Work Integrated Learning: Research Project Report

An investigation of the survival of planted *Acacia erioloba* saplings on the NamibRand Nature Reserve, and factors influencing it.

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1. INTRODUCTION

In recent years many trees have been cut down. This has been due to issues such as population growth and lack of employment that cause people to cut down trees due to poverty and lack of quality education. Many people living in rural areas and urban settlements cannot afford electricity therefore they collect wood for fire, to cook, build and heat up their homes. Trees are also cut down to clear land for agricultural purposes and cattle-raising, resulting in deforestation and increased levels of CO_2 in the atmosphere. Therefore, it has become imperative that more trees are planted. This will help reduce the increase in the amount of atmospheric carbon dioxide.

Planting trees is not just to green the land but they are important because they absorb CO_2 and produce oxygen for us. In our environment trees create recreational opportunities such as camping, for nature study purposes and other outdoor experiences. They also provide shade to wildlife, especially animals that live in very hot environments where temperaturea can get as warm as 40°C, like in the desert. In areas that receive high rainfall trees help to lessen flooding (Kirnbauer et al, 2013) and by slowing the flow in rivers, they enable the recharge of our underground aquifers. Therefore, investigating the survival of the trees we plant is important because it gives answers about how many planted trees survived. This is needed to quide future tree planting programmes, to enhance tree survival and so help us to achieve the ecosystem services that the tree planting initiatives strive to achieve.

When trees are planted, factors such as weather, temperature, rainfall and animals plays a role in the establishment of trees. However, to ensure that the the trees we plant in future will survive, we need to monitor what is happening to the trees we have already planted. We need to be able to identify problems at an early stage, to help us make adjustments to our management of trees in future. Tree growth shows how well trees are adapting to the environmental conditions like weather, especially rainfall. Therefore tree growth is a useful indicator of how healthy the environment is (Dobbertin & Schroeck, 2013) and an important way to investigate how well they are surviving after planting.

NaDEET undertook a tree planting initiative in the NamibRand Nature Reserve in 2020 and the management wanted to know how well the tree saplings were surviving and what factors play a role in their survival.

This study investigated 300, *A. erioloba* saplings that were planted using cocoon technology. The Cocoon is small water reservoir made of thick cardboard paper so that it is biodegradable which is used for sapling growth because it helps to provide water to them.

One of the study objectives was to use the results to recommend effective ways to ensure survival of the saplings by looking at the effectiveness of this water-saving technique (cocoons) on *A. erioloba* sapling's survival. The Epicollect5 App and website was used to collect data during the investigation. Afterwards we analysed the data from the study to see if the Cocoons gave a better chance for *A. erioloba* sapling's survival. However, this technology should not be assumed to perform uniformly well in all environmental conditions and with all tree species, therefore the need to do a pilot study first.

Acacia erioloba trees are well adapted to desert environmental conditions such as scarcity of water, extreme temperatures and nitrogen-poor soil and they belong to the family Fabaceae and subfamily Mimosoideae (Mannheimer & Curtis, 2018). These trees are widely distributed in Namibia and can be found in different habitats: on grass plains, along riverbeds, and in rocky areas, although their preference is sandy soils. *A. erioloba* tree's roots can grow deep underground up to 60 m to reach underground water especially in dryer areas and the trees can grow up to 20 m high. They are a keystone species (Personal communication, Alisa Volkman, March 2021).

Acacia erioloba trees have small, twice compound leaves to reduce transpiration, and long white paired thorns that reflect sunlight and decrease browsing. *A. erioloba* have various uses to animals, and as to us humans, for example, we collect the wood to use as firewood and as poles for fencing (Wickens, et al, 1995). *A. erioloba* trees have a good symbiotic relationship with animals found in the area such as the Oryx, (*Oryx gazella*). The Oryx get shade and food from the trees and in turn, tree seeds are dispersed by the Oryx in their dung. Like for many other plants in semi-desert areas, sandy well-drained soil, prolonged rain events and continued access to groundwater are the main factors that determine the establishment of *A. erioloba* (Personal communication, Shirley Bethune, March 2021).

Figure 1 Acacia erioloba trees.

Source: Own photograph 2021

Figure 2 Acacia erioloba pod.

Source: Own photograph 2021

In 2020, NaDEET started a tree planting initiative that aims at planting 1000 trees on the NamibRand Nature Reserve. To date, approximately 600 trees have been planted. Although other species have been planted, *Acacia erioloba*, was the main tree planted, as it naturally occurs in the area. This study aimed to monitor the survival of at least 300 *Acacia erioloba* saplings that were planted on NamibRand Nature Reserve. This study was done to help advise if the cacoon technique and the sites selected to plant the trees implemented good conservation practices. These trees were planted both, close to homesteads, 460m to the East, and as far away as 6.7 km to the south away from the homesteads. This project aimed to combat climate change by planting indigenous trees to increase carbon sequestration. Saplings were planted between 16 December, 2020 and January, 2021 using cocoon technology.

