# Assessment of the survival and growth of Alnusacuminata trees planted as Riparian buffer strips around Lake karago in Nyabihu district, western province Rwanda

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**Abstract—**Nowadays, people are usually unwilling to adopt the techniques to protect the environment. This study was undertaken to assess the survival and growth of *Alnusacuminata* planted in 2006 as riparian buffer strips around Lake Karago in Nyabihu district, Western province. The data collection was conducted in May, 2014 .The data was then analyzed by using Genstat 14th edition SP1 for Windows software where significantly different means were separated using F.pr at p≥ 0.05. Based on the findings, the statistical analysis revealed a difference in survival and growth in diameter at breast height (DBH) and in height of *Alnusacuminata* trees planted in the two strip plots: lower and upper around Lake Karago. The survival rates are 94.59% and 91.62% for upper and lower strip plots respectively. The growth in diameter shows that the DBHs of *Alnusacuminata* trees in lower and upper quadrants were not significantly different as F.pr= 0.231>0.05. Despite the *Alnusacuminata*trees in the upper strip plot having been better surviving and attaining the greater DBH, lower height means of 16.78m and 17.25m in upper and lower transects respectively have been recorded. It can therefore be concluded that there is no significant difference in survival, height, diameter, density, basal area and volume of the trees planted in two distinct strip plots, upper and lower, around Lake Karago where F.pr. in survival is 0.280; F.pr. in height is0.479; F.pr. in diameter is0.231, F.pr. in density is0.386, F.pr. in basal area is 0.06 and F.pr. in volume is 0.304 which are all greater than 0.05.It would be worthwhile to recommend a better protection of the trees planted as riparian buffer strips around Lake Karago from animal grazing and vandalism which could lead to reduced tree growth and also the use of multiple specific rather than a single species buffer strip for better lake conservation.

**Index Terms—**Basal area; Density; Diameter at breast height (DBH); Growth; Stocking parameters; Tree height and Volume.



## 1. Introduction

Although environmental protection seems to be less known by local people in Rwanda but today it is becoming a priority and an obligation at national as well as international levels to solve the natural environmental based disasters such as global warming due to atmospheric ozone layer depletion, water pollution, desertification and climate change in general [1]. The country is faced with four major environmental challenges: first, water resources need to be conserved and better managed; second, soil fertility has been declining sharply for the last fifteen years and soil erosion is progressing. Third, there has been extensive deforestation in a number of places and four and last, biodiversity is a resource under pressure [2].

Poverty in Rwanda is intimately related to a series of inter locking issues, in particular land, demography, environmental degradation, as well as low and limited sources of growth. It is evidently clear that for progress in poverty reduction to be made, the issues for land, demography and environmental degradation must be immediately dealt with, failure to address issues of land and rising population has led to a deteriorating environmental situation [3].

## 2. Materials and Methods

Tree plantation is one of the environmentally friendly practices used to restore and protect some degrading areas. Trees plantation programs are important in environmental protection where are currently being implemented to establish buffer strips in different endangered areas; around lakes, seas and rivers whose water levels are currently and continuously fluctuating either upwards or downwards leading to the aquatic life deterioration [1].

A riparian buffer zone is a green zone along streams, rivers and lakes. A well designed buffer system may include not only a multi-species buffer area established on land next to the stream, but also plantings that stabilize the stream bank and wetlands constructed to absorb storm runoffs[4].

Although, tree planting programs in different buffer zone areas have been implemented, little has been done on post planting follow up of the survival and growth of planted tree species. Hence, this research aims at filling the information gap by assessing the survival and growth of tree species planted as riparian buffer strips around Lake Karago[4].

### 2.1. Description of the study area

Nyabihu is one of 7 Districts which compose Western province of Rwanda. It has 12 sectors like Bigogwe, Jenda,

Jomba, Kabatwa, Karago, Kintobo, Mukamira, Muringa, Rambura, Rugera, Rurembo, and Shyira. In additional, to the North is bordered byMusanze District and the Democratic Republic of Congo (RCD), to the South Ngororero District and Rutsiro, in the East, Gakenke and Musanzes Districts and to the west Rubavu District[5].

