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THE TRANSPLANTATION OF *Terminalia sericea* FROM THE SANDY SOIL TO THE CLAY WATER-LOGGED AREA IN THE NYLSVLEY NATURE RESERVE

BY

NEMAHUNGUNI N.K

11575152

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SUPERVISOR: MR MH LIGAVHA-MBELENGWA

CO-SUPERVISOR: PROF MP TSHISIKHAWE

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DECLARATION

I Nkhanedzeni Khodani Nemahunguni, declare that this dissertation hereby submitted to the University of Venda for the Degree of Master of Science is my own work except where acknowledged in the text, and has not been previously submitted either as a whole or in part for a degree at any other university.

Signature _____ Date: 13/06/2016

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ABSTRACT

Terminalia sericea Burch. Ex DC is a silvery blue, upright, common shrub or tree of 6 m to 9 m on average whereas individual trees may reach 23 m in height. The species belongs to the family Combretaceae. Its leaves are browsed by cattle, goats and game during the hot, dry season. A great need for it in the reserve is obvious for its nutritional and medicinal need to animals and people respectively. *Terminalia sericea* is seen to be growing and flourishing in sandy soil where there is a shortage of water in the Nylsvley Nature Reserve whereas it is not growing in clay waterlogged area. The situation seems to suggest that *T. sericea* cannot survive in clay waterlogged areas. Transplant experiment method was employed where seedlings of *T. sericea* from the sandy soil areas were uprooted and then planted in the clay waterlogged soil areas while others were planted in the sandy soil areas for control. The experimental design was repeated in different seasons to investigate if seasons have an effect on the establishment of *T. sericea* seedlings. Seedlings establishment proved favourable in early summer than early winter where all seedlings died-out. *Terminalia sericea* showed to be growing at both type of soils at first before the waterlogged area was flooded with water. Thereafter, they died out in clay soil areas which somehow showed that *T. sericea* does not survive in clay waterlogged areas.

Key words: *Terminalia sericea*, sandy soil, clay soil, waterlogged area, seedling establishment.

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Chapter 1

INTRODUCTION

1.1 Background

At least two-third of South Africa's poor people resides in the rural areas, largely within the savanna biome (Shackleton *et al.*, 2004). Fuel wood is the main primary source of energy for the majority of the communities of South and southern Africa. Most of the biomass used for fuel is harvested from the natural wild and woodlands. In densely populated areas, the high pressure on indigenous woodlands for fuel wood, construction timber, building poles and traditional medicine has led to areas with localized shortage of fuel wood and woodlands increasingly threatened (Gandar and Grossman, 1989). Despite the significant contribution of savanna woodlands to meeting the requirements for biomass energy, their management has been neglected (Shackleton *et al.*, 2004).

Woody biomass is a key resource with respect to both ecosystem structure and functioning; it is also useful to rural communities, especially for fuel wood purposes (Shackleton *et al.*, 2004). In terms of ecosystem value, woody species are keystone elements through the provision of fodder for wild and domestic animals, nesting sites and habitats for reptiles and nutrients rich pools for wild animals that feed on plants.

As a multipurpose species, uses of *T. sericea* range from land improvements to medicinal plant. The tree improves sites by draining waterlogged soils, shading out weeds, enriching impoverished soils by deposition of dead materials and also used for erosion control (Eckman and Deborah, 1993). For medicinal uses, roots of *T. sericea* are used to treat bilharzia, colic, pneumonia and diarrhea while leaves are used for stomach disorders (Pohjonen, 1992). The species is also used for carvings, fencing posts, charcoal, fuel wood, building material and tool handles (Eckman and Deborah, 1993).

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Terminalia sericea is a silvery blue, upright, common shrub or tree of 6 to 9 m but individual trees may reach 23 m in height, the species belongs to the family Combretaceae (Palgrave, 1988). *Terminalia sericea* is scattered in open woodlands, or as a dominant or co-dominant in mixed deciduous forest, it is adaptable to drought and moderately adaptable to saline soils, it can tolerate some frost. *Terminalia sericea* have a tendency to form thickets when cut or burnt and becomes weedy, preventing the growth of grasses. It thrives in a range of soil types, moisture conditions and drainage as long as light is not a limiting factor (Pohjonen, 1992).

In agriculture and gardening including botany transplanting or replanting is the technique of moving a plant from one location to another. Most often this takes the form of starting a plant from seed in optimal conditions, such as in a greenhouse or protected nursery bed, then replanting it in another, usually outdoor, growing location. Botanical transplantation are used infrequently and carefully because they carry with them a significant risk of killing the plant (Straus, 2010).

1.2 Aim

The aim of the research project was to establish the effect of two different soil types on the regeneration, establishment and growth of *Terminalia sericea.*

1.3 Objectives

To investigate the regeneration of transplanted of *T. sericea* seedlings in waterlogged clay and sandy soil areas in the Nylsvley Nature Reserve.

To investigate the effects of season on the establishment and survival of the transplanted seedlings of *T. sericea* on sandy and soil areas.

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1.3 Hypothesis

Terminalia sericea grows well in sandy than in clay waterlogged soil areas. Transplanting or replanting is the technique of moving from one location to the other. Most often this takes the form of starting a plant from seed in optimal condition, such as in a greenhouse or protected nursery bed, then replanting it in another, usually outdoor location. Another way of replanting is the uprooting of seedlings from the wild and replant them in another place either in the greenhouse, nursery or in the outdoor. Botanical transplants are used infrequently and carefully because they carry with them a significant risk of killing the plant (Straus, 2010).

1.4 Problem statement

Terminalia sericea is seen to be growing and flourishing in sandy soil areas where there is a shortage of water and nutrients in the Nylsvley Nature Reserve (NNR) whereas it is not growing in clay waterlogged areas at all. The situation seems to suggest that *T. sericea* cannot survive in clay waterlogged areas. This is despite the fact that this species is of great use in defining waterlogged areas. A great need for it is unquestionably obvious for its nutritional and medicinal value to animals and people. The importance of traditional medicine, derived from these plants, is of great importance in most parts of both Africa and Asia (Lawes *et al.,* 2004; Steenkamp *et al.,* 2004 and Moshi and Mbwambo, 2005). Many *Terminalia* species, have been identified as source of medicine, for use in pharmaceuticals and cosmetic production (Dalziel, 1937 and Irvine, 1961). Extract of the flowers, fruits, bark, leaves, stems and roots from species such as *T. glaucescens, T. macroptera* Gill and Perr, *T. laxiflora, T. superba, T. prunioides, T. brachystemma, T. sericea, T. gazensis, T. catappa, T. mollis* and *T. sambesiaca* are used in traditional medicine to treat diseases such as malaria, eczema, candidosis, asthenia, gonorrhea, diabetics, dermatitis, scurfly affection, leprosy and

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tuberculosis (Batawila *et al.,* 2005; Masoko *et al.,* 2005; Fyhrquist *et al.,* 2006 and Kamtchouing *et al.,* 2006).

Terminalia species, have a number of agricultural uses. They are important sources of fodder for animals. *Terminalia sericea* is one of the palatable woody plants found in South Africa savannas (Owen-Smith and Cooper, 1987 and Lawes *et al.,* 2004). Its leaves are browsed by domestic cattle, goats and game during the hot, dry season (Ellery and Ellery, 1997; Mabberley, 1997 and Katjiua and Ward, 2006).

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LITERATURE REVIEW

2.1 The Genus *Terminalia*

2.1.1 Origin and distribution

The family Combretaceae is comprised of 20 genera and about 475 species (Thiombiano *et al.,* 2006). Of these about 200 belong to the genus Terminalia, making it the second largest genus of the family after Combretum (McGaw *et al.,* 2001). The family is distributed throughout the tropical and sub-tropical regions of the world (Lamb and Ntima, 1971). Approximately 54 species of Terminalia are naturally distributed throughout western, eastern and southern Africa (Lebrun and Stork, 1991 and Smith *et al.,* 2004). *Terminalia ivorensis* and *T. superba* are the most important species found in west and central Africa (Norgrove and Hauser, 2002). They are also established in plantations within and outside their natural range, for example, in south and Central America, east Africa, Hawaii, Fiji and the Solomon Islands (Jones, 1969). Within the Malaysian region, further trails exits in Sabah, Kalimatan and the Philippines (Lamprecht, 1989). On the other hand *T. prunioides, T. brachystemma* Welw. Ex Hiern, *T, sericea, T. gazensis* Bak, *T. mollis* Laws and *T. sambesiaca* Engl and Diels are the most species in eastern and southern Africa (Palgrave, 1988 and Masoko *et al.,* 2005)

2.1.2 Botanical description and ecology

The genus Terminalia derives its Latin name (Terminalis = end) from the position of the leaves, which are crowded at the end of the shoots (Lamb and Ntima, 1971 and Rogers and Verotta, 1996). The taxonomy of the genus has not been without problems, with the assignment of sub-genera, especially presenting differing views (Stace, 1965). However, the different species have now been grouped into three sections according to characteristics of the fruits. These sections include the section *Abbreviatae* Excell with shorter fruits, section

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Psidioides Excell with longer fruits and the section *Platycarpae* Engels and Diels emend Excell, with fruits that are broader in the Centre (Carr, 1988).