1.1 The study area and site

The study was done at NaDEET on the farm “Die Duine” on the NamibRand Nature Reserve in the Hardap Region and it lies in a transitional zone between the Namib Desert and the Nama Karoo biome. The area is characterized by reddish, sandy soil that drains easily and the vegetation includes grasses such as *Stipagrostis ciliata* (tall bushman grass) and indigenous trees such as *Acacia erioloba* (camelthorn), and *Acacia karroo* (sweet thorn). Shrubs include *Boscia foetida* (smelly shepherds-bush) and *Lycium boscifolium* (Limpopo honey thorn) (Mannheimer & Curtis, 2018).

The area where the *A. erioloba* trees were planted was ~~is~~ on the gravel plain which is characterized by clay pans, chalky (calcrete), and sandy soils. The average rainfall varies between 0 mm/a in the Namib Desert to 200 mm/a towards the eastern part (Integrated Environmental Consultants Namibia, 2011). The lowest minimum air temperature is 2°C in winter and the highest maximum air temperature is about 40 °C, in the summer.

Figure 3 below shows the the location of the NamibRand Nature Reserve within Namibia and includes an insert with more detail of NamibRand Nature Reserve. The arrow points to NaDEET.

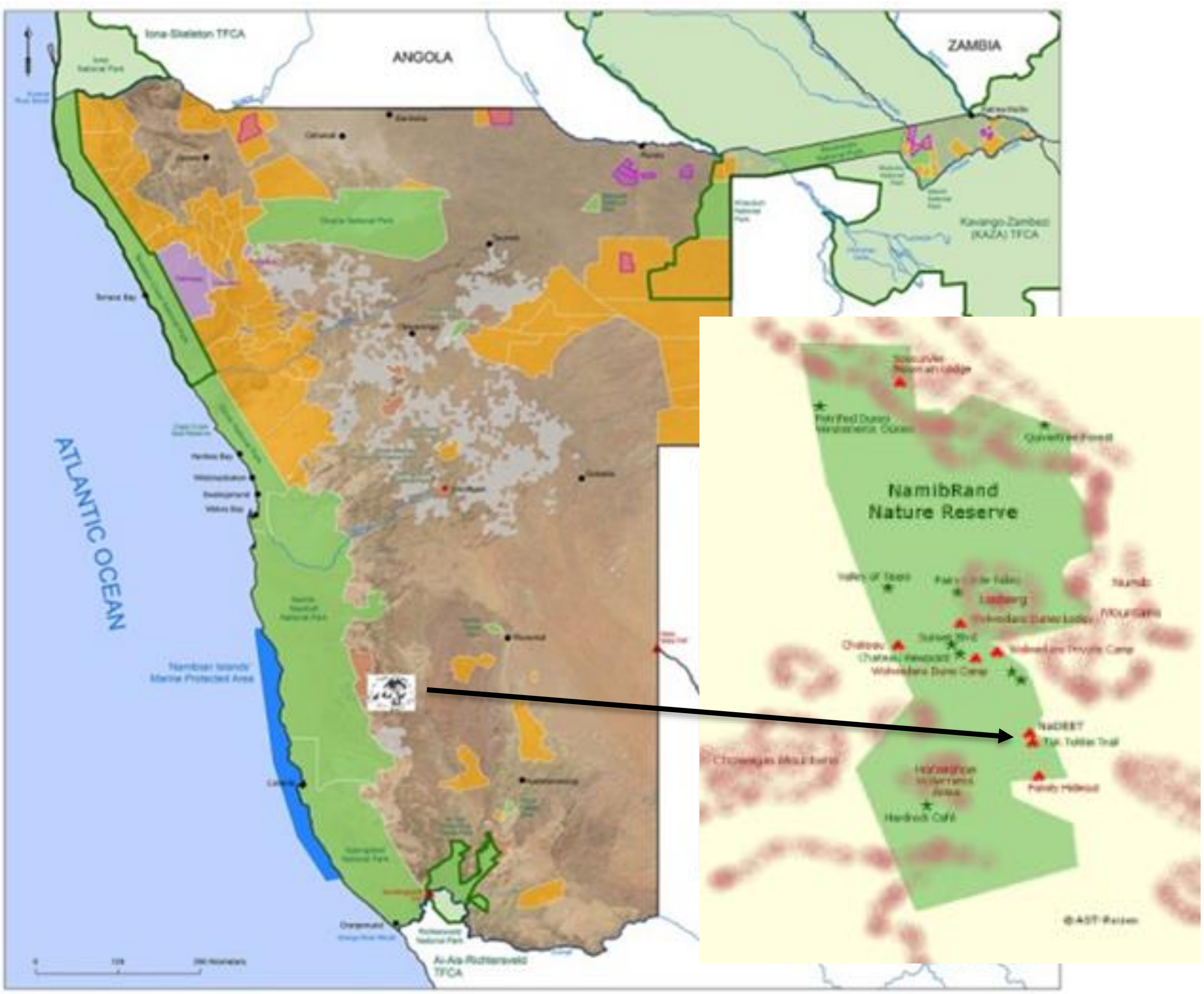

Figure 3 Location of NamibiRand Nature Reserve. Source: NaDEET website 2021

2. AIM AND OBJECTIVES

The aim of this study was to investigate the survival of individual *Acacia erioloba* saplings and the factors that may be influencing it.

