UNIVERSITY OF VENDA

Population biology and ecology of *Vachellia karroo* (Hayne) Banfi and Galasso, in the Nylsvley Nature Reserve, Limpopo Province, South Africa

---

BY

MADILONGA MPHO GIVEN (11561748)

A DISSERTATION SUBMITTED IN PARTIAL FULLFILMENT OF MASTER OF SCIENCE DEGREE IN BOTANY

SUBMITTED TO THE DEPARTMENT OF BOTANY

UNIVERSITY OF VENDA

PRIVATE BAG X 5050

THOHOYANDOU

0950

SOUTH AFRICA

SUPERVISOR: MR. MH LIGAVHA- MBELENGWA

CO SUPERVISOR: PROF MP TSHISIKHAWE

2017

University of Venda
Creating Future Leaders

Declaration

I, Mpho Given Madilonga declare that this dissertation is my original work and has not been submitted for any degree at any other university or institution. The dissertation does not contain other people's writings unless specifically acknowledged and referenced accordingly.

Student's signature…………………………….. Date……………………

Dedication

This dissertation is dedicated to my family and my parents who supported me throughout the study with their guidance and love. I thank my father Makonde Madilonga and my mother Agnes Madilonga as well as my Aunt Takalani Ramashia for their moral support. May the Almighty God keep them and bless them all the days of their lives.

Acknowledgements

I would like to thank the Almighty God for giving me the strength when I was weak, wisdom and courage to conduct my research. I would also like to thank the Department of Botany, University of Venda, School of Mathematical and Natural Sciences for granting me the opportunity and financial support to further my studies. My sincere thanks to my supervisors Mr MH Ligavha-Mbelengwa and Professor MP Tshisikhawe for willing to assist on my study. My deepest gratitude goes to the management of Nylsvley Nature Reserve for allowing me to conduct my study in their Reserve. I thank all the postgraduate students in the Department of Botany who assisted me when I was conducting fieldwork for my project.

Abstract

Plant populations are determined by many elements that impose demographic filters. Following disturbance, in African savanna woodland trees regenerate both sexually and vegetatively. *Vachellia karroo* (Hayne) Banfi and Galasso, family Fabaceae and sub family Mimosideae, commonly known as “sweet thorn” or “soetdoring” (Afrikaans), is a leguminous shrub common throughout Southern Africa. Its distribution range is from the Southwestern Cape northwards into Namibia, Angola, Botswana, Zambia and Zimbabwe. It is a pioneer species and has the ability to encroach rapidly into grassland grazing areas. Therefore, *V. karroo* is considered the most important woody invader of grasslands in South Africa. This study aimed at investigating the population biology and ecology of *V. karroo* in the clay waterlogged site of the Nylsvley Nature Reserve. Plant height, stem circumference, canopy cover, distance between individuals were measured and disturbance levels on individuals of *V. karroo* were estimated during sampling. The results showed that the population of *V. karroo* display an adequate growth curve thus implying that the population of *V. karroo* in the Nylsvley Nature Reserve is healthy and viable. More mature healthy individuals were found in September and December, than during June and July; this is obviously because early summer season, and in September most of the savanna plant species were starting to actively recover from the winter dry season. This is confirmation enough that the population of *V. karroo* is expanding in the clay waterlogged areas of Nylsvley Nature Reserve.

Table of Contents

Contents

List of figures

CHAPTER 1

GENERAL INTRODUCTION

1.1 Background of the study

Plant populations are determined by many elements that impose demographic filters (Maclean *et al*., 2011). Following disturbance, African savanna woodland trees regenerate both sexually and vegetatively. Sexual regeneration is completed via seed germination and establishment of seedlings and their recruitment into the sapling and mature tree stages. Seed production, is consequently an essential degree in the lifestyles history of plant life that regenerate sexually because seeds make contributions to adult alternative and will increase in neighborhood population length; this is contrary to Gambiza *et al*. (2000) and Higgins *et al*. (2000) who suggested that seed limitation is not important for most tree regeneration in savannas. Seed dispersal, predation and seedling mortality can act as robust constraints that hinder forest recuperation after disturbance, and there is growing assist for the idea that demographic ‘‘bottlenecks’’ in seedling recruitment and sapling release are accountable for much of the variety in tree density in savanna ecosystems (Hoffmann, 1999; Higgins *et a*l., 2000; Werner, 2012).

Fire in savanna ecosystems affects tree cover by limiting the recruitment of tree samplings to adults (Gambiza *et al.*, 2000; Higgins *et al.*, 2000; Werner, 2012). On this admire, fire regimes are a main determinant of savanna plants composition, shape and dynamics. Tree recruitment consequently is probable to be limited through survival of tree seedlings because the seedling stage is the most vulnerable phase in the life cycle of trees. This is because seedlings of many woody plant species lack effective protection against fire. The ‘‘fire-trap’’ hypothesis of Gambiza *et al*. (2000), Bond and Keeley (2005) and Higgins *et al*. (2000) emphasizes the precondition of fire suppression for savanna trees to develop quickly from the sapling phase although Werner (2012) observed that sub adult trees grew faster in the season following a single fire compared to trees in fire protected plots. The examine of populace biology turned into nearly completely a subject of zoologists until John Harper genuinely created the sector within the past due 1940s and 1950s after he met Charles Elton, a famous animal ecologist who became stated mostly for his studies of small mammal populations. Harper made the field of plant population biology pretty accessible via ‘Population Biology of Plants’, which was published for the first time in 1977.

Savanna is an ecological community that is dominated by scattered trees and large areas of grasses and forbs (Trollope *et al.,* 1989). The environment is intermediate between the grassland and the forest. Savannas are located in the tropics and subtropics. The minimum rainfall is about 350 mm to 1800 mm per annum.

Savanna is rich in species availability and provides habitat to majority of species. Savanna plants serve as the source of food and energy to the majority of organisms such as people and animals. Most of the nature reserves and parks are savanna ecosystems, for instance, Nylsvley Nature Reserve and Kruger National Park in South Africa. Insects and birds that act as agents of pollination and microorganisms help to clean up the environment thereof (Primack and Enouye, 1993). Savanna occurs in areas in which trees and grasses interact creating a biome that may neither be classified as a grassland or a forest and it usually occurs in hot regions of the world with seasonal rainfall. This result in seasons which are warm and dry that last for about 3 to 8 months, with wet season for the rest of the year (Scholes and Archer, 1997).

Savanna plants are capable of growing in the surroundings of long durations of drought. They have long taproots that are capable of reaching deep into the water table, thick bark to resist annual fire, trunks that may store water and leaves that drop at some point of the winter thereby reducing water loss through transpiration (Cole 1986). The grasses have variations that discourage animals from grazing on them; a few grasses are too sharp or bitter tasting for some animals while other animals do graze on them. Some savanna plants have storage organs such as roots, tubers or bulbs which are used for future development. They regularly develop underground, where they may be better protected from assault by herbivores; they evolve as a mechanical and chemical defences for plant survival through adverse climatic conditions (Cole 1986). Savanna species seem to vary inside the quantity to which they invest in those numerous techniques. For instance, among West African savanna bushes, *Crossopteryx febrifuga* invests in more hearth resistance within the shape of thicker bark, while *Piliostigma thonningii* invests in greater aboveground boom quotes (Hoffmann and Solbring, 2003). Another issue of savanna ecology which has been greatly unexamined is how tree development and survival react to the incredible spatial variability in tree density usual of tropical savannas, even though this could play a crucial role in figuring out the stability between trees and grasses (Hoffmann and Solbring, 2003). The structure of savanna flowers is partitioned among woody and herbaceous layers (Scholes and Archer, 1997).

In nature plants are not evenly distributed. There are a number of factors that affect and influence the population dynamics and distribution pattern of plants. These elements encompass differences in environmental conditions, sources, neighbors and disturbance. Different environmental situations no longer only can regulate the distribution and abundance of individuals, but are likely to change different plant variables (e.g., growth rates, seed production, branching patterns, leaf area, root area and size of the individuals). Plant distribution, survival, and patterns of growth and reproduction reflect the plant's diversifications to a specific environment and are as a consequence an essential part of plant ecology (Chapman, 1987).

Population structure in a number of forestry and ecological studies has been described in line with size-classes or diameter distribution of individuals, with frequency histograms showing the number or percent of individuals in different size-classes (Knight, 1975). Understanding the structure of a population is a first step together with demographic records, which include size-specific growth rates (Condit *et al.*, 1998), may be the foundation for management control (Bruna and Kress, 2002). Trees are important for enhancing the productivity of non-arable land in the seasonally dry tropics and nutrients from depths that are not reachable to grass roots, leguminous species specially have outstanding potential to rehabilitate degraded land, to increase soil fertility and, at the identical time, to offer more than one products (Barnes *et al.*, 1996).

The study of plant population dynamics involves assessing modifications in a population with respect to its size, density and age distribution. Plant population ecology deals with the factors that affect current, past and future trends within and between populations. Many ecological studies have used techniques of predicting population trends from size-class distributions (Condit *et al.*, 1998).

Vachellia karroo (Hayne) is one of the most distributed tree species in Southern Africa. It colonizes degraded land over a really wide range of climatic and edaphic situations, fixes nitrogen and affords high excellent fuel, animal and bee fodder, and a valuable gum (Gourlay and Barnes, 1994).

1.2 Problem statement

Vachellia karroo is the main dominant and somehow only tree / bush species seen establishing, growing, flourishing and maturing in the clay waterlogged sites of NNR. It is a plant species that is obviously supplying suitable habitats for bird species and other animal species that enjoy spending most of their times in the waterlogged environments; they also provide microsites particularly for shade loving small plant species thereof. They also play a pivotal role in those sites by stabilizing the soil or by holding the soil together thereof through their roots.

Vachellia karroo are perennial and should therefore continually form an integral component of the clayey waterlogged sites of NNR and other sites worldwide, of prominence and separating them from other bushes of NNR is that they are resilient to uninviting conditions in the clayey waterlogged conditions of NNR. Notwithstanding *V. karroo* being the main dominant, and probably tree / bush species playing important role in maintaining a savanna nature of NNR particularly in one of the waterlogged belts of the reserve, their population biology has never been attended to date.

1.3 Research Questions

The research answered the following questions:

(i) What is the population size of *V. karroo* in the Nylsvley Nature Reserve?

(ii) Is the population of *V. karroo* expanding or declining in the NNR?

(iii) What are the different size classes of *V. karroo* in the NNR?

(iv) What management plan could be employed to conserve *V. karroo* in the NNR?

1.4 Aim

The aim of the study was to assess the population biology and ecology of *Vachellia karroo* in the clay waterlogged site of the NNR.

1.5 Objectives

(i) To estimate the population size of *V. karroo* in the Nylsvley Nature Reserve.

(ii) To determine whether *V. karroo* population is improving or declining.

(iii) To determine the different size classes of *V. karroo*.

(iv) To broaden a management plan for the conservation of *V. karroo*.

1.6 Null Hypothesis

The population size of *V. karroo* in the clay waterlogged sites of NNR will continue to increase despite such sites being seasonally waterlogged and hence poorly aerated.

1.7 Alternative Hypothesis

The population size of *V. karroo* in the clay waterlogged sites of NNR will not continue to increase because of the sites being seasonally waterlogged and hence poorly aerated.