The district is located in great lakes region of central Africa. It is inscribed between 1° 43′ 42′′ and 2° 20′04′′ of south latitude and in between 29° 33′38′′ and 30° 01′ 11′′ of east longitude. The District has relief of High Mountain with Kalisimbi volcanoes therefore Nyabihu is situated between 1460 m and 4507 m of altitude. The district has abundant rainfall between 1200 mm to 1500 mm per year and average temperature of 15°C.Nyabihu district is dense hydrographic network and all waters of the district join Mukungwa river and belong thus to the Nyabarongo basin. There is also the lake of Karago that spreads on a surface of 27 ha. There is also the natural forest of Gishwati and the Volcanoes National Park which is the cradle of various animal and plant species[5].

### 2.2. Research methodologies

### 2.3. Data collection

The study was conducted on the trees planted as riparian buffer strips around the lake Karago in the sector of Karago. The area was formed into plots laid down by use of line transects. Two transects of 25m width were laid down 6m away from the shores of Lake Karago, that is 6m-31m and 31m - 56m for upper and lower strip plots respectively. The two transects were taken as treatments to assess the effect of distance from lake shores on the survival and growth of *Alnusacuminata* planted as riparian buffer strips around Lake Karago(Figure 1).

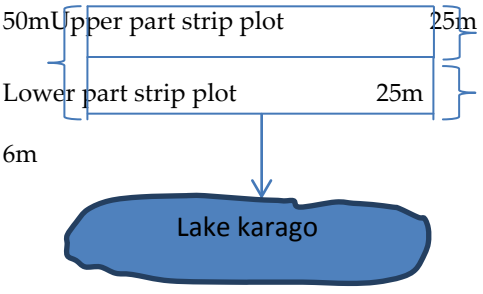


**Figure 1: Strip plot layout**

To carry out inventory and collect information on Survival **(%)***Alnusacuminata*, was quantified by counting the real or existing number of trees in both strip plots and deriving a percentage against the initial number of trees planted, that is, all trees planted; this number founded by counting visible trees plus the empty holes marked as planted. Tree density was measured to express the degree to which the space is made available to the growing of trees; and it was in function of these three elements: number of trees, tree size and the spatial distribution on the ground. It was calculated basing on the actual spacing in the field and the recommended/documented spacing.

### 2.4. Materials

Clinometer (Suunto) was used to measure the height from the base of the tree to the tip (highest point attained by the main stem) [6]. A diameter tape (10 m) was used to measure the diameter at breast height (DBH) above the ground level of tree at 1.30 m; the circumference readings were then converted into diameter by dividing the values of circumference by PI (3.14). The collected data was used to calculate the following parameters:

Basal area (G) is the cross section of tree at breast height (1.3 m above the ground). The basal area per hectare (m2/ha) was calculated by use of the formula below:

$$\mathbf{G= \left(\frac{\Pi}{40000} * d^2\right) \ n}$$

Where: **d** is the Average DBH and **n** is the number of trees per hectare.

The volume per hectare ($m^3$/ha) was calculated by use of a volume equation designed for *Alnusacuminata* as proposed by [7].

$$\mathbf{V\ (m^3) = 2.71828^{-10.0557 + \ln(d)*2.0369 + 0.927718*\ln(h)}},$$

Where: **d** represents DBH (cm) and **h** is total height (m)

### 2.5. Data analysis

The data collected were analyzed by use of Genstat 14th edition SP1 for Windows software where significantly different means were separated using F. probability at F.pr≥0.05.

## 3. Results and Discussions

### 3.1 SURVIVAL

The survival of *Alnusacumunata* trees planted as riparian buffer strips in the upper strip plot was 94.59% and greater than that of *Alnusacuminata* trees in the lower strip plot with 91.62%. Despite of the *Alnusacumin*ata trees in the upper strip plot had better surviving than the *Alnusacuminata* trees in the lower strip plot, the results from statistical analysis showed that there is no significant difference between trees in upper and lower strip plots as F.pr 0.280>0.05.The number of plants raised in nursery should be 20% greater than that to be planted in field. This is done to make up for culling and reserve for replacing dead plants[8]. This implies that any survival rate greater than 80% percent is tolerable unless the beating up reserve is prevailed, otherwise it is a failure. It can be therefore be

concluded that the survival for both strip plots, that is upper and lower strip plots, were normal as they all showed a survival greater than 80%.