2.1 Research Questions:

1. How well are the *Acacia erioloba* sapling planted in cocoons surviving?
2. What is the proportion of the saplings that have survived?
3. Why are they dying or surviving?

2.2 Objectives:

To answer the research questions and achieve the overall aim, the following objectives were formulated:

1. To calculate the proportion of *Acacia erioloba* saplings that have survived.
2. To compare soil types and consider other factors that may be affecting the survival of *A. erioloba* saplings.
3. To use these results to recommend the most effective way to help ensure the survival of *A. erioloba* saplings.

2.3 Research hypothesis:

The hypothesis of this study was:

Null Hypothesis (H_0): Soil type does not play a significant role in the survival of *Acacia erioloba* saplings planted in cocoons.

Alternative Hypothesis (H_A): Soil types play a significant role in the survival of the *Acacia erioloba* saplings.

3. METHODS

3.1 The experimental setup

A systematic sampling method was used. Three hundred , (300) saplings were selected in a systematic way by selecting the first sapling and moving progressively to the next sapling in the order that was used when they were planted (Thomas, 2020). A GPS was used to find the exact location of each sapling. Figure 4 below shows the aerial satellite view of the location and soil types of the saplings planted. This study area extends from the Die Duine farm, southwards to Deception hill.

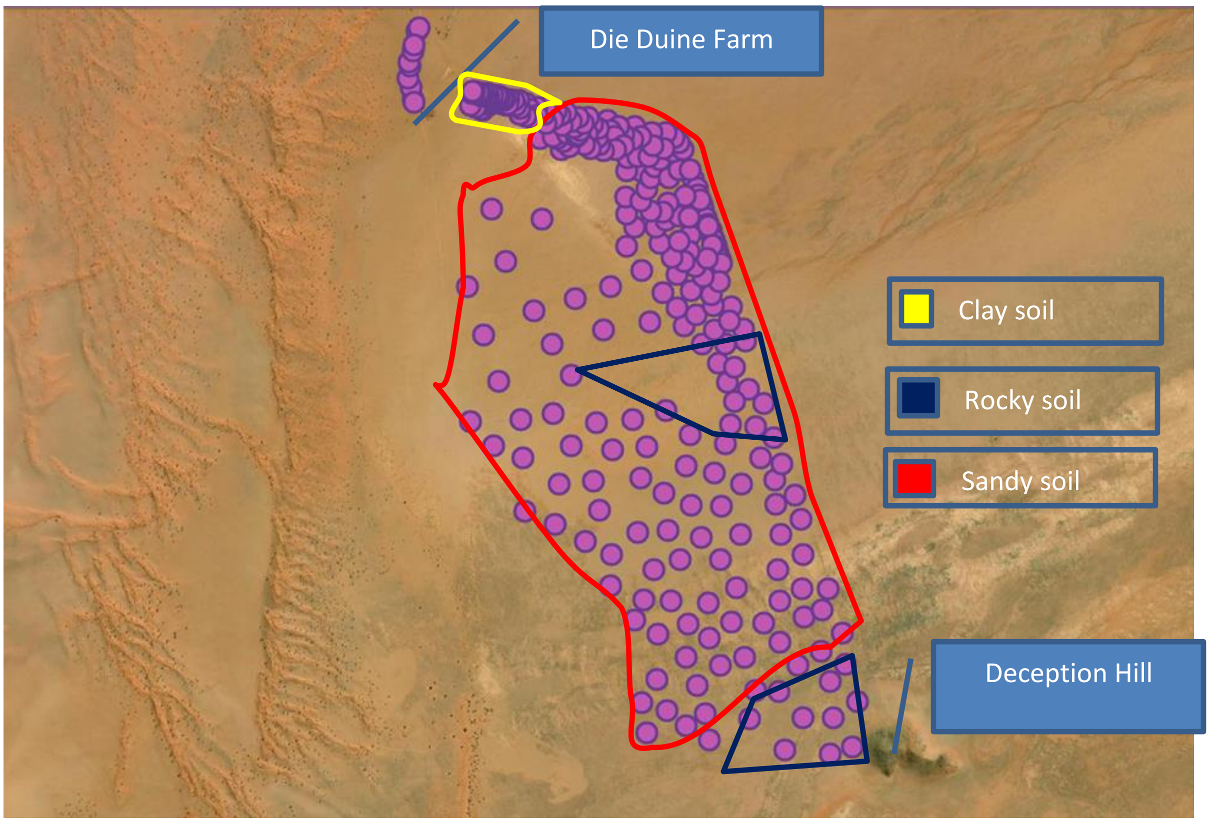

Figure 4. Aerial view showing the location of the planted A. erioloba on the three different soil types in the study area between De Duine Farm and Deception Hill.

Source: Adapted by Hendrin Toivo from Google maps

One survey of the 300 plants was done during the study period, this covered a large area and most of this was done on foot to avoid making tracks. This took time as some plants were over a km apart.

3.2 Calculation of the proportion of saplings that survived

Knowing the survival rate, by counting how many plants had survived out of the number planted, helps us to determine the success of planting using cocoons (Education in Natural Resource Management, & Team of Nature Conservation), and to identify possible threats to the plants.