1.8 Justification for the study

Nature reserves have several advantages to both people and natural ecosystems. They make direct contributions to both local, regional and national economies in the form of tourism, employment and expenditure on reserve control. Nature reserves additionally provide for complementary private sector investments, including infrastructure and industrial services, which incorporates enabled industries consisting of the hospitality industry. Vital social benefits to the public consist of the training of an educational resource; indigenous and background values; and expanded pleasant of spirit, wellness and well-being (LEDET, 2013). *Vachellia karroo* is amongst the greater distinguished tree species of the savanna of the Nylsvley Nature Reserve. Other species within the region consist of *Burkea africana, Dichrostachys cinerea, Terminalia sericea, Securidaca longepedunculata, Combretum zeyheri, Combretum molle, Ozoroa paniculosa, Strychnos cocculoides* and *Strychnos pungens* (Coetzee *et al*., 1976).

It is so important to understand the population structure of *Vachellia karroo* in view that it is one of the species that characterizes the study area. Savanna ecosystem can provide numerous benefits mainly as one of the economically beneficial trees, which are key resources of food manufacturing and fuel wood and livelihoods of the local communities. *Acacia* species in Africa are crucial in terms of browse production and grassland invasion (Moleele, 1998), and are the most studied woody vegetation when it comes to browsing in Africa (Scogings, 2003). It is therefore significant to examine the population biology of *Vachellia karroo* because it is occurring numerously in the clay waterlogged soil sites of the Nylsvley Nature Reserve (NNR).

CHAPTER 2

LITERATURE REVIEW

2.1 Plant description

Vachellia karroo (Hayne) Banfi and Galasso, family Fabaceae and sub family Mimosideae, commonly known as "sweet thorn" or "soetdoring"(Afrikaans), "umuNga" (Zulu Xhosa), "Mookana" (north Sotho) or "Mooka" (Tswana) is a leguminous shrub common at some point of Southern Africa, ranging from the Southwestern Cape Northwards into Namibia, Angola, Botswana, Zambia and Zimbabwe. It is a pioneer species and has the capability to encroach rapidly into grassland grazing regions, and *V. karroo* is now taken into consideration the most important woody invader of grasslands in South Africa (O'connor, 1995).

Figure 2.2: *Vachellia karroo* individual tree

Vachellia karroo is an evergreen tree which is 3 - 15 m tall, hardly ever shrubby; bark on trunk darkish purple-brown to blackish; younger branchlets glabrous or rarely in moderation and inconspicuously puberulous, also with small, inconspicuous light to reddish sessile glands; epidermis flaking off to show a dark rusty purple, now not powdery under bark, from time to time gray to brown and continual; stipules spinescent, up to 7 most 17cm long, as a substitute robust, whitish, frequently deflexed, every now and then fusiform-inflated, up to 1 cm or greater (Orwa *et al.,* 2009). New twigs have a shiny or sticky green appearance on the fresh growing areas, sometimes with a few small red glands. Older twigs are dark brown in colour, flaking to show a reddish under-layer (Barnes *et al*., 1996).

The long, straight thorns are white in colour with brown pointers and are paired at the nodes. They are usually 2 - 5 cm in length, and are occasionally inflated alongside their length. The thorns develop at the later part of the season's growth (Barnes *et al.*, 1996).

Leaves have small to large (sometimes paired) gland at the junction of every pinna-pair, hardly missing on the basal 1-2 pairs; from time to time a large gland at the top facet of the petiole; pinnae 2 - 7 pairs; leaflets five - 15 pairs, 4 - 7 x 1 - 3 mm, glabrous or not often with minutely ciliolate margins, glandular, obtuse to subacute however now not spineless-mucronate at the apex; lateral nerves invisible on the underside (Orwa *et al.,* 2009).

Flowers have deep or golden yellow colour, occurring in axillary pedunculate heads of 8 - 12 mm in diameter, borne alongside shoots of the current season, occasionally aggregated into leaflets' terminal racemes. Calyx 1.25 - 2 mm long, subglabrous; corolla 2.5 - 3 mm lengthy, glabrous or almost so (Orwa *et al.*, 2009).

The smooth, narrow, sickle-formed pods are constricted between the seeds and are reddish brown whilst ripe. The pods are 5 - 10 cm lengthy, 5 - 8 mm wide and cling in bundles, turning into twisted after dehiscing (beginning to launch seeds) at the tree. The olive-green to brown seeds are 5 - 8 x 3 - five mm, rectangular-elliptic and compressed. The seed areole, an awesome location bounded by using an exceptional line, the pleurogram, is lighter in shade, and occupies a big location of the seed (4.5 - 5.5 x 2 - 3.5 mm) (Timberlake *et al.,* 1999).

2.2 Geography and Distribution

Vachellia karroo is the most widely distributed Acacia in southern Africa and found growing from southern Malawi, southern Zambia and southwest Angola to the southern African coast and some areas of Botswana. It’s been introduced to North Africa, Australia, India, Myanmar, South America (consisting of Argentina, Bolivia, Chile and Paraguay), wherein it is frequently used as a living fence. It’s far located from coastal dunes to 2, six hundred meters above sea level, although it's miles maximum not unusual at medium altitudes (1,000 - 1,800 m) (Barnes *et al.*, 1996).

Sweet thorn can grow in a number of habitats, from the arid Karoo desert to the sand dunes of the Kwazulu-Natal and Mozambican coast, however is normally determined in woodlands and bushland on clay and loam soils, often in association with different *Acacia* and *Combretum* species. It can form dense stands in alluvium alongside rivers and on red clay (Bisby *et al.,* 1994).

2.3 Phenology and reproduction biology of *Vachellia karroo*

The species has a mixed reproduction system. It shows a trend of out-crossing, as evidenced by the existence of trees that are completely males. It is zoomophilus, basically insect pollinated because the robust colour of inflorescence and the heavy pollen grains attract insects. Remoted flowers undergo no culmination. Pollinators recorded includes Coleoptera, Diptera, Hymenoptera and Lepidoptera. The fruit pods are dehiscent although they are not explosive; consequently dispersal is mainly via cattle and other herbivores consuming seeds and releasing them through their dung (Milton, 1987).

The reproductive biology of *V. karroo* is interrelated with its morphology and phenology however, regardless of being ecologically one of the maximum prominent tree species in Southern Africa, little is understood approximately this species or its pollination biology (Stone *et al.*, 2003). The flowers of a number of Acacias (together with all individuals of the Australian Acacias subgenus *Phyllodinae*), provide simplest pollen to flowers site visitors and floral nectar is restricted to a minority of species within the subgenera *Acacia* and *Aculeiferum*. Stone *et al.*, (2003) also mentioned that contributors of the subgenus *Phyllodinae* have long-lived, protandrous plant life while most individuals of the subgenera *Acacia* and *Aculeiferum* have short-lived flora that appear like protandrous with a daily patterning in availing provision. The primary praise for pollinators is pollen that is supplied in enough quantities. Pollen of Acacias is supplied in polyads including 4 to 32, but ordinarily sixteen monads (grains) per polyad (Kenrick, 2003). The characteristic of the polyad in duplicate became suggested on by way of (Knox and Kenrick, 1983), and in addition they showed that only one polyad suits on the small stigma and will fertilize all ovules in the ovary.

2.4 Threats and Conservation status

Sweet thorn has a tendency to be an invasive species in poorly managed rangeland, but if the trees are allowed to grow and are then thinned and pruned, and livestock have access to the grass beneath, a parkland can broaden with a high potential for meat production and soil conservation. For good browse production the trees ought to be broadly spaced and have to branch low down; for cattle approximately 2 m high and for goats approximately 1.5 m. Planting about 1,600 stems of *Vachellia karroo* in line per hectare and thinning them to approximately 400 plants per hectare is recommended as an optimum plant density in areas with both cattle and goat herds farming (Carr, 1976).

Sweet thorn is a quick-developing pioneer and easily establishes itself in suitably disturbed regions. It is resistant to frost and drought, and once it has turn out to be hooked up it has no primary threats. Outside its local range it can be a problematic weed (Carr, 1976).

Larvae of the butterflies *Azanus jesous* (topaz-spotted blue), *A. moriqua, A. natalensis, A. ubaldus, Crudaria leroma, Anthene amarah* (black striped hair tail), and the emperor moth (*Heniocha Apollonia*) feed on leaves of *Vachellia karroo*, nevertheless these do not threaten its population (Carr, 1976).

2.5 Taxonomy and ecology of *Vachellia karroo*

Vachellia karroo, also referred to as the sweet thorn, is the most significantly dispensed and abundantly available *Acacia* species in southern Africa with an average density of between four hundred and 800 plants/ha (O'Connor, 1995). The sweet thorn belongs to the subgenus

Acacia with mainly polyploid species with thorns and capitate inflorescences (Pooley, 1998). The plant occupies a numerous range of habitats and is appeared as a variable polymorphic species. Some of the extra wonderful ecotypes have been referred to through Coates Palgrave, 2002 and are actually known as separate species. *Vachellia karroo* is propagated from seeds and is normally a fast growing, small to medium sized thorn tree (Van Wyk and Gericke, 2000). It is far deciduous, but may be almost evergreen under beneficial conditions (Pooley, 1998). The tree commonly has some leaves at the branches at all times of the year, even in the course of durations of drought (Barnes *et al.*, 1996). It is adapted from sea stage to 1800 m on soils ranging from sand to heavy clays, in areas with an annual rainfall low than 200 mm to as excessive as 1500 mm (Pooley, 1998). The tree also grows on acidic infertile soils with large temperature variations (Barnes *et al.*, 1996). The plant has a protracted taproot which allows it to use water and nutrients from deep within the soil profile (Van Wyk and Gericke, 2000). *Vachellia karroo* is able to tolerate intense and frequent defoliations (Teague and Walker, 1988). These positive qualities provide added benefits for its use as a sustainable protein supplement for goats in dry areas. Notwithstanding the positive variation traits, if an area is disturbed or over or underneath-utilised, *V. karroo* turns into invasive (O'Connor, 1995; Smet and Ward, 2005). It has been labelled as one of the dominant woody species that intensifies the problem of bush encroachment in southern Africa (Nyamukanza and Scogings, 2008).

Vachellia karroo is a pioneer species with a maturity climax of 40 years and occupies a successional position among the tropical forest and the bushveld. It grows well in riverine communities as well as in arid environments, where it may do well provided there's continuous availability of groundwater. Large trees are an indication of availability of underground water. *Vachellia karroo* is included in the South African weed listing. It competes for area, water and nutrients with pasture grasses, thus changing their diversity status. Sweet thorn is frost- and drought-tolerant (Orwa *et al.*, 2009).

2.6 Nutritive value of *Vachellia karroo* leaves

In Southern Africa, Acacia species which include *V. karroo* were suggested to be a precious source of forage for herbivores, especially throughout dry durations (Aganga *et al.*, 2000; Dube, 2000). *Vachellia karroo* contain high levels of crude protein (CP) and essential amino acids (Mapiye *et al.*, 2011). The crude protein (CP) ranges for *V. karroo* leaves evaluate favourably with values for other indigenous *Acacia* species (Mapiye *et al.*, 2011). More importantly, the Crude values for *V. karroo* are in the most advantageous range of 110 – 160 g CP/kg dry matter (DM) required for finishing steers (National Research Council, 2000). This makes *V. karroo* doubtlessly crucial crude protein (CP) supplement for cattle grazing low quality forages (Gleghorn *et al.*, 2004).

