CHAPTER 1

INTRODUCTION

GENERAL

Elephant populations are major agents of habitat change and are second only to man in their capacity for altering their environment (Ben-Shahar 1993; Smithers 1983). This can be attributed to the pushing over and uprooting of trees by elephants for social display, as well as to increase the availability of browse and fruits, especially during the dry season, (Jachmann & Bell 1985). Elephants are thus able to alter the composition and structure of the natural vegetation, by means of their foraging activities.

The habitat changes wrought by elephants in eastern, central and southern Africa has attracted much attention over the last few decades. In some areas, regeneration has been suppressed and mature trees ringbarked or felled. This trend of converting forest to woodland or open savannah has been termed "the elephant problem" (Caughley 1976).

The influence elephants can have on the habitat has become one of the most hotly debated topics in African conservation (Hall-Martin 1986). In areas where elephant movements are restricted or where they exceed their food supply, elephant induced damage to habitats increases and they can cause retrogression of the habitat towards complete devastation (Ben-Shahar 1993; Smithers 1983). Although the destruction of trees by these animals is a natural phenomenon, elephants today occur almost exclusively in small, isolated parks and they are therefore able to sway the system to a point which may be undesirable as it affects the ability of the park to reach its management objectives.

Despite intensive utilisation, the affected plant species may survive, and hence not be lost to the ecosystem, but if their density and numbers are affected, the habitat may be altered sufficiently to make it unsuitable for other faunal and floral species. Where elephants convert woodland into grassland, these effects are most pronounced. The species richness of woodland ants and birds has been found to be significantly lower in areas where elephants had removed the tree canopy (Cumming *et al*. 1997; Herremans 1995). This situation may however benefit other species which are better adapted to grassland living, and trees which have been pushed over provide a microhabitat suitable for the establishment of seedlings and grass and provide refuge for small mammals, reptiles and numerous invertebrates.

Elephants are therefore, essential agents of disturbance in many ecosystems but can result in the loss or gain of species (Moolman & Cowling 1994; Smithers 1983). In some conservation areas where elephant numbers increase locally, woody vegetation declines, and the control of elephant numbers is necessary (Ben-Shahar 1993).

Studies have shown that elephants have had damaging effects on baobabs (*Adansonia digitata*) in numerous African reserves, including Mana Pools, Zimbabwe (Swanepoel 1993; Swanepoel & Swanepoel 1986), Ruaha National Park, Tanzania (Barnes 1980; Barnes *et al*. 1994) and Lake Manyara National Park, Tanzania (Weyerhaeuser 1985). Elephants eat the bark and wood of these trees and, by gouging out the wood with their tusks, can excavate large cavities in the trunk. If large enough, these cavities can result in the collapse and death of the trees (Weyerhauser 1985).

Since 1967, an average of seven percent of the elephant population of the Kruger National Park (Kruger National Park) has been removed annually by culling (Joubert 1986; Whyte *et al*. 1998). The impact these animals were able to have on the habitat has therefore been limited. During 1995 and 1996, the National Parks Board, however, reviewed the Kruger National Parks' elephant management policy and decided that controlled fluctuations of elephant numbers were acceptable. The culling programme was therefore, suspended until a revised management plan for the reserve could be approved. This plan was finally accepted in 1999. In this plan, elephant management is based on six zones of elephant density. Two of these zones are botanical reserves, two are high-impact elephant zones in which elephant numbers will be allowed to increase indefinately, and two are low impact zones where elephant numbers will be reduced to allow recovery of vegetation.

Although their numbers have been tightly controlled, it has been suggested that even at these relatively low densities, the Kruger National Park elephant population may be responsible for a decline in the baobab (*Adansonia digitata*) population. Concern has also been voiced that elephant utilisation may have been impacting negatively on other plant species. One of these species is the common star-chestnut (*Sterculia rogersii*), a plant which is very rare in the Kruger National Park (Van Wyk 1984).

