Evaluation of recruitment methodologies for *Boscia albitrunca* in the southern Kalahari, South Africa

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Dissertation accepted in fulfilment of the requirements for the degree *Master of Science in Environmental Sciences* at the North-West University

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Graduation May 2024

ACKNOWLEDGEMENTS

I would like to acknowledge the following individuals and/or entities for their contributions and support throughout this study:

- Ms Chrizette Neethling from EndemicVision for inspiring this study and for sharing her insight and knowledge of the southern Kalahari's ecology and the restoration thereof. A special word of thanks also to Ms Neethling for the assistance she rendered with the statistical analyses for this study;
- My supervisor, Prof Klaus Kellner, for his inputs and the guidance he offered in mastering this field of study;
- Mr Christiaan Harmse for valuable inputs towards the completion of the study;
- Ms Daleen Groenewald for language editing and verifying in-text citations against sources referenced in this dissertation;
- EndemicVision for the assistance they offered not only in terms of funding but also with seed harvesting, planting, transplanting and monitoring;
- The Northern Cape Department of Environment and Nature Conservation for granting EndemicVision a permit for flora harvesting which made the collection of *Boscia albitrunca* seeds possible;
- Van's Lab for soil analyses;
- Jacoline Mans for her inputs and insight, and for sharing her passion for this species;
- The Kalahari East Water Users Association for allowing the collection of stem and root cuttings under their protected tree removal permit;
- Oom Willie and the Kgalagadi pipeline team for making their servitude available for restoration efforts as part of the field trials and allowing access for monitoring purposes;
- The landowners at De Rust for allowing the collection of seeds and all other landowners for allowing access for field trial purposes; and

My fiancé, Jurgens Becker, my parents, Jaap and Diana Hoffman, and my sister, Dedrei Hoffman, for their love, motivation and unfailing faith in me.

ABSTRACT

Boscia albitrunca is protected under the National Forest Act (Act No. 84 of 1998) as well as under the Northern Cape Nature Conservation Act (Act No. 9 of 2009). The survival of this species is threatened by farming practices such as high browsing pressure and thicket control; development pressures of habitat destruction and tree losses coupled with the limited rehabilitation success recorded to date. Even though *B. albitrunca* germinates relatively easy from seed and can be regenerated using vegetative cuttings, long-term survival of both cuttings and seedlings has hitherto proved challenging.

Hundreds of tree destruction permits are issued by the Department of Forestry, Fisheries and the Environment (DFFE) with the requirement to compensate for its loss through the re-establishment of three to ten trees for every *B. albitrunca* lost. Even though these requirements are enforced through a monitoring and reporting system, these compensation requirements have not resulted in the expected survival and/or increase of *B. albitrunca* specimens in the regions they were lost.

This study aimed to determine to what degree soil amelioration affect the recruitment rate of *B. albitrunca* when sowing (freshly harvested or stored seeds) and when planting vegetative cuttings. The soil characteristics and establishment rates of naturally recruited *B. albitrunca* saplings in areas where this species was legally removed were also evaluated.

Nursery trials, field trials and veld assessments were undertaken within a 50 km radius of Kathu town in the Southern Kalahari. A total of 15 soil samples were collected and analysed.

To test the germination, seeds were harvested by hand, cleaned, dried and stored from two respective farms in the study area. Seeds of different ages were then planted in both ameliorated and untreated soils whereafter germination was monitored daily for the first thirty days and then bi-weekly for survival until hardening.

To assess vegetative propagation, root cuttings and stem cuttings were collected from adult trees. Sealed and unsealed cuttings were planted in planting bags (nursery trials) or directly into the ground (field trials). The same monitoring regime as for seed germination applied.

The field trials tested the establishment of the hardened saplings and additional sourced saplings, as well as the survival rate of planted cuttings. The additional saplings were also hardened.

Field trails were monitored for survival and growth bi-annually for a period of 18 months. During the same period, naturally recruiting saplings were georeferenced and monitored bi-annually in an area where topsoil clearance took place for construction.

This study found that *B. albitrunca* prefers well-draining sandy soils, although germination and establishment is not significantly affected by soil nutrient or chemical values. Amelioration further had no significant effect on germination.

B. albitrunca can be successfully recruited from seeds or sealed stem cuttings. Larger cutting sizes had better establishment, and the youngest seeds had the highest mean germination. The correct cleaning and storage of seeds is however very important, and if done correctly, seeds remain viable for up to 12 months. Hothouses were further proven to have shorter germination periods than outdoor trials.

A survival of below 25% were recorded for field trial saplings after 18 months, despite their stunted above ground growth and the coppicing ability of *B. albitrunca* were confirmed.