2.7 Uses and cultural aspects

A red-gold gum is accumulated from the tree and is offered commercially as a gum arabic alternative. The edible gum is usually chewed by youngsters, monkeys and bush-infants. It is also is used in food, pharmaceutical, glue, detergent, ink, paint and agrochemical industries, as well as in glazing activities (Bisby *et al.*, 1994).

Sweet thorn is likewise used in traditional remedy. An infusion of the roots is utilized by the Ndebele towards well known body pains. The Shonas use it for dizziness, convulsions and gonorrhoea, and occasionally as an aphrodisiac. Roots are used in chicken runs to deter parasites. A decoction of the bark is used as an astringent, emetic and as an antidote to ‘tulip’ (Moraea language) poisoning in livestock. The mucilage of the gum is used to alleviate thrush inside the mouth. A substance has been discovered within the heartwood that is said to can control high blood pressure (Bisby *et al.,* 1994).

The wood is dense, difficult and sturdy and is used for furnishings, wagon wheels, yokes, rural implements, fence posts, coffins and timber wool. Products are developed from timber slivers cut from logs and are in particular utilized in packaging, cooling pads in home evaporative cooling structures known as swamp coolers, erosion manipulation mats, and as raw fabric for the manufacturing of different merchandise which includes bonded wood wool boards used as stuffing for stuffed animals. Individual bushes can produce over a cubic metre of wood in 25 years under situations where few different species, consisting of exotics, may want to do as well. The wood has a high calorific cost that makes it precious as a source of fuelwood and charcoal. The bark consists of 19% tannins and yields a dye which offers a yellow-brown coloration to leather (Bisby *et al.,* 1994).

Like many legumes, sweet thorn can fix nitrogen from the air with the aid of symbiotic microorganism dwelling in root nodules, and this nitrogen then enriches the soil. In drylands, it's mostly used to rehabilitate degraded land (which include mine spoil) and to stabilise sand dunes (Bisby *et al.,* 1994).

Sweet thorn could be very powerful when used for stay fencing and forms one of the first-class brushwood fences. *Vachellia karroo* leaves and pods offer excellent forage for cattle and goats. The sweet inflorescences are excellent bee forage; the long flowering season makes this tree a treasured source of pollen and nectar for honey production. The roots are used to wade off evil spirits (as are *Acacia nilotica* roots). Sweet thorn is likewise used for fibres and resins and the seeds are every now and then roasted to make a coffee replacement (Bisby *et al.*, 1994).

2.8 Cultivation

Sweet thorn seeds regularly have an excessive rate of bruchid (beetle) infestation, but once a seed collection has been cleaned, a germination potential of up to 70% can be realized. The seed coat is not very difficult, and nicking or filing can effortlessly crack its dormancy, although this could be hard to carry out because the seed is too small. An alternative approach is to cautiously pound the seed in a mortar, or to pour boiling water over the seeds, followed through with cold water and allowed to soak. The seedlings germinate after five - thirteen days, and are ready to be planted when they reach 50 cm tall. Sweet thorn seedlings grow fast and can easily establish themselves on degraded sites. The trees can live to approximately 25 years old, and few attain ages of 30 - 40 years old (Barnes *et al.*, 1996).

Vachellia karroo has been successfully germinated from seeds at the Kew Botanical Gardens, where it was grown in temperate house. The temperature is kept above 2˚C, as sweet thorn from the UK is not hard. The roots can be invasive, so it is far critical to place plants carefully during planting in order to avoid damage to nearby structures. *Vachellia karroo* will grow well in most types, so long as the soil is free-draining. Bonemeal fertilisers be included in the planting hole. During the rest of the year sweet thorn should be watered regularly from time to time until it is well established. *Vachellia karroo* is susceptible to attack by mealy bugs, and the Kew Botanical Gardens keeps pest population in check by spraying the affected areas with a powerful jet of water system (Barnes *et al.*, 1996).

CHAPTER 3

METHODS AND MATERIALS

3.1 Description of the study area

3.1.1 Locality

Nylsvley Nature Reserve is situated between the latitudes of 24º35'S and 24º40'S, and longitudes of 28º35'E and 28º45'E in Limpopo Province. The altitude of NNR ranges among 1080 m and 1154 m above sea degree with a median altitude of 1100 m. The reserve contains 3965.251 ha (LEDET, 2013). The Waterberg foothills rise to almost 1600 m in the Nyl River catchment and contribute most of the runoff that supplies the floodplain with water. The Nyl River floodplain is the largest inland wetland in South Africa (Noble and Hemens, 1978).

Nylsvley Nature Reserve is situated inside the summer time rainfall region, gets rainfall in the course of the hot summer months, and experiences a cool and dry winter. The reserve has a variable rainfall with the 69-year mean annual rainfall of 623 mm and an annual coefficient of variation of 24%. It experience a mean annual temperature of 19ºC. Maximum mean daily temperature ranges from 29ºC in December/January to 21ºC in June/July, while minimum mean daily temperature varies from 17ºc in December/January to 4ºC in June/July (Scholes and Walker 1993).

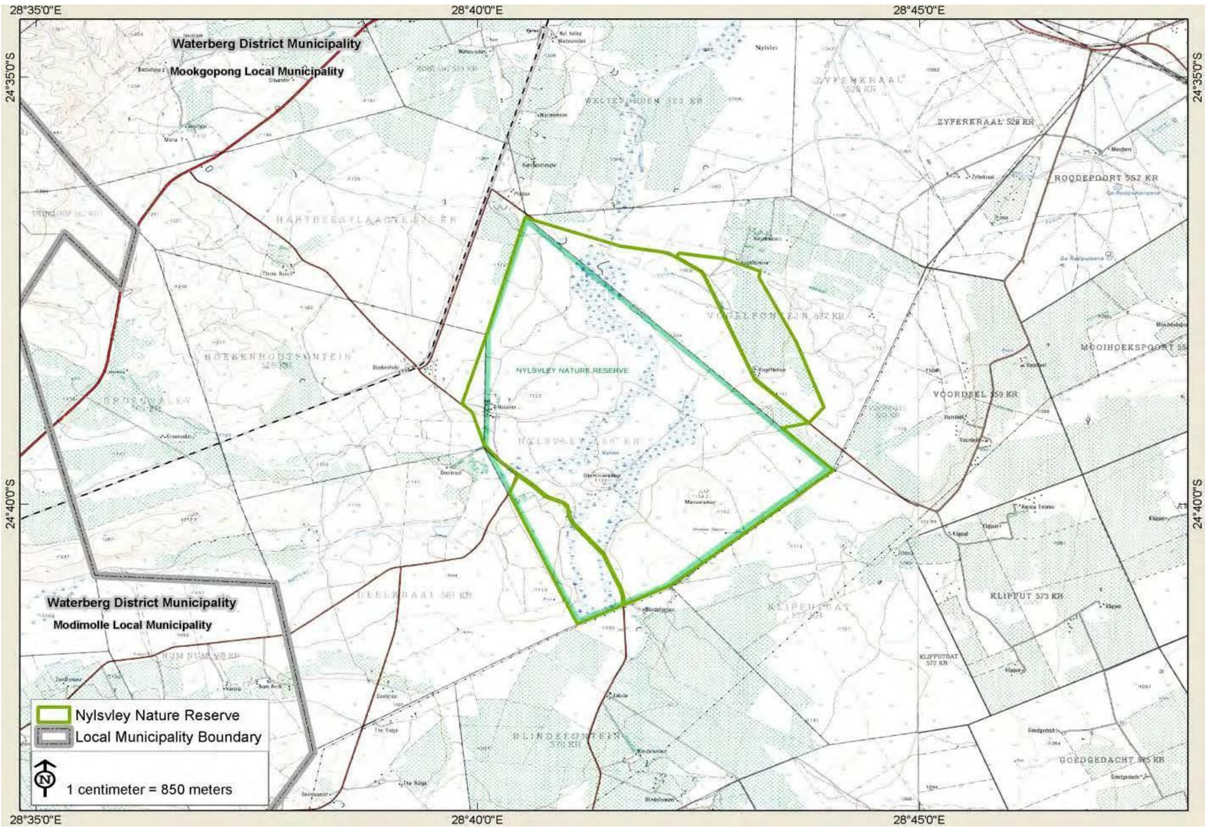

Figure 3.1: Locality map of the Nylsvley Nature Reserve (LEDET, 2013)

The savanna biome covers about 20% of the global land surface, and approximately half of the location of Africa and approximately 35% of South Africa (Scholes and Walker, 1993). Savannas can be discovered over an extensive variety of climatic situations with annual rainfall of less than 300 mm to extra than 1,500 mm and are generally characterized by the coexistences of trees and grasses (Solbrig *et al.*, 1996).

Savanna biome is characterised by a herbaceous layer which is usually dominated by grasses with a woody element and an overstorey of trees. In Southern Africa, bushveld is described by the structure of the vegetation, since the vegetation is mostly comprised of distinct shrub and tree layers that occur in a matrix with a herb layer dominated by grass. The flora of the reserve is comprised of Central Bushveld vegetation units of the Savanna biome and a Freshwater Wetland vegetation unit of Inland Azonal flora (LEDET, 2013).

Savannas are ecosystems that are fire prone and consequently fire become vital in maintenance of both its structure and floristic composition. The prevention of fire results in bush encroachment and diminishes the grass and herbaceous layer. Approximately 600 plant species had been recorded within the NNR. Scholes and Walker (1993) distinguished nine vegetation types, namely; *Burkea africana* savanna, *Diplorhynchus condylocarpon* savanna, *Combretum* savanna, *Acacia tortilis* savanna, antique village sites, *Acacia karroo* savanna, Floodplain grasslands, Grasslands on vertic soils, and Seepline grassland. According to Low and Rebelo, (1998), the vegetation types may again be grouped into two large categories namely; Mixed bushveld and Clay Thorn Bushveld. The south and east is characterized by essentially sandy soil with the exception of Maroelakop and Stemmerskop with soil that originate from sandstones of the Waterberg system. The west and north of the reserve, mainly along the flat country flanking the Nyl River, is underlain by loam or clay soil.

3.1.2 Topography

NNR is described as a reserve with a gentle sloping landscape, with a number of rocky outcrops that spread throughout the area. Stemmerskop which is one of the outcrops is located in the central interior of the reserve at an altitude of 1 132 m above sea level. Maroelakop which is a second outcrop is positioned in the eastern corner of the reserve at an altitude of 1 154.2 m above sea level. A third and unnamed outcrop is located inside the western corner of the nature reserve at an altitude of 1 122 m above sea level (LEDET, 2013).

3.1.3 Geology

Different geological formations occur at the NNR and are grouped as per vegetation units they support. Central Sandy Bushveld found in the NNR is predominantly underlain with sedimentary rocks of the Waterberg group origin. Waterberg rocks in particular consist of sandstone, conglomerate and siltstone of the Alma formation and sandstone, as well as the shale and siltstone of the Vaalwater formation. Volcano-sedimentary rocks of the Karoo Supergroup underlain the Springbokvlakte Thornveld. Mafic volcanics (tholeitic and olivine basalts and nephalinites) of the Letaba formation are in great quantity, with less prominence of mudstones of the Irrigasie Formation and shale and sandstone units of the Ecca group. The Subtropical Freshwater Wetlands geology is most dominated by is Cenozoic alluvium, with Karoo Supergroup volcanic rocks and sediments and Cretaceous (and younger coastal) sediment of the Zululand and Maputaland Groups (LEDET, 2013).