Formula used: Survival rate= $\frac{Number\ of\ saplings\ \ survived}{Total\ number\ of\ saplings\ minitored} \times 100$

All dead saplings were recorded and the proportion that died was obtained by dividing the number of saplings that had died by the number of saplings monitored.

3.3 Measurement of tree health and factors influencing this.

To determine the health of the trees, each surviving sapling was carefully observed by:

a) Measuring the height of each sapling in centimeters.
b) Looking at the leaves of each saplings to determine the degree of wilting, high, moderate or none.
c) Counting the number of branches from the main stem.
d) Recording any damage to the branches or dead branches.

The height and condition was recorded for each sapling sampled and entered into Epicollect5. This was done because plant growt hand condition are both good indicators of the health of a plant. Plant health is influenced by topography and environmental conditions, such as, soil type, topography, and climatic conditions like air temperature, wind and rainfall and by biotic factors like, browsing e.g. by animals such as termites and grasshoppers. All these factors can play a major role in plant survival. Although time was limited this study looked particularly at the soil type in which each sapling had been planted.

The soil types where each sapling is growing were recorded, and the number of surviving saplings in each soil type were counted. This was used to compare the survival rates of the saplings in the three different soil types, sandy, chalk (rocky calcrete) and clay.

3.4 Determination of cocoon condition and factors influencing this

After collecting the data It was downloaded from the csv form created by epicollect5 and saved in excel form for further data analysis and the preparation of the graphs. All unwanted data was removed from the epicollect5 website.

To test the hypothesis of the study a chi square test was used and the p-value to accept the hypothesis was if it ≥0.5.

3.5 Materials

The following materials were used during this study:

- One eTrex® 10 Garmin GPS to find the location of each sapling.
- Cellphone with Epicollect5 data app to record the data.
- Datasheet in case the phone shut down unexpectedly.
- A measuring tape to measure saplings heights.

4. RESULTS

4.1 Determination of the survival of *A. erioloba*

The data collected was used to create the map shown in Figure 5 below that indicates the distribution of *A. erioloba* saplings that are planted on the NamibRand Nature Reserve. The green color represents the live saplings and the brown colour indicates the dead saplings.

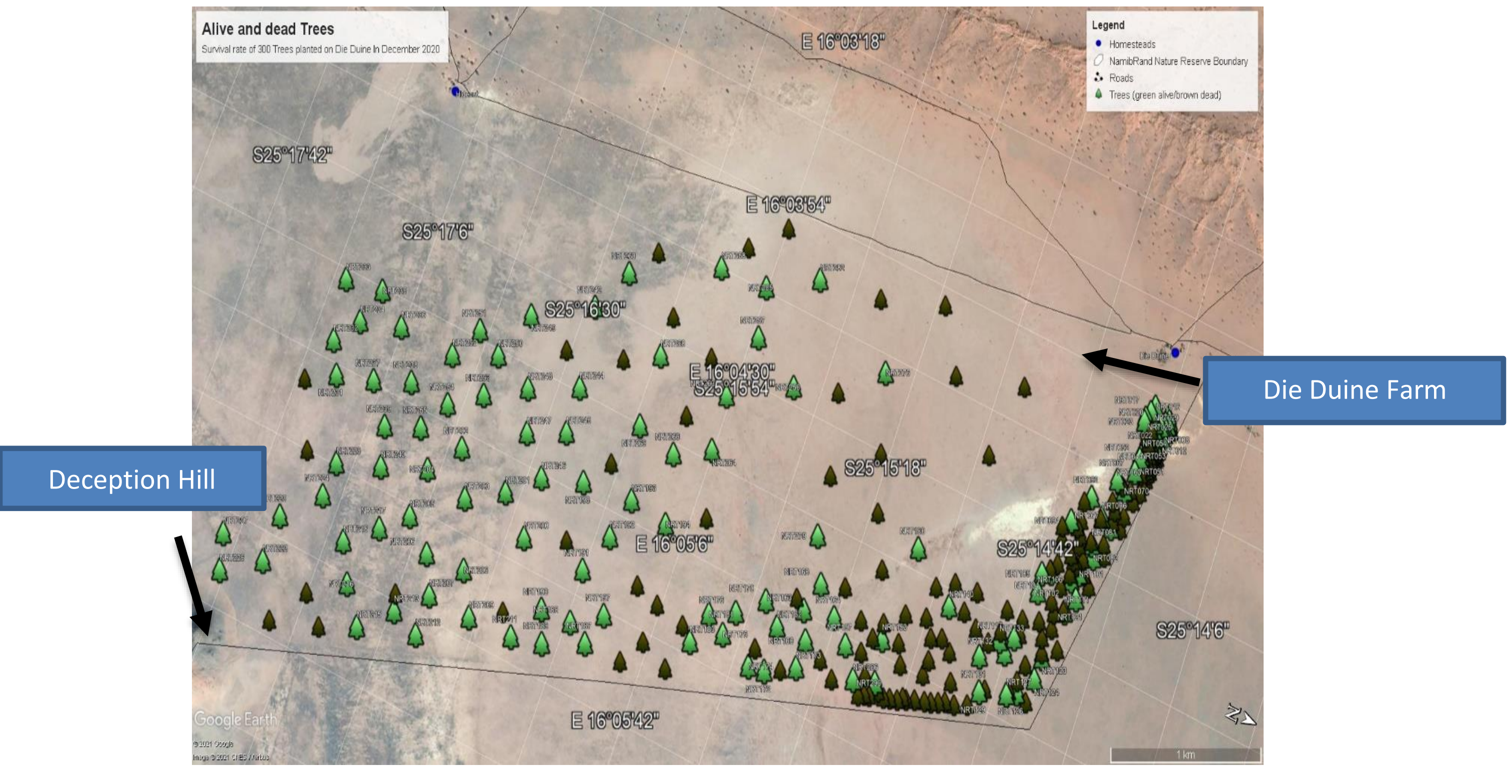

Figure 5 Location of Acacia erioloba saplings on the Die Diune Farm toward Deception Hill