The mission of the Kruger National Park is to maintain biodiversity in all its natural facets and fluxes. Therefore any elephant induced habitat degradation is unacceptable as this would be followed by a decline in species richness and hence biodiversity. Baobabs are especially important for species richness due to the large number of faunal species associated with them. Both Mottled Spinetail (*Telecanthura ussheri*) and Bohm's Spinetail (*Neafrapus boehmii*) use baobabs almost exclusively for breeding in the park, and the loss of these bird species would almost certainly follow the loss of baobabs. Numerous other birds also utilise baobabs for breeding. These include Cape Parrots (*Poicephalus robustus*), Barn Owls (*Tyto alba*), Whiteheaded Vultures (*Trigonoceps occipitalis*), Redheaded Weavers (*Anaplectes rubriceps*), Dickinson's Kestrels (*Falco dickinsoni*) and Redbilled Buffalo Weavers (*Bubalornis niger*). Due to the limited potential for recolonisation of the Kruger National Park by extirpated species, every effort needs to be made to avert any threat to the species richness of the area.

The attempts by many African reserves to conserve biodiversity has in a number of cases been affected by international public pressures against reducing elephant densities in game reserves (Cumming *et al*. 1997). A need therefore, existed to determine whether the populations of *Adansonia digitata* and *Sterculia rogersii* in the Kruger National Park were being negatively affected, and if so, whether these effects would affect the long term survival of the species. If the populations were diminishing, it was necessary to establish if this could be attributed to an overabundance of elephants. If elephant management is required in the Kruger National Park, documented evidence is needed to justify this.

This project was therefore implemented to assess the current status of the *Sterculia rogersii* and *Adansonia digitata* populations of the Kruger National Park and to obtain baseline data which can be used to monitor elephant impact on these species. A proper management policy regarding elephants requires information on the trends of the elephant populations and, especially, their patterns of resource utilisation (Ben-Shahar 1993). Monitoring of the utilisation of rare species such as *Adansonia digitata* and *Sterculia rogersii*, can provide an indication of when elephant numbers have exceeded the threshold of the area and therefore, when management intervention is warranted.

Until recently, the density of elephants on either side of the Luvuvhu River has differed due to different land use and management of these two areas. The area of the Kruger National Park, north of the Luvuvhu River, was only incorporated into the reserve in 1969. Due to the perceived ecological sensitivity and botanical importance of the area, because of the relative abundance of trees such as the baobab (*Adansonia digitata*) and common star-chestnut (*Sterculia rogersii*), elephant numbers were kept at a relatively low density through culling. By comparing the populations of tree species in the two areas, an indication of the long term effects of differing elephant densities can be gained.

RATIONALE AND OBJECTIVES OF THE STUDY

Many factors contribute in a complex manner to determine elephant impact on a plant species or community and the management of elephant numbers (Coetzee *et al.* 1979). Studies of isolated aspects are necessary from time to time (Coetzee *et al.* 1979) as they can contribute to an understanding of these interrelated factors. Recent criticism of the Kruger National Park elephant management policy and its resultant suspension heightened concerns that the elephant population, if left unchecked, could drive certain plant species to extinction and thus affect the biodiversity of the region. These concerns warranted investigation.

For these reasons, this study was implemented to establish and document the current status of, and elephant impact on the *Adansonia digitata* and *Sterculia rogersii* populations of the Kruger National Park, to establish whether the populations are in decline and if so to determine the magnitude of the decline.

The objectives could be achieved by fulfilling the following:

(i) Estimate the density of *Sterculia rogersii* and *Adansonia digitata* in the Kruger National Park north and south of the Luvuvhu River.

(ii) Determine and compare the structure of the *Sterculia rogersii* and *Adansonia digitata* populations in the Kruger National Park north and south of the Luvuvhu River and ascertain if the utilisation of these species by elephant has affected the structure of the populations.

(iii) Determine the extent of elephant damage north and south of the Luvuvhu River for each of the two species and determine if any correlation between damage and elephant density exists as well as determine which size class of tree is most affected.

(iv) Ascertain whether elephant damage causes death of *Sterculia rogersii* trees.

(v) Determine if any correlation exists between damage to *Sterculia rogersii* and to *Adansonia digitata*; the population structure of these two species.

Although this study only deals with a small aspect of elephant management, utilisation of these two tree species has been causing concern. It is hoped that the information will be of value in making decisions concerning the management of the Kruger National Park's elephant population.

THE BAOBAB (*Adansonia digitata* Linnaeus)

The first recognisable reference to a baobab tree in the literature is by the Arab traveller, Ibn Batuta, who in 1352, wrote of a weaver in Mali taking shelter in a hollow trunk while working (Wickens 1982). Since then, the baobab has probably been described more often than any other African tree. The baobab belongs to the family Bombacaceae which contains around 21 genera (Palmer 1977). In 1941, the baobab was brought under the protection of the forestry act, and was the first tree in South Africa to be given universal state protection (Palmer & Pitman 1961).