Key terms: keystone species; propagation; rehabilitation; root cuttings; seed germination; soil amelioration; stem cuttings

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CHAPTER 1 LITERATURE REVIEW

1.1 Background

Natural resources are threatened by poor management decisions and/or new developments, which include, the overutilization by animals, especially livestock, urbanisation, mines or related industrial developments, and the development of renewable energy farms (Geist & Lambin, 2004; Mans, 2018; Shackleton *et al.*, 2006). This and other causes often lead to the degradation or destruction of vegetation and topsoil (Geist & Lambin, 2004; Mans, 2018) and the destruction of *B. albitrunca* trees.

B. albitrunca is one of eight *Boscia* species that occur in South Africa (Bothma, as cited by Alias & Milton, 2003), of which only two (*Boscia albitrunca* and *B. foetida*) occur in the southern Kalahari (Van Wyk & van Wyk, 2013).

B. albitrunca is considered as being ecologically, culturally, and medicinally important in southern Africa (Pendota *et al.*, 2016). It is an evergreen tree that serves as an important source of fodder to both wild herbivores and domesticated livestock in the arid areas of Southern Africa. This tree species further provides shade and shelter to birds and other small mammals and performs ecological services such as nutrient leaching and organic matter replenishment (Alias & Milton, 2003).

B. albitrunca is further considered a keystone species by Alias and Milton (2003) due to its ecological and economic roles in the arid areas of southern Africa. A keystone species is defined as “a strongly interacting species whose top-down effect on species diversity and competition is largely relative to its biomass dominance within a functional group” (Davic, 2003). A keystone species is characterised as a highly influential species that has a significant impact on species diversity and competition, primarily due to its dominant biomass within a specific functional group (Marais, 2019). Keystone species, often called ecological control centres, should be protected (Marais, 2019).

Past research indicates that the recruitment of *B. albitrunca* is threatened by high browsing pressure and the cutting of branches to make this species available for browsing due to its palatability and high nutrient content (Van der Walt & Le Riche, 1999). The increased browsing pressure also contributes to the trampling of seedlings (Van der Walt & Le Riche, 1999).

1.2 Distribution and characteristics of *Boscia albitrunca*

Boscia albitrunca in the family *Capparidaceae* (or *Capparaceae*), order *Cappariales* (Alias & Milton, 2003; Van Wyk & Van Wyk, 2013), is restricted to Africa as a genus, with only a single species occurring in southern Arabia (Palmer, 1981). Of all *Boscia* species, *B. albitrunca* has the widest distribution in South Africa, specifically in dry, open woodland areas and bushveld (Alias & Milton, 2003). This species is commonly known as the shepherd's tree (*witgat* or *matoppie* in Afrikaans and *molthopi* in Setswana) (Alias & Milton, 2003; Van Wyk & Van Wyk, 2013).

Even though Venter and Venter (1998) stated that *B. albitrunca* seemingly prefers dry, open woodland areas where they are commonly found in sandy to loamy calcrete soils, Van der Walt and Le Riche (1999) are of the opinion that this species prefers arid areas with deep aeolian sands that allow its root system to penetrate to greater depths. Irrespective of where it establishes, Van der Walt and Le Riche (1999), concur that since soil type has a direct bearing on the development of the tree's deep taproot system as well as its network of thick, shallow lateral roots, soil type is bound to have a direct bearing on the growth form of the species.

For example, when occurring on dune slopes where it is more challenging to anchor its roots in the loose sands, *B. albitrunca* will take on the form of a shrub rather than a tree (Van der Walt & Le Riche, 1999). Likewise, even though *B. albitrunca* can survive fires better than *Vachellia* and *Senegalia* species that share the same environment (Skarpe, 1980). They are often transformed into multi-stemmed shrubs should they suffer any form of crown damage (Van der Walt & Le Riche, 1999). Under protected conditions, though, Van Rooyen *et al.* (2016) as well as Thomas and Grant (2008) recorded specimens reaching an average height of seven to eight metres.

Generally, *B. albitrunca* can be described as an evergreen tree with a semi-rounded or rounded crown, often displaying an obvious browse line at the bottom that can be correlated to the height of the browsers (Coates Palgrave, 1983; Thomas & Grant, 2008). It has a light coloured, whitish bark – often with pits and folds and even small holes – and it is postulated that the light colouring of the bark of the shepherd's tree might help to reflect radiation to, in this way, avoid overheating of its surface (Marais, 2019).

Depending on rainfall events, *B. albitrunca* will flower from July to November, bearing small, sweet smelling flowers that lend a yellow-green tinge to the entire tree (Thomas & Grant, 2008; Venter & Venter, 1998). Fruits follow from October to March annually and are carried as bunches of yellow berries (Thomas & Grant, 2008).

1.3 Conservation status of *Boscia albitrunca*

Boscia albitrunca is declared as protected under section 12 of the National Forest Act (Act No. 84 of 1998), as well as under the Northern Cape Nature Conservation Act (Act No. 9 of 2009) in South Africa since it is a keystone species in the arid and semi-arid parts of southern Africa (Alias & Milton, 2003; Mans, 2018). According to section 15 (1) of the National Forest Act, 1998 (Act No. 84 of 1998), “no person may (a) cut, disturb, damage, destroy or remove any protected tree; or (b) collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any protected tree, except under a license granted by the Minister.” This act applies to dead and living trees of all species listed as protected trees (Alias & Milton, 2003).

