An investigation on the potential interactions between *Colophospermum mopane* and its neighbouring understory vegetation.

By

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DECLARATION

I MUNONDE HUMBULANI PHILLIP hereby declare that this research is my own original work which has not partly or in full been submitted to any other university in order to obtain a degree.

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Date: 30/04/2014

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Table of contents

Abstract

Colophospermum mopane is a common tree or shrub locally dominant in savanna of sub-tropical region. A study of this tree species was carried out focussing on the two semi-arid areas where it is dominant and prevalent; the main areas considered for this current study are Mopani Bushveld and Tshiungani both located in the Limpopo Province of South Africa. The study focussed mainly on the interaction of *C. mopane* and its understory and nearest neighbour vegetation; the study also considered the response of *C. mopane* to disturbance and also on the plant-animal interactions; the reproductive strategies *of C. mopane* also formed part of this current work. The competitive interactions were established by this study wherein a complete permanent removal of *C. mopane* resulted in the growth, establishment and flourishing of grasses and herbs in the stands that were formerly dominated by *C. mopane* trees. Cutting of *C. mopane* trees revealed that they indeed do resprout vigorously thereafter following rainfall; it was also proved that root suckering is another strategy which *C. mopane* trees use for survival especially after fire. Our current work also revealed that *C. mopane* trees produce abundant amount of seeds and seedlings and this was more obvious immediately after rainfall.

Moisture and light, amongst other environmental factors, are indeed therefore indispensable for the continuous existence and survival of *C. mopane* trees; these factors are also necessary for the continuous coexistence of *C. mopane* and its understory and nearest neighbour vegetation.

Our study established the need for rainfall to keep our mopane woodlands germinating, growing, establishing, producing and reproducing perpetually; rainfall in *C. mopane* dominated stands areas ensures sustained coexistence of *C. mopane* and vegetation of other species.

Chapter 1

Introduction

1.1 **Background**

Colophospermum mopane (*C. mopane*) is a common tree or shrub locally dominant in savanna of the sub-tropical region. Savanna vegetation is characterised by the co-existence of grasses, shrubs, herbs and trees. The ratio of grasses to trees varies considerably among savanna vegetation types but what is common to most savannas is the differential leaf phenology between woody or tree and herbaceous or grass components.

Colophospermum mopane is protected by forestry legislation but a general environmental awareness on biodiversity conservation is lacking. Numerous experimental studies suggest that biodiversity loss is detrimental to ecosystem functions such as production and nutrient cycling (Chikuni,1996). Increased human population and overdependence on natural resources are the major causes of deforestation of mopane woodlands. Mopane woodlands are distinctive woodland types dominated by *Colophospermum mopane* (Chikuni, 1996). Very few tree species are found interspersed among the *C. mopane* trees (personal observation). In some cases *C. mopane* trees are not densely populated but evenly spaced and therefore there should be an increase in herbaceous biomass yield. However, an increase in woody plant density, locally referred to as, bush encroachment, is considered a major factor contributing towards low occurrence or even total absence of herbaceous plants in these habitats (Smit, 2003).

The productivity and composition of any mature stand is determined by both interspecific and intraspecific competition. The degradation of soil health is one of the main reasons for the loss of soil sustainability in dry areas (Tripathi et al., 2007). The roots of the woody plants are fundamental in their competitive interactions with herbaceous plants and other woody plants (Smit, 2005). Plant nutrients may be limiting because of interaction with factors such as high soil sodicity in some habitats that may affect nutrient uptake or plant nutrient demand (Mlambo, 2007). However, larger or older trees are more important in terms of soil enrichment than newly established individuals (Smit, 2004). This is because of leaf litter of *C. mopane*. *Colosphospermum mopane* has a positive influence on soil fertility in the environment and the fertility improvement beneath trees is not at the expense of soil fertility in the tree interspace (Mlambo et al., 2005). This implies however that herbaceous plants growing under the canopy of mature woodlands will increase and have a high yield of dry mass. Soil under the canopy of most trees had higher total nitrogen than outside the canopy (Burman et al., 2002). Trees seem to be the main suppliers of nutrients to understorey herbaceous vegetation through leaf litter. Large trees improve soil quality and grass leaf nitrogen and phosphorus contents beneath canopy are elevated compared to those outside the canopy (Treydte et al., 2007).

Climatic variables like rainfall and temperature are also very important in the determination of the distribution of vegetation in the savanna (Chidumayo 2001). Plants are often exposed to various adverse environmental stresses such as drought, salinity, high and low temperatures. Interactions among climate variables are reported to be responsible for the largest variation in the vegetation canopy phenology (Chidumayo, 2001). Trees adapt their rooting systems in accordance to the prevailing climatic regime (Hipondoka et al., 2006). These (rooting systems) are indeed very important for trees during competition with herbaceous plants for water and nutrients (personal observation and experience). It appears there is a close relationship between rainfall amount and shallow root systems of encroaching tree species for harvesting near-surface water. *Colophospermum mopane* trees are believed to have very long shallow and spreading roots which are expected to pump nutrients towards the plants (Jones et al., 2005). However, this might be a challenge in my study area as topsoil is mainly sand which are nutrient-poor and cannot retain water for a longer time. Shallow rooted annuals result in greater drainage and therefore a greater potential for development of salinity and acidity (Jones et al., 2005). Belowground adaptations are governed by rainfall regime and physiological performance of many trees appears to be directly linked to it (Burke, 2006).

1.2 Problem statement

In most cases at Masisi, Tshenzhelani, Tshiungani and Mopane Bushveld we noticed very few understorey and nearest neighbour understory herbaceous vegetation in population stands dominated by *C. mopane* trees. This is despite the fact that farther away from such stands we do notice variety of plant species somehow flourishing. *Colophospermum mopane* normally survive under areas of fairly low rainfall which might anyway drive one to assume that plant diversity of herbaceous vegetation under C. *mopane* stands thereof should be fairly low. We nevertheless found relatively high plant diversity on our visit to areas referred to here, in sites which were relatively farther away from *C. mopane* individuals. The question thus arises as to what factors cause such a pattern of distribution, that is, why sites dominated by *C. mopane* are not supporting enough of the other type of vegetation under and in their nearest understory. Naturally there is need for ecosystems to support variety of plant species to encourage biodiversity.

1.3 Research question

Do *Colophospermum mopane* compete with its understory herbaceous vegetation for sunlight, moisture and nutrients?

1.4 Aim of the study

The aim of the study is to investigate potential interaction between *C. mopane* and its nearest neighbours and understory vegetation.

1.5 Objectives of the study:

- To assess the vegetation distribution pattern in mopane woodland
- To establish what causes the interaction between *C. mopane* and its nearest neighbour and understory vegetation.
- To assess the extent of the interactions.
- To encourage/ prevent such kind of interactions if necessary.
- To establish whether there could be remedies to the kind of interactions.

1.6 Hypothesis

Null hypotheses:

(1a) Plant species away from *C. mopane* trees will grow better than those closest and under them.

(1b) Plants closest and under *C. mopane* are outcompeted by *C. mopane* trees.

(1c) Other plant species will regenerate fast in the absence of *C. mopane* trees.

On the other hand,

(2a) plant species in stands where *C. mopane* trees have been removed will grow and flourish;

(2b) competition between *C. mopane* and its understory and nearest neighbour is removed when *C. mopane* trees are removed.

Chapter 2

Species Description, Distribution, Ecology, Growing (*Colophospermum mopane)* Uses and Cultural Aspects and Study Sites.

2.1 Species description

Colophospermum mopane (J. Kirk ex Benth.) J. Kirk ex J Leonard is an indigenous tree with butterfly shaped leaflets which are bright green when they emerge but turn into kaleidoscope of autumn colours later in the season. Autumn colours are characteristic of the landscape at the end of growing season. *Colophospermum mopane* trees stay green for many months. Most specimens are multi-stemmed which spread upwards to form a wide spreading rounded sparse crown. Short multi-stemmed *C. mopane* trees dominate the pediment and crest surface, while tall, single-stemmed *C. mopane* trees dominate the flood plain and ephemeral river bed (Teshirogi, 2010). The bark is light to dark grey in colour.

Some *C. mopane* trees can attain a height of up to 30 m and 90 cm in diameter in the northern part of its range, depending on soil conditions and water availability (Palgrave, 2002). They have a tall, narrow crown. The compound leaves are divided into two so that the leaflets resemble butterfly wings arising from a single petiole (personal observation). They are deciduous trees. Flowers are yellow green, small and inconspicuous. The seed consists of a flattened and leathery pod. They are green at first and contain one wrinkled, flat seed dotted with sticky resin glands (Palgrave, 2002). Flowering occurs from December to January; whilst fruiting occurs from April to June. The local distribution of *C. mopane* is governed by the texture of the soil and the degree of slope, both of which affect the drainage. The wood is brown to reddish in colour (Palgrave, 2002). The thin sapwood is yellow to light brown (personal observation). The wood is also very hard, heavy and termite resistant. They can survive in areas where other trees struggle. One of the main characteristics of *C. mopane* is that they can form almost pure dominant stands comprising trees of comparatively even size (Palgrave, 2002).

2.2 Distribution

Colophospermum mopane has fairly broad distribution ranges often extending over several countries (Scholes, et al 1993). Its distribution ranges from southern Angola and northern Namibia, through Botswana, Zimbabwe and southern Zambia to southern Malawi, Mozambique and northern South Africa, being found from 200 to 1200 m in altitude (Timberlake, 1996). It is found growing in alkaline soils which are shallow and not well drained (Palgrave, 2002). It also grows in alluvial soils (soil deposited by the rivers).