The name *Adansonia* is derived from the surname of the eighteenth century French botanist Michel Adanson and was coined in his honour by Linnaeus after publication of the results of his exploration of Senegal in 1757 (Wickens 1982). The species name (*digitata*) refers to the shape of the leaf, which resembles a hand (Venter & Venter 1996) and is derived from the Latin word for finger, *digitus* (Van Wyk 1974).

The baobab is a massive tree, which can grow to a height of over 20 m in this region. The bole is extremely thick and in large specimens, can gain a circumference exceeding 20 m. The flowers which occur from October to December are large and white. The fruit too is large, with a hard outer shell covered in fine hairs. The leaves of seedlings are simple, but later become palmately compound, usually with five leaflets (Van Wyk 1984). Saplings often retain their simple seedling leaf form for many years, but observations have shown that the variation in leaf shape can occur from a very early age (Wickens 1982). Baobabs grow best in areas of dry woodland where the soil is well drained (Venter & Venter 1996; Wilson 1988).

Although the baobab tree is not indigenous to Egypt, the fruits of this tree were known to the ancient Egyptians and were sold in the markets of Cairo, probably for use as a febrifuge (Wickens 1982). It was from these merchants that the tree's common name was derived, as they referred to it as *bu hobab* (Wickens 1982).

The wood of baobab trees is very soft and light and can be used only for paper production (Van Wyk 1984). As a fodder plant, the baobab is of value to a number of herbivores. Elephant, kudu (*Tragelaphus strepsiceros*), nyala (*Tragelaphus angasii*) and impala (*Aepyceros melampus*) eat the leaves of the tree, while the fallen flowers are also relished by various species (Venter & Venter 1996). As already mentioned, elephant also make use of the trunks of baobabs, sometimes causing large-scale damage to the trees. The fruit is eaten by primates (Van Wyk 1984).

These trees are also utilised by man in a number of ways. The roots can be used as a source of water, while young roots and leaves can be cooked and eaten. The pith of the fruit can be used to make a refreshing drink, while seeds can be roasted to produce a coffee substitute. Seeds can also be eaten fresh or dry. The most useful part of the tree , is the bark, which when stripped from the tree, pounded and soaked in water can be used to produce an excellent fibre (Palmer & Pitman 1961). Rope, mats, sacks, clothing, baskets, nets and fishing lines are made from the inner bark (Palmer & Pitman 1961; Venter & Venter 1996). The bark has even been used by Europeans to treat fevers.

Another interesting feature of these trees is the high proportion of water contained in the wood. A tree with a volume of 200 m^3 contains an estimated 136 kl of water (Palmer & Pitman 1961). Due to the fact that baobabs are able to survive even when the trunks are hollow, they have served as houses, prisons, storage barns and places of refuge from wild animals (Coates Palgrave 1984). In Sudan, baobabs are often hollowed out and used as water tanks which are filled during the rainy season, enabling people to survive in the countries' extremely dry climate. Rain water also accumulates naturally in hollow trunks, and people travelling through baobab areas, such as the bushmen, regularly used this source of water (Palmer & Pitman 1961).

Numerous myths and superstitions have evolved surrounding the baobab tree. This is probably due to the size attained by some trees as well as their unusual appearance. Among these is a belief by some Africans that young baobabs no longer exist (Coates Palgrave 1984). Other beliefs are that God planted these trees upside down and that spirits inhabit the flowers and a lion will therefore devour anyone who plucks one from a tree. It is also believed that protection from an attack by a crocodile can be derived from drinking a draught of water in which the seeds of a baobab have been soaked and stirred. Another belief is that a man who drinks an infusion of the bark will become mighty and strong (Coates Palgrave 1984).

Baobab trees occur in most sub-Saharan African countries although it has been introduced into some countries in which it occurs (Wilson 1988). Specimens can also be found on the Cape Verde Islands, and on the islands of the Gulf of Guinea (Wilson 1988). There are a total of nine *Adansonia* (baobab) species, seven of which occur on Madagascar (Wilson 1988) and one each in Australia and Africa. The baobabs present in India were probably introduced by man early in the thirteenth century at the start of the African slave trade (Wickens 1982). There is much uncertainty over the origins of trees growing on the Arabian peninsula as these specimens may occur there naturally or may have been introduced by Arab traders (Wickens 1982; Wilson 1988). The most suitable habitat for these trees consists of deep well-drained soils at altitudes between 450 m and 600 m above sea level and an annual rainfall of between 300 mm and 500 mm (Wickens 1982).