Terminalia species, range from small and medium size shrubs or trees to large deciduous forest trees, ranging in height from 1.5 to 75 m tall (Lebrum and Stork, 1991 and Schmidt *et al.,* 2002). Some species, such as *T. ivorensis, T. superba* and *T. trichipoda* have cylindrical boles that are very straight and long with small to large, flat buttresses (6 m above the soil surface) and are sometimes branchless for up to 30 m and 2 - 5 m in girth (Lemmens *et al.,* 1995). Mature trees are extensively flat topped, with a wide horizontal canopy of evenly distributed foliage arising from the apex of the straight bole (Dupuy and Mille, 1993). It is these characteristics, and their relatively fast growth, that make *T. ivorensis* and *T. superba* popular timber species. Other species such as *T. sericea* and *T. prunioides* are common as small shrubs to bushy trees that may be single or multi-stemmed with a girth of up to 1.5 m (Palgrave, 1988).

The bark of Terminalia trees is smooth and light grey to dark brown when young and on brachlets. The inner bark and contact zone with the cambium is frequently yellow. In mature trees, the bark surface cracks and flakes off in long thin strips or small patches, often becoming blackish and developing deep longitudinal fissures as the trees grow (Keay, 1989 and Lemmens *et al.,* 1995).

The root system of Terminalia trees are frequently fairly shallow. As the trees age, the tap roots disappear. In the tall species such as *T. ivorensis,* bitterness from which descending roots arise at some distance from the trunk, developed to support the trees (Keay, 1989 and Lamprrecht, 1989).

The leaves are frequently simple and obovate, clustered spirally at the ends of the dwarfed lateral branchlets, or crowded near the ends of the branches. Some species, like *T. brasssii* Excell, have prominent glands at the leaf bases (Lamb and Ntima, 1971). In mature trees crown is usually flat or very slight domed, giving Terminalia trees a distinctive shape.

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Terminalia trees are bi-sexual or hermaphroditic with male and female flowers carried on the same plant. These flowers are apetalous, small, and cream to pale, bright yellow or greenish-white, in spicate inflorescences. The stalked male flower tends to be grouped towards the apex and the bisexual flowers towards the base of the inflorescence (Palgrave, 1988). Terminalia species have an effective system of self-incompatibility. Although male and female flowers are in the same plant, self-pollination cannot produce viable zygotes (Newbegin *et al.,* 1994). The flowers are pollinated by various insects, for example *Coleopter*, *Diptera, Hemiptera*, *Hymenoptera* and *Lepidoptera* (Uzoechina, 1978). The flowering-to-fruiting period may last about 4 months, depending on the species and the locality where it is grown (Palgrave, 1988 and Keay, 1989).

Terminalia fruits, in combination with leaf characteristics, are of great diagnostic value and absolutely essential to distinguish between species (Coode, 1969 and Excell and Stace, 1972). The fruits are hard, flattened, two-winged and to some extent inconsistent in size, especially the length and width of the wings. The general seed shape is consistent however, specific characters such as fruit colour when ripe (yellow, red, purple, green, brown or pink) depending on the species and fruit morphology (elongate, broad, narrow, ovoid or elliptic) vary and are helpful in species differentiation (Dale and Greenway, 1961; Palgrave, 1977 and Keay, 1989). The fruits of some Terminalia trees, together with the bark, are important sources of tannin (Lemmens and Wulijarni-Soetjipyo, 1991; Ellery and Ellery, 1997 and Mabberley, 1997). Terminalia fruits differ from those of closely related Combretum species, in having a sclerenchymatous endocarp (Lamb and Ntima, 1971). Most of the African Terminalia species, produce fruits from January to September, with the exception of species such as *T. ivorensis* and *T. glaucescens* planch; Benth that produce fruits from July onwards (Palgrave, 1988 and Keay, 1989)

The African species of Terminalia generally occurs in various environments. Some species such as *T. ivorensis* and *T. superba* develop as elements of the canopy or sub-canopy layer in evergreen, semi-deciduous to deciduous, primary and secondary forests (Keay, 1989). Some species such as *T. sericea* on the other hand, thrive well in open woodlands to wooded

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savannas and mixed deciduous forest (Dale and Greenway, 1961; Lebrun and Stork, 1991 and Carr, 1994). Terminalia trees can tolerate light to moderate shade, when young (Jones, 1969). Thereafter, they should receive full overhead light for optimal growth (Veenendaal *et al.,* 1996). Few individuals of this genus are able to grow at high altitude; most species perform well at altitude less than 2000 m above sea level. The climate in which Terminalia trees grow varies from areas with year round rain for species occurring in the forest areas (> 2000 mm per annum) to seasonal with moderate rainfall (< 1200 mm per annum) for those occurring in savanna zones (White, 1983).

2.2 Propagation and management of Terminalia species

Terminalia species, can be propagated naturally by seeds or through vegetative methods with wildings, seeding, stump plants or striplings (Lemmens *et al.,* 1995). However, obtaining suitable plant for propagation is difficult and with most Terminalia species, propagation is not easy (Carr, 1994).

Freshly fallen seeds should be collected from the ground, as seeds still on the tree may not be fully mature. Sometimes the seeds are collected from the tree by cutting off the branches, because fallen seeds may often be parasitized by insects, leading to low viability. As far as possible, seeds should be collected from healthy mother trees with a vigorous stem and crown (Browse, 1979 and Hartman and Kester, 1983). The number of fruits and seeds (per kilogram) vary greatly between Terminalia species, for example *T. ivorensis* can produce 5500 - 7300 seeds/kg (Lamb and Ntima, 1971), *T. superba* can produce 8000 - 10000 seeds/kg (Groulez and Wood, 1985) and *T. prunioides* 8200 seeds/kg (Palmer and Pitman, 1972). Seeds are extracted with grass or leaves. After a day or so the fruit wing is stripped off and the seeds are extracted from the fruit wings manually (Carr, 1994).

In general, seeds vary in the length of time that they remain viable. The viability of the seeds varies between species. The viability of most species diminishes rapidly, with the exception of *T. superba* and *T. sericea* of which their seeds can be stored in sealed containers at 2 - 4 °C for one year, adding to its suitability for commercial uses (Groulez and Wood, 1985).

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Seeds of Terminalia species, must undergo a period of dormancy before germination occurs. There are two types of dormancy in plants, namely physical and physiological dormancy (Weber and Stoney, 1986). Several methods of pre-treatment can be used to overcome the two types of dormancy in seeds of Terminalia species. As seeds of Terminalia species, are covered by a hard protective coat, the physical dormancy ends when the seed coat is opened through different process such as mechanical abrasion, nicking or soaking in water (Browse, 1979 and Weber and Stoney, 1986). Most often, for some species of Terminalia, seeds are pre-treated by soaking in water for 12 - 48 hours, by manual scarification, or, in the case of *T. ivorensis,* by alternative soaking and drying for one week (Lamb and Ntima, 1971). For *T. ivorensis* the germination rate is 10 - 50 %, but up to 93 % under experimental temperature fluctuations, while for *T. superba* it is 60 - 80 % (Lemmens *et al.,* 1995), 15 - 35 % for *T. prunioides* and 1 - 2 % for *T. sericea* (Carr, 1994). However, as the viability in seeds is not assured, covering seeds or fruits in the seedbed is important for increasing the germination percentage. Light shade is generally applied during germination, but it should be removed after one to two months. The seedbed should be watered frequently to provide adequate moisture during germination (Browse, 1979). The sowing medium should be sand with low level of "fines" of a light soil, half mixed sifted compost to promote good drainage and avoid water logging during heavy rain periods (Carr, 1994).