The species usually forms large monotypic stands on landscapes with heavy calcareous and sometimes sodic soils (Mapaure 1994) This tree does not grow well outside of suitable hot, frost-free, summer rainfall area (Palgrave, 2002. Palmer et al.,1972).

2.3 Ecology

Colophospermum mopane is often deciduous in winter which is possibly an adaptation to drought since winters are dry and not so very cold in the lowveld (Grant et al., 2002). The lovely reddish new leaves appear in October in anticipation of summer rain (Palgrave, 2002). Game enjoy the protein rich leaves and pods. Elephant pressure may be part of the reason for the stunted appearance of some areas of mopane scrub. Domestic animals find the pungent leaves unpalatable at first but will feed on them once used to the taste (Palgrave, 2002).

2.4 Growing *C. mopane*

The mopane has a rather limited horticultural potential in areas outside of hot, summer rainfall of Southern Africa. It is not tolerant to cold and frost. It would be a good addition to wildlife gardens and for adding autumn and spring aesthetics. It is best grown from seed. The seedlings are initially slow growing but the growth rate speeds up once a height of 20 cm is reached (Palgrave, 2002).

2.5 Uses and Cultural Aspects

Some of its economic uses include amongst others (a) tying of kraal fences, post and hut frames through the use of their bark (Rodin, 1985), (b) provision of medicine (Mashabane *et al.*, 2001), (c) provision of firewood, timber and poles (Mojeremane et al., 2005), (d) provision of dry season browse and as food plant for mopane worms (Timberlake, 1996); and (e) promotion of traditional religious communication with ancestors (Bainbridge, 2012). It has the heaviest timbers and is apparently difficult to work with because of its hardness but this also makes it termite resistant (Palgrave, 2002).

2.6 Study sites

Figure 2. Map of Limpopo Province –Microsoft Encarta.

Two study sites were selected: Tshiungani and Mopane Bushveld. Tshiungani is about 75 km east of Messina in the Limpopo Valley. It lies in the summer rainfall

Chapter 3

Literature Review

Colophospermum mopane tree grows in hot, dry, low-lying areas in the far northern parts of southern Africa. *Colophospermum mopane* is the single dominant tree species in mopane woodland which is a major vegetation types in central and southern Africa, occupying 550,000 km^2 (Mapaure 1994). The tree is a major food source for the mopane worms which are the caterpillars of the *Imbrasia belina* moths. I believe most researchers are interested to study about the life cycle of *I. Belina* because of their economic importance in communities especially those that feed and sell them.

Like most of the plants growing in dry areas, *C. mopane* trees are believed to have an influence on neighbouring and understorey herbaceous vegetation. They have an influence on soil nutrient concentration. Soil nutrient concentrations outside canopies of small, medium and large *C. mopane* trees are similar, implying that tree size had no significant influence on soil nutrient concentrations in the tree interspaces (Mlambo et al., 2005). Mlambo (2007) also reported that mature trees seem to be the major suppliers of nutrients to the understorey herbaceous vegetation in the crown zone in the form of litter. But surprisingly, there is no or very few understorey and nearest neighbouring herbaceous vegetation in population stands of *C. mopane* dominated trees.

Above-ground competition between large trees and understorey can be minimised by tree thinning (Smit, 2005). Smit (1998) also found that thinning of *C. mopane* trees reduces competition, and thus probably leads to sufficient sunlight reaching the herbaceous vegetation and therefore resulting in a vigorous positive response by herbaceous vegetation. Forest managers on the other hand, remove understorey vegetation because they compete with large trees in the plantations for soil resources (Zhao et al., 2011).

Scholes (2010) pointed out that the recovery period after tree removal is shortened by high rainfall and lengthened by drought. Rainfall makes conditions suitable for growth of most plants. Therefore herbaceous vegetation in a cleared stand of *C. mopane* trees will probably grow faster than *C. mopane*, but because of shorter region in southern Africa, with the hot summers and cold winters. Due to the low rainfall and high evaporation rate of the Limpopo Valley, the area is classified as being semi-arid and the average annual rainfall of the area is about 330 mm, about 75% of it during November to March period. Precipitation is erratic and mostly occurs in the form of thunderstorms. An average of five rainy days per month is experienced during the rainy seasons. The rate of evaporation is very high. Average summer temperature is above 30°C.

The soil type in Tshiungani is mainly loose sand. The area is closer to Tshiungani village and cattle and goats from the area move freely in the study areas as there is no fence. There was no indication that animals or humans frequent the study area during the study. No cow dung were observed at the site(s) during the study.

Mopane Bushveld is about 80 km west of Messina in the Limpopo Valley. It also lies in the summer rainfall region in southern Africa, with the hot summers and cold winters. The average annual rainfall and temperature are almost the same in Limpopo Valley. The soil type consists mostly of white or cream-coloured sandstone. The limestone forms as a result of a water-impermeable layer close to the surface, where water accumulates but is drawn to the surface where it evaporates, leaving increased concentrations of lime at and just below the surface. The game in the area include giraffe, eland, kudu, waterbuck, red hartebeest, gemsbok, zebra, wildebeest and impala. No mopane worm droppings and bird nesting sites which had an influence on undercanopy surface soil properties were observed in all the study areas. In all study areas the landscapes are characterised by denuded soil surfaces, a lack of perennial cover and severe soil erosion.

recovery of period of *C. mopane* trees the herbaceous vegetation may be suppressed quickly again. This is supported by Chidumayo (1994, 1997) who pointed out that shoot growth in the woody components starts in the dry season, one to three months before the start of the rainy season while the growth of the grass components is largely restricted to the rainy season.

The root system has an influence on the amount of nutrients taken by the plants (Gregory, 2006). Generally *C. mopane* has a massive, shallow and spreading root system that is thought to extend up to 7.6 times the height of plant (Smit *et al* 1998) and most plants concentrate a greater proportion of their root systems within surface soils because that is where most soil nutrients are concentrated. Deep roots may allow access to deeper water during dry seasons. Cutting lateral roots in *C. mopane* may reduce competition for soil nutrients with neighbouring and understorey vegetation.

The absence of good herbaceous plant cover *in C. mopane*- dominated vegetation increases susceptibility to soil erosion (Timberlake, 1996). It can then be deduced that *C. mopane* accelerates soil erosion by suppressing herbaceous plant cover in order to expand its zone. Soil erosion then increases nutrient loss which in the end results with high competition for soil nutrients between *C. mopane* and the understory herbaceous vegetation.

Resprouting is a common response in woody plants subject to regimes of high severity which can destroy most or all above ground biomass (Hodgkinson, 1998), and it offers a competitive advantage to plants in environments with high disturbance frequency, low resource availability or where seedlings have a high probability of drought induced mortality (Bond at al., 2003). It has also been reported that resprouting is an evolutionary adaptation that enables a plant to regenerate after the destruction of its aerial parts (Bond et al., 2001) Resprouters store energy reserve so that it can be used in times of stress. Allocation of resources to storage in resprouters has tradeoffs; resprouters generally produce few flowers and floral rewards, fewer seeds, have slower growth and maturation rates (from seeds), and have fewer seedlings and poorer seedling survival than seeders (Bell 2001, Bond at al., 2001, Spooner 2005). Enright (1998) also reported that plants in environments with high disturbance frequency often possess biological attributes that increase the probability of survival and/ or recruitment following disturbance. In their investigation Bellingham and Sparrow (2000) also observed that resprouting success concerns the maintenance of the current generation, whereas seeding concerns production of future generation.

Litter accumulation on the soil surface serves as a temporary sink for nutrients which are liberated gradually, thereby guaranteeing a permanent contribution of nutrients to the soil (Burghouts et al., 1998; Mlambo et al 2008). Inorganic nutrients within litter are released to plants slowly during decomposition. Sayer (2006) reported that litter production and dynamics can control the structure and function of soil micro-organisms. Soil micro-organisms help to make nutrient available to plants. Trees directly influence organic matter additions to the soil through litterfall and the amount of energy available to meet the maintenance requirements of soil microbial community (Mlambo et al., 2007).

Descheemaeker et al., (2006) also reported that soil fertility, soil water retention, tree density, tree age structure and species composition are major factors governing litter production of woody communities within the same climatic region. However, *C. mopane* leaf litter decomposes relatively slowly and appears to be of relatively low quality because of high lignin and phenolics (Ferweda et al 2005) and as a results low litter quality could suppress decomposition by microbes (Day et al.,2007).

Open areas with bare ground or sparse grass cover are favourable sites for seedling recruitment (Mlambo et al., 2004) and erratic rainfall may account for most of the fluctuation in recruitment of *Colophospermum mopane* as it grows in hot, dry, low-lying areas. Seedlings grow fast during rainy seasons. Lindh (2003) reported that growth and establishment of tree seedlings is strongly influenced by belowground competition for moisture and nutrients.

Chapter 4

Tree cutting

The assessment of interspecific interactions between *C. mopane* trees and their understory and nearest neighbour vegetation

4.1 Study Sites

Tshiungani – Described in Chapter 2

4.2 Experimentation

An investigation into the interactions between *C. mopane* tree individuals and their understory and neighbouring vegetation.

4.3 Materials and Methods

Two 2500 m x 2500 m adjacent stands, both dominated by juveniles and adult *C. mopane* tree individuals in about equal proportion were demarcated in an extended mopane woodland vegetation area of about 10 km x 10 km in area. Random sampling was carried out by marking 50 quadrats each of 1 m x 1 m area in both stands.

