

**Report title**

**The distribution of height and trunk diameter of  
different tree species in relation to the main river  
channel as a potential indicator for age of trees in the  
Kuiseb River**

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## Title

### **The distribution of height and trunk diameter of different tree species in relation to the main river channel as a potential indicator for age of trees in the Kuiseb River**

## Abstract

Tree height and diameter at breast height (dbh) were measured on four tree species namely *Acacia erioloba*, *Faidherbia albida*, *Tamarix usneoides* and *Euclea pseudebenus* in relation to the main river channel at two study sites along the Kuiseb River. The two sites Gobabeb and Swartbank were pre selected by the Gobabeb Training and Research Centre as part of their long-term ecological research programme. The main aim of the study was to find out whether actual size is affected by the position from the main channel. The results obtained at Gobabeb shows that size for *Acacia erioloba* is not affected by the position but has to do much with the plant morphological characteristics like having a deep taproot to access underground water. For *Faidherbia albida* it's more distributed closer to the main river channel therefore position for this tree species plays a role.

## 1. Introduction

This short-term research project was conducted in the Kuiseb River at Gobabeb Training and Research Centre in the central Namib Desert. The project is a sub-component of the Gobabeb In-Service Training (GIST) programme's overall theme for 2005: "achieving a better understanding of the relationship between vegetation of the Kuiseb River and the floods recharging the alluvial aquifers". This project is contributing to the Floodwater recharge of alluvial Aquifers in Dryland Environments (WADE) project. The project that aims to look at aspects related to water resources in arid environments and the relationship between floods and ground water (Anon, 2005). There are nine work packages in the WADE project of which the Desert Research Foundation of Namibia (DRFN) is one of the partner (partner 4) and the GIST programme is part of. The content of work package for DRFN is socio-economic survey, information dissemination, site characterization (by geological and vegetation survey) and integrated water resource management (IWRM). My research project was focused on site characterization in the Kuiseb River at Gobabeb, the WADE study site in Namibia.

The Kuiseb River is one of the twelve largest ephemeral rivers situated in western Namibia with a catchment area of 14700 square kilometres that rises in the Khomas Hochland (Jacobson, Jacobson and Seely, 1995). Ephemeral rivers are rivers that only flow for a short period after good heavy rains in their upper catchments and are dry for long periods. According to Henschel (2004) the Kuiseb river is a linear oasis that serves as a lifeline in the apparently stark landscape. It interconnects people and plants at both ends and along it. The Kuiseb's surface floods are triggered by rainfall events in the upper catchments and display a high spatio-temporal variability (Henschel, Makuti and Moser, 2004). These floods are crucial for the recharge of groundwater, a source of water and nutrients that keep the riparian forest of the western ephemeral rivers alive. Floods are the main contributing factor to the shaping of soils and vegetation of the Kuiseb River and other ephemeral rivers. According to Jacobson, Jacobson and Seely (1995) during floods logs are often lodged against trees growing in or along the river channel creating small blockages that trap more organic material creating debris pile that provide excellent habitat for new germination and establishment of vegetation when floods recede. Tree species found along the Kuiseb River that relies on groundwater for their main water supply and on surface floods for

regeneration and establishment includes *Faidherbia albida*, *Acacia erioloba*, *Tamarix usneoides*, *Enclea pseudebenus* and *Salvadora persica*. The Kuisieb River plays an important socio-economic role for those that depend on it for water. Its groundwater is used by commercial farmers in its upper catchment, the local Topnaar communities residing in the Namib Naukluft Park and the coastal towns municipalities, industries and mines for daily use. The vegetation plays an important role too. It provides food (fodder and detritus), water (in the form moisture) and shelter for the fauna found along the Kuisieb River. This research project was conducted in the Kuisieb River at the Gobabeb Training and Research Centre in the Namib Desert. The aim for this research was to find out whether or not the actual size of trees is affected by position on the floodplain in relation to the main river channel and whether size could be a potential indicator for age of trees. According to [www.gurd.bc.ca](http://www.gurd.bc.ca) (2005) size by itself is the worst indicator of tree age; factors playing a role in age of tree are their location and favourable conditions. Some very oldest trees on a site tend to be some of the smallest and are extreme dwarfs. Trees are a product of their growing site. Therefore any growing site will enhance or retard the growth of the trees.

### **1.1 Study site**

Two study sites were selected namely the **Gobabeb Training and Research Centre** and **Swartbank**.

The Gobabeb Centre (23°33'S, 15°02'E) is situated in the basin of the Kuisieb River in the central Namib Desert. The Centre's mean annual relative humidity is 50% and the temperature is 21.1°C with an altitude of 408 metres above sea-level (Henschel,1998). The Centre was established for the improved management of the desert environment. This settlement is located 48km downstream from the Gobabeb by road. Its altitude is 306 meters above sea-level. The two study sites were selected to compare vegetation, in relation to the water table as it differs at both sites. According to Kasaona (2003) the water level at Gobabeb is constant with its water table varying gradually at depth of 4 to 6 meters whereas at Swartbank the water table fluctuates at the depth of 10 to 17 meters, due to heavy under ground water abstraction.