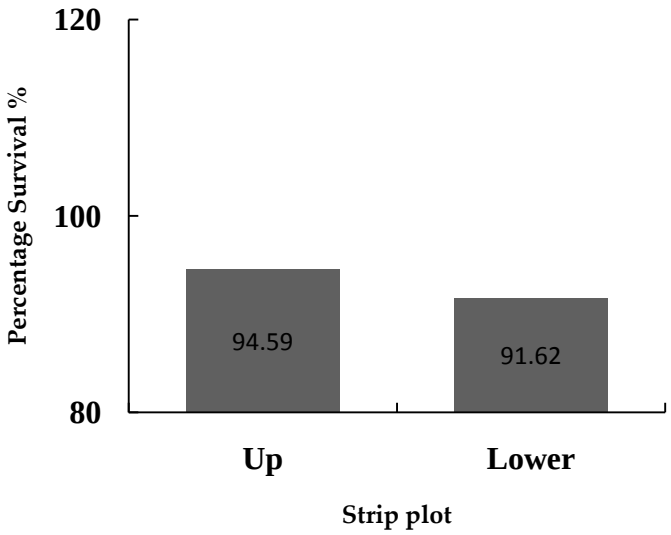


**Figure 2: Average survival rate of *Alnusacuminata* trees in upper and lower strip plots**

### 3.2. Growth parameters

#### 3.2.1 Height

Based on findings, the height of *Alnusacuminata* trees in the lower strip plot with 17.25m mean height showed greater height than that of *Alnusacuminata* trees in the upper strip plot with 16.78m mean height. Even if the height of *Alnusacuminata* trees in lower strip plot was greater than that in the upper strip plots, the results from Genstat showed that upper and lower were statistically similar in terms of their height as F.pr= 0.479. The variation in height amongst different strip plots is presented in Figure 4 below.

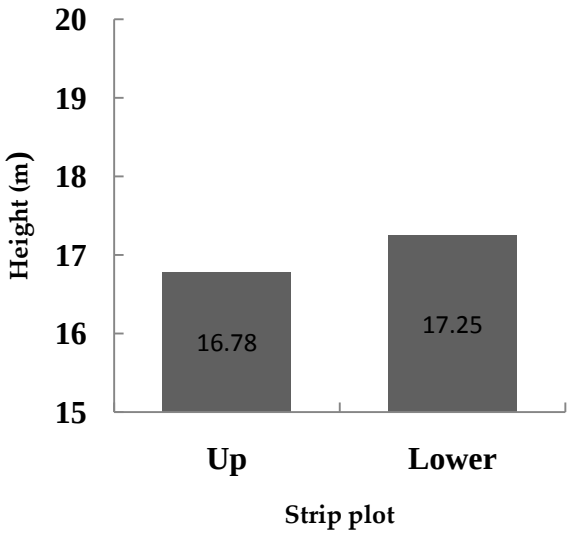


**Figure 3: Average height (m) of *Alnusacuminata* trees in upper and lower transects**

Height of *Alnusacuminata* varied in the different strip plots, upper and lower. The average height as obtained from the statistical analysis for the strip plots was 17.01m.The height was generally low in comparison to the expected height of 81 feet (24.7 m) at the age of 8 years [9].

#### 3.2.2 Diameter at breast height (DBH)

Generally, the DBH in the upper strip plot (31m-56m from the lake shores) was greater than that attained by the lower strip plot (6m-31m from the lake shores) at 8 years after plantation. Even if the DBH of trees in the upper strip plot is greater than that of trees in the lower strip plot, their difference is not significant as F.pr= 0.231>0.05.

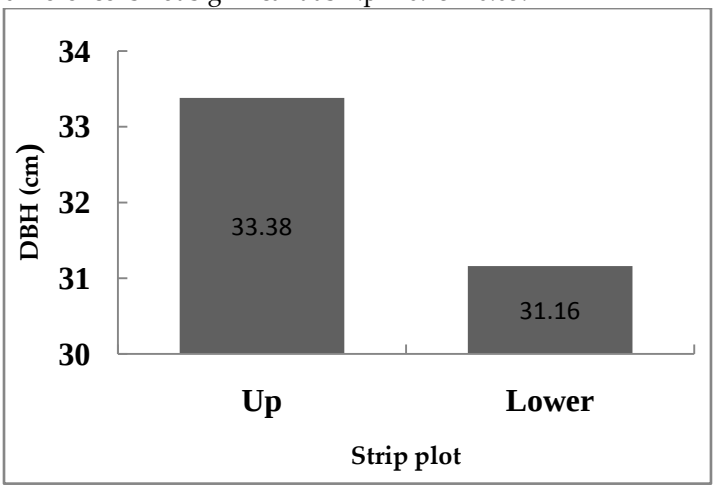


**Figure 4: Average DBH of *Alnusacuminata* trees in both strip plots, upper and lower**

#### 3.2.3 Density

The density which is the number of trees per hectare was calculated using the formula Nt/ha. The calculations