3.1.4 Soils

NNR is characterized by a variety of soils which can usually be grouped as per the vegetation unit they support. Central Sandy Bushveld is supported by well-drained, deep Hutton or Clovelly soils, usually with a centenary series from Hutton on the hilltops to Clovelly on the lower slopes. Shallow, skeletal Glenrosa soils also occur in the reserve. Springbokvlakte Thornveld soils also found in the reserve are red-yellow apedal which are freely drained with an excessive base reputation and selfmulching, black, vertic clays. The vertic soils, with a fluctuating water table, experience prolonged intervals of swelling and shrinking in the course of moist and dry periods; considerable soil cracking when dry; a surface with loose soil; excessive amount of calcium carbonate; and gilgai micro-relief. Champagne and arcadia clayey, waterlogged soils, containing certain levels of decaying organic matter, particularly in relatively efficient reed beds, are related to subtropical Freshwater Wetlands (LEDET, 2013).

3.1.5 Drainage and Hydrology

NNR has the Nyl River which flows via the central and north-eastern parts of the reserve thereby forming a grassland floodplain measuring 70 km in length. It is considered one of the largest grassland floodplain in South Africa. The Nylsvley grassland floodplain is a natural inland wetland which is classified as a seasonal floodplain wetland. It is comprised of a seasonal river associated with a grassland floodplain. The floodplain gets most of its influx from streams and rivers draining from the south-eastern edge of the Waterberg plateau, with its primary water input coming from the Olifantspruit (contributing eighty percent of the overall annual drift), with the Groot Nyl and Klein Nyl Rivers making minimal contributions. Some of the Sub-catchments feeding the floodplain are the Groot Nyl, Klein Nyl, Olifantspruit, Modderloop/Rasloop, Middelfonteinspruit, Hessie-se-Water, De Wet Zyn Loop, Bad se Loop, Tobiaspruit, Andriespruit and Kootjie se Loop (LEDET, 2013).

Run-off acquired from a number of tributaries is dynamic, as influenced by differing flow gradients and degrees of surface water storage, causes water deliver to the floodplain to be sporadic and difficult to quantify. Due to the variability in water delivery, the Nylsvley area is certainly subjected to seasonal flooding and fluctuation in water levels. The alternating wetter and drier periods allow for various and dynamic atmosphere (LEDET, 2013).

On average, inundation of at least some of the components of the floodplain happens for the duration of three out of every five years, at some point of the summer time that lasts from October to April. The persistent of flood waters occur at some point of the 12 months until the following wet season. The depth of Nylsvley floodplain depends at the type of flooding that happens, but rarely exceeds one meter. The dry season of the floodplain is generally characterized by dry floodplain, with water only available in permanent pools located within the main stream of the Nyl River. Hydrologically the floodplain acts as a basin through temporarily storing floodwater and then later releasing it slowly releasing it back into the main river channel. It is believed that the floodplain contributes significantly to groundwater recharge within the area (although this has no longer been showed thru adequate investigation), with fairly high groundwater yields in the Waterberg area occurring within the lower floodplain vicinity. The Nylsvley floodplain wetland performs a vital role in offering water for neighborhood flora and fauna, which is important in supporting the biodiversity of the area. The NNR is placed inside an Upstream Freshwater Priority Area (LEDET, 2013).

3.1.6 Vegetation

The vegetation description for the NNR as per Mucina and Rutherford 2006 follows:

The vegetation of the reserve accommodates Central Bushveld vegetation units of the Savanna Biome and a Freshwater Wetland vegetation unit (Alluvium plants) of Inland Azonal flora. A herbaceous layer (normally dominated by means of grasses) with a woody component – most typically of an overstorey of trees characterizes a Savanna Biome. In Southern Africa, bushveld is a description of the plant life shape, as the vegetation most often does now not comprise clear shrub and tree layers, and the shrubs and bushes forms a matrix with a grass-dominated herb layer. Savannas are fire prone ecosystems and consequently fire is crucial to retaining its structure and floristic composition. The exclusion of fire results in bush encroachment and a diminishing grass and herbaceous layer. Scrubby and coppiced savanna (i.e., an increase in browse potential at the rate of grazing) are favoured by mid-dry seasonal burns, while early wet season burns favour grass production. Patch mosaic burning favours a higher range of plant life structure and floristic composition. High intensity fire can kill shrub and tree components, thereby resulting in a discounted browse potential. Alluvium vegetation is a complex and dynamic flora determined by way of the interplay of numerous ecological elements, such as sedimentation-to-erosion rates; sediment load; water chemistry and nutrient load; and the frequency and period of flooding, among others. The flora is made up of an intricate complex of aquatic macrophytes; marginal reed beds and great flooded grasslands; ephemeral herblands; and riverine thickets. Alluvium vegetation is not fire inclined and fire must be excluded from vegetation units on this biome. Central Sandy Bushveld is characterised by sandy plains and catenas supporting tall, deciduous *Terminalia sericea* and *Burkea africana* woodland on deep sandy soils, with *T. sericea* regularly dominant at the lower slopes of sandy catenas. Low broad-leaved *Combretum* woodland is dominant on shallow, rocky or gravelly soils. Species of *Acacia, Ziziphus* and *Euclea* are often determined on the flat and lower slopes on eutrophic sands, as well as much less sandy soils. Dominant tree and shrub species consist of *Acacia erubescens*, *Acacia nilotica* and *Acacia tenuispina*. Dominant grasses encompass *Aristida bipartita* and *Bothriochloa insculpta* (Mucina and Rutherford, 2006).

3.2 Sampling and measurements

The study was conducted in the Nylsvley Nature Reserve Limpopo Province, South Africa. Field work was done in July, September and December 2015 using the quadrat method. Fifty and hundred meter measuring tapes were laid down and then 10 m by 10 m quadrats were constructed within rectangular stands produced by laying down 50 m x 100 m. Individuals of *V. karroo* which included seedlings, juveniles and mature trees were sampled from each quadrat. The individuals within the quadrats were counted and recorded and their sizes measured. Each of the quadrat was marked, and a camera was used to take pictures of the quadrats as well as sampling procedures. Plant heights were measured by using a 5 meter height rod and extrapolation was employed on plants taller than 5 metres. The following parameters were recorded on each and every sampled individual: basal stem circumference (cm), Plant heights (m), Canopy cover (m), and damage estimates on a sliding scale of 0 - 5.

Stem circumference measurements have been taken on the basal area of the individuals. Basal area measurements have been used in place of diameter at breast height (DBH) due to the fact most plants were multi-stemmed at breast height.

Stem circumference size-class factors of 0-10 cm represents the seedlings, while 11-20 cm represents juveniles and 21-30 cm and other classes above represents the mature trees of *V. karroo*. The height size class of 0-2 m represents seedlings, while 2.1-4 m represents and 4.1-6 m and other classes above represents mature trees of *V. karroo*. The canopy size-class of 0-2 m represents seedlings, while 2.1-4 m represents juveniles and 4.1-6 m and other classes above represents the mature trees of *V. karroo*.

The disturbance intensity was estimated by means of a sliding scale of 0 to 5 as follows:

0 - No damage,

1 - Traces of damage,

2 - Light damage,

3 - Moderate damage,

4 - Severe damage,

5 - 100% damage.

Ten quadrats of 10 m x 10 m were sampled in July 2015 and data on nighty eight (98) individuals of *V. karroo* were recorded. The population structure of *V. karroo* was expressed through a stem circumference size-class distribution, plant height size-class distribution and canopy size-class distribution.

Eighteen quadrats of 10 m x 10 m were sampled in September 2015 and data on one hundred and nighty one (191) individuals of *V. karroo* were recorded. The population structure of *V. karroo* was also expressed through a stem circumference size-class distribution, plant height size-class distribution and canopy size-class distribution.

Fourteen quadrats of 10 m x 10 m were sampled in December 2015 and data one hundred and fifty eight (158) individuals of *V. karroo* were recorded. The population structure of *V. karroo* was also expressed through a stem circumference size-class distribution, plant height size-class distribution and the canopy size-class distribution.

All of these measurements were taken in the Nylsvley Nature Reserve clay waterlogged site.

Figure 3.2: The background stand of *V. karroo* in the Nylsvley Nature Reserve waterlogged clay site.

Figure 3.3: An illustration of how quadrats were constructed.

Figure: 3.4: Measurement of the stem circumference of *V. karroo* in the NNR.

Figure 3.5: The measurement of the canopy cover of *V. karroo* in the Nylsvley Nature Reserve.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Stem circumference size-classes factor

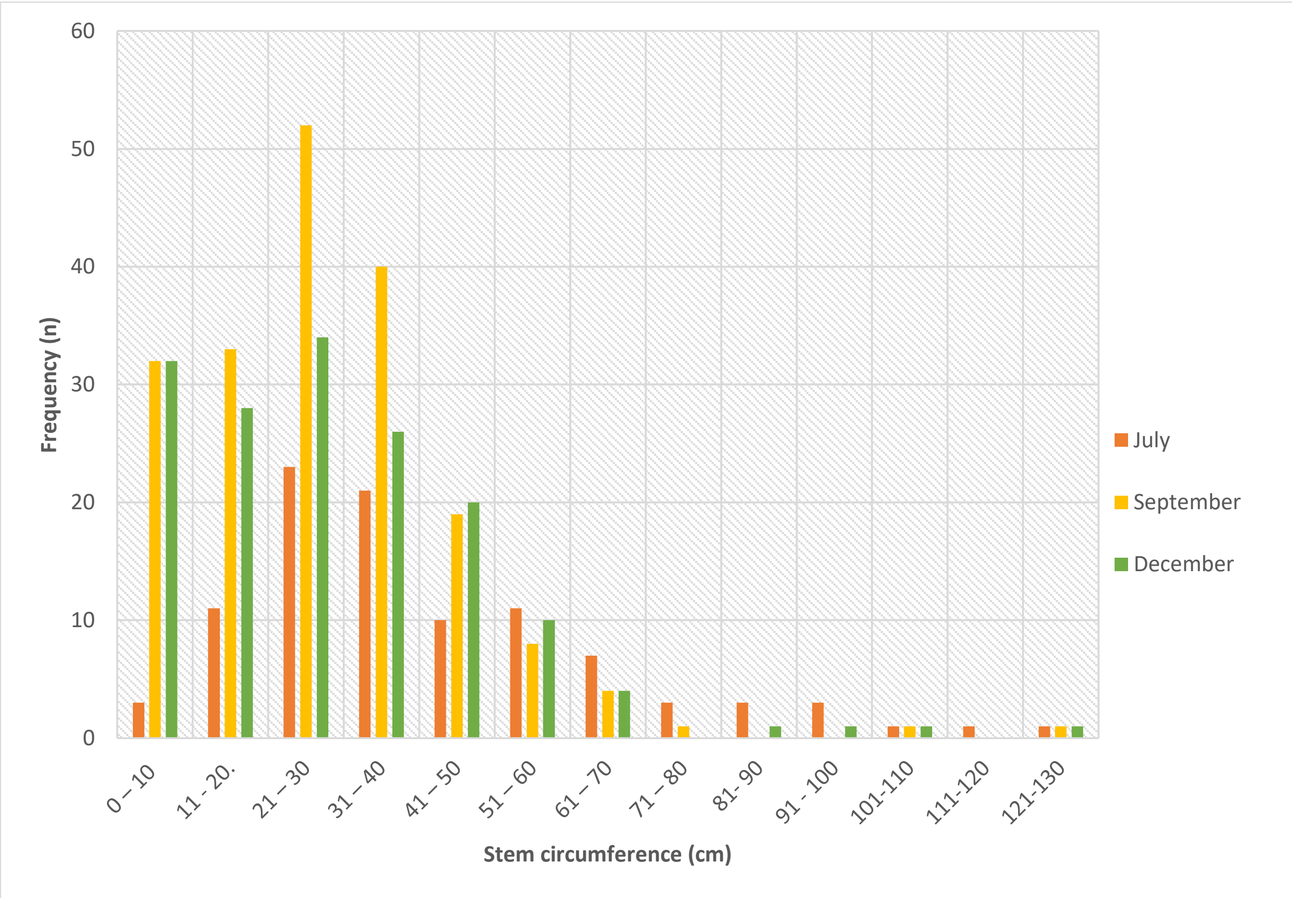

Figure 4.1.1: Stem circumference size-class distribution of *V. karroo* in the clay waterlogged site of the Nylsvley Nature Reserve.