source: Adapted by Andreas Keding using Google Maps

The pie-chart in Figure 6 shows that 48% of saplings survived and 53% of saplings had died.

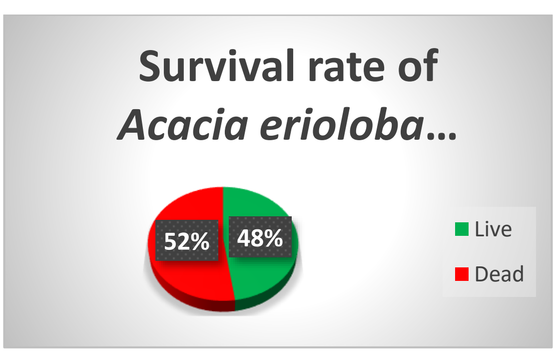

Figure 6 Proportional survival of Acacia erioloba saplings.

4.2 Comparison of soil types and other factors affecting survival and plant health

Figure 7 shows that in clay soil, of the 35 of saplings planted there, 83% survived. This is the highest proportion of survival in the different soil types observed. This was followed by chalk (rocky calcrete) and sandy soils where 35% and 46% of the saplings planted survived respectively.

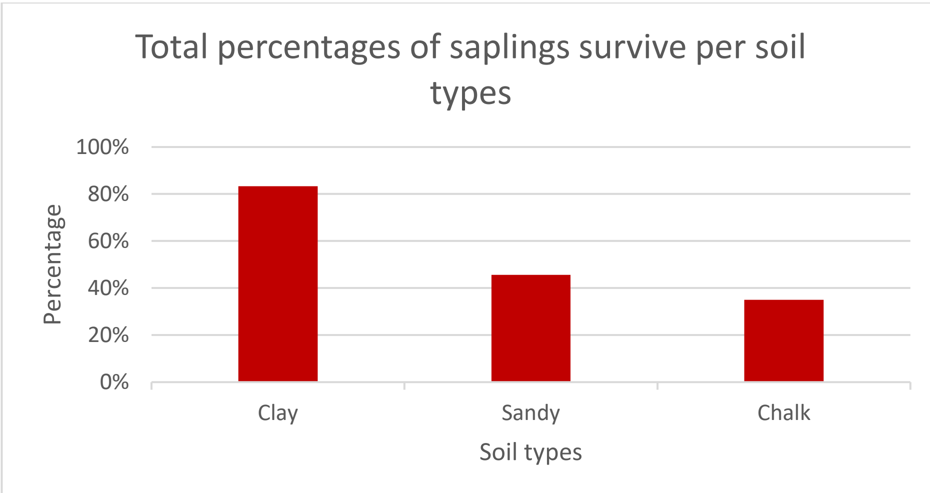

Figure 7. Percentage of saplings that survived in clay, sandy and chalk soils.

As, one objective was to look at damage to the surviving saplings and the factors may be influencing the survival of *A. erioloba* saplings, Figure 8 below, indicates the proportion of heathy saplings as well as saplings damaged by animals, weather (wind, rain, temperature) and unknown factors that were observed.

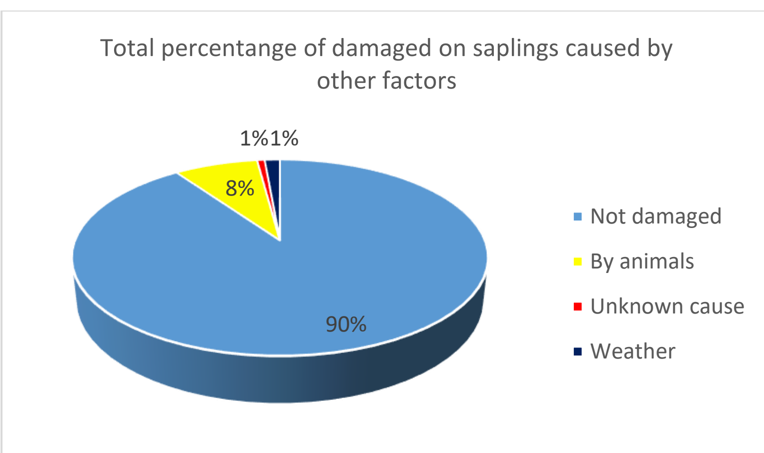

Figure 8 Proportion of damage caused by animals,wind and unknown factors

These results show that a most of the surviving saplings (total of 90%) were not damaged, and that for the 10% that were damaged, the factors causing this damage were most likely browsing by animals, weather and unknown causes. Thus these results indicate that factors likely to influence the survival of the saplings were due to browsing by insects like grasshoppers and termites, (8%), by climate most likely wind or rain, (1%) and by unkown reasons for the other 1% could not be determined.