## **2. Objectives**

### **2.1 Personal objectives**

1. To have a better understanding of the relationship between vegetation and flood in the Kuisieb Basin at the end of GIST
2. To gain more knowledge and skills on how to conduct research
3. To pass my IST and obtain my national diploma
4. To gain and improve my knowledge in the use of computer spreadsheets for data entry and analysis
5. To contribute to the long-term vegetation mapping and study of vegetation dynamics in the Kuisieb River

### **2.2 Project objectives**

1. To determine the distribution of height of identified species of selected trees across the Kuiseb River.
2. To determine the distribution of trunk diameter of identified species of selected trees across the Kuiseb River.
3. To correlate size and height of trees with position on the flood plain
4. To test potential relationship between size distribution of trees and the flood history of the Kuiseb River
5. To examine relationship between height and diameter of selected tree species
6. To examine current size and compare with size of trees as previously recorded

### **3. Materials and Methods**

A total of ten transect were done at Gobabeb and two transect at Swartbank. Because of the river changing its course the floodplain at Swartbank is wider therefore we only managed to cover two transects there. We used a dumpy level and a staff for the transect layout at both sites. The transect length were varying at both study site with Gobabeb transects ranging from 111-380 meters in length and at Swartbank the length was varying from 1978 -2000 meters in total..

#### **Objectives**

- 1. To determine the distribution of height of identified species of selected trees across the Kuiseb River**

**Height measurement [m]:** All straight standing tree species along the ten transect within a 10m-width range were measured, GPS coordinates at the accuracy of 6 meters were recorded in the data sheet, and data was analysed using Microsoft Excel.. To estimate the height of the tree, a 30cm ruler was held in a vertical position with the observer's arm stretched out horizontally at 90 degrees to the body. Holding the ruler vertically I moved away from the tree until the ruler was in line vision with the highest tip/top part of the tree canopy. When the ruler was in vision line with the vegetation, distance from the tree to the person was measured using a 50 meter measuring tape. The following formula was used to calculate tree height:

**height of tree = (30cm/arm length)\*distance moved by the person from the tree.**

Trees species were sorted into height classes: class 1 (0-4.9m), class 2 (5-8.9m), class 3 (9-12.9m), class 4 (13-16.9m), class 5 (17-20.9m), class 6 (21-24.9m), class 7(25-28.9m), class 8 (29-32.9m).

- 2. To determine the distribution of trunk diameter of identified species of selected trees across the Kuiseb River**

**Trunk Diameter measurement [cm]:** Diameter measurements were done on all the trees species that height measurements were taken. A measuring tape was wrapped around the tree trunk at the height of 1.3 meters the international standard height at which to measure tree diameter from ground level.

**3. To correlate size and height of trees with position on the flood plain**

Global Positioning System (GPS) coordinates were taken at each tree within the given cross section length and width.

A measuring tape was used to measure the distance from main channel

The data was entered in Microsoft Excel programme and analysed and then processed into the Arc-view 3.1 program and the points were fixed onto the orthophoto.

Methods and materials used for objective 1 are applicable for this objective too.

**4. To test potential relationship between size distribution of trees and the flood history of the Kuiseb River**

A combination of remote sensing and GIS (fixed-point photography of past years' vegetation) were used to identify trees on the photographs). Some of the vegetation on the photographs has been identified with the help of my fellow GIST students. I did not use this method because most of the trees on the photographs where not found along the transect. Time was also a limiting factor too to carry out the measurements. The other reason was that the tree canopies where overlapping each other therefore it was difficult to confidently say that there is a relationship.

**5. To examine relationship between height and diameter of selected tree species**

Methods and materials used for objective 1 are applicable here too.

**6. To examine current size and compare with size of trees as previously recorded**

Methods and materials used for objective 1 are applicable here too.

Analysed data from previous vegetation studies done on trunk diameter and height were not used because I only came across two studied trees for my project. The tag numbers I had were not available on the previous studies data sheets.

## **4. Results and Discussion**

Expected Accuracy of Results

### **Tree Height Data**

Due to ground level visibility problems and changes in ground profile encountered, the tree heights mat vary up to 1-2 meters from the actual heights. This factors reduces the precision of the method used.

### **Trunk Diameter**

Few problems were encountered in obtaining accurate diameter readings, thus they are likely accurate to approximately 1 centimeter. The problems were the thorns and squeezed trunks.

### **Objective 1**

#### **4.1 Determine the distribution of height of the mentioned tree species across the Kuiseb River**

The distribution map is only produced for the Gobabeb study site

**Table 1: Height class distribution of the four tree species across the Kuiseb River in percentage at Gobabeb and Swartbank**

Species	Gobabeb							
	Height class in %							
	1	2	3	4	5	6	7	8
<i>Acacia erioloba</i>	-	8.5%	40.4%	27.7%	17%	6.4%	-	-
<i>Faidherbia albida</i>	3.8%	-	11.5%	15.4%	19.3%	26.9%	15.4%	7.7%
<i>Euclea pseudobennus</i>	20%	20%	40%	20%	-	-	-	-
<i>Tamarix usneoides</i>	-	80%	-	20%	-	-	-	-

Species	Swartbank							
	Height class in %							
	1	2	3	4	5	6	7	8
<i>Acacia erioloba</i>	30%	45%	22.5%	1.3%	1.3%	-	-	-
<i>Faidherbia albida</i>	33.3%	-	16.7%	16.7%	33.3%	-	-	-
<i>Euclea pseudobennus</i>	-	100%	-	-	-	-	-	-
<i>Tamarix usneoides</i>	-	-	-	-	-	-	-	-

A total of 47 *Acacia erioloba* trees were studied at Gobabeb and 80 trees at Swartbank. The results show that height distribution of class 3 (9-12.9 m) predominates at Gobabeb and height class 2 (5-8.9m) predominates at Swartbank. There were more trees recorded at Swartbank during the study period even though only two transects were covered compared to Gobabeb where ten transects were done. There was no height class 1 recorded at Gobabeb while at Swartbank 30% was recorded in this height class see the table below. A total of 26

*Faidherbia albida* trees were recorded at Gobabeb with only 6 recorded at Swartbank. The results in the table show that out of the total recorded at Gobabeb the height class 6 (21-24.9 m) predominates at the site whereas at Swartbank no trees were recorded in that class height but its height class 2 and 5 being equally distributed with both having a 33.3%. The records for *Euclea pseudobennus* at Gobabeb were equally distributed in class 1, 2 and 4. Each recorded 20% with its highest percentage in class 3 and nothing in the other height classes. At Swartbank the only height class recorded was class 2 with a 100% record. A total of 5 *Tamarix usneoides* recorded at Gobabeb with the height class 2 being the most dominant class followed by class 4 with no other height class recorded at this site. At Swartbank there

was no *Tamarix usneoides* recorded. See appendix 1 for the height distribution map at Gobabeb. See appendix 1 height distribution at Gobabeb.