Figure 4.1.1 represents the size-class distribution of stem circumference of *V. karroo*, size measures were categorized as follows: The frequency is the number of individuals in any given size-class from the entire population sampled.

4.2 Height size-classes factor

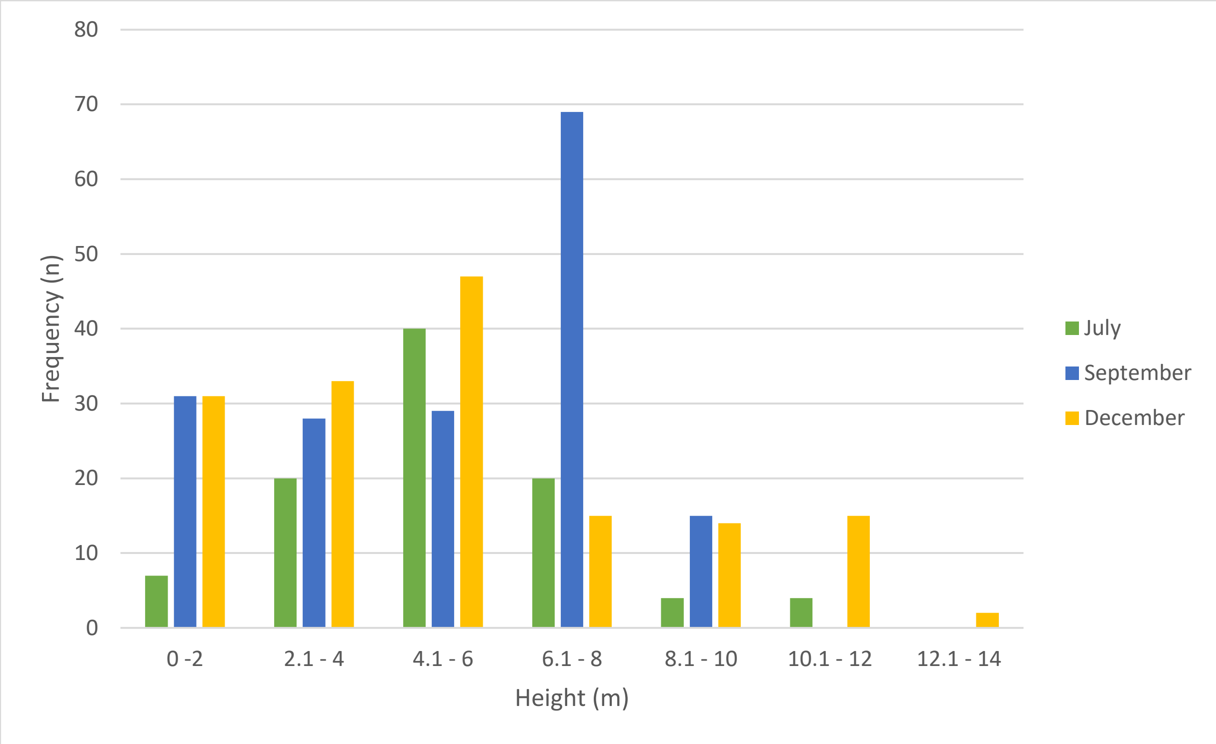

Figure 4.2.1: Plant height size-class distribution of *Vachellia karroo* in the Nylsvley Nature Reserve in July, September and December 2015. Frequency is either the number or percentage in any given size class with respect to the entire population sampled.

4.3 Canopy size-class distribution factor

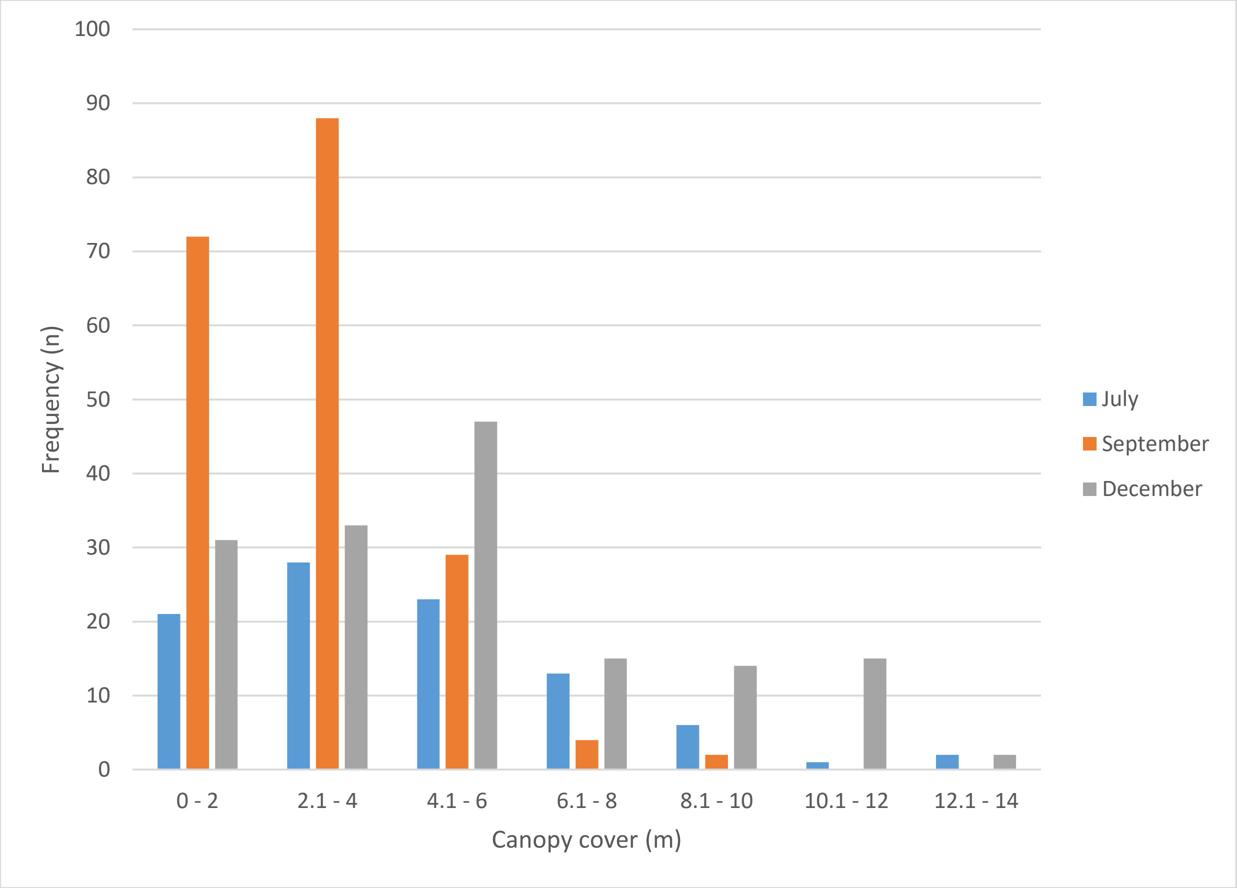

Fig 4.3.1: Canopy size-class distribution of *V. karroo* in the Nylsvley Nature Reserve in July, September and December 2015. Frequency is either the number or percentage in any given size class with respect to the entire population sampled.

4.4 Distance size – class distribution factor

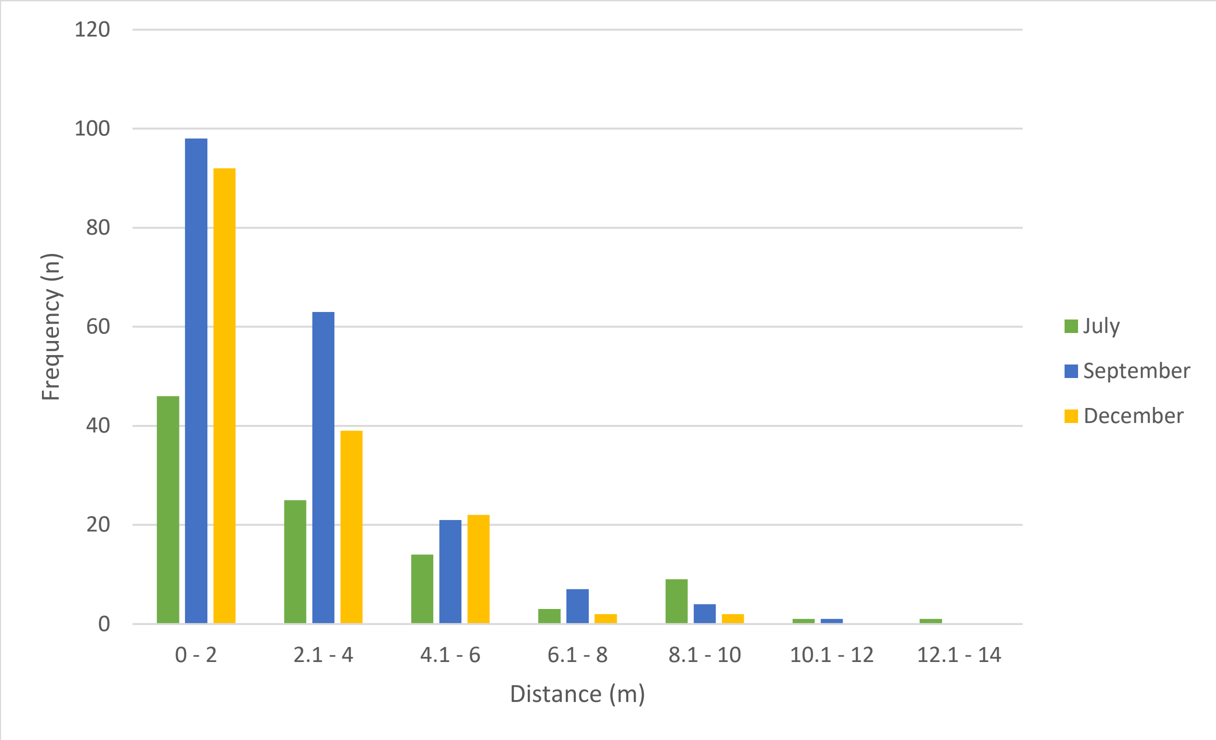

Fig 4.4.1: Distance size-class distribution of *V. karroo* in the Nylsvley Nature Reserve in July, September and December 2015. Frequency is either the number or percentage in any given size class with respect to the entire population sampled.