In South Africa, the natural distribution of baobabs is limited to the Northern Province and Mpumalanga as the trees are susceptible to frost. Baobabs are conspicuous in the Limpopo basin, especially in the dry, frost-free country north of the Soutpansberg mountains and the Olifants River in the east. A few stragglers occur to the south of this, with a number of trees growing in the Waterberg region and one near Rustenburg (Wickens 1982). The popularity of the baobab as an ornamental tree has resulted in its introduction into numerous parts of the world, including Cairo, Mauritius, Malaysia, Java, New Caledonia, Hawaii, the Philippines, the West Indies, the Antilles, Guyana, Cuba and Florida (Wickens 1982). South Africans have also cultivated these trees, with specimens occurring as far afield as Durban and Cape Town.

AGEING OF BAOBABS

The massive size which mature baobab trees can attain has often been thought to be associated with great age, but this is a debatable point (Coates Palgrave 1956). Due to the interest and uncertainty surrounding the age of these trees, and the relevance of baobab age to this study, some of the ageing techniques and results of attempts at ageing these trees have been reviewed here. The ageing of baobabs is especially pertinent to discussion in later chapters.

Some Africans believe that young baobabs no longer exist (Coates Palgrave 1984). Although this is known to be untrue, the speculation which has always surrounded the age of baobab trees, has resulted in ageing of baobabs having a long and colourful history which began during the eighteenth century. The Frenchman after whom the tree was named, Michel Adanson was the first to attempt estimates of baobab age. He believed some specimens to be over 5000 years old (Swart 1963) and placed the age of one at 5500 years (Palmer & Pitman 1961). The trees he aged in 1749 were situated on the Magdalene Islands west of Cape Verde and had been inscribed with the names of European sailors who had landed there between 1400 and 1600 AD (Wickens 1982). David Livingstone however did not believe that trees older than the great biblical flood could exist, and according to calculations made by Bishops Usher and Lightfoot that the earth's creation took place in 4004 BC, the trees which Adanson had aged were alive before the flood. This implied that the flood could not have taken place and angered Livingstone who used growth rings to assess the age of a number of trees, the largest of which he believed was over 4000 years old (Wickens 1982).

Although baobabs do show well-defined growth rings, the extraction of cores is time consuming and due to the size of the trees, the labour involved in obtaining a complete section with a smooth surface is enormous (Swart 1963). The centre of the trunks are also porous, many of the trees being entirely hollow, making ring counting impossible (Swart 1963). There has also been speculation that these rings are not annual (Coates Palgrave 1956; Palmer & Pitman 1961), but are formed irregularly, after a rainy season, or even a storm or for other reasons (Palmer & Pitman 1961).

Swart (1963) reported on a baobab tree which was felled in the Zambezi valley during bush clearing operations in the Lake Kariba area in 1960. This tree had a girth of over 14 m and samples were obtained from various parts of it for use in carbon dating. The heartwood was 1010 ± 100 years old, while the sample midway between the centre and outside of the tree gave an age of 740 ± 100 years. Indications were that the tree increased in radius more slowly over the latter half of its life, with an annual average increment in radius of 0.0015 m over the last 1.14 m of the total radius (Swart 1963).

According to Palmer and Pitman (1961), it is fairly well established that young trees put on about one foot (0.305 m) in diameter in 10 years, but that older trees grow more slowly.

These authors quote records of the growth rates of individual trees from scattered localities. One baobab, planted in Dongola, grew to 7.6 m in 15 years, one in the Transkei reached a height of 6.1 m in 20 years, while one tree in Messina took only two years to reach a height of 3 m. In this same garden in Messina, most trees grew to five or 6 m in 17 years after receiving water and manure only in the nursery stages.

According to Venter and Venter (1996), the growth rate of cultivated trees is moderate to fast in the first 5 years, during which time they grow at a rate of 0.5 to 0.8 metres per year. Similarly, Coates Palgrave (1984) states that baobab plants which receive good treatment reach 7 m in 20 years and also that trees with a girth of 25 m have been estimated to be over 3000 years old.