We randomly saw about half the number of all *C. mopane* tree individuals in one of the two stands with sharp saws aboveground at ground and knee heights. The sawn stems and branches were left nearby their parent stumps. No *C. mopane* individuals were sawn in the other stand. Sawing was carried out during June 2010 for four days.

Necessary care was taken to cause minimal disturbance to any understory and nearest neighbour vegetation of *C. mopane* during sawing. Assessment of understory and nearest neighbour vegetation of *C. mopane* vegetation was carried out. The quadrats in both stands were then marked for easier identification during our second and other successive visits.

We made our second and third visits during September 2011 and then December 2011 to monitor any developments in both the stands; our observations were made for two full days during each of our visit, that is, during September 2011 and December 2011. Other visits to the study area was again carried out in June 2012 and December 2012;

our final visit was on the 18/06/2013 to take the photos (see Figures 4.1 and 4.2) that we deemed were necessary to have our Materials and Methods section make better sense to the reader who is unfamiliar with area.

Average vegetation percentage covers were then compared using ANOVA after their estimation.

4.4 Results

Immediately after the first rains, in September of the same year after cutting all cut *C. mopane* trees in our chosen quadrats regenerated. *Colophospermum mopane* trees soon started to cover the whole quadrat as shown in figures 4.1 and 4.2 below.

There was no significant difference observed in terms of the average vegetation percentage covers of grass and herb species growing in the quadrats where *C. mopane* trees were cut and those in quadrats were they were not cut (p = 0,34). There was no obvious change in the grass and herb vegetation composition in quadrats of stands where *C. mopane* trees were cut and where they were not cut. Tree removals did not seem to have an influence on their understory or neighbouring vegetation in the short term after rains.

Understory and neighbouring vegetation did not show any improvement in terms of growing up and expansion even three years after cutting of *C. mopane* trees (see Figure 4.1). *Colophospermum mopane* nevertheless still continued to grow and flourish; cut *C. mopane* trees were indeed seen doing very well at Tshiungani (see Figure 4.2) after regeneration as contrasted to the cut ones at Mopane Bushveld (see Figure 6.1); they all died. Spaces that were unoccupied by understory and neighbouring vegetation of *C. mopane* in stands where *C. mopane* trees were cut and uncut were still seen prevailing (see Figure 4.1). There was no obvious proof of difference in terms of understory percentage vegetation covers in both the two stands (disturbed and undisturbed) (see Figure 4.3 and Table 1).

We found *C. mopane* tree individuals recovering in the disturbed stand during our second visit in December 2011, and the grass and herb vegetation were continuing to grow and flourish; they had closed all the gaps. All the stumps of the sawn *C. mopane* were regenerating. There was no significant change in the understory and nearest neighbour percentage vegetation covers in the disturbed and undisturbed stands (see Figure 4.1).

Table 1 Analysis of variance comparison of average vegetation percentage cover per quadrat of disturbed and undisturbed stands of *C. mopane* around Tshiungani village.

	N	Sum	average	variance	P
Disturbed Quadrat	50	167	3.34	4.35	Ns
Undisturbed Quadrat	50	151	3.02	1.2	

Key: Significance level is at $p < 0.05$.

ns = not significant

** = highly significant

* = significant

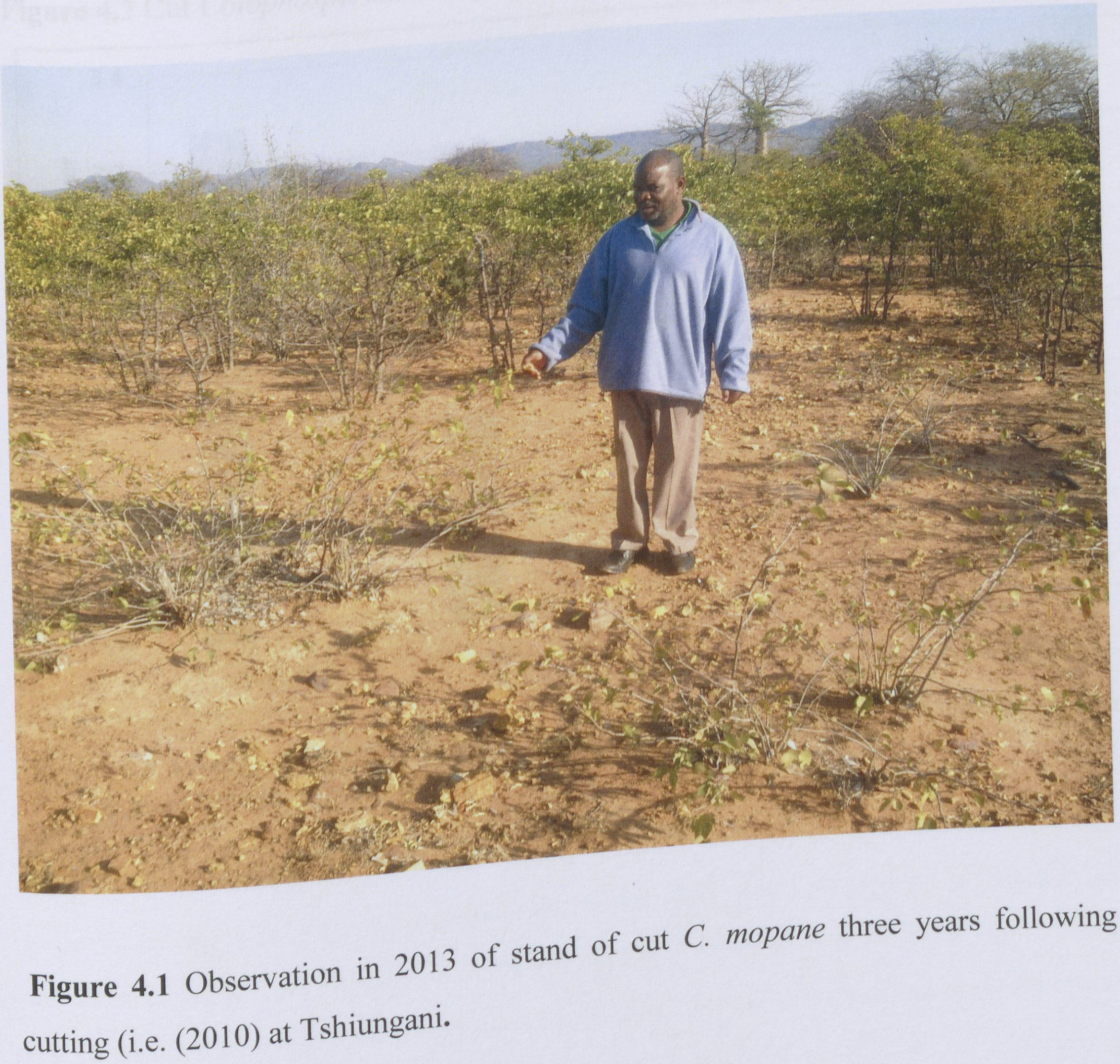

Figure 4.1 Observation in 2013 of stand of cut *C. mopane* three years following cutting (i.e. (2010) at Tshiungani.

Figure 4.2 Cut *Colophospermum mopane* after the first rains at Tshiungani.

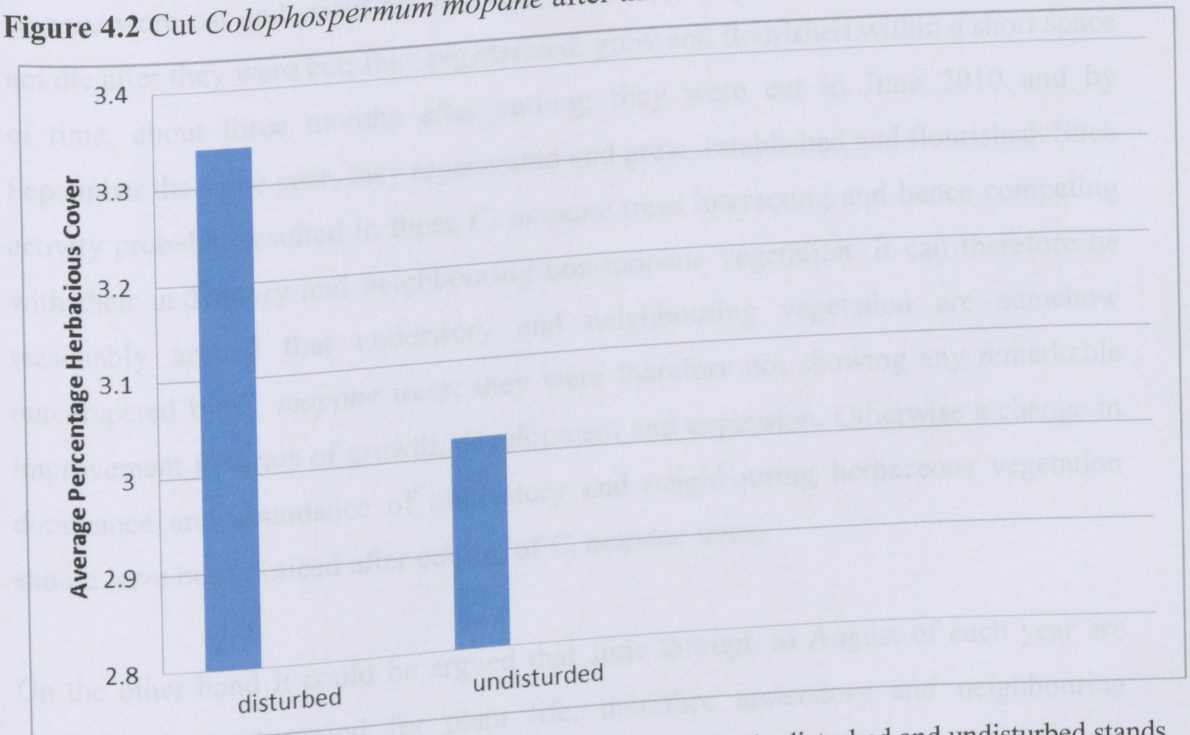

Figure 4.3 Average vegetation percentage cover per quadrat in disturbed and undisturbed stands of *C. mopane* trees in June 2013.