Physiological dormancy of Terminalia seed ends within two weeks after sowing and is followed by epigeous germination which lasts two to five weeks. Pricking out should be done early enough to avoid disturbing the rapidly developing taproot (Lemmens *et al.*, 1995). For *T. superba,* pricking out is recommended six weeks after sowing when two leaves have developed (Groulez and Wood, 1985), whereas for *T. ivorensis*, it should be as soon as the two cotyledons unfold and the seedlings are 20 - 30 cm tall (Lamb and Ntima, 1971).

As an alternative to overcome seed viability problem, long growth periods and inconsistency of seed germination (Carr, 1994), vegetation propagation through cutting and stump plants can be used (Lemmens *et al.,* 1995). However, vegetation propagation has in Africa been used early for species such as *T. ivorensis* and *T. superba* in Africa (Fisher, 1976).

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The planting stock for vegetation propagation should be taken from young, vigorous shoots or suckers from healthy, mature trees, during the dormant season, to encourage fast-growing stems (Browse, 1979). Short cuttings are taken from different parts of the stem (e.g. from the rejuvenated stump plants and from branches). These stems (25 - 35 cm long) are cut just above the proposed top bud and horizontally at the base, if possible dipping in a rooting hormone before planting. Depending on the species, the cuttings can be placed either in pots filled with water, or directly into a trench which is kept moist (Hartman and Kester, 1983). After a period of time shoots will produce roots, and they can then be transplanted to a permanent site. Stumps should have a diameter of at least 1.3 cm. cutting of *T. superba* and *T. ivorensis* produce roots within two weeks, with a rooting percentage of 11 - 100% for *T. superba* according to the degree of rejuvenation (Lemmens *et al.,* 1995). However the method of using rejuvenated stump plants and from branches could not be used with *T. sericea* for it lives in sandy soil and requires a tap root to access the required nutrients from the environment and a growth hormone cannot produce a tap root.

2.3 Functional uses of Teminalia trees

Terminalia species provide economical, medicinal, spiritual and social benefits. The wood of Terminalia species are highly appreciated as constructional timber. It is currently used for lights construction, door and window frames, coffin boards, mouldings, beams, rafters, joists, floorings, furniture, carts, tools handles, spindles, shuttlews, picker sticks, walking sticks, bowls, boat building, masts, mine props, foundation piles, venner and plywood (Irvine, 1961; Lumens *et al.,* 1995; Schmidt *et al.,* 2002 and Smith *et al.,* 2004). *T. sericea* and *T. catalpa* L. are important sources of tannin, as well as gum and resins for glazing pottery (Irvine, 1961; Lemmens and Wulijarni-Soetjipto, 1991 and Ellery and Ellery, 1997). Dyes of various colours (black, red, orange, yellow, brown) are extracted from the leaves, fruits, barks and roots of thyme species such as *T. mollis* Lawson, *T. ivorensis, T. laxiflora* Engl and Diels, *T. catappa* L, and *T. superba* are used for decorating the walls of the houses and buildings with mural, for dyeing clothes, mattings, rattan, spoons and walking sticks (Dalziel, 1937 and Errington and Chisumpa, 1987). The seeds of some species are edible and considered one of the flavoured tropical nuts. Furthermore, consumable oil can be extracted from the seeds of *T. catappa* and used as a substitute for groundnut (*Arachis hypogea*), cotton seed (Gossypuim species) and silk cotton seed (Ceiba species) oils (Irvine, 1961).

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In Africa, forests are sometimes used for ritual and spiritual purposes. Certain trees can serve to link the living with their ancestors, as this is often symbolized in the relationship between the sky and the earth. In Southern Africa, Tswana people believe that good crops are ensured at harvest and planting time by thrusting a stick of *T. sericea* into the floor of a shrine in homage to ancestral spirits, and that cutting down an entire tree will result in hail-storms (Coates-Palgrave, 1977).

The importance of traditional medicine, derived from these plants, is of great importance in most parts of both Africa and Asia (Lawes *et al.,* 2004; Steenkamp *et al.,* 2004 and Moshi and Mbwambo, 2005). Many Terminalia species, have been identified as source of medicine, for use in pharmaceuticals and cosmetic production (Dalziel, 1937 and Irvine, 1961). Extract of the flowers, fruits, bark, leaves, stems and roots from species such as *T. glaucescens, T. macroptera* Gill and Perr, *T. laxiflora, T . superba, T. prunioides, T. brachystemma, T. sericea, T. gazensis, T. catappa, T. mollis* and *T. sambesiaca*are are used in traditional medicine to treat diseases such as malaria, eczema, candidosis, asthenia, gonorrhea, diabetics, dermatitis, scurfly affection, leprosy and tuberculosis (Batawila *et al.,*2005; Masoko *et al.,* 2005; Fyhrquist *et al.,* 2006 and Kamtchouing *et al.,* 2006). The bark of *T. macroptera* is burned and used by Sudanese women as a perfume (Irvine, 1961).

Terminalia species, have a number of agricultural uses. They are important sources of fodder for animals. *T. sericea* is one of the palatable woody plants found in South Africa savannas (Owen-Smith and Cooper, 1987 and Lawes *et al.,* 2004). Its leaves are browsed by domestic cattle, goats and game during the hot, dry season (Ellery and Ellery, 1997; Mabberley, 1997 and Katjiua and Ward, 2006).

Terminalia species, are commonly established in the "taungya system" (Lamb and Ntima, 1971). Were they are combined in the early stages with the growing of agriculture crops like banana and cocoa (Nichols *et al.,* 2001 and Norgrove and Hauser, 2002). *Terminalia ivorensis* and *T. superba* have been successfully used in this respect throughout West Africa,

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particularly in Cameroon (Diaw *et al.,* 1999; Norgrove and Hauser, 2002). In this part of the continent, cacao farms are managed in harmony with several tree species by adjustment of forest cover to provide shade for cacao trees for example *Theobroma cacao* (Chocolate tree). One of the advantage of the system is that it reduces the initial costs of establishment by alleviating the cost of the forest clearing and weeding in the first two or three years of the agricultural crop. In addition, many of these shade trees provide additional services and incomes through the provision of medicinal products and timber (Sonwa *et al.,* 2000). The cultivation of the crops greatly stimulates the early growth of the trees, providing fertilization through the leaf litter (Singh *et al.,* 2002; Goma-Tchimbakala and Bernard-Reversat, 2006). This form of tree management through enhancement of carbon sequestration confers environmental sustainability to the cocoa plantations and thus justifies its use as a model of promotion within the framework of developing agroforestry systems with perennial crops in Africa.

In West and central Africa, native Terminalia species, are of great economic importance as they are among the most important export timbers. In 1995, Cameroon exported 62000 tons of Terminalia logs, together with 15000 tons of sawn wood, 1000 tons of veneer (thin slices of wood, usually thinner than 3 mm (1/8 inch).) and an unrecorded amount of plywood. This amount of exported Terminalia is ranked third in national export for the country (Anonymous 1999). During the same period, the Democratic Republic of Congo exported 3000 tons 0f Terminalia logs, 1000 tons sawn wood and small quantities of veneer, while the other Congo republic exported 10000 tons of logs (Anonymous, 1997). Cote d'Ivoire exported 7000 tons of logs and a small amount of veneer, while Ghana exported 18000 tons of Terminalia logs, 3000 tons of sawn wood and 1000 tons of veneer during 1995 (Anonymous, 1997). The wood of African Terminalia species is used particularly in Egypt, France, Belgium, Germany, Nederland, Switzerland, USA, Philippines, Brazil, Thailand and Japan (Anonymous, 1997).

Terminalia sericea is important in traditional medicine. The leaves and roots are boiled in water and the infusion is taken orally for the treatment of coughs, diarrhoea and stomach aches. The leaves can be used as an antibiotic for wounds. In case of bleeding, a paste can be made by cooking the leaves in water and placing them on the wounds. The wood is used as a source of energy for cooking and boiling water, for constructing huts, for fencing material

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and for solid structures. Leaves are food for caterpillars during the rainy season (Pohjonen, 1992). The species is also used for carvings, fencing posts, charcoal, fuel wood, building material and tool handles (Eckman and Deborah, 1993).