### **Objective 2**

#### **4.2 Determine the distribution of trunk diameter of identified species of selected trees across the Kuiseb River**

See appendix 2: The vegetation map that shows trunk diameter distribution of the four studied tree species across the Kuiseb River at Gobabeb

The map shows that *Acacia erioloba* trunk diameter is more distributed across the river at Gobabeb compared to the other three trees species. The *Tamarix usneoides* has the least diameter distribution because there were not much sample size along the transect I did my study along.

### **Objective 3**

#### **4.3 To correlate size and height of trees with position on the flood plain for Gobabeb and Swartbank**

The results in figure 1 and 2 show that there is a poor correlation in height for *Acacia erioloba* with position on the floodplain at both Gobabeb and Swartbank. Position does not seem to be affecting the height class. The R squared linear regression done on the excel programme shows a poor correlation for see appendix 3. Results for *Faidherbia albida* at Gobabeb shows that there is no correlation for height with position on the floodplain whereas the trunk diameter shows that there is a correlation. The bigger diameter is closer to the main channel. At Swartbank it shows that there is a correlation between the height and trunk diameter with position on the floodplain. The further the *Faidherbia albida* is position the height class and diameter also decrease. The results shows that position on the floodplain does affect the height and diameter for *Acacia erioloba* at both study sites as this a poor correlation with the linear regression test done on excel. The correlation test for *Euclea pseudebenus* and *Tamarix usneoides* was not done because there were not enough recordings done at both study sites for this two tree species see appendix

### **Objective 4**

#### **To test potential relationship between size distribution of trees and the flood history of the Kuiseb River**

Although there are changes seen on the vegetation photograph of 1967 and 1997 and trees marked, I could not test the potential relationship between size distribution and flood history of the Kuiseb River. The proposed method was too crude for me to test the relationship. The reason being that a lot of tree canopies are overlapping each other which made it difficult to know which tree is which just by looking at the photos. If aerial photos were taken after every flood from 1967 and marked it would have been useful but with a thirty years difference it was not really possible. The other reason was that, the flood records available are from the year 1977 and the photo was taken ten years before the flood records. In that year vegetation along the Kuiseb at Gobabeb had long been there. If there were different aerial photo taken since the flood records were done it would have been possible the help of experts using the software to produce a map that will show how the size distribution has change over time. See appendix 4



## **Objective 5**

### **To examine relationship between height and diameter of selected tree species**

The graph shows that there is not relationship between height and trunk diameter for *Acacia erioloba* at Gobabeb and there is a relationship shown at Swartbank. The relationship is stronger at Swartbank with a linear regression of 0.5 at Swartbank whereas Gobabeb has a lower sum of 0.2. The bigger trunk diameter is found in the smaller height class with only two individuals found in height class 5 and 6 for both there is no relationship between height and trunk diameter for *Acacia erioloba*. The relationship for *Faidherbia albida* at is also not strong whereas there is a stronger relationship at Swartbank for this tree species. See appendix 5 and 6.

## **5. Conclusions**

The height and trunk shows that there is no relationship for the four tree species in relation to their position on the floodplain appeared to be closely related to water accessibility of ground water. This is proven by the distance *Acacia erioloba* is distributed at Gobabeb and Swartbank compared other tree species because this species can easily cope with drought and water table fluctuations because of their deep taproot that can grows deep to get to the underground aquifers whereas *Faidherbia albida* has shallow roots therefore it is mostly distributed near water course. I have also observed that the *Acacia erioloba* at Swartbank in height class 4 and 5 are under a fungal attack this may also be the answer as to why are dying out whereas at Gobabeb the height 4 dominate class. The results produced are not the precise heights but rather estimates, because very oldest trees on a site tend to be the smallest, they are extreme dwarfs. A tree is a product of its growing site therefore any growing site will either enhance or retard the growth of the tree Always remember that size by itself is the worst indicator of tree age so therefore factors playing role in age of the tree is the location and favorable conditions.

## **6. Recommendations**

I recommend that the same study be done every year so that one can make strong good conclusions, as there are a lot of factors that may influence the results that I did not do for these project. Trees grow if the conditions are favorable for them; with the little fog moisture they receive we do not know how much of it they utilize to grow so they must take that into consideration too. This might not be the case but without floods during the period of study at Gobabeb the trees were flowering and looking healthy so that can be playing a role too. The person to do the same project must also look at other environmental factors such as: elements in the soil, ions in the water and fungal attacks on the trees. Try out other methods for measuring height to have at least two estimates that one can draw conclusion on. The study species must be monitored every year to see new growth and measurements done on seedlings too.