Tree features which have been correlated with age include radial width and transverse area of sapwood, diameter and basal area (Sellin 1994; Sellin 1996; Stephenson & Demetry 1995; Tyrrel & Crow 1994; Yang & Murchison 1993). Numerous attempts have been made to correlate the girth of baobab trees with their age (Caughley 1976; Swanepoel 1993; Weyerhauser 1985; Wilson 1988). These attempts have met with varying degrees of success and have in some instances, even come in for criticism (Guy 1982).

Caughley (1976) worked in Zambia's Luangwa valley, and aged baobabs by measuring girth and converting this to age using the equation:

$$\text{Age (years)} = 0.213 \times \text{girth (cm)}.$$

This equation was calculated by using growth rings and determining the increase in radius for each ring laid down. It was found that growth was faster for the first 30 years but slowed as the tree aged.

Barnes (1980) studied Baobabs in Ruaha National Park, Tanzania. He used core samples obtained from trees and used the ring width of the core samples to determine the annual increment in radius. No difference in growth rate of the different size classes was obtained and there was no difference in growth rate of trees growing in three different soil and vegetation types. The radius of the 71 trees assessed, increased by a mean of 0.43 cm annually.

Weyerhauser (1985), worked in Lake Manyara National Park in Tanzania, and used the growth rate figure calculated by Barnes (1980) in which a linear relationship between girth and age exists. Using this method, each metre of the girth at breast height (GBH) represents 40 years of growth. Barnes' calculations were made in Ruaha National Park, Tanzania where the climate is similar to that at Lake Manyara.

Guy (1982) cautions against the use of girth as a method for calculating age, and states that growth rates of baobabs vary through the life of the plant and in general decrease with age.

Wilson (1988) assessed five baobab populations in Zambia, Sudan, Mali, Kenya and Tanzania and used either growth rings or empirical observations to determine growth rates and convert size to age classes. It was determined that very few trees live to an age in excess of 400 years. The multiplication factors for converting girth (cm) to age in the various populations were 0.370 for Tanzania, 0.213 for Zambia, 0.91 for Sudan, 0.164 for Mali, and 0.114 for Kenya. The data used for calculating the Tanzania and Zambia growth rates were from the trees studied by Barnes (1980) and Caughley (1976) respectively.

In Mali, baobabs are cultivated as an agricultural crop and the ages of these trees are therefore known. Wilson (1988) derived the equation ($y = 3.25 + 0.081\ x$) to calculate the age of these trees where x is the girth at breast height (cm). According to this equation, a tree with a GBH of 25 m is only 206 years old. Trees of known age in central-southern Africa gave girth conversion factors of 0.174 (mean of three trees), 0.191 (three other trees close together in the same garden), while one tree at Bagomoyo in Tanzania had a factor of 0.116 (Wilson 1988).

Baobabs in Mana Pools National Park, Zimbabwe, grew slowly initially, increasing in girth at a rate of 0.2 m annually (Swanepoel 1993). This was the rate of growth until the tree had a girth of 2.5 m, whereafter the rate increased to 0.78 m per year until the trees had attained a girth of 6.0 m. Thereafter growth was extremely slow, with the girth of trees only increasing by 0.10 m each year (Swanepoel 1993).

Von Breitenbach (1985) used a different approach to the ageing of baobabs. Instead of ageing the trees based purely on the size of the stem, he combined measurements of stem diameter, tree height and crown width with the shape and growth form of the tree to obtain rough estimates of the tree age.

From the above discussion, it is obvious that a number of opinions exist as to the growth rates of baobab trees. Although many of these studies were conducted in areas with vastly different climates, and therefore different growth rate figures were obtained, the one common aspect appears to be that baobabs grow quickly during the early part of their lives, with the rate of growth slowing later.