4.5 Disturbance estimates percentages

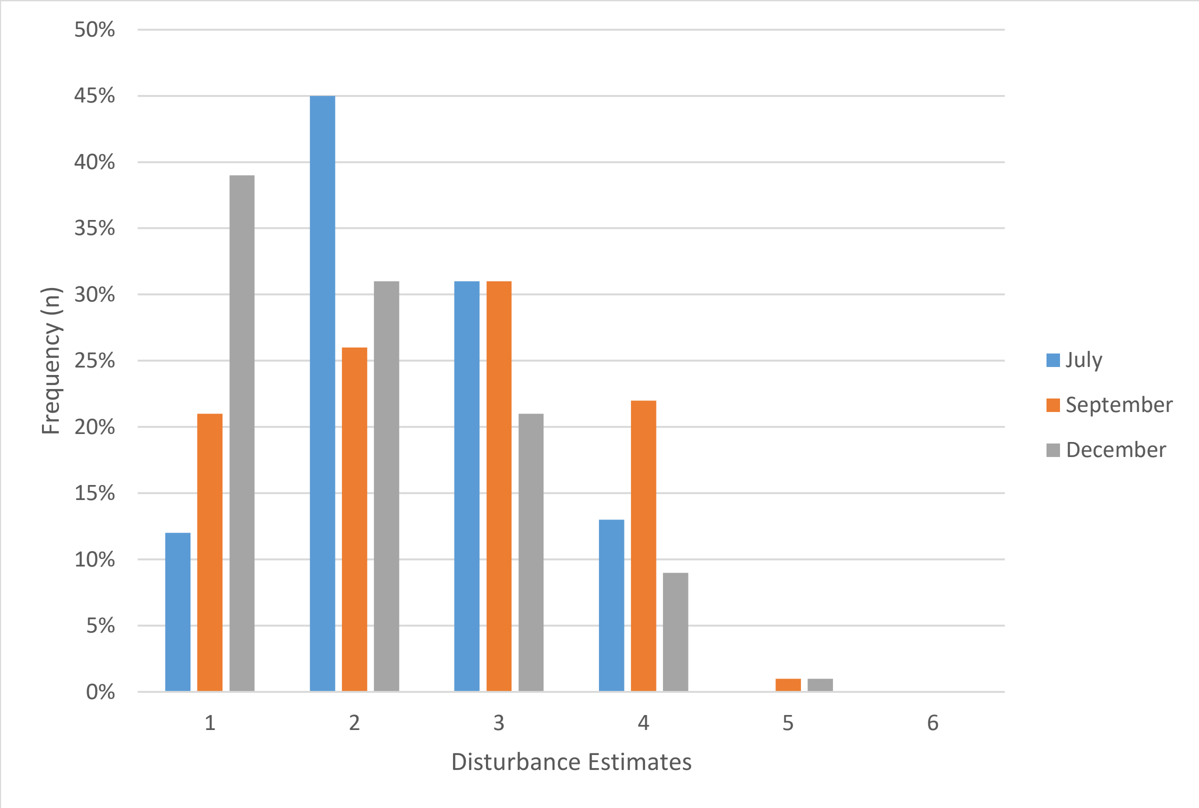

Fig 4.5.1: Disturbance estimates of *V. karroo* in percentages on the sliding scale of 0 to 5. Data collected at the Nylsvley Nature Reserve in July, September and December 2015.

From figure 4.1.1, it was noted that very few seedlings and juveniles were found ranging from 0-10 cm in July whereas in September and December higher number of seedlings were found. Individuals that were ranging from 11-20 cm in terms of stem circumferences, were found higher in September when compared to those of other seasons and also big number of individuals ranging from 21-30 cm were observed in September 2015 as compared to those of other two seasons, and this was followed by the ones in December month (see Figure 4.1.1). Individuals that were ranging from 31-40 cm were those approaching mature sizes and the higher number of those were found in September than in the other seasons (see Figure 4.1.1).

Sizes from 41-50 cm are also mature trees and such were found to be few individuals in both seasons which were summer and winter.

In a similar way and already reported under seedlings, juveniles and adults responded no different from the manner in which they showed for stem circumference in terms of height, canopy cover and intraspecific distance competition (see Figures 4.2.1, 4.3.1, 4.4.1 and 4.5.1). Similar to sizes 31-40 cm and 41-50 cm, 121-130 cm were also found to be very few in numbers. What we classified as seedlings and juveniles are generally known to be less competitive amongst one another whilst mature or adult individual plant species compete intensely due to their big sizes and naturally because of their occupation of bigger spaces than those occupied by young plants. There is therefore self thinning of seedlings and juveniles as they grow towards adulthood. It is therefore not puzzling to have all the graphs of the four parameters, which are stem circumference, heights, canopy cover and distance between individual seedling and juvenile plant species to be at their peaks but declining as they approach adulthood; this therefore is clear confirmation that plant individual species could be aggregated at their young age but as they grow older they tend to compete for resources such as moisture, light amongst others and eventually some of the individuals get outcompeted, particularly those that are weak competitors. This is in line with the following phrase: survival of the fittest which originated from Darwinian evolutionary idea as a manner of describing the mechanism of natural selection. This expression is often attributed to Charles Darwin and even though it seems within the 5th version of his origin of species, 1869 it is there attributed to Herbert Spencer. It is therefore naturally general that adult mature plants would be found sparsely distributed.

More mature healthy individuals were found in September and December, than during June and July; this is obviously because early summer season, and in September most of the savanna plant species were starting to actively recover from the winter dry season. Plants have advanced a various suite of tolerance developments inclusive of compensatory increase, elevated photosynthesis and activation of dormant meristems (Choeni and Sebata, 2014). There were high number of individuals from the entire population sampled in the adult population. If new seedlings are not recruited well into the adult population, it means that the population may additionally come to be locally extinct (Ryniker *et al.*, 2006). This can also be affected by the season as it was on winter when the data was collected, many tree species become dormant in winter and hence we found few seedlings.

For data collected in July, September and December 2015, the canopy size-class distribution between 0-2 m showed highest number of individuals in September as compared to other seasons as already reported previously. A general high number of seedling individuals and adult is indication that the population of *V. karroo* is healthy and viable. Tree canopy cover is the percentage of an area protected by way of the vertical projection of tree crowns (Jennings *et al.*, 1999). Canopy cover performs an important function in defining contemporary and future wooded area characteristics via effects on understory species composition and structure (Canham *et al.*, 1990).

Distance class from 0 – 2 m displayed the highest number of individuals, and there was a decrease in the number of individuals from this to the remaining size – classes. Distance from each individual represented the distribution pattern of *V. karroo*. We have found that young individuals of *V. karroo* were closely distributed. Their distribution pattern showed that they are clumped. Some of the studies report that the nearest neighbour analysis indicates that if aggressive interactions are present, there will be a marked reduction within the size of one or each of the competing neighbours, or a substantial increase in the length of plants whilst neighbours are eliminated (Pielou, 1962). Smith and Walker (1983) and Wiegand *et al*., (2005), indicated that larger plants have smaller neighbours due to their competitive effects. Nearest neighbour analysis has nevertheless been criticized for underestimating the prevalence of competition because the closest neighbour might not have the greatest competitive impact on a target plant if the closest neighbour may be very small in comparison to other plants within the neighbourhood (Shackleton, 2002). This limitation can be overcome via using more than one nearest neighbour (Shackleton, 2002). Juvenile *V. karroo* plants will be aggregated in relation to larger trees, either because of facilitation, directed seed dispersal or environmental heterogeneity. With growth of the juvenile plants, competition will increase between juvenile and mature plants (Wiegand *et al.*, 2006), so that the association disappears in the large length classes.

Figure 4.5.1 represents the disturbance estimates of *V. karroo* data which was collected in July, September and December 2015 at the Nylsvley Nature Reserve. Individuals with no damage were only 12% in July and 21 % in September and in December it was 39% individuals with no damage of the total sampled individuals. Individuals with traces of damage in July were very high compared to those of other seasons. Individuals with moderate damage in July and September were very high as compared with those in December season. Individuals with severe damages were only 13% in July and in September it was 22%; very few individuals were found with severe damage in December 2015. The main disturbances which seemed to have an effect on *V. karroo* are fire and herbivory in the Nature Reserve. Fire seems to have a bad effect on mature trees by way of destructive their canopies and stems (Tshisikhawe *et al.*, 2012). The potential of plants to tolerate or compensate for herbivore harm is enormously variable though

(Brody and Irwin, 2012). In this regards the number of individuals per season were different, it is therefore reason enough to find more individuals of *V. karroo* in September, and one hundred and nighty one individuals were sampled in September 2015. In December 2015 one hundred and fifty eight individuals of *V. karroo* were sampled and higher number of seedlings individuals were also found as compared to the individuals that were collected in July 2015; only nighty eight individuals of *V. karroo* were sampled; few number of seedlings and juveniles found in July is attributed to the fact that July is the months when plant species are generally dormant.

Plant population structure may also change as a result of modifications in recruitment of individuals at low diameter size classes or exploitation of individual at high size classes or throughout the class size structure. According to Cunningham (2001) population structural change is the function of regeneration pattern of individuals within the community. In a plant population density-dependent mortality is usually brought about by a shift in the direction of much less aggregated distributions of plants, possibly as a result of intraspecific competition for an evenly distributed resource (Wolf, 2005). Vegetative duplicate, clumped seed dispersal, heterogeneity of soil resources, temporary local release from recruitment limitation, disturbances, facilitation, or a combination of these elements can result in aggregation of plant population (Phillips and Macmahon, 1981; Skarpe, 1991). Plants are randomly spaced either as a result of the absence of processes that causes regularity or aggregation or due to the fact that processes influencing regularity and aggregation are balancing each other, for example in a transient state between aggregation and regular distribution (Skarpe, 1991). Competition also leads to a negative spatial autocorrelation in plant size, in order that taller plants have smaller neighbours (Cannell *et al*., 1984; Purves and Law, 2002). The distributions of plant species may be motivated by means of area of interest factors along with variations in habitat systems, substrate traits, useful resource gradients, and environmental conditions, or neutral elements inclusive of dispersal limitation (Woods, 2013). Species which are taller than their neighbours have the potential to intercept more light, and competition for light is therefore highly uneven (Hirose and Werger, 1994; Schwinning and Weiner, 1998). Tall and small species may additionally coexist because they are adapted to special elements of the light gradient (Thomas and Bazzaz, 1999), and because of a trade-off between maximum size and duration to adulthood (Kohyama, 1992).

In general, the size distribution may also differ between taxonomic groups and communities. Sometimes a unimodal distribution of species sizes is found (Ritchie and Olff, 1999), whereas others expect, on theoretical grounds, a multimodal distribution (Scheffer and van Nes, 2006). The distribution of maximum species sizes and the packing of species in communities might also vary along environmental gradients. Despite the potential importance of variations in height, there have been few quantitative studies of size distribution of tree species in unique woodland communities (Porter *et al.,* 2008).