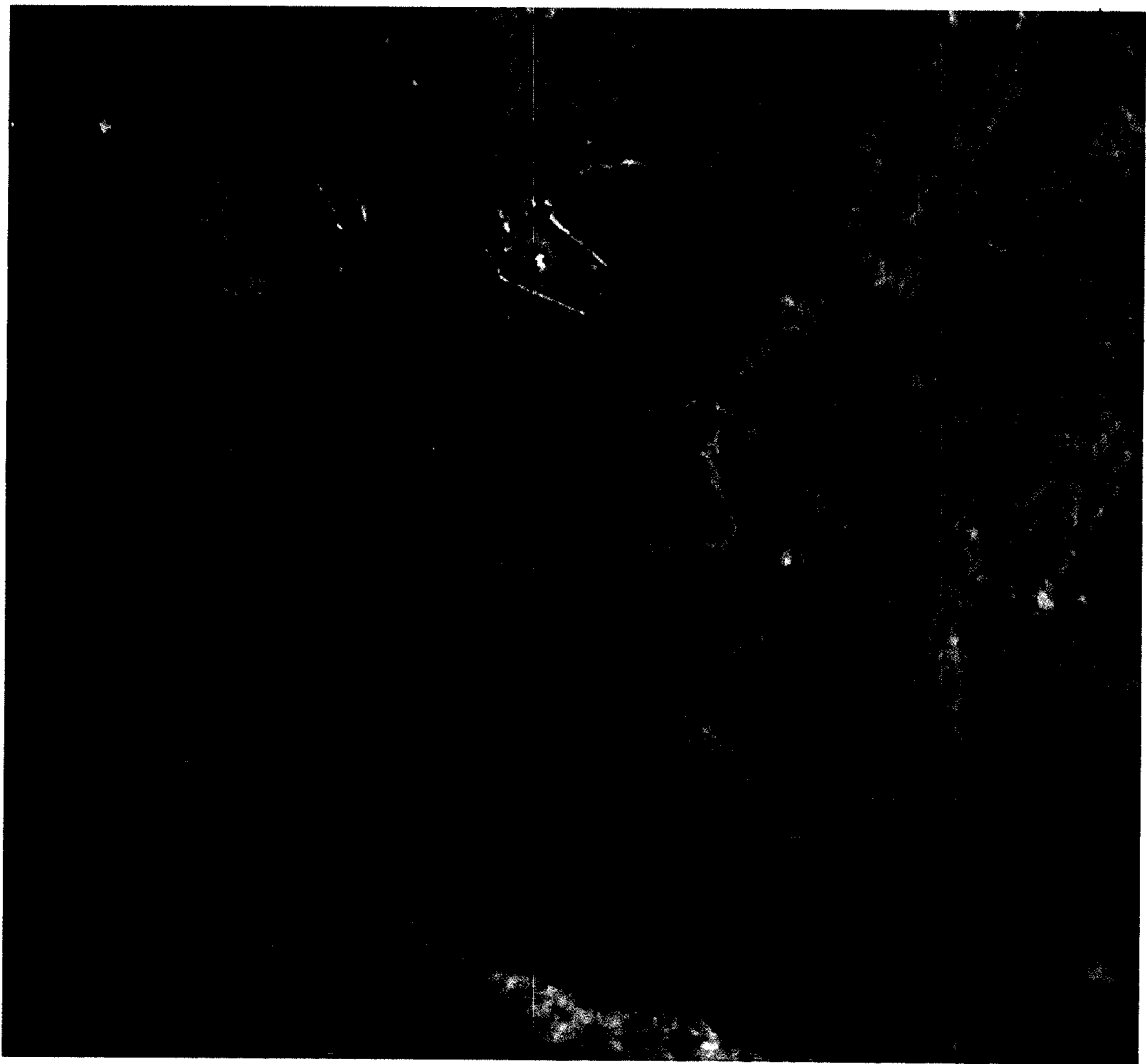
## **Acknowledgements**

I would like to thank Dr. Mary Seely and Mark Gardiner for their support during the four months I spend at Gobabeb. The GIST members for their support although it was not always possible I made it through with their help and Kristin Wouters for helping me

with the arc-view map. Last but not least all staff members at Gobabeb for making my stay great.

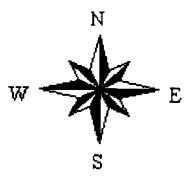
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### Legend

- Tamarix usneoides.shp
  - 2
  - 4
- Euclea pseudebenus.shp
  - ▲ 1
  - ▲ 2
  - ▲ 3
  - ▲ 4
- Acacia erioloba.shp
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
- Faidherbia albida.shp
  - 1
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
- Gbb\_refpoints.shp
  -



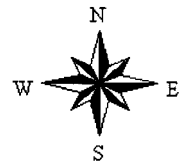
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Author: Kristin Wouters  
Date: 04.11.2005



## Legend

- Diam tamarix usneoides.shp
  - 10 - 15
  - 15.1 - 25
- Diam euclea pseudebenus.shp
  - ▲ 10.1 - 15
  - ▲ 15.1 - 25
  - ▲ 25.1 - 40
- Diam acacia erioloba.shp
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  - 25.1 - 40
  - 40.1 - 65
  - 65.1 - 90
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  - 25.1 - 40
  - 40.1 - 65
  - 65.1 - 90
  - 90.1 - 115
- Gbb\_refpoints.shp
  - Gbb\_refpoints.shp



0 0.07 0.14 0.21 0.28 0.35 0.42 0.49 0.56 0.63 0.7 Kilometers

Author: Kristin Wouters  
Date: 04 11 2005

Appendix 3

Figure 1 and 2: Shows the height class and trunk diameter for *Acacia eioloba* with position on the floodplain at Gobabeb

