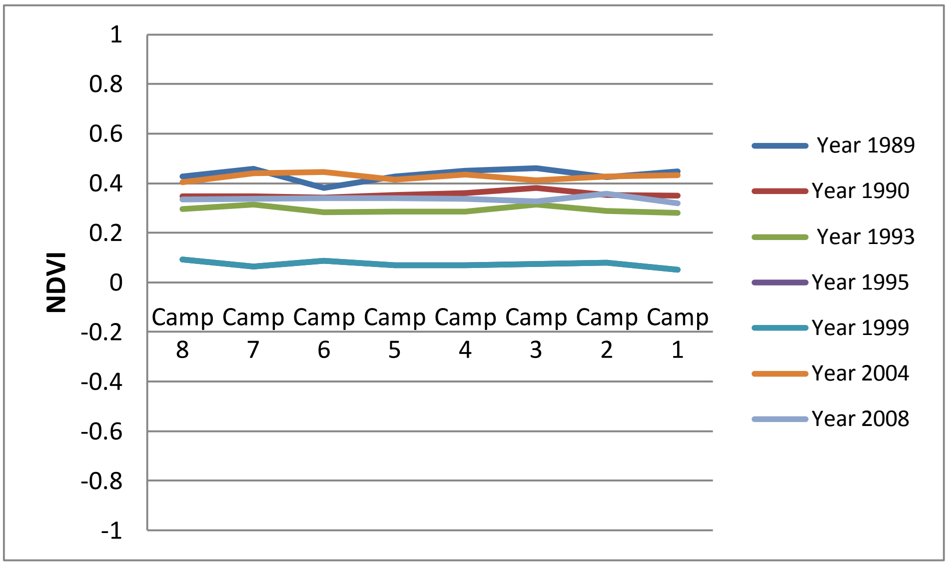


Fig 4.11 Mean NDVI per camp over the years.

Fig 4.11 shows healthier vegetation in 1989 followed by 1990, 1993 and 2004. There was a decline in NDVI in 1999 and 2008. A low NDVI was observed in 1995 in which the mean is 0.0723.

4.6 Discussion

The results show that bush encroachment is an ongoing process. Remote sensing is a good tool for assessing and monitoring bush encroachment. The results show an increasing trend in woody species densities over the years. There has been high woody species density in 2004 compared to 1989 in all the camps. Vegetation mapping in the Irvine System at Towoomba Research Station in Bela Bela has resulted in two classes. These classes are bush and grass. The results show that the study area has been encroached over the years by bush.

Independent of grazing treatments, the number of woody species increased at different rates in different camps, indicating that bush encroachment was a phenomenon which occurred naturally, irrespective of rest or grazing treatments that were involved. For example camps 6, 7, and 8 were the camps being encroached the most while camp 1 where continuous grazing occurred experienced a moderate encroachment over the years. This is centrally to the report by Jordaan (2004) where bush encroachment was predominant with continuous grazing. The results also show that increased human activities, though not encouraged have a negative effect on bush encroachment. Increased human activities slow down bush encroachment.

Satellite remote sensing with higher resolution can be good tool for rangeland monitoring at lower costs. Field surveys in land-cover assessment at large scales require extensive funds and sampling efforts, besides they generate time delays (Smit et al. 2011). Land-cover classification and change detection have been successfully performed using remote sensing techniques. They have the power of streamline and automated processes for further applications. Vegetation indices (VI) are the capstone input in land-cover classification. For that purpose, the implementation of VI in algorithm development and new approaches has increased.

Research shows that relatively little work has been undertaken previously using Landsat Thematic Mapper data, in combination with GIS techniques, to map floristic composition and vegetation structural components to ascertain major savanna determinants in the context of natural resource depletion (Fiorella and Ripple, 1993).

Increasing importance is being attached to mapping vegetation cover using Thematic Mapper data, although this has mainly taken place in wetter climatic belts (Niemann, 1993). A number of image processing techniques were undertaken to assist in the detection of community groupings. These included the development of Normalised difference Vegetation Index and change detection analyses based on known pixel sites to identify spectral patterns in the vegetation cover. The vegetation cover components comprised woody vegetation cover (WVC) and live herbaceous cover.

CHAPTER 5

Conclusion

The results revealed that remote sensing is a potential tool for rangeland quality assessment and monitoring. The results also show that regrowth also occurs even after bush control. Accurate land cover maps for rangelands management can be generated with relatively little effort in areas that are difficult to access. The study further indicated that unsupervised classification enabled the generation of a detailed land cover map though it does not clearly indicate the separation of different grazing intensity at Towoomba Research Station in Bela Bela.

Regarding grazing capacity, the results showed that bush encroachment has an effect on the grazing capacity of the veld. Total woody species density has generally increased from 1989 to 2004 in instances where the images were taken in summer. Relatively disturbed vegetation was observed where the images were taking during the winter months. This indicates that, the season at which satellite images are captured is an important consideration in interpretation of remotely sensed data. Regrowth of disturbed or cut biomass was evident in all the camps and this necessitates the need for continuous monitoring. Across the various camps, grass productivity decreased with increasing encroachment.

Although problems remain with respect to validation of land cover classifications, the present study gives insight into land-use patterns and intensity levels which has so far not been available. It also presents a more realistic appraisal of livestock grazing pressure in the Towoomba Research Station and sets a framework for future research. The procedure chosen was optimal for the geographic constraints present in the study area. The procedure presented here is applicable to rangeland areas elsewhere and would lead to similar quality of results. However, the key to an improved land cover product lies primarily in the sensor quality and repetition rate of the satellites. Upcoming sensor systems and satellite constellations will provide improved capability in near future. It is recommended that minimal cutting of trees should take place in order to maintain the savanna structure of the rangeland.

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