As an indication of stress on the surviving plants, the degree of wilting was recorded. As shown in the graph in Figure 9 below, most of the surviving plants, sixty-two per cent of the saplings, did not show any signs of wilting but. 4% of saplings were very wilted and one third of the surviving plants (34%) were in a moderately wilted condition, showing clear stress.

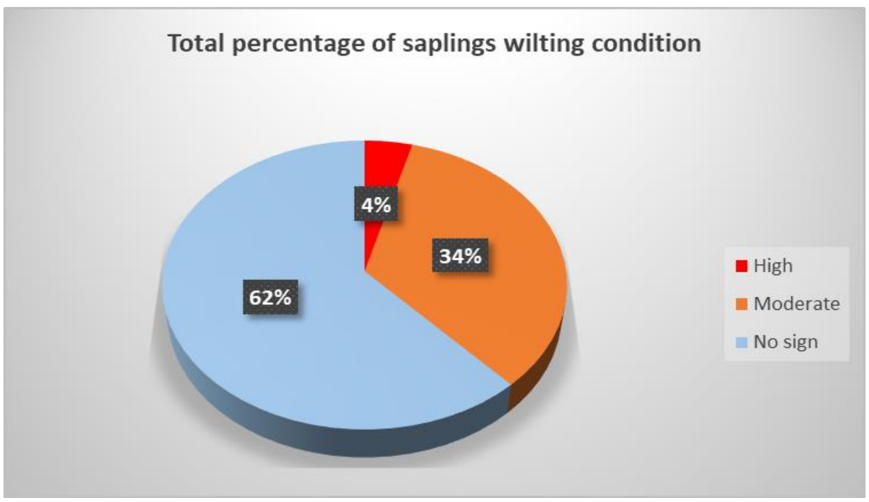

Figure 9 Wilting condition of the surviving saplings.

Graph 5 show the number of days spent on planting A. erioloba sapings in each month and number of saplings survived in each day.

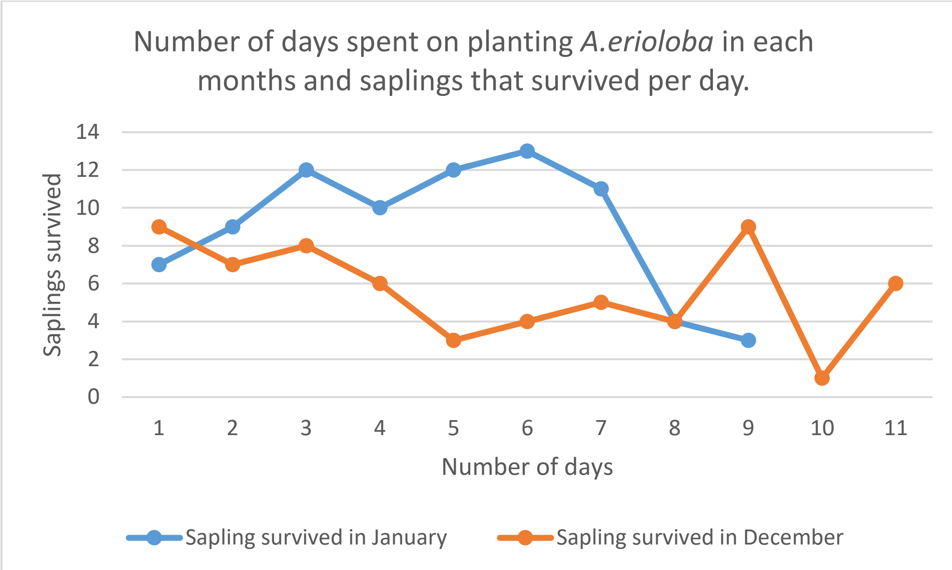

Figure 10 Days spent on A.erioloba plantation and number of saplings survived in each day

As shown in graph 5 only 9 days of plantation spent in January and the highest number of saplings that survived is 13 on the 6th day and only 3 on the last day which was the 15 January 2021. While in December the highest number of saplings that survived is 9 on the 9th and the first day of the plantation.

4.3 Observation of cocoon's condition

The study also observed the cocoon's condition. As shown in Figure 10 below, out of 143 cocoons that were protecting the surviving saplings, only 19 cocoons were still in very good condition showing no damage, but most of the cocoons, almost 90% (124 cocoons) were damaged. Of these damaged cacoons, 70% (88 cacoons) were still able to protect the saplings, while the others 36 cacoons were so damaged that they were not protecting the saplings at all.