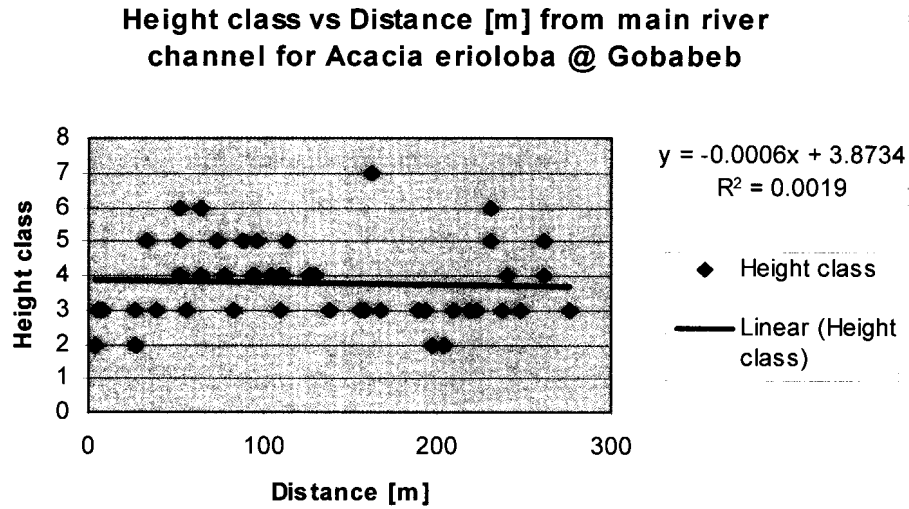


Figure 1: Shows the height class

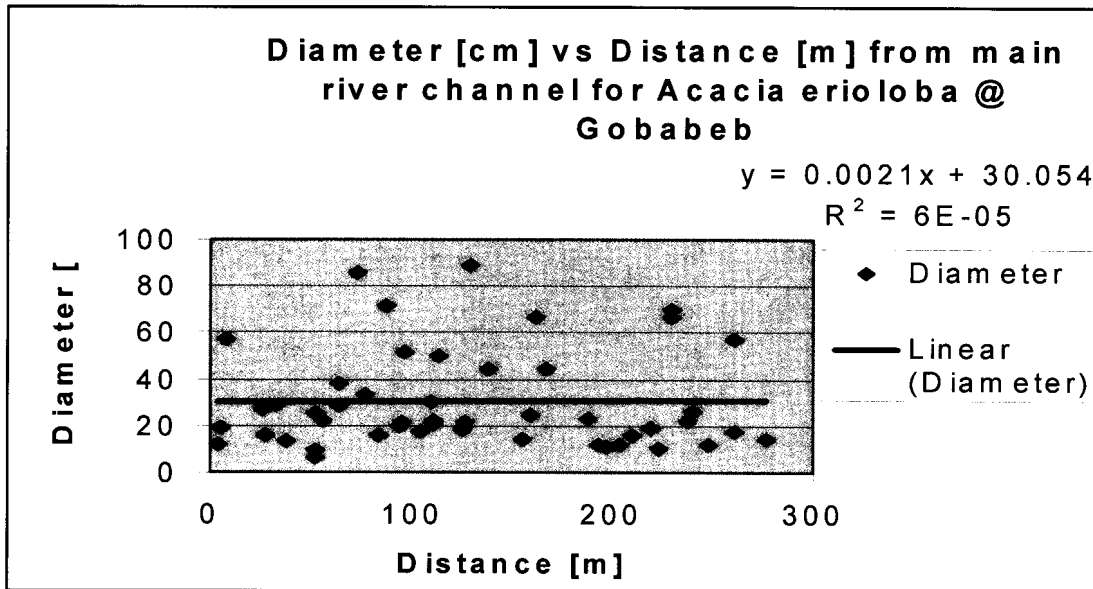


Figure 2: Shows the trunk diameter

Figure 3 and 4: Shows the height class and trunk diameter for *Faidherbia albida* with position on the floodplain at Gobabeb