2.4 Pests and diseases

Relatively few studies of the pests and diseases affecting Terminalia species, have been carried out. There are many insect species associated with Terminalia species, but as yet, no widespread pest problems have emerged. Nevertheless some locally common species are potentially dangerous, mostly affecting the early stages of the trees (Lamb and Ntima, 1971).

2.4.1 Insects

2.4.1.1 Fruit Borers

A 3-mm-long weevil (Nanophyes spp.) is considered the most serious pest of *T. ivorensis* and *T. superba* in Nigeria and Ghana. The weevil deposits its eggs in the ripening seed on the tree and can reduce germination by up to 40% (Lamb and Ntima, 1971). Attacked seed can be recognized by the presence of a dark brown spot, consisting of excrement, on the seed surface.

2.4.1.2 Stem Borers

Stem damage caused by a thridid moth, *Triidesmodes ramiculata* Warren and Ambrosis beetles (Dolipygus species) have been reported from higher altitude zones in Nigeria and Ghana (Lamb and Ntima, 1971). The larvae of the moth occur as shoot borers on *Terminalia* seedlings in nurseries as well as in plantation (Lamb and Ntima, 1971). The death of infested shoots results in the production of multiple stems. This moth is considered to be of potential importance (Groulez and Wood, 1985). The Ambrosia beetle prefers to attack newly felled trees and those which are injured or sickly, leading to very serious economic damage as they reduce the tree quality and consequently reduce the financial returns (Robert, 1987).

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Zeuzera coffeae Nietner is a branch boring caterpillar, primary infesting branches of Terminallia species in Africa and Asia (Lamb and Ntima, 1971). However, it can also attack saplings where it may be found in the main stems (Biiger, 1988). It has a wide host range in the south pacific region, including several important plantation species such as *Paraserianthesfalcate* Becker, *Casuarina equisetifolia* L, *Eucalyptus deglugpta* Blume, *Swietenia* macrophyla King, *Tectona* grandis L, *Terminalia* brassii Excell and *T. ivorensis* (Biiger, 1988). Elsewhere, in Panama, multiple xylem borer attacks by a Cossula sp, was observed on *T. ivorensis,* affecting wood quality where the incidence is high (Kapp *et al.,* 1997).

2.4.1.3 Defoliators

Many insects feed on the leaves of Terminalia species. *Zononocerus variegatus* L, the variegated grasshopper, is widely distributed throughout tropical Africa and feeds on the leaves of young trees in nurseries and plantations (Akanbi and Ashiru, 1991 and Messi *et al.,* 2006). A number of coleopterans (*Trochalus* sp, *Maladera* sp, *Pseudotrochalus* sp) (Browne, 1968). and lepidopterans (*Maurilia phaea* Hamps, *Negeta luminosa* Wkr, *Westermania cuprewa* Hamps, *Torrix dinota* Meyrick, *Trabala lambaurni* Beth-Baker) also feed on the leaves of Terminalia species in nurseries and plantation (Brown, 1968) in Cote d'Ivoire and Nigeria, several species of caterpillars infest plantations of *T. invorensis* and *T. superba* but the most serious defoliator is *Epiccerura pergrisea* Hampson which can cause severe damage to its hosts (Akanbi and Ashiru, 1991 and Kanga and Fediere, 1991). Sucking pests such as Cryptoflata species as well as Otionotus species and *Tricocepsalbesence* Funkh have been reported to occur commonly in Ghana where their adults and colonies of nymphs affect the growth of *T. ivorensis* shoots, mainly in nurseries (Browne, 1968). In Papua New Guinea, *Roeselia lignifera* walker causes substantial harm to *T. brassii* plantations. The larva of this moth was associated with defoliation of young entire plantation in the country (Lemmens *et al.,* 1995). Leaf cutting ants (*Atta* sp) have damaged young plantation of *T. inveronsis* in Panama (Kapp *et al.,* 1997).

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2.4.1.4 Termites

When Terminalia trees are split, many insects, notably termites, usually infest them (Lamb and Ntima, 1971). However, these insects occur only sporadically and are not a major threats (Browne, 1968).

2.4.1.5 Wildlife

In Eastern Nigeria, the foliage of *T. ivorensis* are prone to browsing by small antelopes (*Cephalopus Maxwelli* Hamilton-Smith, Maxwell's duiker), which may give rise to injuries (Browne, 1968). Other serious damage is caused by elephants (Lamb and Ntima, 1971). These wounds, from wildlife, could open trees for infection by pathogens, such as those residing in the genus *Ceratocystis*, as recently shown in South Africa for *T. sericea* (Kamgan *et al.,* 2008).

2.4.2 Diseases

Terminalia species, are potential hosts for many fungal pathogens in Africa and elsewhere. It is however, evident that the incidence of pathogens on Terminalia species, has not been studied thoroughly. Very few pathogens have been reported from Terminalia species. The majority of diseases that have been reported may include limited details, often representing no more than a brief mention. Often the causal agents were identified based only on morphology and not classified to the species level. This is problematic for the establishment of quarantine guidelines (Kamgan *et al.,* 2008).

2.4.2.1 Roots diseases

Piening (1962) reported *Armillaria mellea* (Vahl ex Fr). Kummer, the honey fungus, associated with a Terminalia species in Ghana. However no particulars were given. Certainly, modern taxonomic treatments of the genus Armillaria in Africa has shown that it represents

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numerous species (Coetzee *et al.,* 2000 and Mwenje *et al.,* 2006) suggested that the fungus on Terminalia was identified only in the broad sense. More recently, it was observed that root rot caused by species of *Rosellinia* and *Phytophthora*, leads to die-back of *T. ivorensis* in Panama and Costa Rica (Kapp *et al.,* 1997).

2.4.2.2 Stem diseases

In nurseries and forests plantations in Nigeria, (Parker, 1964), reported die-back, leaf spot and canker due to a *Sphaeronaema sp* on *T. ivorensis*. The main symptoms were a cessation of growth, accompanied by die-back of the main shoots, but wilting and yellowing of the foliage occurred occasionally. Otherwise, observation of black stem cankers, frequently associated with reddening of leaves, causing mortality and stagnation in nurseries plants were repeated in this country (Lamb and Ntima, 1971). An Endotheilla species has also been found on canker on *T. ivorensis* in Ghana (Ofosu and Cannon, 1976), while pinks disease caused by *Erythricium salmonicolor* Berk, causes stem canker on tropical almond (*T. catappa*) in India (Thompson and Evans, 2006). Recently (Gryzenhout *et al.,* 2005) described of a new pathogen *Rostraureum tropicale* Gryzenh and M.J Wingf in association with dying *T. iveronsis* in Ecuador.

2.4.2.3 Leaf diseases

Some foliage diseases caused by unidentified species of *Cercospora, Ramularia, Irenina* and *Spaceloma* have been reported from *T. superba* in Africa (Groulez and Wood, 1985). In Brazil, *Korinomyces terminalia* causes leaf spots on seedlings and young *T. ivorensis* plants (Hodges and Ferreira, 1981) and *Auerswaldiella parvispora* causes black blotches on leaves (Farr, 1989).

2.4.2.4 Stain diseases

When freshly felled, logs are liable to attack by fungi whose effect is mainly aesthetic, this is nevertheless serious in a wood renowned for its agreeable colour. In this respect blue stain of logs caused by *Lasiodiplodia theobromae* (pat). (Mweje *et al.*, 2006) was described on *T.*

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superba by Fougerousse. The fungus is able to completely spoil the lustrous creamy-white colour of the log even if only the sheen of the wood is altered.

2.5 Conservation status

Silver cluster-leaf is not listed on the Red Data List as a threatened species. The species therefore seems to be fairly conserved in South Africa

2.6 Distribution and habitat

Terminalia sericea occurs in a variety of types of open woodlands particularly on sandy soils. It may grow as a dominant or co-dominant species in mixed deciduous forests such as *Brachystegia, Colophospermum mopane*, *Combretum* or *Acacia* forest. It occurs from Tanzania and the DRC southwards to Angola and Namibia, Zimbabwe, Botswana and South Africa. A good place in South Africa to find silver cluster-leaf is the Kruger National Park (KNP) area (Pohjonen, 1992).