B. albitrunca is further protected provincially in the Northern Cape under the Northern Cape Nature Conservation Act (Act No. 9 of 2009) and also in Namibia under the following ordinance and proclamation: Preservation of Trees and Forests Ordinance of 1952 and the Proclamation of the South West Africa Administration (No. 486 of 1972).

1.4 Role of keystone species in an ecosystem

Figure 1-1 below illustrates a typical keystone structure ecosystem where numerous species rely on a tree for food, shelter or as a nesting site (Tews *et al.*, 2004). In instances such as these, eco-diversity is directly reliant on the tree.

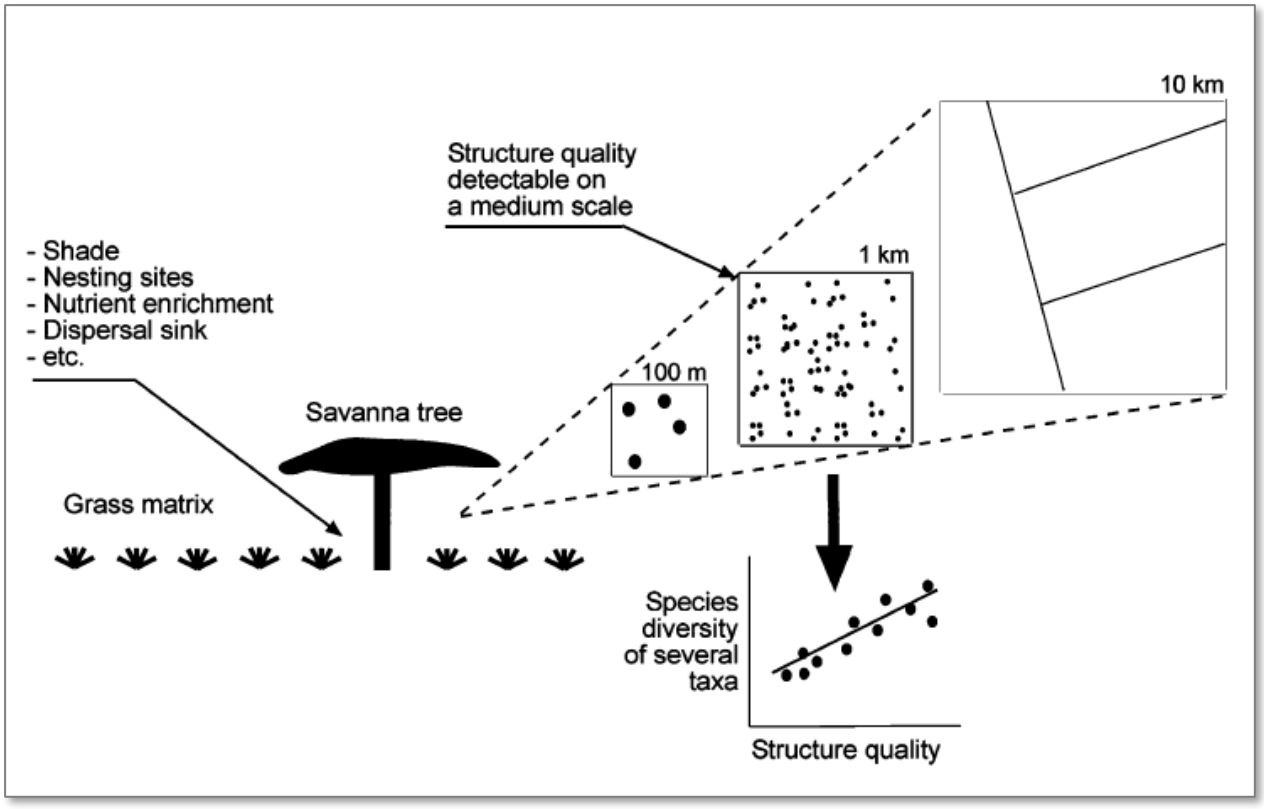

Figure 1-1: Ecosystem structure of a keystone savanna tree (Tews *et al.*, 2004)

The importance of conserving keystone species based on the role they play in generating spatial heterogeneity is emphasised by Dean *et al.* (1999), who found that without the nutrient-enriched shade patches provided by these trees to the benefit of biodiversity, arid savannas could well be considered as oligotrophic.

Likewise, Payton *et al.* (2002) concluded that an area's species diversity will decrease when the density of a keystone species decreases since this could cause a series of ecological reactions that can result in ecosystem degradation. This view is supported by Alexander *et al.* (2011) and Tews *et al.* (2004), who found that keystone-dependent communities become vulnerable and/or unstable with regard to their structure, function or diversity when a keystone species is removed.