THE COMMON STAR-CHESTNUT (*Sterculia rogersii* N.E. Brown)

Sterculia rogersii forms part of the Sterculiaceae or cacao family. The family is distributed throughout the world in tropical and subtropical regions and is famous as the source of chocolate and cocoa. This is produced from the fermented seeds of the tropical American tree, *Theobroma cacao* (Pooley 1993). The African members of the family are of negligible economic value. They are used to a certain extent as sources of medicine, fibre, firewood, timber and as decorative plants (Van Wyk 1974). The family has 60 genera with well known South African trees belonging to the *Dombeya* and *Sterculia* genera (Germishuizen 1997; Palmer & Pitman 1961). There are about 700 Sterculiaceae species, of which about 230, from six genera occur in southern Africa (Germishuizen 1997). In the Kruger National Park, this family is represented by 21 species, from six genera, including one exotic genus. Five of these species are trees (Van Wyk 1974). Trees of the Sterculiaceae family are used by skipper butterflies (Hesperiidae) for breeding (Pooley 1993). The *Sterculia* genus consists of about 300 species of deciduous and evergreen trees, three of which occur in South Africa (Kruger 1973; Palmer 1977).

The name, *Sterculia* is derived from the Latin Sterculius. This was the name of the Roman god whose responsibility it was to fertilise the lands. His name was in turn derived from the word 'stercus', which means manure. This name was coined as a reference to the foul-smelling flowers of certain members of the genus (Van Wyk 1974). The species, *rogersii*, was named after Archdeacon F.A. Rogers, an amateur botanical collector, who collected extensively in southern Africa during the early 1900s (Germishuizen 1997). This species is now known as the common star-chestnut, but has in the past also been known as the succulent chestnut, ulumbu tree and squat sterculia.

The common star-chestnut is a small, deciduous tree, which resembles a *Commiphora*, or small baobab (Pooley 1993; Van Wyk 1974). Specimens have a thick stem which usually branches from near the ground into a number of thinner stems. The flowers are small, red and green, the fruits are slightly larger and consist of a number of lobes. The flowers usually appear during July, while the fruit is present on the tree from September to March. The common star-chestnut is a slow growing tree (Van Wyk 1984).

Sterculia rogersii trees occur at low altitudes in Mozambique, Botswana, Zimbabwe, Swaziland and South Africa (Coates Palgrave 1984). It is a species which is confined to southern Africa (Van Wyk 1974). The common star-chestnut occurs throughout the Kruger National Park, but are very rare in all areas except for the Pafuri region where the species is fairly common (Van Wyk 1984). Many specimens are present on the Pafuri ridges and in the area between the Limpopo and Luvuvhu Rivers. A few plants occur in rocky places in other locations, some close to Malelane and some in the Punda Maria and Olifants rest camps (Van Wyk 1974). The preferred habitat of these trees is in dry areas, and it grows almost exclusively in stony environments (Coates Palgrave 1984; Van Wyk 1974). Although dense stands of this species do not occur, it is sometimes associated with dense plant communities, of which *Colophospermum mopane* is the most important component (Van Wyk 1974).

The wood of *Sterculia rogersii* trees is very soft, light, fibrous and coarse in texture. It's air-dry mass is only 540 kg/m^3 (Van Wyk 1984). As a result of these poor qualities, the timber is worthless and not put to any known use (Van Wyk 1974). Fibre made from the bark is used by Africans to weave fishing nets and to sew sleeping mats (Coates Palgrave 1984) as well as in the construction of huts (Pooley 1993). The seeds are eaten by people, birds and game, while the leaves and young stems are browsed (Pooley 1993). The tree is also used in decorative gardens in frost free areas (Pooley 1993; Van Wyk 1984).

AGEING OF THE COMMON STAR-CHESTNUT

Ageing of *Sterculia rogersii* trees is of relevance in later chapters and is therefore discussed here. The common star-chestnut, resembles the baobab in a number of ways, and can even be confused with a young baobab (Pooley 1993; Van Wyk 1974). One reason for these similarities is that both these trees have very soft, fibrous wood. The wood of *Sterculia rogersii* does exhibit growth rings. The rings are very thin, finely sinuous, darker than the rest of the wood and extremely close together. As with the baobab, there is doubt as to whether these rings each represent a full years growth. (Van Wyk 1974). This makes it exceedingly difficult to estimate the age of *Sterculia rogersii* trees.

If each ring does represent a years growth, then a branch with a 0.10 m diameter is 170 years old (Van Wyk 1974). This is an extremely slow growth rate and indicates an increase in girth of only 0.0018 m per year. This implies that some star-chestnut trees in the Kruger National Park are more than 2500 years old. If *Sterculia rogersii* trees do live to this age, then some specimens are among the oldest trees in the world, and have attained an age usually associated with extremely long-lived plants such as *Welwitshia mirabilis*. Although common star-chestnuts are slow growing trees (Van Wyk 1984), it is unlikely that they live to such an age, and these growth rings are probably not annual.