4.5 Discussion

The fact that all cut *C. mopane* trees regenerated immediately after the first rainfall, is an indication that only cutting without a follow up by chemical spraying does not have any fatal consequences on the trees like *C. mopane* as was the case with cut and sprayed *C. mopane* trees at Mopane Bushveld (to be discussed in Chapter 6). The resurrection of *C. mopane* after cutting is proof that they had food reserves probably in the roots plus buds which brought about regeneration after being cutting. Just cutting of trees probably does not prevent them from interacting with their neighbours be it of similar species or different ones; otherwise we should have seen understory and nearest neighbour vegetation doing well after cutting of *C. mopane* trees at Tshiungani. This manifestation does not necessarily imply no competition between understory and nearest neighbour vegetation with *C. mopane* trees; competition might somehow be at a limited degree.

Average understory and nearest neighbour vegetation covers of stands where *C. mopane* were cut and uncut did not differ probably because cut *C. mopane* trees did not die after they were cut; they regenerated, grew and flourished within a short space of time, about three months after cutting; they were cut in June 2010 and by September the same year, they regenerated and grew, established and flourished. Such activity probably resulted in those *C. mopane* trees interacting and hence competing with their understory and neighbouring non-mopane vegetation. It can therefore be reasonably argued that understory and neighbouring vegetation are somehow outcompeted by *C. mopane* trees; they were therefore not showing any remarkable improvement in terms of growth, development and expansion. Otherwise a change in dominance and abundance of understory and neighbouring herbaceous vegetation should have been noticed after cutting of *C. mopane* trees.

On the other hand it could be argued that June through to August of each year are generally dormant period for plant life, therefore understory and neighbouring vegetation of *C. mopane* might have been in their dormant phases. The foregone statement is somehow diluted by the fact that even three years later both the understory and neighbouring herbaceous vegetation in *C. mopane* stands did not improve in terms of growing up and expansion, they were somehow still in similar standing as they were three years before cutting *C. mopane* trees. This is therefore strong confirmation that cut *C. mopane* trees never stopped interacting and somehow competing with their understory and nearest neighbour vegetation even after they were cut.

In his investigations, Mlambo (2010) observed that decomposition was fastest in the intercanopy area exposed to solar radiation and that the concentrations of soil nutrients beneath trees increased with tree size. This should have a positive influence on the growth of grasses and herbs under and near *C. mopane* dominant stands. This is contrary to what we have observed at Tshiungani where we found no difference in terms of average vegetation covers in intercanopy areas and understorey areas of *C. mopane* trees.

4.6 Conclusion.

From the observation made after the first rain and during subsequent visits it was clear that any form of competition between *C. mopane* and the understorey and nearest neighbour vegetation never stopped even after cutting of *C. mopane* trees (see Figure 4.1). The understory grass and herbaceous vegetation was the same in and outside the disturbed and undisturbed stands of *C. mopane* tree individuals; after the first rain. *Colophospermum mopane* dominated stands somehow still supported similar amount of grass and herbaceous vegetation cover that was supported by the stands with about half *C. mopane* trees randomly cut.

Chapter 5

Tree root trenching

5.1 Study sites.

Tshiungani – Described in Chapter 2.

5.2 Experimentation

An investigation into the effects of *Colophospermum mopane* on both their understorey and nearest neighbour vegetation.

5.3 Materials and Methods

Two 2500 m x 2500 m adjacent stands, both dominated by juveniles and adult *C. mopane* tree individuals in about equal proportion were demarcated in an extended mopane woodland vegetation area of about 10 km x 10 km in area. Random sampling was carried out by marking 50 quadrats each of 3 m x 3 m area in both stands.

Fifty *C. mopane* trees composed of both juveniles and adults were randomly selected in the study area from the two chosen stands. Root trenching were done during June 2010 for six days.

The lateral roots of *C. mopane* were dug, exposed and cut, and then the parent trees were then immediately on the same day covered with the same dug soil (see Figures 5.1, 5.2, 5.3 and 5.4). Minimal soil disturbances under and nearest to the *C. mopane* trees were caused. Only the side roots (except the taproots) of the trees were cut using a sharp saws and no other plant parts were damaged in the process. The dug portion under the trees and the uncut taproots were carefully covered on the same day immediately after cutting other roots (see Figure 5.4). All the affected *C. mopane* individual trees were marked and recorded to facilitate identification of treated individuals during successive visits.

We made our second and third visits during September 2011 and then December 2011 to monitor any developments in both the stands; our observations were made for two full days during each of our visit, that is, during September 2011 and December 2011.

Other visits to the study area was again carried out in June 2012 and December 2012; our final visit was on the 11/06/2013 to take the photos (see Figure 5.5) that we deemed were necessary to have our Materials and Methods section make better sense to the reader who is unfamiliar with area.

Average vegetation percentage covers of grass and herbs were then compared using ANOVA after their estimation.

Any root competitive interaction between *C. mopane,* and their understory and nearest neighbour vegetation was not necessarily entirely removed when all *C. mopane* tree individuals had their lateral roots trenched; only lateral roots were cut but and the tree were therefore not left to die.

Figure 5.1 Digging of *C. mopane* tree individual

Figure 5.2 *Colophospermum mopane* showing root suckering.

Figure 5.3 *Colophospermum mopane* showing root suckering

Figure 5.4 *Colophospermum mopane* tree after lateral roots were trenched and the parent tree immediately on the same day covered with the same dug soil.

5.4 Results

Three months after trenching all *C. mopane* trees were found responding as if nothing had happened to some of their roots. They appeared like any other *C. mopane* trees in their vicinity which were not trenched (see Figures 5.4 and 5.5**).** Similarly in three years' time the same trenched *C. mopane* trees showed no sign of having been disturbed; they were growing and flourishing whilst their understory and neighbouring vegetation showed no significant improvement in terms of establishment, growth, development and flourishing (see Figure 5.5). The understory and nearest neighbour vegetation were in similar standing pre- and post- trenching of *C. mopane* trees during both three months and three years observations. Trenching of some roots of C. *mopane* tree individuals, that is, lateral roots, did not have any significant effect regarding changing the status of their understory and nearest neighbour vegetation; they stayed somehow stagnant for a period of three years (see Table 2).

There was also no significant differences between the average vegetation percentage covers of the herbaceous vegetation under and nearest to the trenched and non-trenched C. *mopane* trees ($p = 0.67$)(see Figure 5.6 and Table 2). None of the herbaceous vegetation did seem to capitalize from the disturbance of their neighbouring *C. mopane* trees. There was therefore no evidence of competitive interactions between *C. mopane* tree individuals and their understory and nearest neighbour herbaceous vegetation.

Figure 5.5 Root trenched *C. mopane* individuals photographed three months later immediately one week after rain.

Table 2. Average herbaceous percentage cover and variance per quadrat next to trenched C. *mopane* (where all lateral roots were cut) and non trenched quadrat (where there was no disturbance).

	N	Sum	average	variance	P
Trenched	50	159	3.18	3.13	ns
Non trenched	50	156	3.32	2.34	

Key: Significance level is at $p < 0.05$.

ns = not significant

** = highly significant

* = significant

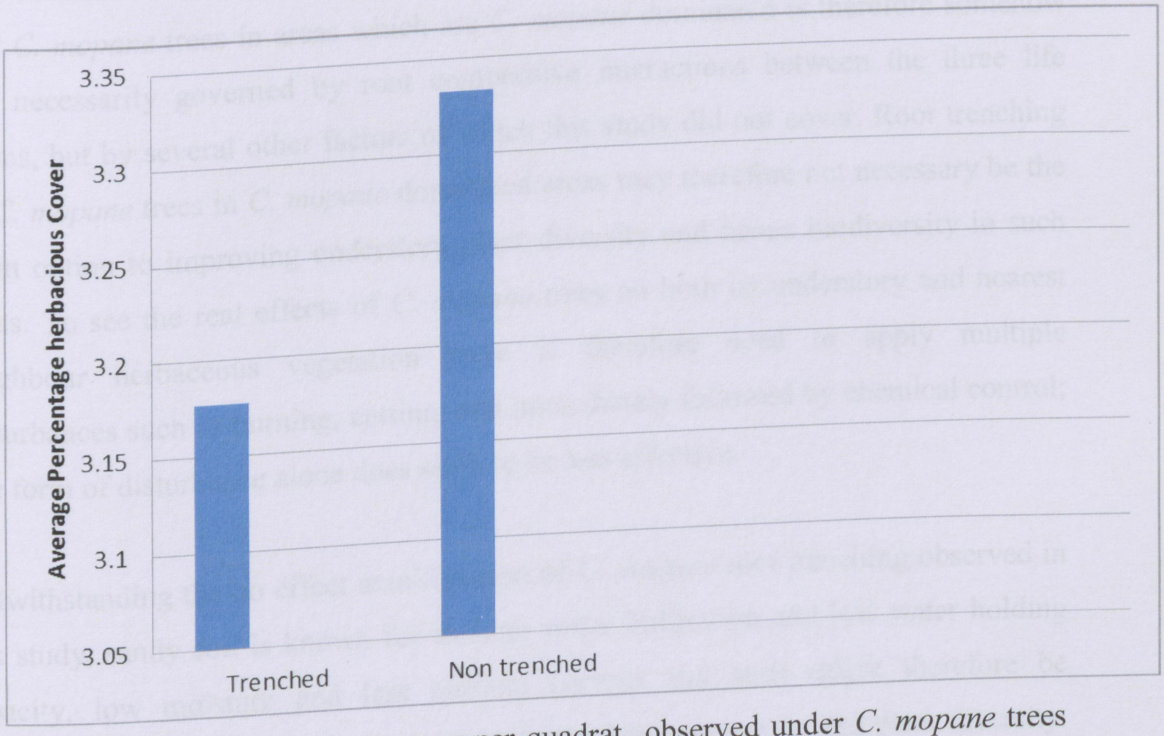

Figure 5.6. Average percentage cover per quadrat observed under *C. mopane* trees which were trenched and non-trenched (those in open space) observed in 2013.