1.5 *Boscia albitrunca* as a keystone species

1.5.1 Fauna and flora

Boscia albitrunca primarily serves as a source of browsing material for livestock and game and as a shelter and shade for other animals in the arid areas of South Africa (Alias & Milton, 2003; Kos, 2007). Land users often cut the branches of adult specimens of this species so that the palatable leaves with their high nutrient content are readily available as fodder (Coates Palgrave,

1983; Van der Walt & Le Riche, 1999; Van Rooyen *et al.*, 2016). This species is also often naturally coppiced due to herbivory, resulting in some specimens growing as flat, multi-stemmed shrubs instead of trees (Van der Walt & Le Riche, 1999).

In addition to serving as a source of browsing material, *B. albitrunca* also contributes to nutrient cycling and, according to Alias and Milton (2003:3), performs ecological services such as "reducing nutrient leaching, mitigating soil degradation, preventing soil erosion, sequestering carbon and replenishing organic matter."

In arid and semi-arid savannas, trees and shrubs serve as focal points for animal activity since they provide nesting and perch sites, shade and food (Dean *et al.*, 1999). Particularly, they create microhabitats that contrast with the surrounding open habitats, thereby promoting biodiversity and lending structure to the plant community (Kos, 2007). The nutrient quality of the soil underneath these trees is also elevated due to animal carcasses, faeces and fallen bird nests (Dean *et al.*, 1999).

Research (Dean *et al.*, 1999) has shown that *B. albitrunca* saplings establish well if they occur underneath other large trees, such as *Vachellia erioloba* (camelthorn). The larger *V. erioloba* trees often also serve as perch sites for birds or resting sites for other fauna, and this contributes to the dispersal of *B. albitrunca* seeds (Dean *et al.*, 1999; Kos, 2007). Hence, threats to other large trees in arid areas could impact the natural recruitment of *B. albitrunca* saplings negatively, given that frugivorous birds utilise mature trees more often than dead trees or saplings (Dean *et al.*, 1999). Kos (2007) also found that seed rain (i.e. the deposition of seeds under the canopy of a tree due to bird activity) appears denser under larger trees in an area.

Hughes *et al.* (1993) and Milewski (1982) found that the distribution of plants with fleshy fruits is dependent on the availability of potassium (K) and, to a lesser extent, on nitrogen (N) in soils. Frugivore-dispersed plants, such as *B. albitrunca*, are likely to colonise subcanopy sites such as the nutrient-enriched sites under leguminous *V. erioloba* host trees (Dean *et al.*, 1999). In the latter study, greater nitrogen, phosphorus and potassium concentrations were observed under *V. erioloba* host trees than in the surrounding soils, whilst intermediate levels of these elements were recorded under dead trees of the same species. Campbell *et al.,* cited by Dean *et al.* (1999), explained that nutrient enrichment underneath trees in open savannas such as the Kalahari can largely be ascribed to animal activity and not simply to plant litter on the soil surface.

Once the large host trees under which *B. albitrunca* and other fleshy-fruited shrubs tend to establish die, the favourable conditions offered underneath these trees change due to an increase in soil temperature and heightened radiation (Belsky & Canham, 1994). As they disintegrate,

animal activity also decreases under dead host trees. Given these conditions, Dean *et al.* (1999) found that only a few tree species, such as *Boscia albitrunca*, *Grewia* spp. and *Ziziphus* sp. are likely to survive in the absence of host trees, adding that host trees are not out-competed and/or killed by fleshy-fruited trees that establish underneath them: They are simply outlived by the latter.

The Kalahari is known for its harsh climatic conditions, and it is common knowledge that plants in this region have developed mechanisms that enable them to survive under such conditions (Caylor *et al.*, 2002; Privette *et al.*, 2004; Ringrose *et al.,* 2002; Scholes *et al.*, 2002). Two physiological characteristics of *B. albitrunca* allow this species to remain in foliage throughout the dry season. These are its sclerophyllous leaves that can withstand extreme droughts during daytime and frost events at night (Wand *et al.*, 1999) and its tap-root system that can supply the tree with moisture from deep subterranean sources (Alias & Milton, 2003).

Boscia albitrunca provides microhabitats for birds and other mammals by buffering the extreme day temperatures experienced in arid regions, resulting in a difference of more than 20 degrees Celsius compared to the average temperature of the surrounding barren sand (Bothma, cited by Alias & Milton, 2003). Consequently, the refuge provided by these trees reduces animals' water and energy consumption, which is otherwise required to regulate their body temperature (Le Houérou, 1980).

Furthermore, in their study of the relationship between termite mounds and trees, Wildermuth *et al.* (2021) found that 42% of the mounds were associated with *B. albitrunca* specifically and, notably, that these mounds were taller than those associated with other deciduous tree species, presumably due to the dense shade *B. albitrunca* offers.