It is more likely that these growth rings are formed more often, their formation possibly linked to rainfall. If each growth ring is laid down after rainfall, there could be up to 38 rings laid down per year as there are, on average, 38 days in the year on which rain falls in Pafuri. However, some of these rainfall events take place over more than one day and there are therefore probably fewer rings than this laid down annually. The actual number probably lies somewhere between one and 38.

If a rainfall event is considered to be the period from when the rain falls until there is no longer water available for the plant in the ground, then there will be fewer rainfall events than days of rain in a year. Such a rainfall event and a rain day are most probably not distinguishable by the plant. At the height of the wet season (November to March), there will be water available to the plant between different rains and more than one day of rain would therefore, become one rainfall event. Rain which falls in the form of showers often continues for a number of days and in such cases more than one rain day will only be one rainfall event. As there are probably around ten rainfall events per year, approximately ten growth rings are produced by these trees annually. The larger *Sterculia rogersii* plants in the Kruger National Park are thus estimated to be around 300 years old. Little is known of the lifespan of indigenous tree species, but some trees used for timber have known lifespans of 400 years (Hemlock) and 450 years (Douglas Fir) (Tyrrell & Crow 1994).

RECENT HISTORY OF THE KRUGER NATIONAL PARK ELEPHANT POPULATION

During the early part of the twentieth century, hunters eliminated elephants from most of the area now occupied by the Kruger National Park. Elephants were still present in the Portuguese territory east of the Lebombo Mountains and occasionally did wander across (Stevenson-Hamilton 1937), but a small nucleus is believed to have survived in the remote and secluded forested area near the Olifants Gorge (Pienaar 1963). No information on elephant numbers is available prior to their discovery in 1905. Since this time, regular estimates on the number of the population have been recorded. The first such report was by the parks first warden, Colonel James Stevenson-Hamilton who mentioned the existence of 10 elephant in the area between the Olifants and Letaba Rivers in 1905 (Van Wyk & Fairall 1969). In 1912, the population was estimated at 25, and grew steadily, due to the absolute protection afforded it, and also augmented by the immigration of elephant from the then Portuguese territory in the east (Pienaar 1963). Regular estimates of the population were made (1926: 100; 1931: 131; 1936: 250; 1946: 480; 1947: 560; 1954: 740; 1958: 995) until 1960 when the first aerial census was undertaken and 1186 elephant were present (Pienaar

1963; Whyte *et al.* 1998). In 1964 a complete census by helicopter was undertaken. There were 2474 elephants in the Kruger National Park at this time (Van Wyk & Fairall 1969).

Undoubtedly, the replacement of ground counts with aerial ones resulted in greater accuracy and hence, the apparent growth spurt of the elephant population. The population was, however, increasing during this time due to immigration of large numbers of elephants into the Kruger National Park from the neighbouring countries of Portuguese East Africa (Mozambique) and Rhodesia (Zimbabwe). These animals moved into the reserve where they received protection from the hunting activities in the adjacent regions (Van Wyk & Fairall 1969).

The elephant recolonisation of the Kruger National Park, was initially centred in the area around the Letaba River, and this was where the population initially increased and from where it dispersed. This dispersal was led by the scouting patrols of solitary bulls, followed by small groups who slowly began infiltrating the entire reserve (Van Wyk & Fairall 1969). The process was extremely slow, but in 1931, elephants began recolonising the northern mopani-veld, and then moved in a southerly direction during 1939 - 1941 (Pienaar 1963). During 1941, they were seen in the area south of the Sabie River for the first time in almost 100 years. During the summer of 1952, the Pretoriuskop area was first re-entered by two bulls, completing the recolonisation process (Pienaar 1963; Van Wyk & Fairall 1969).

The growth of the elephant population continued and inclined steeply during the 1960's (Joubert 1986), until 1967, when the first culling campaigns were initiated to maintain the population at around 7000 animals (Whyte *et al.* 1998). The population limit was imposed to ensure the perpetuation of viable populations of all large mammal species in the Kruger National Park and to minimise possible elephant damage to the vegetation (Coetzee *et al.* 1979). Culling of elephant continued for the next three decades, removing an average of seven percent of the population annually (Whyte *et al.* 1998).