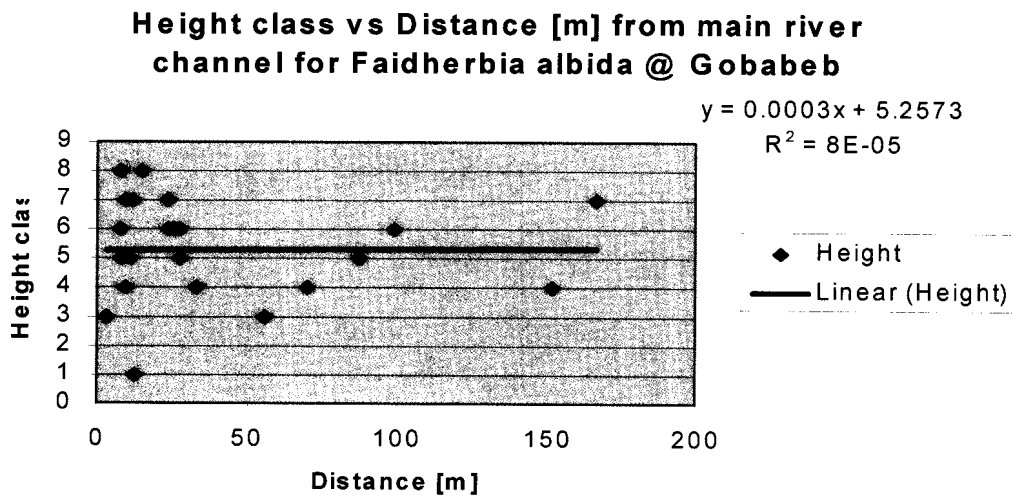


Figure 3

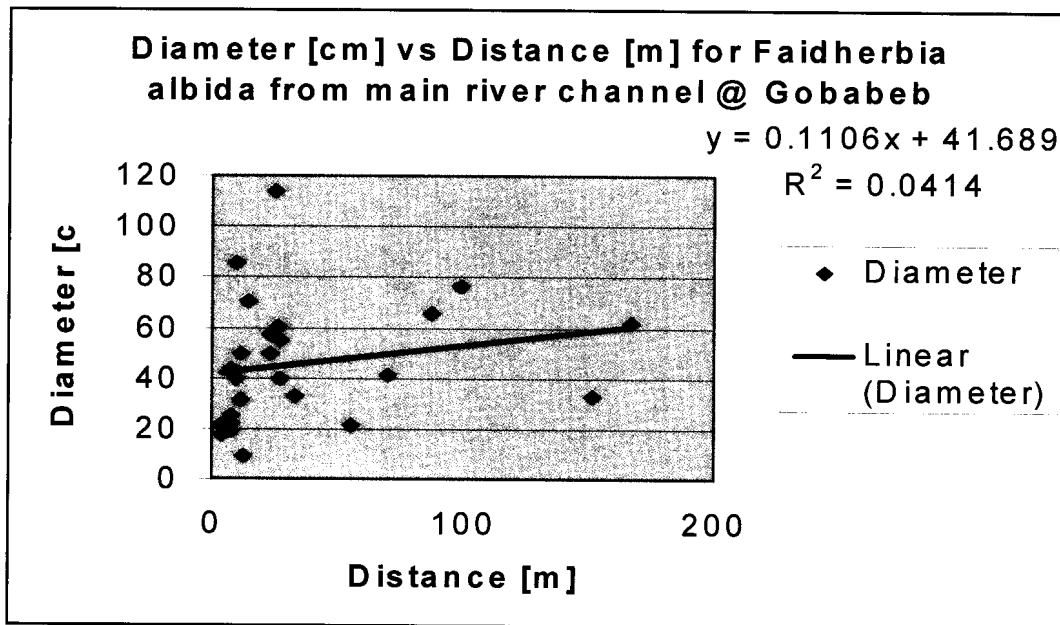


Figure 4

Figure 5 and 6: Shows the height class and trunk diameter for *Faidherbia albida* with position on the floodplain at Swartbank

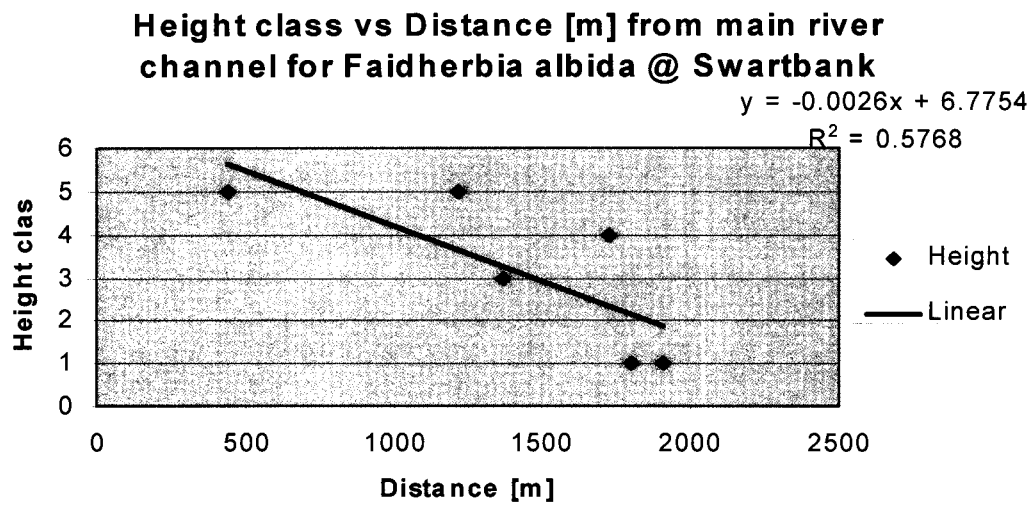


Figure 5

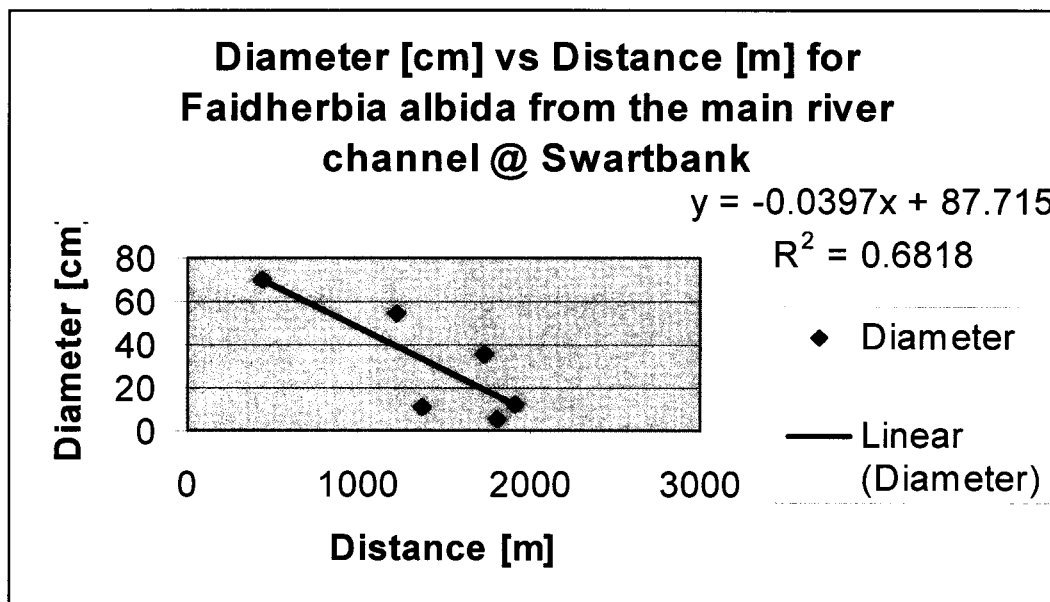


Figure 6

Figure 7 and 8: Shows the height class and trunk diameter for *Acacia erioloba* with position on the floodplain at Swartbank