5.5 Discussion

Colophospermum mopane trees did not show any deterioration three months and three years following root trenching. This manifestation might be strong indication that root trenching alone is not enough to cause any negative effect on the life of *C. mopane* trees. Understory and nearest neighbour low lying vegetation in the stands of *C. mopane* three months and also three years later neither responded positively or negatively to root trenching of *C. mopane* trees thereof, and such is a reflection that competition if any between *C. mopane* trees and their understory and neighbouring herbaceous vegetation may not be root competition, or root competition may not be very strong. For the whole period of three years there was fairly enough rain falling in the semi-arid area of Tshiungani which should have stimulated improvement in terms of growth and establishment of understory and neighbouring herbaceous vegetation in the stands of *C. mopane*, that is, if there is root competition between *C. mopane* and both its understory and herbaceous vegetation.

The coexistence of both the understory and nearest neighbour herbaceous vegetation and *C. mopane* trees in areas which are *C. mopane* dominated is therefore somehow not necessarily governed by root competitive interactions between the three life forms, but by several other factors of which this study did not cover. Root trenching of *C. mopane* trees in *C. mopane* dominated areas may therefore not necessary be the main option to improving understory plant diversity and hence biodiversity in such areas. To see the real effects of *C. mopane* trees on both its understory and nearest neighbour herbaceous vegetation there is therefore need to apply multiple disturbances such as burning, cutting, and immediately followed by chemical control; one form of disturbance alone does seem to be less effective.

Notwithstanding the no effect manifestation of *C. mopane* root trenching observed in this study, sandy soil is known for its high water infiltration and low water holding capacity, low moisture and less nutrient content and such might therefore be contributing to supporting both low vegetation percentage covers and plant diversity. As a result the low lying vegetation percentage covers in *C. mopane* dominated stands should reasonably be sparsely distributed; such soil type would generally also support less number of plant species.

5.6 Conclusion

From the observation made after the first rain and other subsequent visits, there was no evidence of any obvious competition between trenched *C. mopane* trees and their understory grass and herbaceous vegetation. The understory grass and herbaceous vegetation covers in stand of trenched *C. mopane* trees and one where no trenching was carried out was also almost similar.

6.1 Study Sites

Mopani Bushveld – Described in Chapter 2.

6.2 Experimentation

The response of grass and herb vegetation in the disturbed and undisturbed stands of *Colophospermum mopane* tree individuals

6.3 Materials and methods

Two 2500 m x 2500 m stands, one composed of both juveniles and adult *C. mopane* tree individuals in almost equal proportion and another one disturbed by sawing all C. mopane tree individuals three years (i.e., June 2007) before our first visit, were demarcated in a mopane woodland vegetation area. Random sampling was carried out by marking 50 quadrats each of 1 m x 1 m quadrats in both stands.

All *C. mopane* tree individuals in the disturbed stand were sawn with sharp saws aboveground at knee height followed by chemical spraying of Garlon Four Herbicide (personal communication with the Farm Manager of Mopane Bushveld). The sawn trees were left in the stand in such a way that grazing and browsing animals were able to access and leave the stand with ease (personal communication with the Farm Manager of Mopane Bushveld). Data sampling (i.e., estimation of vegetation percentage covers of understory and nearest neighbour vegetation in disturbed and undisturbed stands) was carried out during June 2010 for one full week; *C. mopane* trees were not actively growing then. All C. mopane tree individuals in the experimental (disturbed) stand were sawn. Care was taken during sawing to cause fairly minimal disturbance on the soil in the stand. The quadrats were then marked for easy identification during our second and other successive visits.

We made our second visit to Mopane Bushveld in December 2011; our observations in both the disturbed and undisturbed stands took us two days.

Average vegetation percentage covers were then compared using ANOVA after estimation (see Table 3).

Figure 6.1 Undisturbed *Colophospermum mopane* stand.

Figure 6.2 Disturbed *C. mopane* stand (grasses and herbs continuing to grow and flourish three years after complete removal of *C. mopane* tree individuals).

6.4 Results

Low lying (grass and herb) vegetation started to grow and establish well three months later after disturbance in the disturbed area immediately after the first rainfall had occurred (personal communication with Mopane Bushveld Farm Manager). The dominant vegetation on the site was *C. mopane* trees with very few sparsely distributed understory vegetation surviving before cutting of *C. mopane* individuals (see Figure 6.1 - personal communication). It is clear in figure 6.1 that in sites where *C. mopane* dominated understory vegetation was indeed sparsely distributed.

It was only one year later following cutting of *C. mopane* followed by chemical (Garlon Four Herbicide) spraying on the sawn ends of *C. mopane* individual plants that grasses and herbs were seen starting to grow, establish, develop and flourish. Second and third years after disturbance saw the grasses and herbs in the disturbed *C. mopane* stands flourishing and dominating; no *C. mopane* trees were seen resprouting (see Figure 6.2). Figure 6.2 clearly shows no or very few open spaces after *C. mopane* were eradicated; all the open extended spaces which used to prevail before *C. mopane* trees were sawn are almost covered by grasses and herbs (see Figure 6.2).

The following plant species were found to occur in the disturbed area after the demise of *C. mopane* trees: *Corchorus asplenifolius, Melhalia acuminata, Indigofera hedyantha, Ledebouria sandersonii, Aspalathus chortophila, Ornithogalum juncifolium, Eragrostis rigidor* and *Aristida meridionalis*.

The aftermath of chopping down all of the *C. mopane* trees were dead dry tree branches and dead leaves (leaf litter); the leaves have since then dried out and probably decomposed whilst some of the dead dry branches are still seen strewn in some sections of the disturbed area (see Figure 6.2).

The results of average vegetation percentage covers of grasses and herbs per quadrat in cut and intact stands of *C. mopane* were statistically analysed using ANOVA; such analysis proved highly significant difference between *C. mopane* dominated stand and one where *C. mopane* trees were completely cleared (see Figure 6.3 and Table 3).

Table 3 Statistical analysis (ANOVA) on average vegetation percentage covers per quadrat between disturbed and undisturbed stands of *C. mopane*.

Stands	N	Sum	Average	Variance	P
Cut	50	2280	45.6	224.1	**
Intact	50	625	12.5	62.5	

Key: Significance level is at $p < 0.05$.

ns = not significant

** = highly significant

* = significant

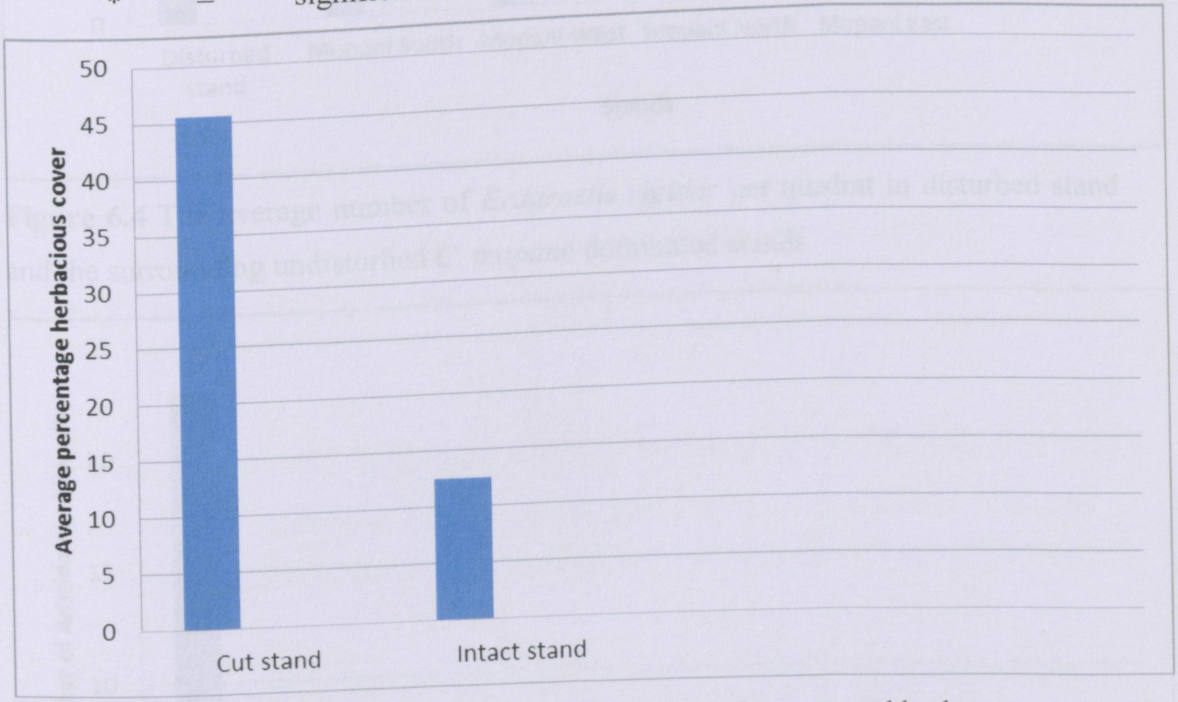

Figure 6.3 The average vegetation percentage covers of grasses and herbs per quadrat in cut and intact stands of *C. mopane*.