showed 562 trees/ha and 533trees/ha at the age of 8 years calculated as the arithmetic mean of the mean densities per plots, upper and lower. The result from Genstat showed that there is no significant between upper and lower strip plot (F.pr. = 0.386). The figure below shows the mean density per strip plot from which was derived the density per hectare.

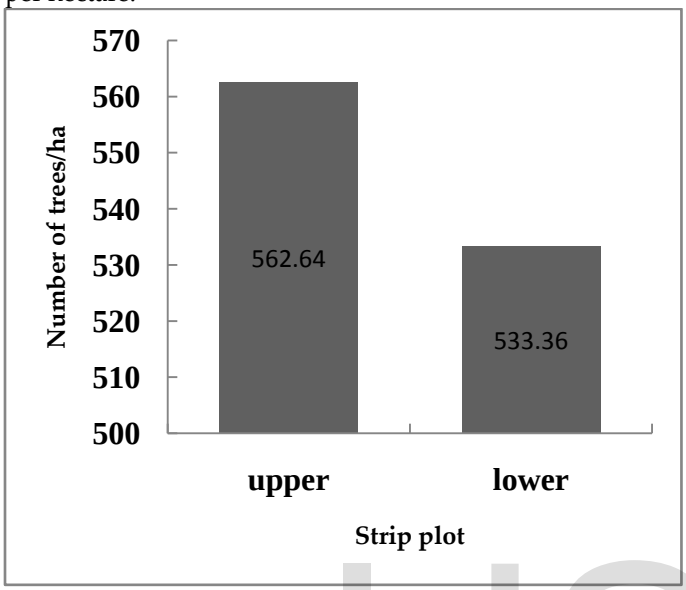


**Figure 5: Trees density in Upper and Lower strip plots**

### 3.2.4 Basal area per hectare (G)

Generally, the basal area in the upper strip plot (49.27m²/ha) was greater than that attained by the lower strip plot 40.72m²/ha at 8 years after plantation. Even if the basal area of trees in the upper strip plot is greater than that of trees in the lower strip plot, their difference is slight difference as F.pr= 0.06>0.05.

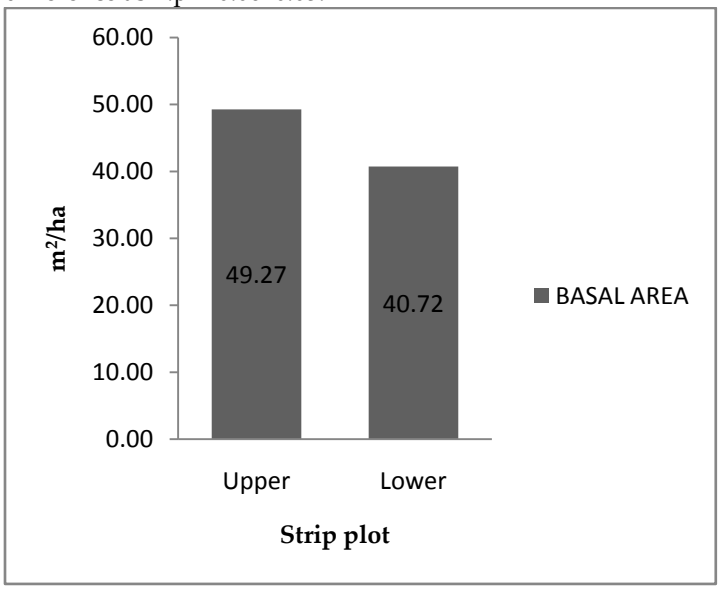


**Figure 6: basal area in Upper and Lower strip plots**

### 3.2.5 Volume per Hectare (V)

Based on findings, the height of *Alnusacuminata* trees in the upper strip plot with 0.74m³ mean volumes showed greater volume than that of *Alnusacuminata* trees in the lower strip plot with 066m³ mean volumes. Even if the volume of *Alnusacuminata* trees in upper strip plot was greater than that in the lower strip plots, the results from Genstat showed that lower and upper were statistically similar in terms of their volume as $F.pr_{(Calculated)}$= 0.479. The variation in volume amongst different strip plots is presented in Figure 4 below.