Given that termite mounds could be regarded as patches of increased nutrients and higher vegetation diversity in savannas (Joseph *et al.*, 2013; Sileshi & Arshad, 2012), trees that would benefit from this symbiotic relationship commonly established after the mounds, and this observation also holds for *B. albitrunca* (Wildermuth *et al.,* 2021). However, a study by Van der Plas *et al.* (2013) found that trees commonly associated with termite mounds have low or no nitrogen-fixing abilities, increased water requirements, and evergreen and broad leaves. This does not quite hold true for *B. albitrunca.*

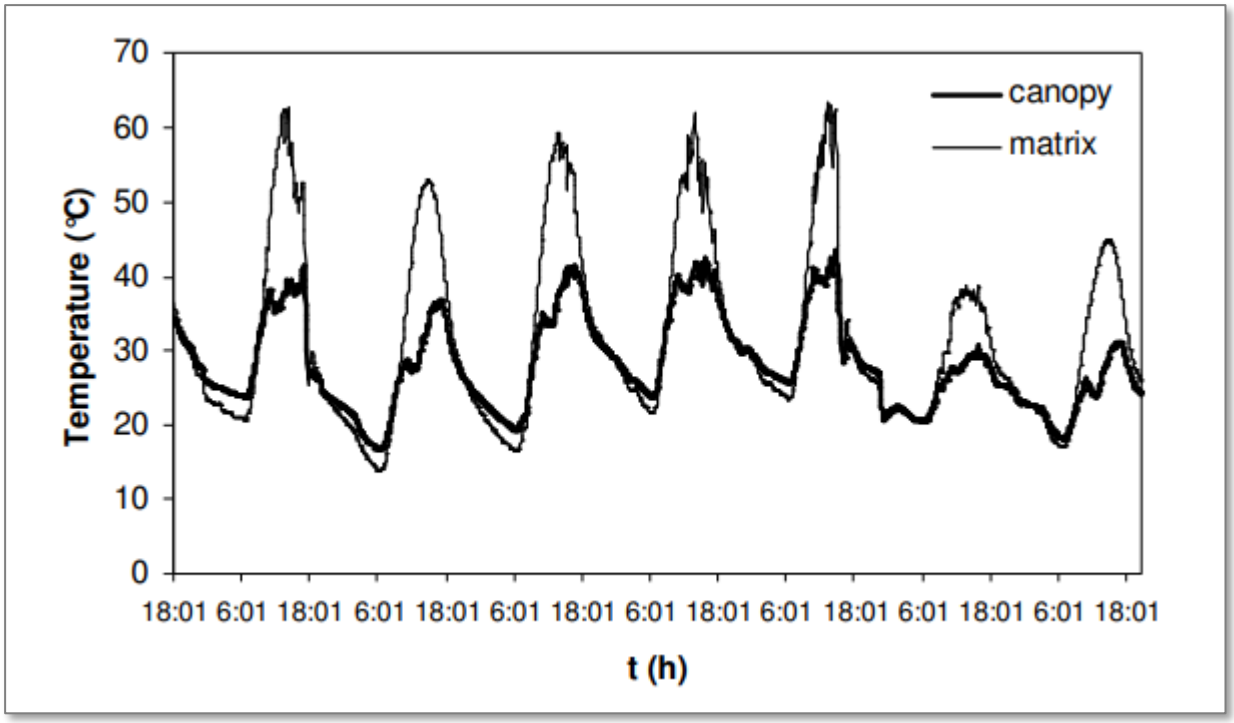

Figure 1-2: Temperatures measured at five-minute intervals between 13 and 20 February 2003 in the microhabitat provided by *Vachellia erioloba* compared to adjacent landscape matrix (Kos, 2007) [Key: readings below canopy (—); adjacent landscape matrix (—)]

In addition, due to the shade *B. albitrunca* provides, evaporation is reduced, and soil moisture levels underneath their canopies remain higher for most of the wet and dry seasons compared to surrounding grasslands (Dean *et al.*, 1999), thereby improving the survival of shade-tolerant plant species (Smith & Goodman, 1986). Furthermore, this species is responsible for the hydraulic redistribution of water resources, an action whereby adjacent vegetation is provided with water through root uptake or by means of the soil mycorrhizal network (Warren *et al.*, 2008). During hydraulic redistribution, the roots of a plant act as conduits that transfer water from moist to dry soil (Lubczynski, 2009), thereby serving as a mechanism that facilitates the survival of understory vegetation (Meinzer *et al.*, 2004).

Hydraulic redistribution takes place in one of two possible water movement directions, namely hydraulic ascent and hydraulic descent (Lubczynski, 2009). During dry seasons, the hydraulic ascent takes place during the daytime and entails the ascent of water from the taproots and shallow lateral roots to the stem and canopy of the plant (Figure 1-3 a). At night, the water flow descends away from the canopy towards the shallow soil layer (Figure 1-3 b). During wet seasons, abundant water at the surface and shallow subsurface is transported to deeper soils

where it is stored for upcoming dry periods but, as Lubczynski (2009) pointed out (Figure 1-3 c), transcends can also occur during wet seasons in response to photosynthesis and/or sunlight.