Competition between the woody and herbaceous components is frequently invoked as one of the major processes influencing the structure and function of African savannas (Knoop and Walker, 1985; Stuart-Hill and Tainton, 1989; Teague and Smit, 1992; Scholes and Walker, 2004; Scholes and Archer, 1997). It has also been argued that competition between trees may be a sizeable determinant of woody community structure and productivity (Smith and Goodman, 1986; Teague and Smit 1992; Scholes and Walker, 2004). The presence or absence of competitive interactions between plants can be determined in a number of approaches. For woody plants across a range of biomes, including savannas, it has been inferred from the spatial distribution of individuals within the community (Phillips and MacMahon, 1981; Fowler, 1986; Midgley and Watson, 1992). In southern African savannas the maximum not unusual technique has been nearest-neighbour methods which assume that aggressive interference between neighbouring plants, if present, might be manifested through a reduction in the size of one or both of the competing neighbours (Shackleton, 2002).

Competition with herbaceous plants is also important at the seedling stage (Bush and van Auken 1990; McPherson 1993; Davis *et al.*, 1998). Thus, the current application of nearest neighbour studies to detect competition are possibly at an incorrect resolution and should be focussed on, or certainly include, the smallest individuals.

Plant population structure can also change due to changes that occurs in recruitment of individuals at low diameter size classes or exploitation of individuals at high size classes or throughout the class size structure (Rocky and Mligo, 2012). Ecologically, there may be co-existence of individuals that may have small and large size classes among successional guilds unless disturbance has taken place (Rocky and Mligo, 2012).

Ecologists frequently use size distribution to indicate the health of a population. The presence of large numbers of juveniles relative to adults, is understood to signify that a population is stable, possibly growing, whereas few juveniles may be seen as a warning that the population is in decline (Condit *et al.*, 1998). In the absence of direct estimates of population size through time, this appears to be a reasonable shortcut (Condit *et al.*, 1998). In most of the time it is easy to obtain estimates of size distribution from a population although much difficult to get long-term population trends (Condit *et al.*, 1998).

A common characteristic of woody plants occurring in areas susceptible to excessive disturbance is the ability to resprout after disturbance (Bellingham and Sparrow, 2000; Bond and Midgley, 2003). Sprouting of woody plants is an adaptive trait which allows for survival after considerable damage from fire or physical disturbance by initiating new vegetative growth from roots or stems (Hodgkinson, 1998; Bond and Midgley, 2001).

Woody plants are either killed or resprout from vegetative tissue after extreme injury from disturbances along with herbivory, fire, floods, hurricanes, landslides, or logging (Bond and Midgley, 2001). The distinctive responses to damage are both ecologically and evolutionarily critical. Sprouters can occupy the equal area for masses to thousands of years and have minimum adjustments in population size (Bond and Midgley, 2001). Characterizing sprouting behaviour is consequently critical for predicting how species will respond in models of vegetation dynamics, in determining extinction risks for threatened species, and in developing utilization methods for woody plant management (Bond and Midgley, 2001).

A number of studies has investigated the fine-scale spatial distribution of woody vegetation in arid and semi-arid environments (Barot *et al*., 1999; Bucini and Hanan, 2007; Dean *et al*., 1999; Smet and Ward, 2006; Strand *et al.,* 2007). Most of such studies found spatial associations between woody vegetation, even though a spatial repulsion of woody plants is anticipated in water-restricted ecosystems due to competition (Dean *et al.*, 1999; Meyer *et al.*, 2008; Milton and Dean, 1995; Skarpe, 1991). Understanding about the drivers of flora structure and dynamics in savannas are important for the management of tree or shrub encroachment, i.e. an increase of woody vegetation related to a reduction of the grass layer (Roques *et al.*, 2001).

Large numbers of juvenile relative to adult trees typically form an inverse J-shaped size-class distribution, which is usually taken to mean that the population is healthy. Bell-shaped size-class distributions, where there are fewer juvenile than adult trees, represents a population in decline (Venter and Witkowski, 2010). However, bell-shaped size-class distributions are not always a trouble for large, longer-lived species, in which trees can preserve population levels with low or episodic recruitment (Condit *et al.*, 1998).

Condit *et al.*, (1998) prove that trees which develop swiftly in small size-classes and trees which have a high rate of survival will show off flat size class distribution slope, and also that large, long-lived trees are able to maintain population degrees with low or episodic recruitment.

CHAPTER 5

GENERAL CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The population of *V. karroo* in the clay waterlogged areas of Nylsvley Nature Reserve is predominantly healthy. Large numbers of juvenile relative to adult trees typically form an inverse J-shaped size - class distribution, which is usually taken to mean that the population is healthy. This implies that in the future there will be resources for scientific researchers to use. Large number of juveniles were found as compared to the adult trees in both season which are winter and in summer. This is confirmation enough that the population of *V. karroo* is expanding in the clay waterlogged areas of Nylsvley Nature Reserve. It is therefore safe to argue that the population of *V. karroo* in the NNR is well conserved to date.

5.2 Recommendations

It is recommended that studies similar to this one should be done in the other clayey waterlogged sites of other reserves besides Nylsvley Nature Reserves. This is for the sake of comparison of how plant species of *V. karroo* respond to clayey waterlogged conditions. The two potential conspicuous threats on the population of *V. karroo* appeared to be fire and digging by small animals. The management of Nylsvley Nature Reserve are doing greater work in conserving the *V. karroo* in the clay waterlogged area.

CHAPTER 6

REFERENCES

Aganga, A.A., Adogla-Bessa, T., Omphile, U.J. and Tshireletso, K. 2000. Significance of browses in the nutrition of Tswana goats. *Archivos de Zootecnia*, 49: 469-480.

Barnes, R.D., Filer, D.L. and Milton, S.J. 1996. *Acacia karroo: monograph and annotated bibliography* (No. 32). Oxford Forestry Institute, Department of Plant Sciences, University of Oxford.

Barot, S., Gignoux, J. and Menaut, J.C. 1999. Demography of a savanna palm tree: predictions from comprehensive spatial pattern analyses. *Ecology*, 80(6): 1987-2005.

Bellingham, P.J. and Sparrow, A.D. 2000. Resprouting as a life history strategy in woody plant communities. *Oikos*, 89(2): 409-416.

Bisby, F.A., Buckingham, J. and Harborne, J.B. 1994. Phytochemical dictionary of the Leguminosae. Volume 1. Plants and their constituents. Volume 2. Chemical constituents.

Bond, W.J. and Keeley, J.E. 2005. Fire as a global 'herbivore': the ecology and evolution of flammable ecosystems. *Trends in ecology & evolution*, 20(7): 387-394.

Bond, W.J. and Midgley, J.J. 2001. Ecology of sprouting in woody plants: the persistence niche. *Trends in Ecology and Evolution*, 16(1): 45-51.

Bond, W.J. and Midgley, J.J. 2003. The evolutionary ecology of sprouting in woody plants. *International Journal of Plant Sciences*, 164(S3): S103-S114.

Brody, A.K. and Irwin, R.E. 2012. When resources don't rescue: flowering phenology and species interactions affect compensation to herbivory in *Ipomopsis aggregata*. *Oikos*, 121(9): 1424-1434.

Bruna, E.M. and Kress, W.J. 2002. Habitat fragmentation and the demographic structure of an Amazonian understory herb (*Heliconia acuminata*). *Conservation Biology*, 16(5): 1256-1266.

Bucini, G. and Hanan, N.P. 2007. A continental-scale analysis of tree cover in African savannas. *Global Ecology and Biogeography*, 16(5): 593-605.

Bush, J.K. and Van Auken, O.W. 1990. Growth and survival of *Prosopis glandulosa* seedlings associated with shade and herbaceous competition. *Botanical Gazette*, 151(2): 234-239.

Canham, C.D., Denslow, J.S., Platt, W.J., Runkle, J.R., Spies, T.A. and White, P.S. 1990. Light regimes beneath closed canopies and tree-fall gaps in temperate and tropical forests. *Canadian Journal of Forest Research*, 20(5): 620-631.

Cannell, M.G.R., Rothery, P. and Ford, E.D. 1984. Competition within stands of *Picea sitchensis* and *Pinus contorta*. *Annals of Botany*, 53(3): 349-362.

Carr, J.D. 1976. The South African Acacias. *The South African Acacias.*

Chapman, A.R.O., 1987. Population and community ecology of seaweeds. *Advances in Marine Biology*, 23: 1-161.

Choeni, H. and Sebata, A. 2014. Interspecific variation in the resprouting responses of Acacia species following simulated herbivory in a semi-arid southern African savannah. *African Journal of Ecology*, 52(4): 479-483.

Coates Palgrave, K. 2002. Trees of Southern Africa. New edition revised and updated by Meg Coates Palgrave. *Cape Town: Struik*, 1212: 118.

Coetzee, B.J., Van der Meulen, F., Zwanziger, S., Gonsalves, P. and Weisser, P.J. 1976. Phytosociological classification of the Nylsvley nature reserve. *Bothalia*, 12(1): 137-160.

Cole, M.M. 1986. *The savannas, biogeography and geobotany*. Academic Press.

Condit, R., Sukumar, R., Hubbell, S.P. and Foster, R.B. 1998. Predicting population trends from size distributions: a direct test in a tropical tree community. *The American Naturalist*, 152(4): 495-509.

Cunningham, A.B. 2001. *Applied ethnobotany: people, wild plant use and conservation*. Earthscan.

Davis M.A., Wrage K.J. and Reich P.B. 1998. Competition between tree seedlings and herbaceous vegetation: support for a theory of resource supply and demand. *Journal of Ecology*, 86 (4): 652-661.

Dean, W.R.J., Milton, S.J. and Jeltsch, F. 1999. Large trees, fertile islands, and birds in arid savanna. *Journal of Arid Environments*, 41(1): 61-78.

Dube J.S., 2000. The use of *Acacia karroo* and *Acacia nilotica* leaves as dry season supplementary feeds for livestock. *Strategies for Dry season Feeding of Animals in Central and Southern African*, 121-127

Fowler N. 1986. The role of competition in plant communities in arid and semiarid regions. *Annual Review of Ecology Systematics*, 17(1): 89–110.

Gambiza, J., Bond, W., Frost, P.G.H. and Higgins, S. 2000. A simulation model of miombo woodland dynamics under different management regimes. *Ecological Economics (Amsterdam)*, 33(3): 353-368.

Gleghorn, J.F., Elam, N.A., Galyean, M.L., Duff, G.C., Cole, N.A. and Rivera, J.D. 2004. Effects of crude protein concentration and degradability on performance, carcass characteristics, and serum urea nitrogen concentrations in finishing beef steers. *Journal of Animal Science*, 82(9): 2705-2717.

Gourlay, I.D. and Barnes, R.D. 1994. Seasonal growth zones in the wood of *Acacia karroo* Hayne: their definition and implications. *The Commonwealth Forestry Review*, 73(2): 121-127.

Higgins, S.I., Bond, W.J. and Trollope, W.S.W. 2000. Fire, resprouting and variability: a recipe for grass-tree coexistence in savanna. *Journal of Ecology*, 88(2): 213-229.

Hirose, T. and Werger, M.J.A. 1994. Photosynthetic capacity and nitrogen partitioning among species in the canopy of a herbaceous plant community. *Oecologia*, 100(3): 203-212.

Hodgkinson, K.C. 1998. Sprouting success of shrubs after fire: height-dependent relationships for different strategies. *Oecologia*, 115(1): 64-72.

Hoffmann, W.A. 1999. Fire and population dynamics of woody plants in a Neotropical savanna: matrix model projections. *Ecology*, 80(4): 1354-1369.