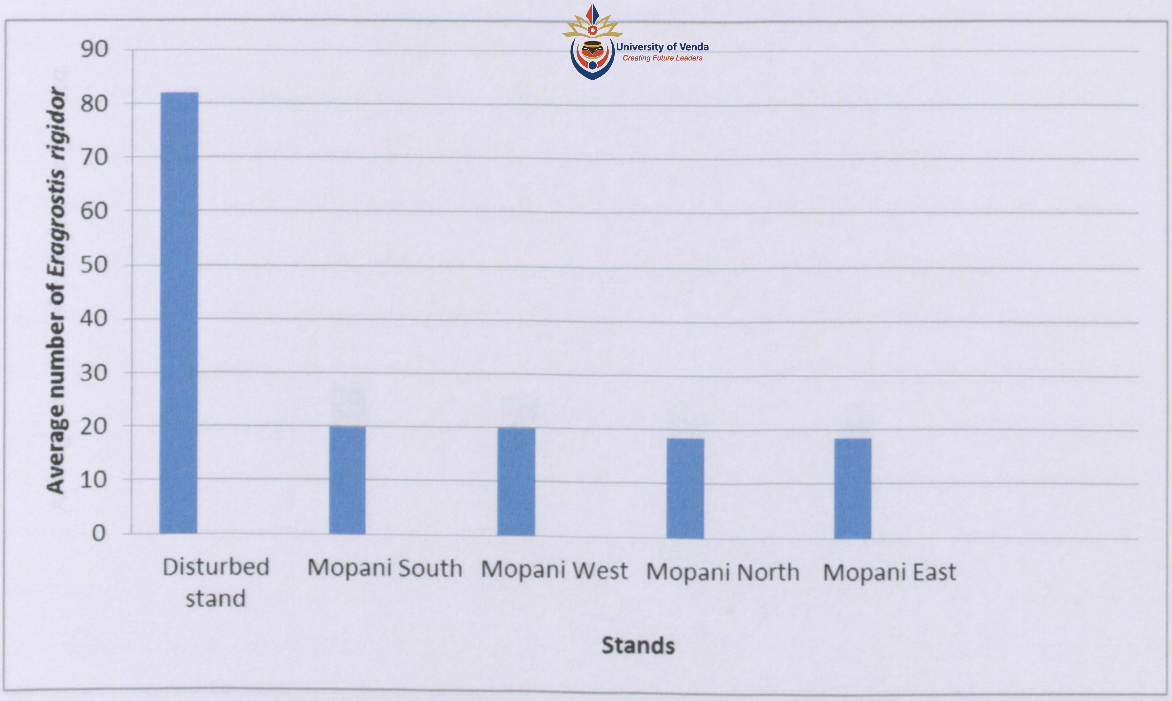

Figure 6.4 The average number of *Eragrostis rigidor* per quadrat in disturbed stand and the surrounding undisturbed *C. mopane* dominated stands.

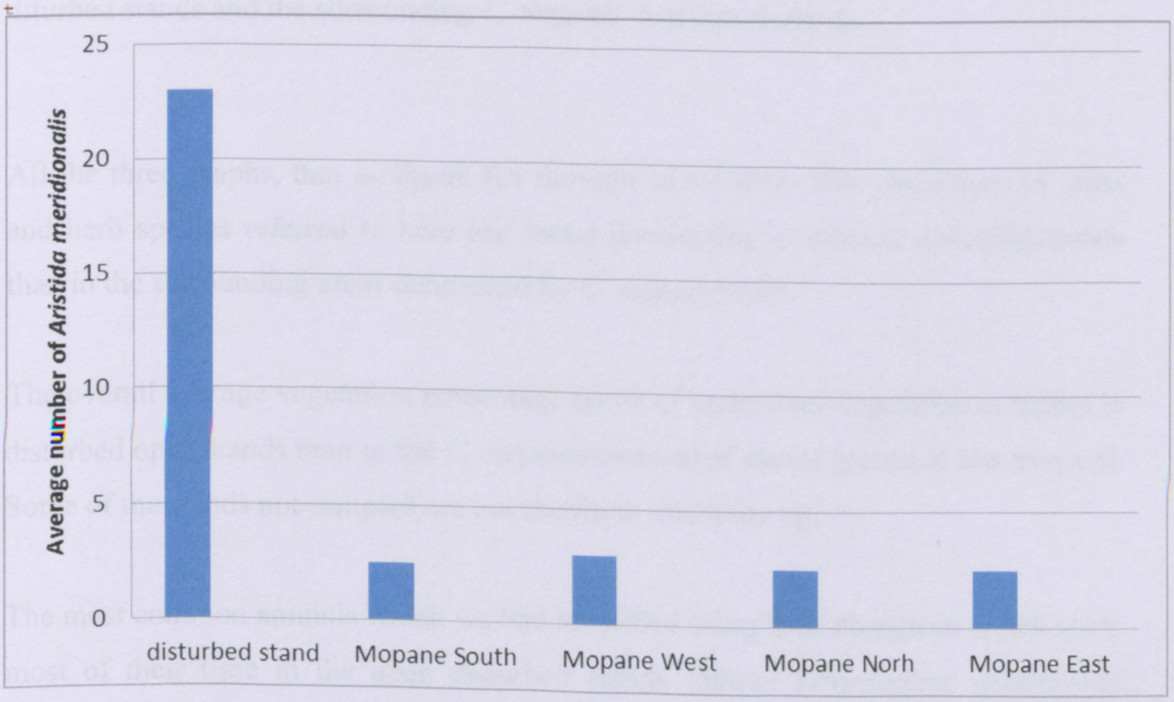

Figure 6.5 The average number of *Aristida meridionalis* per quadrats in opened disturbed stands and the surrounding *C. mopane* dominated stands.

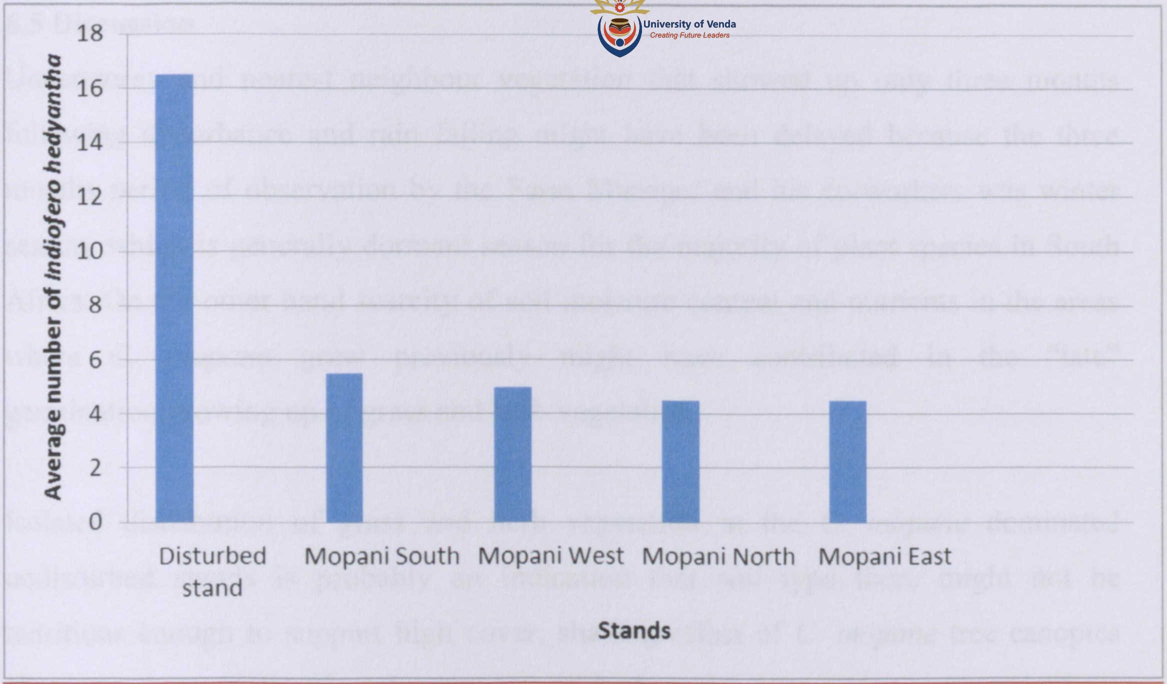

Figure 6.6 The average number of *Indigofera hedyantha* per quadrat in opened diturbed stands and the surrounding *C. mopane* dominated stands.