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Chapter 3

STUDY AREA, MATERIALS AND METHODS

3.1 Study area

The study was carried out in the Nylsvley Nature Reserve(NNR) which is situated in an extensive undulating to flat terrain between 1080 and 1140 m altitude. Prominent hills are Maroelakop (1140 m) in the south and stemmerskop (1090 m) further north. The small and shallow Nyl River runs across the reserve from south-west to north-east in a strip of flat bottomland that divides the study area into a number of gently sloping elevations. The south-eastern elevations are underlain by sand stone, grits and conglomerate bands of the Waterberg system and the north-eastern elevations by felsite of the epicrustal phase of the bushveld igneous complex (LEDET, 2013).

The area has a moderately low summer rainfall with a dry, mildy frosty, winter period. Several soil series associated with differences in geology and topography occur. The uplands have non-calcareous, relatively sandy soil with broad-leaved deciduous savannas and seasonal grasslands. The bottomlands have calcareous clay soil with microphyllous deciduous thorn savannas and seasonal grasslands (LEDET, 2013).

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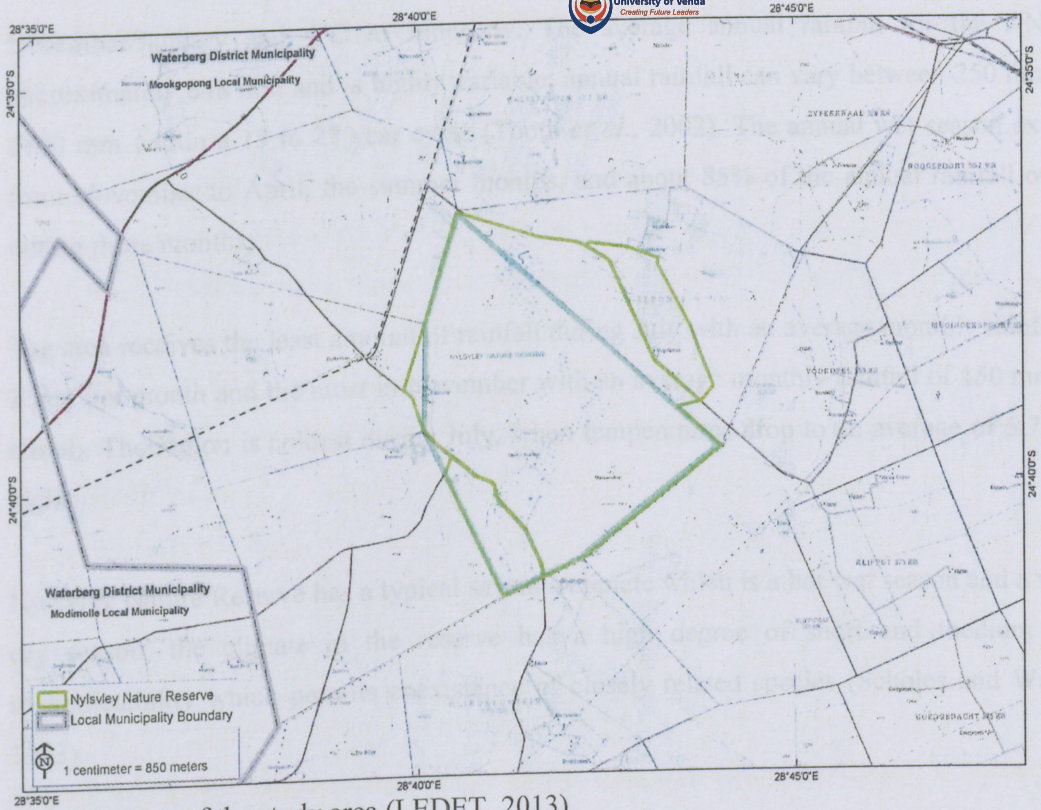


Figure1: Map of the study area (LEDET, 2013).

The Nylsvley Nature Reserve covers 3120 ha in area; it is a mixed bushveld type (Acock's, 1953). The reserve comprises the farm Nylsvley situated between 24^0 36 and 24^0 42s latitude and 28^0 40 and 28^0 44E longitude, on the Springbok flats, 10 km south of Naboomspruit now known as Mookgophong. The Nature Reserve is in a savanna biome.

3.1.1 Climate and weather patterns

Climate indicates the weather conditions over a period of years and includes the daily, seasonal as well as annual variations in these attributes. Vegetation patterns are influenced by climate. Climate has a direct influence on a plants life cycle because of the role that factors like temperature, light exposure as well as moisture play (Schulze, 2003).

The Nylsvley Nature Reserve lies in the bushveld, which has a warm climate with a mean annual temperature of 18.6°C (Frost, 1987). According to Frost (1987), maximum daily temperatures at the NNR range from a mean of 29°C in December/January to 21°C in June/July while minimum daily temperatures vary between approximately 17°C in

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December/January and 4°C in June/July. The average annual rainfall for the NNR is approximately 648 mm and is highly variable: annual rainfall can vary between 250 mm and 1100 mm within a 15 to 21 year cycle (Tooth *et al.*, 2002). The annual wet season extends from November to April, the summer months, and about 85% of the annual rainfall occurs during these months.

The area receives the least amount of rainfall during July with an average monthly rainfall of 3 mm per month and the most in November with an average monthly rainfall of 150 mm per month. The region is coldest during July, when temperatures drop to an average of 5.7°C at night.

Nylsvley Nature Reserve has a typical savanna climate which is a hot wet season and a warm dry season; the climate in the reserve has a high degree of short and medium term unpredictability which permits coexistence of closely related species (Scholes and Walker, 1993).

Nylsvley Nature Reserve is a drought prone environment and rainfall is in the hot summer months (Scholes and Walker, 1993). Nylsvley Nature Reserve is situated in the summer rainfall region, receives rainfall during the hot summer months and experiences cool dry winter (Dippenaar-Schoeman, 2009).
The atmosphere at NNR is relatively dry throughout the years, but is especially dry in winter. The mean monthly atmospheric water content varies from 5.2 g/m^3 in July to 13.5 g/m^3 in January (Scholes and Walker, 1993).

The high radiation and the consequent high temperatures and saturation deficits in NNR lead to high potential rates of evaporation (Scholes and Walker, 1993).

3.1.2 Flora and fauna

The savanna biome covers about 20% of the global land surface, and about half of the area of Africa and about 35% of South Africa (Scholes and Walker, 1993). Savannas can be found over a broad range of climatic conditions with annual rainfall of less than 300 mm to more

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than 1,500 mm and are generally characterized by the coexistence of trees and grasses (Solbrig *et al.*, 1996).

Savanna is characterized by an herbaceous layer usually dominated by grasses with a woody component and most typically an overstorey of trees. In southern Africa, bushveld is an apt description of the vegetation structure, as the vegetation most often does not comprise distinct shrub and tree layers and the shrubs and trees occur in a matrix with a grass dominated herb layer. The vegetation of the reserve comprises Central Bushveld vegetation units of the Savanna biome and a Freshwater Wetland vegetation unit of Inland Azonal Vegetation (LEDET, 2013).

Savannas are fire prone ecosystems and therefore fire is essential to maintaining both its structure and floristic composition. The exclusion of fire results in bush encroachment and a diminishing grass and herbaceous layer.

Approximately 600 plant species have been recorded in the NNR (Scholes and Walker, 1993), and the following nine vegetation types have been distinguisged *Burkea africana* savannah, *Diplorhynchus condylocarpon* savannah, *Combretum* savannah, *Acacia tortilis* savannah, *Acacia karroo* savannah, Floodplain grasslands, Grasslands on vertic soils and Seepline grasslands. These vegetation types may be further grouped into two broad categories (Low and Rebelo 1996): Mixed Bushveld and Clay Thorn Bushveld.

Nylsvley Nature Reserve provides a suitable habitat to a wide variety of birds, mammals, reptiles, fish and insect species. Seventy-nine mammal species have been recorded in the reserve, as well as 382 birds, 22 fish, 23 lizards, 1 worm lizard, 17 frogs and 29 snake species (Dippenaar-Schoeman, 2009). The importance of the invertebrates of the NNR is not being overlooked (LEDET, 2013).

3.1.3 Geology and soils

A variety of geological formations occurs at the NNR and can generally be grouped according to the vegetation unit they support. The geological sub-strata of the Central Sandy Bushveld are mostly sandstone, siltstone, shale and conglomerate (Mucina *et al.*, 2006). The

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Central Sandy Bushveld at the NNR is predominantly underlain by sedimentary rocks of the Waterberg group.