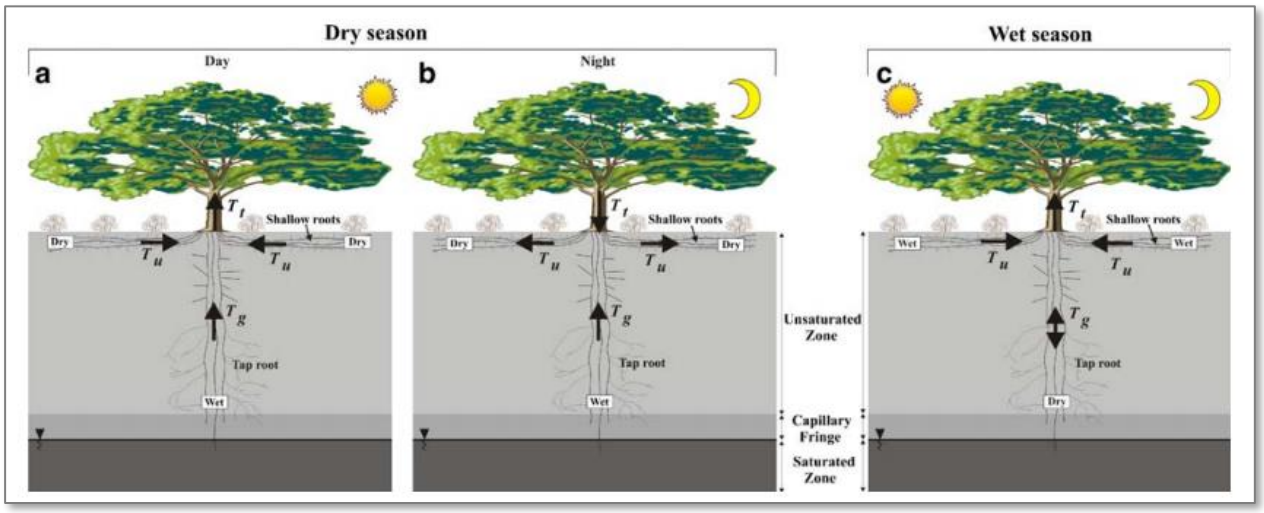

Figure 1-3: Hydraulic redistribution (a) during daytime of the dry season; (b) during night-time of the dry season; (c) during day- and night time of the wet season (Lubczynski, 2009)

In terms of ecosystem services, *B. albitrunca* benefits nature and has served many human needs throughout the centuries.

1.5.2 Human consumption

1.5.2.1 Utensils and tanning

Since it lacks heartwood, the wood of *B. albitrunca* is not sought after (Figure 1-4) and is primarily used for the production of household utensils (Chavarro-Rincon, 2009; Van der Walt & Le Riche, 1999). The cutting and burning of the wood of this species are even prohibited due to superstitions held by certain indigenous tribes (Coates Palgrave, 1983). However, in a study conducted by Koloka and Moreki (2011), it came to the fore that some respondents use the bark of *B. albitrunca* in combination with either *Elephantorrhiza elephantina* or *Terminalia sericea* as a tanning agent.

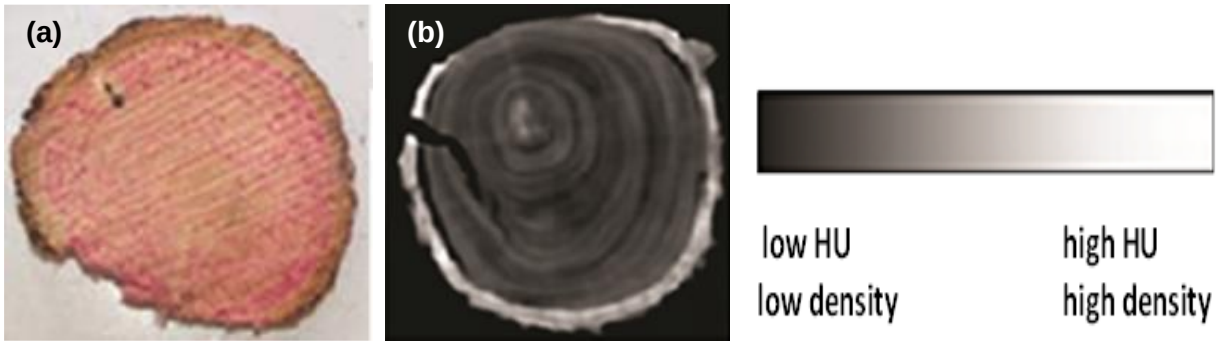

Figure 1-4: **(a) The stem disc indicates that the wood of *B. albitrunca* has no well-defined heartwood; (b) X-ray imagery of *B. albitrunca* stem disk stained with Eosin-B solution in which tree rings can be distinguished. The scale indicates the Hounsfield units (HU), which are proportional to tissue density (Chavarro-Rincon, 2009)**