All the three graphs, that is, figure 6.4 through to 6.6 show that abundance of grass and herb species referred to here are found dominating in cleared disturbed stands than in the surrounding areas dominated by *C. mopane* trees.

The overall average vegetation percentage cover of understory vegetation is higher in disturbed open stands than in the *C. mopane* dominated stands (personal observation). Some of the stands not sampled are not shown in this write up.

The most common animals which we had identified using their droppings which spent most of their time in the open disturbed stands follow: *Tragelaphus strepsiceros* (kudu), *Equus quagga* (zebra), *Taurotragus oryx* (eland), *Aepyceros melampus* (impala), *Sylvicapra grimmia* (duiker) and *Lepus europaeus* (scrub-hare); they did not seem to have any noticeable negative effects on the grass and herb cover though.

6.5 Discussion

Understorey and nearest neighbour vegetation that showed up only three months following disturbance and rain falling might have been delayed because the three months period of observation by the Farm Manager and his co-workers was winter season, which is generally dormant season for the majority of plant species in South Africa. On the other hand scarcity of soil moisture content and nutrients in the areas where *C. mopane* grew previously might have contributed in the "late" germination/growing up of grass and herb vegetation.

Isolated distribution of grass and herb vegetation in the *C. mopane* dominated undisturbed stands is probably an indication that soil type there might not be nutritious enough to support high cover; shading effect of *C. mopane* tree canopies also contribute in limiting the number of both understory and nearest neighbour vegetation.

Competition for light, soil moisture content and limited nutrients between *C. mopane* and understory vegetation is obviously playing a prime role in preventing the prevalence of understory vegetation; understory vegetation are probably suppressed by *C. mopane* trees. *Colophospermum mopane* trees always dominate and prevail wherever they are in their stands. Understory vegetation are sparse and sometimes are almost absent with ground under *C. mopane* entirely bare. Whether there might be any allelopathic effects from *C. mopane* to understory vegetation was not investigated by this current study; this nevertheless may not be ruled out.

The disturbed stands that we had studied had their *C. mopane* trees cut and then chemically controlled by spraying their sawn ends with Garlon Four Herbicide; such kinds of disturbances obviously contributed in completely barring *C. mopane* trees from resprouting; all "cut" trees died. The grasses and herbs that established thereafter showed very good life; they grew, flourished and eventually entirely filled all the stands which were previously dominated by *C. mopane* tree individuals. The fact is that all *C. mopane* tree individuals that were "cut" and sprayed by Garlon Four Herbicide were totally rendered inactive by killing them, and such completely removed competition between grasses-herbs and C. *mopane* trees; such action wholely benefitted grasses and herbs with the result that they continued growing and flourishing uninterrupted. They were therefore during our observation three and half years later after "wiping out" all *C. mopane* trees found closing almost all the gaps left behind by dead *C. mopane* trees.

Dead branches and decomposed leaves of cut *C. mopane* trees plus dung of the animals such as *Tragelaphus strepsiceros* (kudu), *Equus quagga* (zebra), *Taurotragus oryx* (eland), *Aepyceros melampus* (impala), *Sylvicapra grimmia* (duiker) and *Lepus europaeus* (scrub-hare) that visited the disturbed stands contributed to enhancing soil fertility of the stands that were formerly vegetated and dominated by *C. mopane* trees. Such is manifested by the dominance, prevalence and flourishing of the grasses and herbs in those stands where C. *mopane* trees were completely and fatally removed.

The significant difference results shown statistically through the use of ANOVA is confirmation that the interaction between *C. mopane* and its understory vegetation at Mopani Bushveld is indeed negative. This therefore implies that plant species diversity and hence biodiversity is discouraged in stands where *C. mopane* trees dominate at Mopane Bushveld and this manifestation could be existing in other areas outside the bounds of Mopane Bushveld.

6.6 Conclusion

Any interactive competitive interactions between *C. mopane,* and their understory and nearest neighbour vegetation was entirely removed when all *C. mopane* tree individuals were cleared. When *C. mopane* trees are killed completely using chemicals or herbicides understory and nearest neighbour vegetation should flourish. This is because such vegetation can use resources such as moisture, nutrients and sunlight with less interference.

Chapter 7

Reproduction

7.1 Survival strategies of C. mopane

7.2 Study sites

Mopane Bushveld and Tshiungani – Described in Chapter 2

7.3 Materials and Methods

Very young small plants of *C. mopane* were identified in all the four stands, two per study site, that were identified for this study. Fifty very young plants ("seedlings") were chosen per 2500 m x 2500 m stand; they were then dug out to establish whether they were seedlings or root suckers. Of all the young plants dug out and uprooted we found all of them being seedlings at their early stages of development.

On the other hand we dug out fifty adult plants of *C. mopane* to establish whether they were undergoing root suckering or not.

We also carried out cutting experiments wherein fifty individuals were cut at both ground and knee levels. A period of three months was allowed to lapse before checking whether the individuals will resprout or not. We were fortunate to have rainfall pouring three to four times during the period between cutting and observation.

7.4 Results

7.4.1 Seed production and germination

Colophospermum. mopane trees produce greenish cream flowers which are inconspicuous (personal observation and communication). Many pods, which are flattened, kidney shaped and indehiscent are produced (see Figure 7.1). They are dispersed mainly by wind during dry season (personal observation). We found numerous seeds germinating and producing many seedlings in our areas of observation (see Figures 7.2 and 7.3) following a number of days of rainfall. Germination of the seeds is prolific in years of relatively high rainfall and fairly low in years of relatively low rainfall (personal observation). Numerous seedlings are observable under and in the neighbourhood of *C. mopane* individuals (Palgrave, 1988 and personal observation).

The seeds also germinate easily provided they are planted while still in the pods, but seedlings are slow growing and are susceptible to damping off (Palgrave, 1988).

7.4.2 Root suckering

In addition to seed production *C. mopane* trees also use root suckering as a method of reproduction (see Figure 7.4 and 7.5). Root suckering in *C. mopane* trees is very common in areas where fire frequency is very high; fire frequency does disturb flowering though. The tree above and others where we had found root suckering occurring had fires scars on them. Out of fifty dug and excavated individuals we found forty of them root suckering.

7.4.3 Resprouting

Tree individuals of *C. mopane* both cut at knee and ground levels were found resprouting vigorously three months following cutting (see Figures 7.6 and 7.7). It rained about three times before resprouting occurred. Even three years following cutting individual *C. mopane* were seen continuing to have their sprouts growing and flourishing. They were never seen dying for the whole period up till 2013 when we made our final observation. Hundred percent of all the cut tree individuals of C. mopane were found resprouting and producing numerous seeds and seedlings. Our findings are not in agreement with Bell (2001), Bond and Midgley (2001) and Spooner (2005) who reported that resprouters generally produce few flowers and fewer seeds, and have fewer seedlings and poorer seedling survival than seeders.

Figure 7.1 Colophospermum mopane seeds before germination.

Figure 7.2 Colophospermum seedlings.

Figure 7.3 Colophospermum mopane seedlings

Figure 7.4 *Colophospermum mopane* showing root suckering.

Figure 7.5 *Colophospermum mopane* showing root suckering

Figure 7.6 Cut *Colophosremum mopane* resprouting.

Figure 7.7 Cut C. mopane juvenile resprouting.

7.5 Discussion

7.5.1 Seed production and germination

During years of good rainfall in semi-arid areas dominated by *C. mopane* woodland vegetation, branches of live *C. mopane* trees are seen studded with seeds containing brownish pods. A number of such seeds do germinate following good rains.

The fact that many seeds were found germinating and growing up three months and also three years after cutting following good rains indicated that reproduction through seeds is common. Numerous seedlings were mainly observable under and in the neighbourhood of *C. mopane* individuals after rain (personal observation). Our observation are in concord with the following findings: Open areas with bare ground or sparse grass cover were favourable sites for seedling recruitment (Mlambo et al., 2004) and erratic rainfall may account for most of the fluctuation in recruitment of *Colophospermum mopane* as it grows in hot, dry, low-lying areas. Seedlings grow fast during rainy seasons. Lindh (2003) reported that growth and establishment of tree seedlings is strongly influenced by belowground competition for moisture and nutrients.

7.5.2 Root suckering

We found root suckering occurring but such was only in *C. mopane* trees that were having fire scars; this prompted us to conclude that root suckering in *C. mopane* is probably stimulated by fire. We nevertheless realize no common occurrence of root suckering in *C. mopane*; we therefore think that such is because there is less fire taking place in their areas of occurrence; their habitats are semi-arid with less burning fuel to bring about enough burning fire.

7.5.3 Resprouting

This method of reproduction was found common; such observations prompted us to strongly believe that cutting is a good method of encouraging resprouting; both juveniles and adults all seem to be advantaged by cutting. Many savanna bush/tree individuals such as *Acacia karroo, Burkea africana, Dichrostachys cinerea, Terminalia sericea* and so on are encouraged to resprout vigorously following cutting and of course at good times of the year, mainly winter season is good for cutting (personal observation). Neke et al., (2006) reported on many savanna woody plant species resprouting or coppicing vigorously growing new shoots from roots and stumps following the damage or removal of above ground parts. They would be seen resprouting in early summer season (personal observation). Other forms of disturbances such as fire also play a role in activating resprouting (personal observation). Where plants are exposed to frequent disturbances, such as fire in tropical savannas many woody species are reported to sprout from lignotubers and other underground tissues (Bond *et al*., 2001). We nevertheless found no lignotubers in *C. mopane* trees but sprouting was indeed impressive and we believe that such regrowth is from the lateral roots; the fact that sprouting also came from the stems is indication that some food reserves and buds do occur in the *C. mopane* stems.