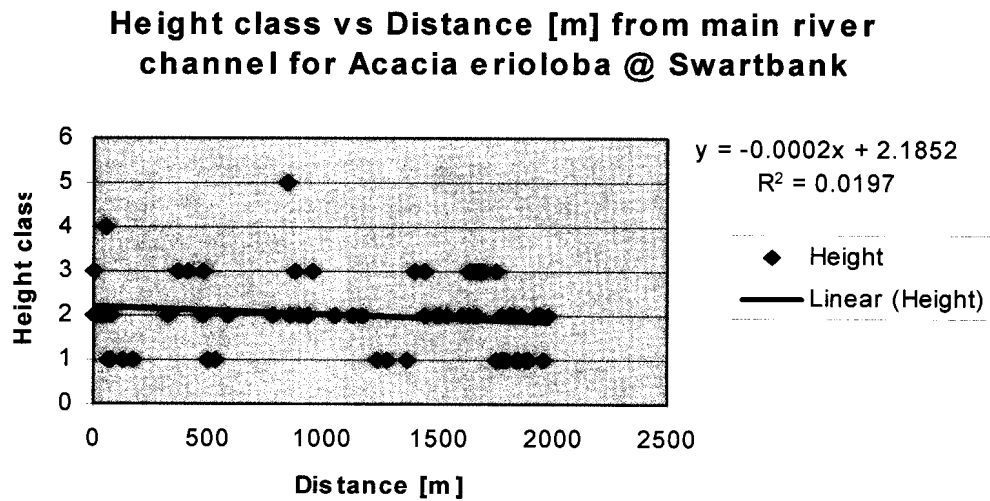


Figure 7

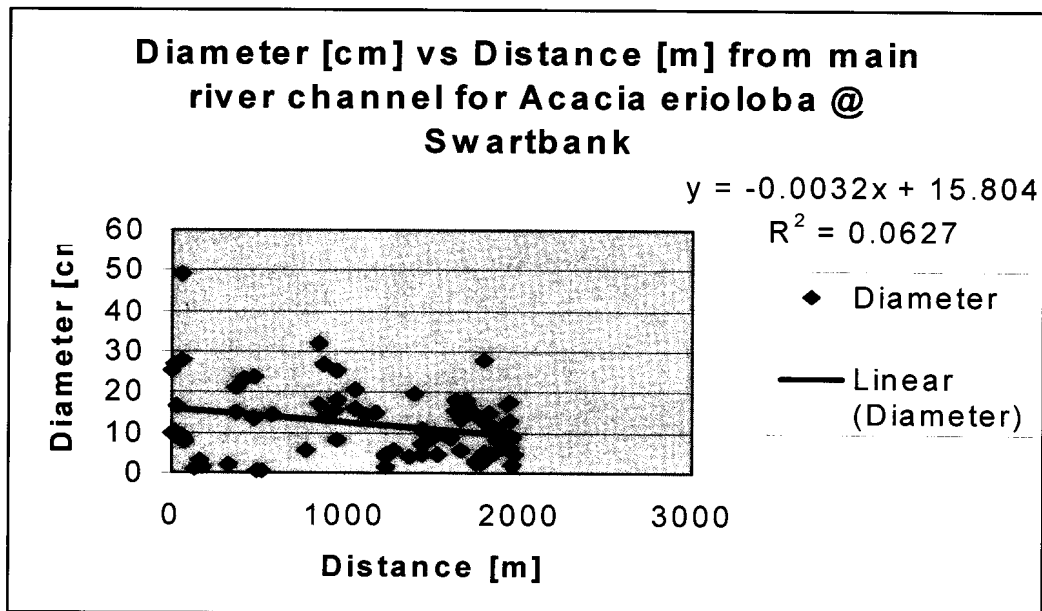
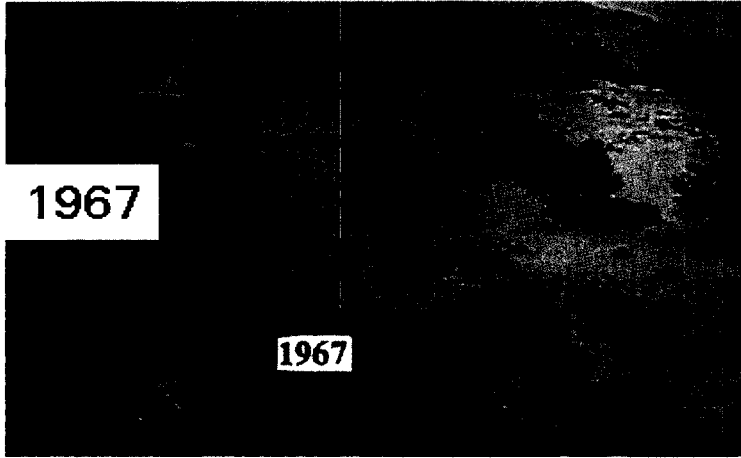


Figure 8



Appendix 4

Vegetation photographs taken from the same spot from different years



Appendix 5

Figure 1 and 2: Shows the relationship between trunk diameter and height for *Acacia erioloba* at Gobabeb and Swartbank