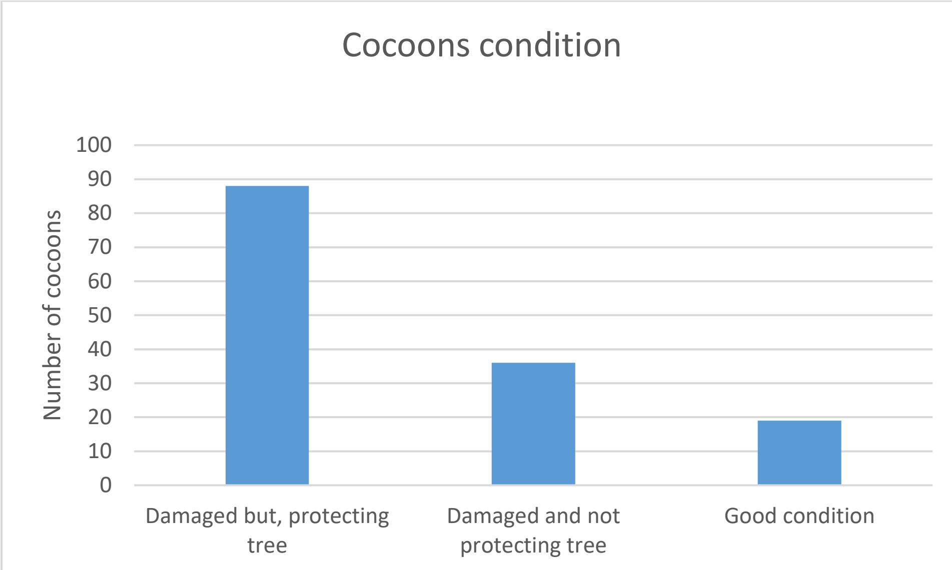

Figure 10 Number of Cocoons around the 143 surviving A erioloba saplings that were:

Damaged yet to still protect the saplings, damaged and not able to protect the saplings or in good condition.

4.4 Testing the Hypothesis

To test the hypothesis of the study a chi square test was used and the p-value to accept the hypothesis was, if $P \geq 0.5$. After dividing the observed number of saplings that survived by the expected number, the p-value obtained was 0.5. Therefore it was noted that the type of soil does play a significant role in the survival of the saplings.

5. DISCUSSION

5.1 Survival rate

The result of the study indicates that only 48% of *A. erioloba* saplings planted between 16 December 2020 and 23 January 2021 survived, which indicate that these saplings face challenges such as a dry environment with low rainfall*, high evaporative losses, strong* wind and high temperature, yet for almost half of them the cocoon technology used gave support by providing them with sufficient water to grow and transpire.

5.2 Comparison of soil types and other factors affecting survival

A higher survival of saplings in clay soil was recorded compared to chalk and sandy soil , as 83% of saplings planted in clay soil survivedcompared to 46% in sandy soild and 35% in chalk. Therefore soil type was one of the factors that contributed to the survival of *A. erioloba* saplings. This is because this area is dry with extremely high temperatures and clay soil has smaller air spaces which makes its infiltration slow and gives good water holding capacity. This indicates that water is decreasing more slowly in cocoons that are in clay soil than in sandy and chalk soils.

Factors such as insects (grasshoppers, termites), high temperature, low rainfall and wind (Sandquist, 2014) play a role in the survival of trees especially those planted in the wild causing them to stress and dry out. Observations during this study confirmed that factors such as browsing by termites and grasshoppers and weather conditions can damage saplings and so influence their survival. According to Andreas Keding (personal communication) the past years had no rain and this year's rainfall resulted in more insects such as grasshoppers and termites that damaged the saplings. When transplanting plants it is important that you are not too rough with the roots as too much damage to them can result in transplant shock or death (Stone, 1955). It’s all about being gentle and taking your time, especially when you are transplanting seedlings. Seedlings that develop a strong root system after planting establish a proper water balance and can respond to field site environmental conditions without limitations, but seedlings with root damage are unable to absorb water for the plant (Morgolis & Brand, 1990).

Although these factors influence the survival of saplings, 90% of the saplings planted at NaDEET survived without damage which indicates a good sign because these saplings, planted in the wild. were exposed to many abiotic and biotic factors that could damage them.

The saplings were planted between mid December 2020 and late January 2021 and the nearest saplings were 460 m east from the NaDEET base extending as far away as Deception hill that was 6.7km south from the base. Since the the trees were planted the area around the house at “Die Duine”, received started 43 mm of rain while a total of 116 mm was received at the Hideout campsite (Personal communication, Cornelius Bekeur, May 2021) close to where the Deception hill is located. The amount of rainfall in in the time between planting and the survey is likely to have played a role in the survival of saplings, being higher in the west.

Of 165 saplings that were planted in December only 62 saplings survived and of those that were planted in January, 81 of 135 saplings survived. This could mean that *A. erioloba* may survive in a dry environment but they need water from rain to support them while still young.

The desert where these saplings were planted is a dry area with low average rainfall of about 100mm per year (Muzino & Yamagata, 2005) and high evaporation rates. Although the results show that 62% of the saplings that survived, showed no signs of wilting, 4% showed a high wilting and 34% moderate wilting which can be seen as stress. Wilting is caused by high evaporation due to wind and heat and a lack of enough rain causing the saplings to lose water through transpiration and then wilt and die. I removed a paragraph here as being too confusing

Although the low amounts of rainfall after planting may have played a role, damage of roots during transplantation could have also played a role as in some areas only 1 to 3 saplings survived out of 15 saplings planted on the same day.