1.5.2.2 Beverages and foodstuffs

In his study, Rampedi (2010) identified *B. albitrunca* as one of the beverage-making plant species in the Limpopo Province. He warned that overexploitation of this species' seeds should be guarded against to ensure that natural populations are not depleted. Furthermore, as early as 1999, Van der Walt and Le Riche (1999) reported that fruits are commonly used as appetisers or to infuse yoghurt, while Coates Palgrave (1983) found that flower buds sometimes serve as a substitute for capers.

As far as *B. albitrunca's* roots are concerned, Van der Walt and Le Riche (1999) found that indigenous tribes of the Kalahari and North West produce coffee and porridge from the shallow lateral roots. They also use fresh and/or dried roots as a preservative for dairy products such as milk and butter and to prevent bacterial growth on bread and fruits.

1.5.2.3 Medicinal remedies

In a study conducted by Maroyi in 2019, it was found that all parts of *B. albitrunca* (i.e., leaves, roots, fruit, bark and stem) are used throughout Africa to treat a whole array of ailments. Those findings are summarised in Table 1-1 below. Note that all secondary sources are as per Maroyi (2019).

Table 1-1: Medicinal uses of *Boscia albitrunca* across Africa (Maroyi, 2019)

Medicinal treatment	Country	Part of tree					Secondary source
		Leaves	Roots	Fruit	Bark	Stem	
Constipation	Mozambique; Namibia	x	x				Cheikhyoussef & Embashu, 2013 Bruschi *et al.*, 2011
Diarrhoea	Mozambique	x					Ribeiro *et al.*, 2011
Ear problems	Namibia	x					Van den Eynden & Van Damen, 1993
Emesis	Eswatini	x	x				Masarirambi *et al.*, 2019 Long, 2005
Epilepsy	Namibia; South Africa; Eswatini	x	x	x	x		Masarirambi *et al.*, 2019 Msangi, 2014 Van Wyk & Gericke, 2007 Van Damme *et al.*, 1992 Long, 2005 Sobiecki, 2008 Pendota *et al.*, 2015 Maema *et al.*, 2016 Masondo, 2019
Eye problems	South Africa	x					Pendota *et al.*, 2015
Lactation	Namibia			x			Msangi, 2014
Haemorrhoids	Botswana; Mozambique; Namibia; South Africa; Eswatini	x	x	x			Masarirambi *et al.*, 2019 Van Damme *et al.*, 1992 Govender, 2005 Heath & Heath, 2009 Palgrave, 2002 Ribeiro *et al.*, 2011 Long, 2005 Pendota *et al.*, 2015
Headaches	Namibia; South Africa		x				Cheikhyoussef & Embashu, 2013 Semenya & Maroyi, 2019a Semenya & Maroyi, 2019b
HIV/AIDS	South Africa; Zambia		x				Mogale *et al.*, 2019 Semenya & Potgieter, 2014 Semenya *et al.*, 2013a Semenya *et al.*, 2013b Maroyi, 2019 Semenya *et al.*, 2013c Chinsembu, 2016
Hypertension	South Africa		x				Semenya & Wadesango, 2018
Magical healing	South Africa		x				Sobiecki, 2008
Muscular pain	Mozambique		x				Bruschi *et al.*, 2011
Respiratory infections	South Africa		x				Semenya & Maroyi, 2019c

Medicinal treatment	Country	Part of tree					Secondary source
		Leaves	Roots	Fruit	Bark	Stem	
Skin diseases (chicken pox and rash)	Botswana; Namibia	x	x				Neelo *et al.*, 2015 Cheikyoussef *et al.*, 2011
Snakebite	South Africa				x		Maema *et al.*, 2016
Syphilis	Botswana; Namibia	x	x			x	Chinsembu, 2016 Cheikyoussef *et al.*, 2011 Hedimbi & Chinsembu, 2012 Chinsembu *et al.*, 2015
Ethnoveterinary medicine (anthrax, poultry diseases, fertility; eye, liver and lung infections)	Botswana; Namibia; South Africa; Zambia	x	x		x		Govender, 2005 Heath & Heath, 2009 Palgrave, 2002 Gabanakgosi *et al.*, 2012 Gabalabatse *et al.*, 2013 Moreki *et al.*, 2012 Moreki, 2013 Setlalekgomo & Setlalekgomo, 2013 Chinsembu, 2015a Chinsembu, 2015b Nyako *et al.*, 2016 Marius *et al.*, 2017

As is evident from the above, the value *B. albitrunca* adds to arid and semi-arid ecosystems implies that it is well deserving of the accolade “tree of life” (Van der Walt & Le Riche, 1999). Unfortunately, unchecked exploitation of this species’ many benefits may lead to its destruction (Alias & Milton, 2003).