Springbokvlakte Thornveld is underlain by volcano-sedimentary rocks of the Karoo Supergroup. Tholeitic and olivine basalts and nephalinites are most abundant with mudstones, shale and sandstone being less prominent. The most dominant geology found in Subtropical Freshwater Wetlands is Cenozoic alluvium, with Karroo Super group volcanic rocks and sediments and Cretaceous sediment of the Zululand and Maputaland Groups.

Soil of the NNR can generally be grouped according to the vegetation unit it supports. The soils that are present in the Central Sandy Bushveld are either well drained deep Hutton or Clovelly soils but Glenrosa soils are also present in this vegetation unit (Mucina and Rutherford, 2006). Springbokvlakte Thornveld soils are predominantly deep vertic clays but freely drained with high base status and self-mulching (LEDET, 2013).

Waterlogged soils, containing certain levels of decaying organic matter, especially in highly productive reed beds, are associated with Subtropical Freshwater Wetlands (LEDET, 2013).

3.2 Materials and Methods

Transplant experiment method was used to remove *Terminalia sericea* seedlings from their original sandy soil areas to clay soil area, sandy soil area and in an artificial mixture of 50/50 mixture of clay and sand soil. The mixture soil was composed of a 1:1 ratio of sand and clay soil. We carried the process of seedling excavation and transplantation to the three different areas which are clay, sandy and mixed soil areas. The seedlings were immediately watered after transplantation. The first set of 35 *T. sericea* seedlings uprooted from sandy soil area were transplanted into an area of a mixture of sand and clay soils. The pH of the soil was also measured and found to be somehow saline in area where we mixed sand and clay.

Another set of 35 individuals also of *T. sericea* seedlings were uprooted and replanted in their same original sandy soil areas to serve as control. Recorded pH was found to be acidic.

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The third set of 35 individuals of *T. sericea* seedlings was uprooted and planted in the clay waterlogged area. Soil thereof was pure clay and pH. recorded was found to be basic. All transplanting of the three sets of *T. sericea* seedlings was done in July 2013 on the same day; watering of all set of transplanted plant individuals was carried out for two days in succession, first watering on the day of transplanting and then on the day following the first one.

Watering of all transplanted seedlings was carried out immediately after planting them to prevent them from drying out since they had been exposed to some external stressful conditions such as dry-air, sunlight radiation, and transportation distance from area of transplant and time interval between uprooting and re-planting amongst them.

The experimental design was repeated in a similar fashion in a different season of the following year which was April 2014 to establish if seasons had effects on the survivorship of the transplants. Similar experiments as in 2013 were repeated, it was done as follows: one hundred and five seedlings of *T. sericea* were transplanted from one of the sandy areas of the reserve. The seedlings were then divided into three groups of 35 seedlings; one group was planted in the clay waterlogged soil areas, the other group was planted on the clay-sandy area where soils in each microhabitat of each individual was a mixture of clay and sandy soil in a ratio of 1:1 and the last group at sandy soil to serve as control.

The experimental design was repeated again in a similar fashion in another two different seasons one in December 2014 and the last one in September 2015 to further establish if seasons had effects on the survivorship of the transplants of *T. sericea* seedlings. Such experiments were repeated as follows: One hundred and five seedlings of *T. sericea* were transplanted from one of the sandy areas of the reserve. The seedlings were then divided into three groups of 35 seedlings; one group was planted in the clay waterlogged soil areas, the other group was planted on the clay-sandy area where soils in each microhabitat of each individual was a mixture of clay and sandy soil in a ratio of 1:1 and the last group on sandy soil to serve as control as in the other seasons.

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Transplantation of seedlings into those three areas of three different soil types, was carried out to establish whether the non-occurrence of *T. sericea* on clay waterlogged area was due to seed dispersal problem; whether non-germination of seeds in clay areas is a challenge was not tested by this study.



Figure 1: *Terminalia sericea* seedling being uprooted from sandy soil area.

Figure 1 above shows the seedling of *Terminalia sericea* being carefully uprooted from its original sandy soil area using picks and spades to excavate around the seedlings. After being dug the seedlings were carefully pulled out manually to prevent force which could have resulted in having the main root being cut instead of removing the seedling with main root undamaged (see figure 1).

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FIGURE 2: *Terminalia sericea* seedling planted in clay soil area

Figure 2 above shows the seedling of *Terminalia sericea* already planted on clay soil area; this seedling was planted few minutes after uprooting them from their original sandy soil areas. In each case after transplanting and hence planting all seedlings were fed with equal amount of water.

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Figure 3: *Terminalia sericea* getting watered

Figure 3 above shows the seedling of *Terminalia sericea* being watered immediately after transplantation making use of tap water and plastic tabs. The watering was done by the students of the University of Venda as seen in figure 3 above.

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4.1 Results and Discussion

Table 1: Statistical results using Microsoft Excel

Soils type	Seedlings planted	Number survived after 3 Months	Number survived after 6 Months	Seasons
Mixed Clay	35	4	1	1
Clay	35	5	0	1
Mixed Sand	35	4	5	1
Sand	35	8	9	1
Mixed Clay	35	0	0	2
Clay	35	0	0	2
Mixed Sand	35	0	1	2
Sand	35	9	6	2
mixed sand	35	0	0	3
Sand	35	0	0	3
mixed clay	35	0	0	3
clay	35	0	0	3
mixed sand	35	0	0	4
Sand	35	0	0	4
mixed clay	35	0	0	4
Clay	35	0	0	4
Mean		1.875	1.375	
Standard deviation		3.117157	2.753785	
confidence norm 95%		$p < 0.05$	$p < 0.05$	

Legend: (Season 1: July 2013; Season 2: Aprill 2014; Season 3: December 2014 and Season 4: September 2015)

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Table 1 above shows the results of all transplanted seedlings in different seasons. It includes the number of seedlings that were planted in each season also the number of seedlings that managed to survive the transplantation process and after how long the results was recorded in each season. The table also indicates the different types of soils where the seedlings of *Terminalia sericea* were planted on. After the recording of the results observed in the field the means of all values were calculated with their standard deviations. The table also shows the confidence level of values at 95%.



Figure 3: Regeneration of *Terminalia sericea* seedlings on sandy soil area

Figure 3a above shows one of the seedlings of *Terminalia sericea* that have survived the transplantation process on sandy soil areas regenerating and flourishing after the period of three months, figure 3b shows the regeneration of one of the seedlings that were planted on the sandy soil area and in a mixture of sandy and clay soil after three month from transplantation.