The cocoons' condition also played a role in survival. It was observed that out 143 cocoons around the surviving saplings, 88 cocoons were damaged but still protecting the saplings while 36 cocoons were so damaged that they did not protect the saplings. Ground squirrels were one of the animals that damaged the cocoons because there are times when they where seen digging on the cocoons lids and we found their holes in the cocoon lids or around the cages that protected the cocoons. The damag was more on the cocoons planted in the sandy soil because it was easier for the squirrels to dig in sand than in clay and chalk soil. Termites were also a cause of damaged to the cocoons as they eat up the cocoon lids or rootbowls that protect the saplings.

Limitations of the study

The short period allocated for the WIL reduced the time to collect data, especially on the growth as *A.erioloba* grows very slowly. I was planning to measure plant growth as my second objective but due to a short period, I was unable to measure growth as I was not able to go back to each sapling several times.

Another limitations was insufficient information about the planting process in the data I was able to retrieve. I did not plant the saplings therefore am unable to confirm what happened.

6. CONCLUSION AND RECOMMENDATION

The study was to investigate the survival *A. erioloba* saplings that where recently planted using cocoons technology. 48% of *A. erioloba* saplings survived. Factors such weather, animals and other unknown factor played a role on the survival of *A. erioloba* saplings. Although these factors caused damage to the surviving saplings, 90% of these saplings are not damaged. After comparing soil types, the outcome was that clay soil had the highest survival with 83% compared to sandy and chalk with 46% and 35% respectively. The amount of rainfall since the transplantation also played a role in the saplings survival. Planting trees is important but monitoring them is needed can help guard against "surprises" brought about by climate or interactions with animals.

From my observations, I recommend that next time when planning to plant trees using the cocoon technology, soil type should considered because the cocoons in clay decreased the rate of the saplings loosing water, it was slower compared to sandy and chalk soils . It also harder for animals like ground squirrels that are damaging the cocoons to dig in clay soil.

I also recommend that NaDEET should consider planting other trees such as the *Boscia foetida and Parkinsonia africana, b*ecause they are also occurring natural in the area.

In terms of the cocoon technology, I notices that the cocoon lids are too flat and once too much sand blown by the wind accumulates on it, they fell in. Therefore the lid's shape needs to be in a better form so that even when the strong wind blows sand on top of the lid the sand will naturally run off easily.

Although the technology used was intended to provide water to the saplings I think it will be good to water the saplings, until their roots grow enough to reach the underground water because water in the cocoons is also lost through evaporation and transpiration due to high temperatures and wind in the area.

Finally during transplantation, human error, in this case maybe rough handling of the small saplings, can occur easily, especially when different people are involved. Therefore it will be good to encourage people, responsible for planting the saplings, to be cautious with the saplings especially their roots.

7. ACKNOWLEDGMENTS

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5. REFERENCES

Dobbertin, M & Schroeck, R. (2013). The growth measurements in long-term monitoring forest in Europe. *Forest monitoring: methods for terrestrial investigations in Europe with an overview of North America and Asia 12*, 183-204. Elsevier.

Education in Natural Resource Management, & Team of Nature conservation (n.d.). Engaging with Nature Plant survival rates Teacher information pack.

Integrated Environmental Consultants Namibia. (2011). Dealing with climate change. In *Lets act to deal with climate change*. http://www.iecn-namibia.com/-content/Erongo,%20Karas,%20Hardap%20&%20Khomas%20toolkit.pdf

Kirnbauer, M. C, Baetz,B. W, Kenny, W. A. (2013). Estimating the stormwater attenuation benefits derived from planting four monoculture species of deciduous trees on vacant and underutilized urban land parcels. *Urban Forestry & Urban Greening, 12*(3), 401-407.

Mannheimer, C & Curtis, B. (2018). *Le Roux and Muller's field guide to the trees and shrubs of Namibia* (2nd ed.). Namibia Publishing House.

Morgolis, H. A. & Brand, D. G. (1990). An ecophysiological basis for understanding plantation establishment. *Can. J. For. Res*, 20: 375-390.

Muller, M. A. N. (2007). *Grasses of Namibia.* Ministry of Agriculture, Water and Forestry.

Muzino, K. & Yamagata, K. (2005). Vegetation succession and plant use in relation to environmetal changes along the Kuiseb River in the Namib Desert. *African Study Monographs*, *30,* 3–14.

Sandquist, R (2014). Plants in deserts: Ecology and the environment. *The plant sciences, 8*.

Stone, E. C. (1955). poor survival and the physiological of planting stock. *For science*, 1: 89-94.

Thomas, L. (2020, October 2). *Scribbr*. How to perform systematic sampling: https://www.scribbr.com/methodology/systematic-sampling/#:~:text=Systematic%20sampling%20is%20a%20probability%20sampling%20method%20where%20researchers%20select,a%20list%20of%20the%20population.&text=Decide%20on%20your%20sample%20size%20and%20calculate%20

Welcome to the Namib Desert Environmental Education Trust (NaDEET). (n.d.). https://nadeet.org/

Wickens, G. E, Seif El, A. G, Nahal, L. (1995). *Role of Acacia species in the rural economimy of dry Africa and the Near East.* Food and Agriculture Organization