Hoffmann, W.A. and Solbrig, O.T. 2003. The role of topkill in the differential response of savanna woody species to fire. *Forest ecology and management*, 180(1): 273-286

Jennings, S.B., Brown, N.D. and Sheil, D. 1999. Assessing forest canopies and understory illumination: canopy closure, canopy cover and other measures. *Forestry*, 72: 59-73.

Kenrick, J. 2003. Review of pollen–pistil interactions and their relevance to the reproductive biology of Acacia. *Australian Systematic Botany*, 16(1): 119-130.

Knight, D.H. 1975. A phytosociological analysis of species-rich tropical forest on Barro Colorado Island, Panama. *Ecological Monographs* 45: 259-284.

Knoop, W.T. and Walker B.H. 1985. Interactions of woody and herbaceous vegetation in a southern African savanna. *Journal of Ecology*, 73: 235-253.

Knox, R.B. and Kenrick, J. 1983. Polyad function in relation to the breeding system of Acacia. *Pollen biology. Amsterdam: Elsevier*, pp.411-417.

Kohyama, T. 1992. Size-structured multi-species model of rain forest trees. *Functional Ecology*, 6: 206-212.

Limpopo Department of Economic Development, Environmental and Tourism (LEDET). 2013. five-year strategic plan for the Nylsvley Nature Reserve, Limpopo Province, South Africa.

Low, A.B. and Rebelo, A.G. 1998. Vegetation of South Africa, Lesotho and Swaziland: a companion to the vegetation map of South Africa, Lesotho and Swaziland.

Maclean, J.E., Goheen, J.R., Doak, D.F., Palmer, T.M. and Young, T.P. 2011. Cryptic herbivores mediate the strength and form of ungulate impacts on a long-lived savanna tree. *Ecology*, 92: 1626-1636.

Mapiye, C., Chimonyo, M., Marufu, M.C. and Dzama, K. 2011. Utility of *Acacia karroo* for beef production in Southern African smallholder farming systems: A review. *Animal Feed Science and Technology*, 164(3): 135-146.

McPherson, G.R. 1993. Effects of herbivory and herb interference on oak establishment in a semi-arid temperate savanna. *Journal of Vegetation Science*, 4(5): 687-692.

Meyer, K.M., Ward, D., Wiegand, K. and Moustakas, A. 2008. Multi-proxy evidence for competition between savanna woody species. *Perspectives in Plant Ecology, Evolution and Systematics,* 10(1): 63-72.

Midgley, J.J. and Watson, L. 1992. Nearest neighbour interactions amongst adult Proteaceae in the southern Cape. *South African Journal of Botany,* 58(3): 207-208.

Milton, S.J. and Dean, W.R.J. 1995. How useful is the keystone species concept, and can it be applied to *Acacia erioloba* in the Kalahari Desert? *Zeitschrift für Okologie und Naturschutz,* 4(3): 147-156.

Milton, S.J. 1987. Phenology of seven Acacia species in South Africa. *South African Journal of Wildlife Research-24-month delayed open access,* 17(1): 1-6.

Moleele, N.M. 1998. Encroacher woody plant browse as feed for cattle. Cattle diet composition for three seasons at Olifants Drift, south-east Botswana. *Journal of Arid Environments*, 40(3): 255-268.

Mucina, L. and Rutherford, M.C. 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria. *Memoirs of the Botanical Survey of South Africa*.

National Research Council. 2000. *Inquiry and the national science education standards: A guide for teaching and learning*. National Academies Press.

Noble, R.G. and Hemens, J. 1978. *Inland water ecosystems in South Africa, a review of research needs*. National Scientific Programmes Report, 34(1): 1-150.

Nyamukanza, C.C. and Scogings, P.F. 2008. Sprout selection and performance of goats fed *Acacia karroo* coppices in the False Thornveld of the Eastern Cape, South Africa. *South African Journal of Animal Science*, 38(2): 83-90.

O'connor, T.G. 1995. *Acacia karroo* invasion of grassland: environmental and biotic effects influencing seedling emergence and establishment. *Oecologia*, 103(2): 214-223.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. 2009. Agroforestry database: a tree species reference and selection guide version 4.0. *World Agroforestry Centre ICRAF, Nairobi, KE*.

Phillips, D.L. and MacMahon, J.A. 1981. Competition and spacing patterns in desert shrubs. *The Journal of Ecology*, 69: 97-115.

Pielou, E.C. 1962. The use of plant-to-neighbour distances for the detection of competition. *The Journal of Ecology*, 50: 357-367.

Pooley, B. 1998. A field guide to wild flowers of KwaZulu-Natal and the eastern region. *Durban: Natal Flora Publications Trust 630p.-col. illus.. ISBN 062021502X En Icones, Maps. Geog, 5*.

Poorter, L., Hawthorne, W., Bongers, F. and Sheil, D. 2008. Maximum size distributions in tropical forest communities: relationships with rainfall and disturbance. *Journal of Ecology*, 96(3): 495-504.

Primack, R.B. and Inouye, D.W. 1993. Factors affecting pollinator visitation rates: a biogeographic comparison. *Current Science*, 65: 257-262.

Purves, D.W. and Law, R. 2002. Experimental derivation of functions relating growth of *Arabidopsis thaliana* to neighbour size and distance. *Journal of Ecology*, 90(5): 882-894.

Ritchie, M.E. and Olff, H. 1999. Spatial scaling laws yield a synthetic theory of biodiversity. *Nature*, 400(6744): 557-560.

Rocky, J. and Mligo, C. 2012. Regeneration Pattern and Size-Class Distribution of Native Tree Species in Exotic Plantation in Pugu Forest Reserve, Tanzania. *International Journal of Biodiversity and Conservation*, 4(1): 1-14.

Roques, K.G., O'connor, T.G. and Watkinson, A.R. 2001. Dynamics of shrub encroachment in an African savanna: relative influences of fire, herbivory, rainfall and density dependence. *Journal of Applied Ecology*, 38(2): 268-280.

Ryniker, K.A., Bush, J.K. and Van Auken, O.W. 2006. Structure of *Quercus gambelii* communities in the Lincoln National forest, New Mexico, USA. *Forest Ecology and Management*, 233(1): 69-77.

Scheffer, M. and van Nes, E.H. 2006. Self-organized similarity, the evolutionary emergence of groups of similar species. *Proceedings of the National Academy of Sciences*, 103(16): 6230-6235.

Scholes, R.J. and Archer, S.R. 1997. Tree-grass interactions in savannas 1. *Annual review of Ecology and Systematics*, 28(1): 517-544.

Scholes, R.J. and Walker, B.H. 1993. Nylsvley: the study of an African Savanna.

Scholes, R.J. and Walker, B.H. 2004. *An African Savanna: synthesis of the Nylsvley study. Cambridge University Press.*

Schwinning, S. and Weiner, J. 1998. Mechanisms determining the degree of size asymmetry in competition among plants. *Oecologia*, 113(4): 447-455.

Scogings, P.F. 2003, July. Impacts of ruminants on woody plants in African savannas: an overview. In *Proceedings of the VIIth International Rangelands Congress* (Vol. 26: 955-957).

Shackleton, C. 2002. Nearest-neighbour analysis and the prevalence of woody plant competition in South African savannas. *Plant Ecology*, 158(1): 65-76.

Skarpe, C. 1991. Spatial patterns and dynamics of woody vegetation in an arid savanna. *Journal of Vegetation Science*, 2(4): 565-572.

Smet, M. and Ward, D. 2005. A comparison of the effects of different rangeland management systems on plant species composition, diversity and vegetation structure in a semi-arid savanna. *African Journal of Range and Forage Science*, 22(1): 59-71.

Smith, T.M. and Goodman, P.S. 1986. The effect of competition on the structure and dynamics of Acacia savannas in southern Africa. *The Journal of Ecology*, 74: 1031-1044.

Smith, T.M. and Walker, B.H. 1983. The role of competition in the spacing of savanna trees. *Proceedings of the Annual Congresses of the Grassland Society of Southern Africa*, 18(1): 159-164.

Solbrig, O.T., Medina, E. and Silva, J.F. 1996. Determinants of tropical savannas. In *Biodiversity and savanna ecosystem processes* (pp. 31-41). Springer Berlin Heidelberg.

Stone, G.N., Raine, N.E., Prescott, M. and Willmer, P.G. 2003. Pollination ecology of Acacias (Fabaceae, Mimosoideae). *Australian Systematic Botany*, 16(1): 103-118.

Strand, E.K., Robinson, A.P. and Bunting, S.C. 2007. Spatial patterns on the sagebrush steppe/Western juniper ecotone. *Plant Ecology* 190(2): 159-173.

Stuart-Hill, G.C. and Tainton, N.M. 1989. The competitive interaction between *Acacia karroo* and the herbaceous layer and how this is influenced by defoliation. *Journal of Applied Ecology*, 26: 285-298.

Teague, W.R. and Smit, G.N. 1992. Relations between woody and herbaceous components and the effects of bush-clearing in southern African savannas. *Journal of the Grassland Society of southern Africa*, 9(2): 60-71.

Teague, W.R. and Walker, B.H., 1988. Effect of intensity of defoliation by goats at different phenophases on leaf and shoot growth of *Acacia karroo* Hyane. *Journal of the Grassland Society of Southern Africa*, 5(4): 197-206.

Thomas, S.C. and Bazzaz, F.A. 1999. Asymptotic height as a predictor of photosynthetic characteristics in Malaysian rain forest trees. *Ecology*, 80(5): 1607-1622.

Timberlake, J.R., Fagg, C. and Barnes, R. 1999. Field guide to the Acacias of Zimbabwe. *Harare: CBC Publishing 160p.-illus. ISBN, 797419365*.

Trollope, W.S.W., Potgieter, A.L.F. and Zambatis, N., 1989. Assessing veld condition in the Kruger National Park using key grass species. *Koedoe*, 32(1): 67-93.

Tshisikhawe, M.P., Baloyi, O., Ligavha-Mbelengwa, M.H. and Bhat, R.B. 2012. The population ecology of *Securidaca longepedunculata* Fresen. in the Nylsvley Nature Reserve, Limpopo Province, South Africa. *Phyton*, 81: 107-112.

Van Wyk, B.E. and Gericke, N. 2000. *People's plants: A guide to useful plants of Southern Africa*. Briza Publications.

Venter, S.M. and Witkowski, E.T.F. 2010. Baobab (*Adansonia digitata* L.) density, size-class distribution and population trends between four land-use types in northern Venda, South Africa. *Forest Ecology and Management*, 259(3): 294-300.

Werner, P.A. 2012. Growth of juvenile and sapling trees differs with both fire season and understorey type: Trade-offs and transitions out of the fire trap in an Australian savanna. *Austral Ecology*, 37(6): 644-657.

Wiegand, K., Saltz, D. and Ward, D. 2006. A patch-dynamics approach to savanna dynamics and woody plant encroachment–insights from an arid savanna. *Perspectives in Plant Ecology, Evolution and Systematics*, 7(4): 229-242.

Wiegand, K., Ward, D. and Saltz, D. 2005. Multi-scale patterns and bush encroachment in an arid savanna with a shallow soil layer. *Journal of vegetation science*, 16(3): 311-320.

Wolf, A. 2005. Fifty year record of change in tree spatial patterns within a mixed deciduous forest. *Forest Ecology and Management*, 215(1): 212-223.

Woods, C. 2013. Factors influencing the distribution and structure of tropical vascular epiphyte communities at multiple scales. PhD Thesis. Clemson University. South Carolina, United State of America.