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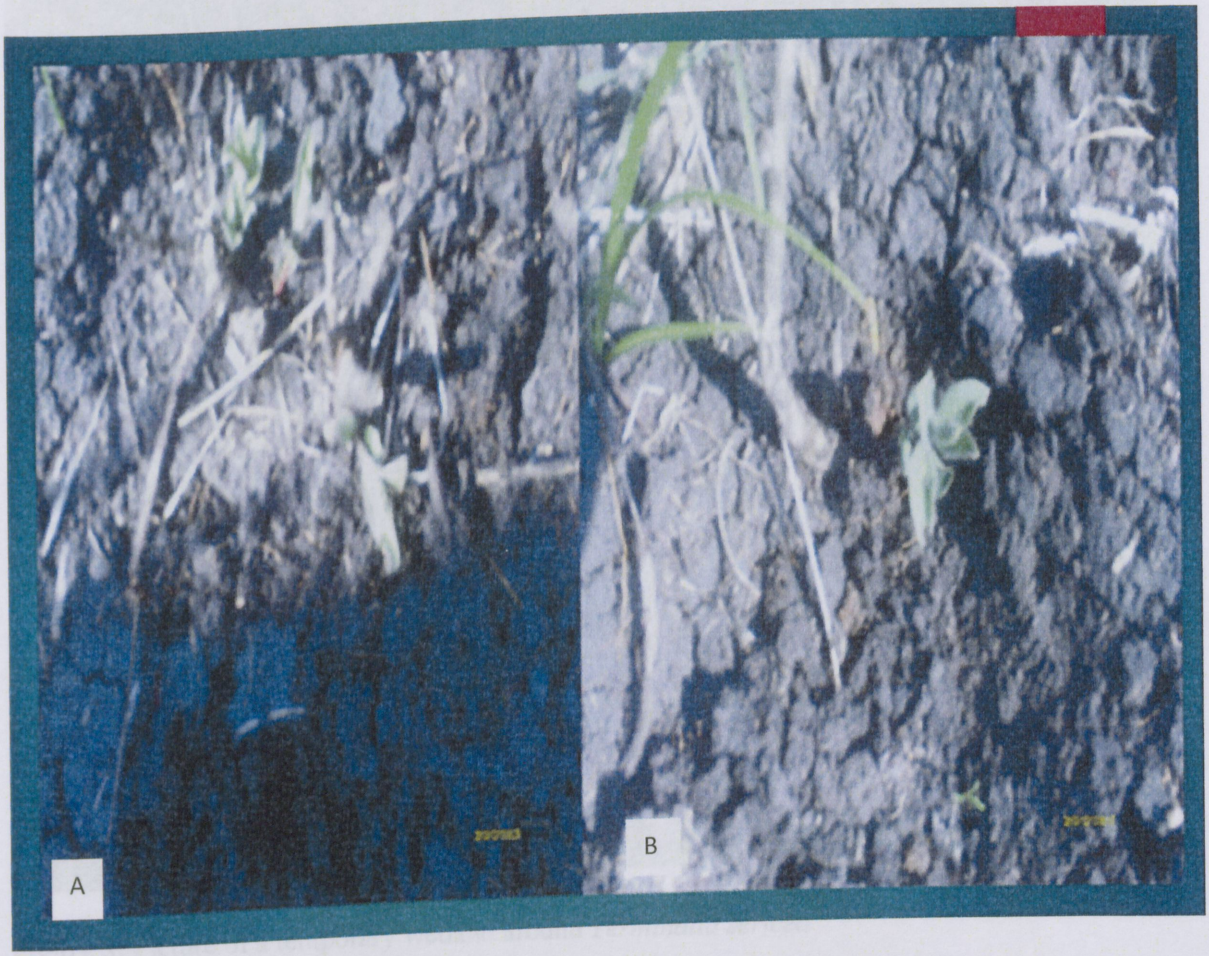


Figure 4: Regeneration of *Terminalia sericea* seedlings from clay water-logged areas

Figure 4a above shows one of the seedlings of *Terminalia sericea* that have survived the transplantation process on clay soil areas regenerating and flourishing after the period of three months, figure 4b shows the regeneration of one of the seedlings that was planted on the clay soil area but in a mixture of sandy and clay soil area after three months following transplantation.

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Figure 5: Picture of a temporary wetland around *Terminalia sericea*

Figure 5 above shows the *Terminalia sericea* seedling in a pool of water after heavy rain in the clay waterlogged area, the seedling at first after transplantation showed life for three months before there was heavy rain but after heavy rain the seedlings died out probably because of the access water supply as indicated in figure 5.

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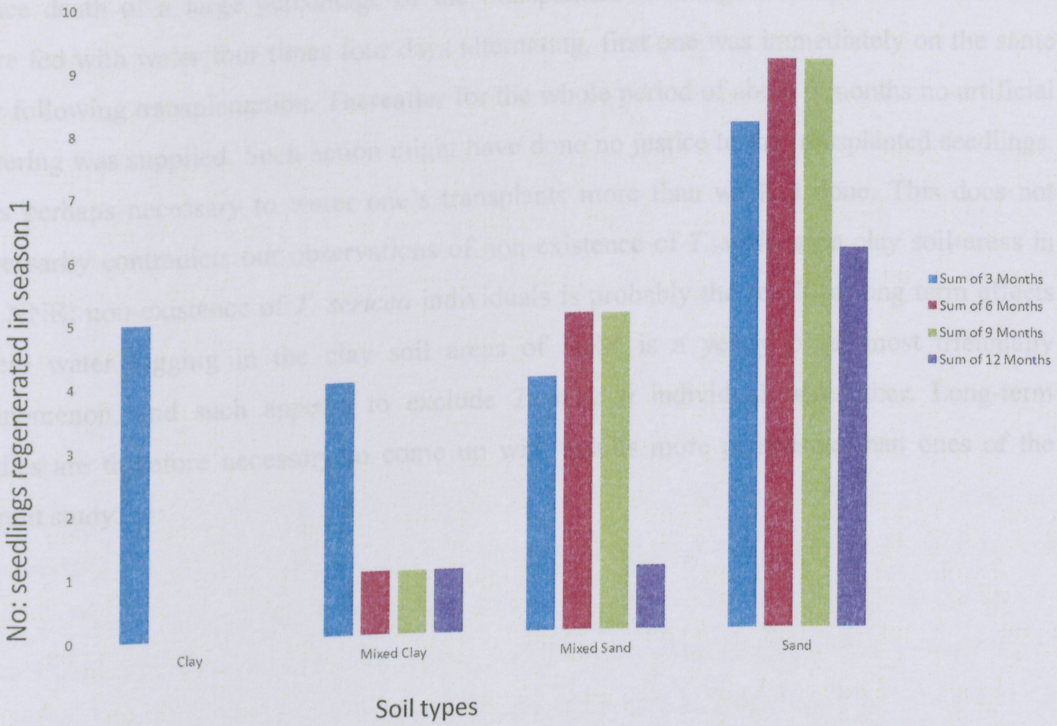


Figure 6: Performance of seedlings of *Terminalia sericea* transplanted in (July 2013) after about 6 months

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Only 5 out of 35 seedlings transplanted into clay soil survived while in a 1:1 clay - sandy soil mixture in water-logged area only 4 out of 35 seedlings survived (Figure 1). Survival of 4 out of 35 seedlings might be an indication that *T. sericea* may rarely survive in clay soil whether not waterlogged or not, and this further on suggests that once the area is water-logged, the transplanted seedlings would find it very challenging to even start life. Waterlogging conditions interfere with plant aerobic respiration by blocking diffusion of atmospheric oxygen into the roots of transplanted *T. sericea.* Such action has been reported to cause a dramatic decline in levels of energy-rich adenylates, ion uptake, and transport (Huang *et al.,* 2003; Vartapetian *et al.,* 2003). Such conditions where plants are deprived of gaseous supply such as oxygen causes their death. It should nevertheless be noted that it was not only in water-logged clay areas where poor performance and death of transplanted individuals resulted but also in sandy soil areas. This might be signal that it is not only waterlogging conditions that barricade the establishment and survival of seedlings; transplant errors or

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artefacts or shocks during transplanting might have also contributed to poor performance and hence death of a large percentage of the transplanted seedlings. Transplanted individuals were fed with water four times four days alternating, first one was immediately on the same day following transplantation. Thereafter for the whole period of about 6 months no artificial watering was supplied. Such action might have done no justice to the transplanted seedlings. It is perhaps necessary to water one's transplants more than we had done. This does not necessarily contradicts our observations of non-existence of *T. sericea* on clay soil areas in the NNR; non-existence of *T. sericea* individuals is probably the result of long term effects where water logging in the clay soil areas of NNR is a yearly or at most triennially phenomenon, and such appears to exclude *T. sericea* individuals altogether. Long-term studies are therefore necessary to come up with results more persuasive than ones of the current study.