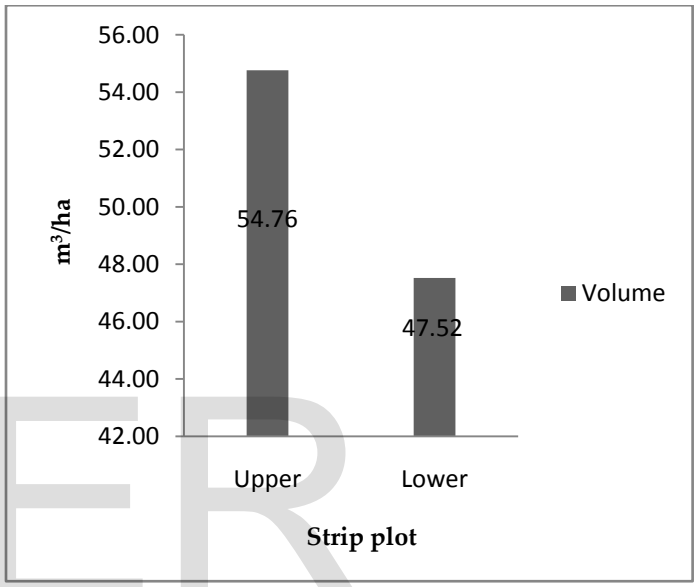


**Figure 7: volume in upper and lower strip plot**

## 4. DISCUSSION OF THE RESULTS

The number of trees per hectare is a very important parameter as it directly influences competition and hence the growth characteristics of trees. The proper spacing of trees in sole cropping is 3m by 3m[10], translating to 1,111trees/ha. According to the results, the low number of trees per hectare in the woodlots could either be an indication of heavy thinning or low initial planting stocking rates. At the two buffer strip plot around Lake Karago the number of trees/ha is significantly lower as compare to the standards, about 562 trees/ha in upper and 533 trees/ha in lower strip plots because of irregular spacing found in that *Alnusacuminata* plantation around Lake Karago.

Stand basal area is a very useful parameter for quantifying a forest stand. It may be seen as a summary of the number and the size of trees in a stand and can be used to estimate stand volume or as a useful measure of the degree of competition or the density of a stand [11]. The amount of basal area in a stand is a function of the number of trees

and the size of the trees, as such; it is a measure of the overall level of competition for resources between trees in the stand. Stand basal area of fully stocked stands frequently lies in the range 20- 50 m2/ha which is the case in our study. In the case of heavily thinned stands and young poorly stocked crops, basal areas of 10-20 m2/ha are common [11].

## 5. CONCLUSION

The main objective of this study was to assess the survival, density and as well as growth rate of *Alnusacuminata* planted as riparian buffer strips around Lake Karago. Based on the findings, it can be concluded that *Alnusacuminata*planted as pure stand around Lake Karago in 2006. The survival rate of *Alnusacuminata*was found normal because it is greater than 80% in all strip plots, where it was 94.59% in the upper strip plot and 91.62% in the lower strip plot and the two were nor significantly different (F.pr= 0.280>0.05) as shown by statistical tests.

According to findings, the growth in height of *Alnusacuminata*trees in lower strip plot (17.25m) was better than that of *Alnusacuminata*trees in upper strip plot (16.78m) but the statistical test showed that the two heights, height in lower and upper strip plots, are not significantly different F.pr= 0.479>0.05.

The findings also showed that the growth in diameter (diameter at breast height or DBH), basal area and volume for the upper strip plot are better than that in lower strip plot. The statistical test results showed that there are not significantly different with $F.pr_{(calculated)}$ are 0.231, 0.06and $0.304>0.05_{tabulated}$.

Finally, it can be concluded that the distance from the lake shores has a little or no effect on the growth of *Alnusacuminata* trees planted as riparian buffer strips around Lake Karago for its protection. During field observation, it was seen that a number of factors like animal grazing and human trafficking in the forest and irregular spacing between trees may have affected either directly or indirectly the growth of the *Alnusacuminata* trees planted as riparian buffer strips around Lake Karago.

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