Chapter 8

Plant – Animal Interactions

8.1 Study Sites

Mopani Bushveld - Described in Chapter 2.

8.2 Materials and Methods

In pursuit of investigating plant-animal interactions we collected dungs of different animals from both the 2000 m x 2000 m stands. Huge numbers of dung of different animals were collected from a stand were all *C. mopane* were sawn and sprayed with Garlon Four Herbicide; whilst few dungs also of different animals were collected from an undisturbed 2500 m x 2500 m stand. We did not know what animals which excreted those dungs and accordingly we consulted with the Farm Manager and also with the Nylsvley Nature Reserve Rangers for dungs identification. The Farm Manager and the Nylsvley Nature Reserve Rangers were all of great assistance to us; they identified all the animals through the use of the animal dungs that we had taken to them. The most common animals which spent more time in the open (disturbed) and in the closed (undisturbed) stands were as follows: *Tragelaphus strepsiceros* (kudu), *Equus quagga*(zebra), *Taurotragus oryx*(eland), *Aepyceros melampus* (impala), *Sylvicapra grimmia* (duiker) and *Lepus europaeus* (scrub-hare). The following plant species were found to occur more in the disturbed area than in the undisturbed area after the demise of *C. mopane* trees: *Corchorus asplenifolius, Melhalia acuminata, Indigofera hedyantha, Ledebouria sandersonii, Aspalathus chortophila, Ornithogalum juncifolium, Eragrostis rigidor* and *Aristida meridionalis*.

Results of average number of dungs per quadrat were analysed using ANOVA (see Table 4); such average number of dungs per quadrat were also represented graphically (see Figure 8).

8.3 Results

We found big numbers of dung in disturbed stand than in undisturbed stand; the average difference between the dungs found in the disturbed and undisturbed stands was found to be statistically significant. We found the same type of animals but in different frequencies visiting both the stands. Disturbed stand was found to be visited more frequently than the undisturbed stand. The following animals were found to be frequent guests to our stands: *Tragelaphus strepsiceros* (kudu), *Equus quagga*(zebra), *Taurotragus oryx*(eland), *Aepyceros melampus* (impala), *Sylvicapra grimmia* (duiker) and *Lepus europaeus* (scrub-hare).

The identified animals seemed to be more attracted to grassy stands than to stands dominated by *Colophospermum mopane*. These can be seen by the number of droppings in the open spaces as contrasted to the ones in the closed stands (see Figure 8). We found more bones of dead animals in the undisturbed stand than in the disturbed stand.

Interspaces between *C. mopane* had fewer grasses and herbs growing in them whereas grasses and herbs dominated in disturbed the stand; this observation implies that majority of grasses and herbs prefer to establish, grow, develop and flourish in open areas than in closed areas. Animals also preferred feeding on grasses and herbs in open stand than in closed ones; which might be an indication that animals feel safe from predators in open areas than in closed ones. On the other hand it could be argued that grasses and herbs in open areas where there is less competition between them and trees might be more palatable than ones which in under canopies of *C. mopane* where competition might be occurring. This study could nevertheless not go into the testing of whether there is differing palatability in grasses and herbs occurring on the two stands.

The following are plant species which were found to be fed upon by the identified animals: *Corchorus asplenifolius, Melhalia acuminata, Indigofera hedyantha, Ledebouria sandersonii, Aspalathus chortophila, Ornithogalum juncifolium, Eragrostis rigidor* and *Aristida meridionalis*; feeding on those plants was more in the disturbed stand than in the undisturbed stand.

In order to establish whether the identified animals feed upon the identified plants or not, we checked whether such plants were browsed/grazed or not.

Table 4. Average number of animal droppings per quadrat in disturbed (where all trees were cut) and undisturbed stands (where there was no disturbance)

Stand	N	Sum	Average	Variance	p
Disturbed	50	109	2.18	3.53	**
Undisturbed	50	6	0.12	0.1	

Key: Significance level is at $p < 0.05$.

ns = not significant

** = highly significant

* = significant

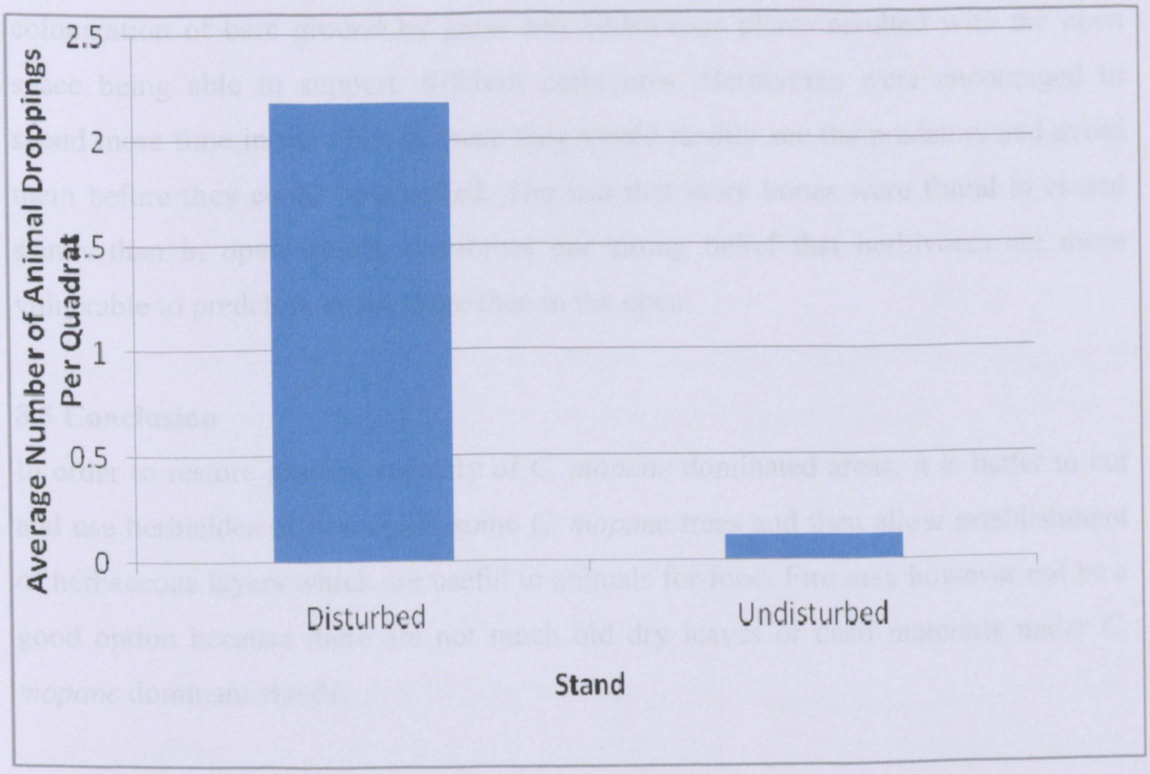

Figure 8 Average number of animal droppings found in disturbed and undisturbed stands

8.4 Discussion

Such is an indication that the predators hid thereof to ambush their prey. The presence of the droppings in the open stands probably fertilizes the soil and these therefore result with more plant species taking advantage and hence establishing, growing and developing there. The decaying cut down *C. mopane* tree branches, leaves and stems also contributed to the fertility of the soil.

It took three months for nutritious herbs and grasses to cover the whole stand created quickly and animals to move into these areas. The animals utilize the new food resources because there are very few under the *C. mopane* tree individuals or in the surrounding area. Britz et al., (2007) reported that an increase in tree cover leads to reduced productivity and profitability; and soil fertility has been found to be higher around dead trees than under live trees (Ludwig *et al.,* 2004). It appears that in *C. mopane* stands grasses and other understory plants are reduced or eliminated and most grazers prefer open spaces where there are more grasses (see figure 8). A quick colonization of bare ground by grass and herbaceous plants resulted with the open space being able to support different herbivores. Herbivores were encouraged to spend more time in the open because they would readily see the predators and avoid them before they could be attacked. The fact that more bones were found in closed stands than in open stands, reinforces our strong belief that herbivores are more vulnerable to predators attack there than in the open.

8.5 Conclusion

In order to restore grazing capacity of *C. mopane* dominated areas, it is better to cut and use herbicides or fire to kill some *C. mopane* trees and then allow establishment of herbaceous layers which are useful to animals for food. Fire may however not be a good option because there are not much old dry leaves or dead materials under *C. mopane* dominant stands.

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competing with their understory and nearest neighbour vegetation even after they were cut.

In his investigations, Mlambo (2010) observed that decomposition was fastest in the intercanopy area exposed to solar radiation and that the concentrations of soil nutrients beneath trees increased with tree size. This should have a positive influence on the growth of grasses and herbs under and near *C. mopane* dominant stands. This is contrary to what we have observed at Tshiungani where we found no difference in terms of average vegetation covers in intercanopy areas and understorey areas of *C. mopane* trees.

4.6 Conclusion.

From the observation made after the first rain and during subsequent visits it was clear that any form of competition between *C. mopane* and the understorey and nearest neighbour vegetation never stopped even after cutting of *C. mopane* trees (see Figure 4.1). The understory grass and herbaceous vegetation was the same in and outside the disturbed and undisturbed stands of *C. mopane* tree individuals; after the first rain. *Colophospermum mopane* dominated stands somehow still supported similar amount of grass and herbaceous vegetation cover that was supported by the stands with about half *C. mopane* trees randomly cut.