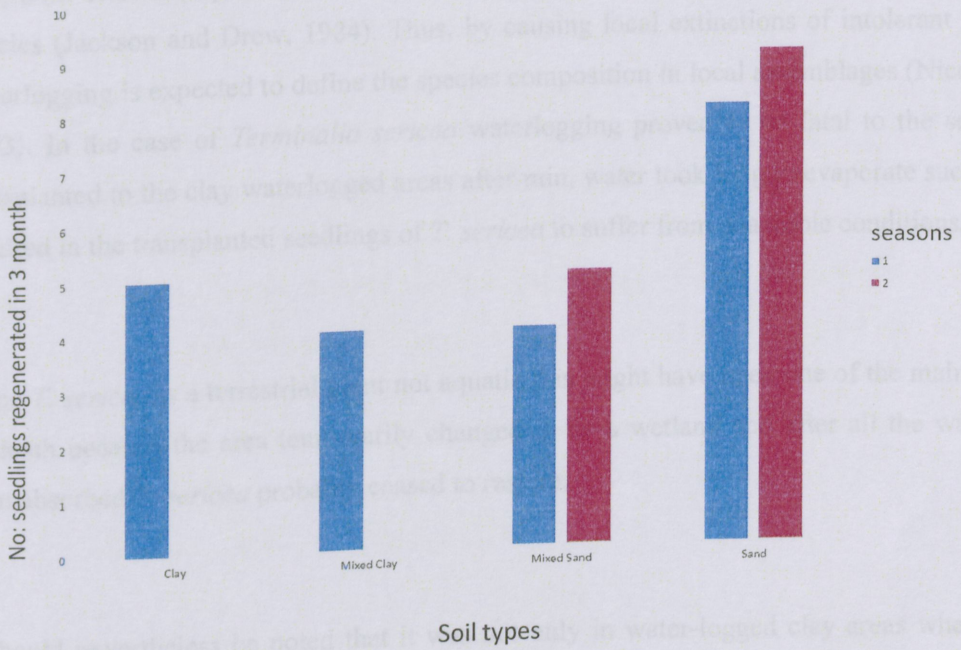


Figure 7: Comparison of seedlings performance of season 1 (July 2013) versus season 2 (April 2014)

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Figure 7 above showing the comparison of transplants according to their seasons where season 1 is showing a distinct regeneration of seedlings in both experimental design and control where the sandy soil serves as control, whereas none of all seedlings that were planted in the second season regenerated an indication suspectedly that time of transplantation was not favourable or perhaps relatively short waiting period about 6 months between transplantation and observation times; else human artefacts during transplantation might be culprits to the observed transplanted seedlings non-recovery. Our conscious distrust on the effects of cold winters is for now something that we may not go by because reports by Palgrave (1988), are that it can survive cold winters and some frost.

Waterlogging plays an important role in determining plant distribution in terrestrial communities (Visser *et al.,* 2003), since the consequences to plants lives may be fatal (Nicol *et al.,* 2003). Waterlogging ceases plant aerobic respiration, causing a dramatic decline in levels of energy-rich adenylates, ion uptake, and transport (Huang *et al.,* 2003, Vartapetian *et al.,* 2003). Even if a short period of waterlogging does not kill the plants, it has considerable long-term effects on plant growth (Malik *et al.,* 2002), reducing the competitive abilities of species (Jackson and Drew, 1984). Thus, by causing local extinctions of intolerant species, waterlogging is expected to define the species composition in local assemblages (Nicol *et al.,* 2003). In the case of *Terminalia sericea* waterlogging proved to be fatal to the seedlings transplanted to the clay waterlogged areas after rain, water took long to evaporate such that it resulted in the transplanted seedlings of *T. sericea* to suffer from anaerobic conditions.

Since *T. sericea* is a terrestrial plant not aquatic this might have been one of the main causes of death because the area temporarily changed to be a wetland and after all the water had been absorbed *T. sericea* probably ceased to respire.

It should nevertheless be noted that it was not only in water-logged clay areas where poor performance and death of transplanted individuals resulted but also in sandy soil areas. This might be signal that there have been transplant artifact or shock which might have resulted in the unsuccess rate of survival.

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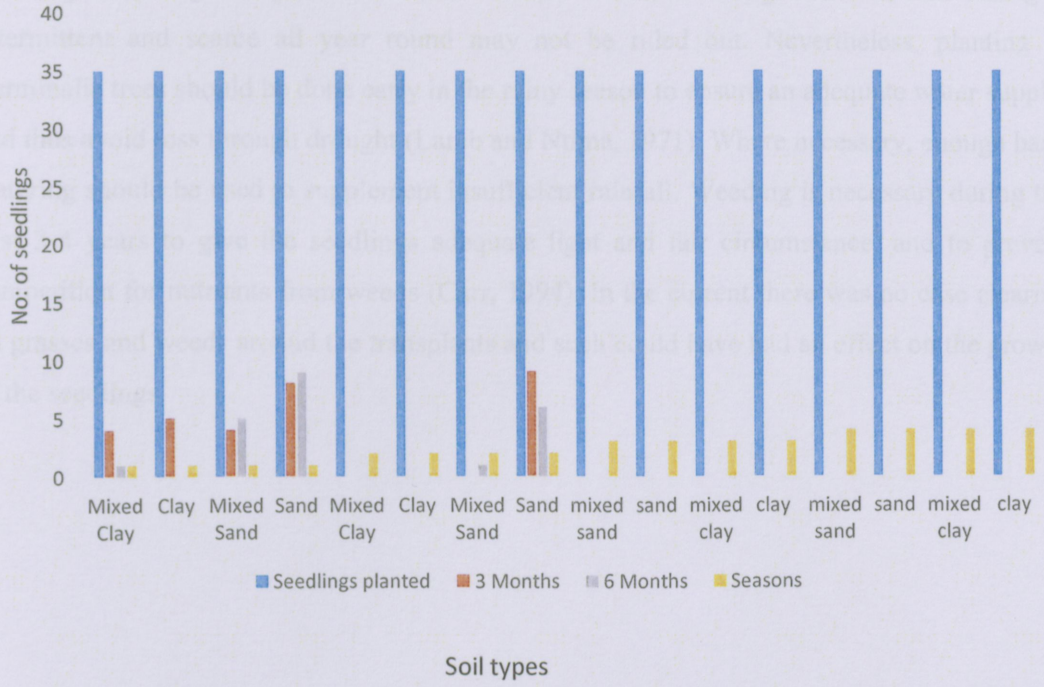


Figure 8: Comparison of seedlings performance of all the four seasons

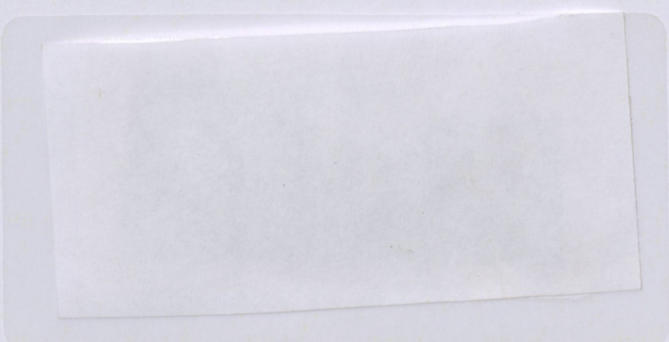
Figure 8 above shows the comparison of transplants according to their seasons where season 1 is showing a distinct regeneration of seedlings in both experimental and control settings; none of the seedlings that were planted in the second season to the last season regenerated, an indication suspectedly that time of transplantation was not favourable if not human error during transplantation process leading to failure of seedlings to regenerate. Notably in seasons 3 and 4 none of the seedlings showed any form of regeneration including the once that were used as control not neglecting the theory that suggest that in season four it is a more convenient time for higher plants to grow since grasses have undergone dormancy to reduce competitions between seedlings and grasses (Scholes and Archer, 1997).

Seedling recruitment, survival and growth is a critical life stage for woody plants during which they compete with grasses for resources such as light, space, water and nutrients (Scholes and Archer, 1997). This suggest that higher plants are more likely to benefit during dry seasons but suprisingly for *T. sericea* seedlings that are known to be the dry season

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growers could not survive such might be due to transplantation shock or few (four) days of watering following transplantation. The concept of climate change wherein rain falling is intermittent and scarce all year round may not be ruled out. Nevertheless, planting of Terminalia trees should be done early in the rainy season to ensure an adequate water supply, and thus avoid loss through drought (Lamb and Ntima, 1971). Where necessary, enough hand watering should be used to supplement insufficient rainfall. Weeding is necessary during the first 3-4 years to give the seedlings adequate light and fair circumstance, and to prevent competition for nutrients from weeds (Carr, 1994). In the current there was no case clearing all grasses and weeds around the transplants and such could have had an effect on the growth of the seedlings.



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5.1 CONCLUSION

The role of soil type in plant species distribution in savannah ecosystem amongst others is important to consider in trying to understand the biological ecology of plant communities thereof. Plant biology and ecology in any ecosystem are dictated by many different factors that prevail. Edaphic factors particularly moisture and texture in clay waterlogged areas seemed key factor to barring the penetration and hence establishment of *T. sericea* plant individuals in the Nylsvley Nature Reserve. The fact that there was low amount of rain falling throughout our work clear out conclusion on why there was also no satisfactory seedling regeneration on the sandy soil areas of NNR.

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Chapter 6

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