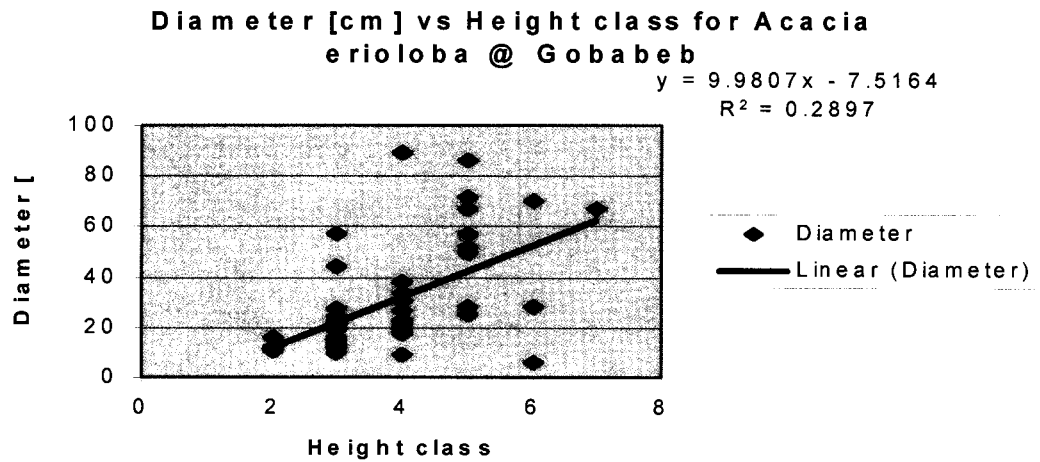


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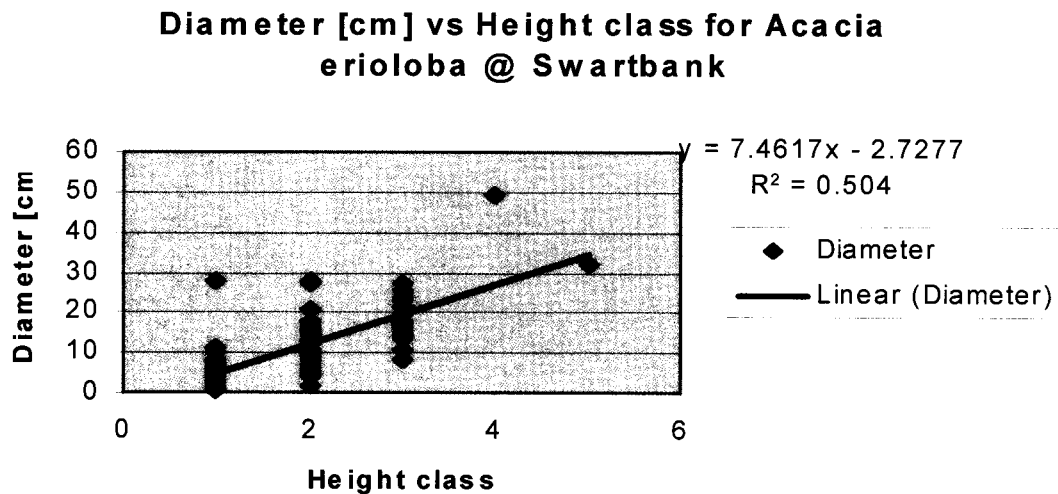


Figure: 2

Appendix 6

Figure 1 and 2: Shows the relationship between trunk diameter and height for *Faidherbia albida* at Gobabeb and Swartbank

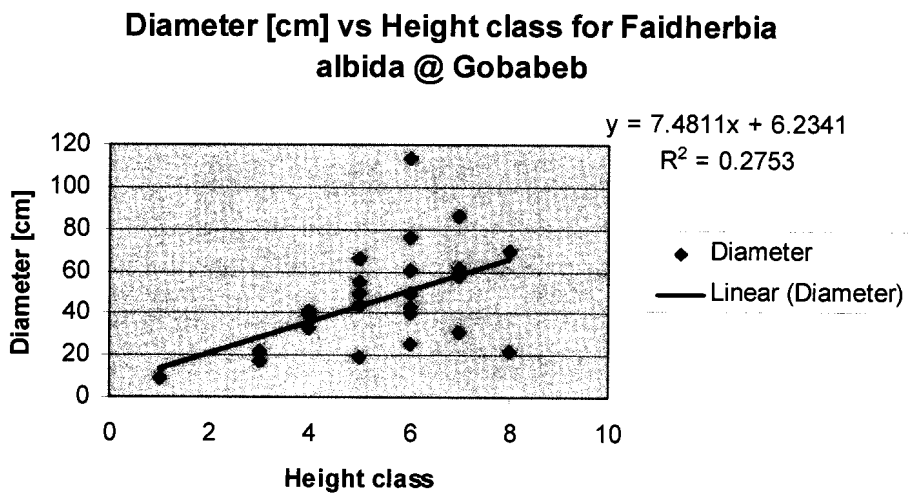


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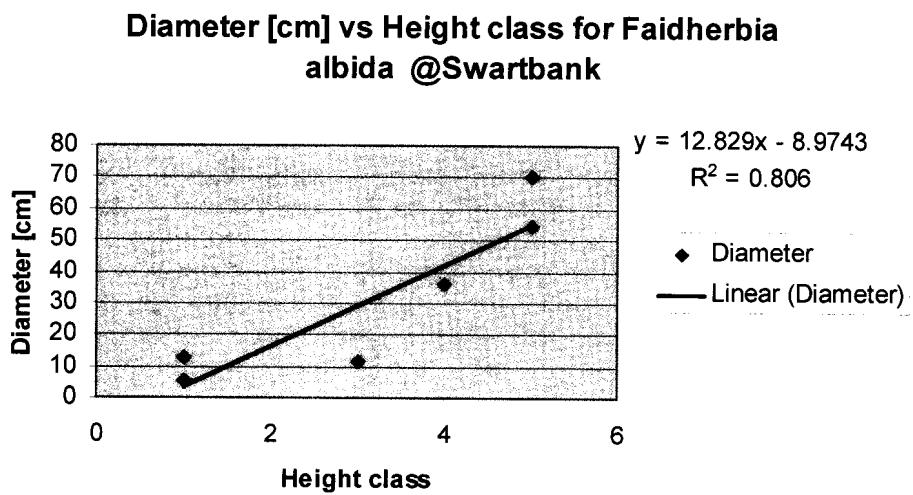


Figure:2