1.6 Threats to the survival of *Boscia albitrunca* as a keystone species

Given that fleshy-fruited plants are a particularly important reliable water source for animals in desert and arid ecosystems, their conservation ought to be prioritised (Bronstein *et al.*, 2007). In areas such as these, seeds are often the only means by which the continued presence of certain plants can be viably sustained over the long term (Cabin & Marshall, 2000; Guo *et al.*, 1999; Kinloch & Friedel, 2005; Pake & Venable, 1996) and should, therefore, be considered as a crucial part of these ecosystems (Van Rooyen, 1999).

Nevertheless, given that bark plays an important role in insulating a tree’s trunk against harmful environmental conditions and protecting it against desiccation or drying out, Cunningham (2001) and Romero (2006) is of the opinion that bark-stripping poses an even greater threat to the survival of *B. albitrunca* than excessive harvesting of its fruit and/or flowers and overgrazing do.

Nott and Stander (1991) states that bark-stripping can suppress a tree's growth to maturity and even increase the risk of its mortality (Gill, 1992).

Another threat to *B. albitrunca* is the "woody shoot parasites" that infest these trees (Madisa *et al.*, 2017). Commonly referred to as mistletoes, these bush-like growths parasite host trees when birds disperse their seeds on a suitable host plant's bark, where the seed then germinate and become completely dependent on the host tree for water and minerals (Glatzel & Geils, 2009). Moreover, in their study, Madisa *et al.* (2017) found a negative correlation between the host's survival and the mistletoe volume, implying that the more infested the host tree, the higher its risk of mortality.

Even though it may not be the targeted species, the application of arboricides to control woody species during bush clearance exercises also poses a long-term threat to the survival of *B. albitrunca*. This is evidenced by the study conducted by Erasmus (cited by Alias & Milton, 2003), who found that using arboricides to clear *Senegalia mellifera* resulted in large-scale mortalities amongst *B. albitrunca* 15 years after application.

Interestingly, even though the brown-veined white butterfly (*Belenois aurota*) of the *Pieridae* family plays an important role in the pollination of *B. albitrunca,* evergreen trees resorting under the order *Cappariales* are often defoliated by larvae belonging to the same family that feed on these trees (Taylor, 1959; Van Wyk & Van Wyk, 2013). This defoliation is, however, not recorded to result in the demise of this species.

As pointed out earlier, the removal of large trees, increased grazing pressure normally following above-average rainfall events in the southern Kalahari and the application of arboricides all impact the habitat structure of the regions in which *B. albitrunca* occurs (Seymour & Dean, 2010). Such changes in habitat structure inevitably result in the alteration of floral and faunal compositions, often leading to biodiversity loss.

With reference to *B. albitrunca* specifically, only exceptionally large trees can support the communal nests of the southern African endemic *Philetairus socius* (sociable weaver) and, hence, to also provide both food and shelter for commensal species such as *Polihierax semitorquotas* (pygmy falcon), *Tyto alba* (barn owl) and *Bubo lacteus* (giant eagle owl) as well as predatory species, such as snakes (*Naja* spp.) and honey badger (*Mellivora capensis*) (Dean *et al.*, 1999).

Given that *B. albitrunca* depends on fruit-eating fauna for the dispersal of its seed, threats regarding dispersal, recruitment and propagation of this species will be discussed in detail in the section to follow.

1.7 Dispersal, propagation and recruitment of *Boscia albitrunca*

1.7.1 Seed dispersal

Plants are sessile and their mobility is mainly restricted to their seed dispersal. Hence, species that coexist in a certain habitat depend on the ability of those species to disperse to that habitat (Kos, 2007). Generally, seed dispersal can be spatial (through gap detection) or temporal (in response to rainfall events). Ultimately, though, seeds will only germinate where their regenerative traits allow it to and where the habitat is favourable (Kos, 2007). Moreover, seed dispersal plays a critical role in maintaining plant diversity (Cordeiro & Howe, 2003; Harms *et al.*, 2000).

In their study on the ecology of seed dispersal, Howe and Smallwood (1982) observed certain general adaptations and/or modifications (i.e. signs) in the fruits and seeds of plants that could be ascribed to dispersal agents (i.e. animal, wind, water or self). Their observations are summarised in Table 1-2 below.

The seeds of *B. albitrunca* have fleshy nutrients and chemical attractants, which result in the dispersal thereof by means of animals, specifically vertebrates and ants (Table 1-2). The sugars, proteins and fats contained in the seeds are called elaiosomes and serve as a food source for insect species such as ants (Howe & Smallwood, 1982).

Table 1-2: General adaptations/modifications of *B. albitrunca*'s fruits and seeds in response to dispersal agent (adapted from Howe & Smallwood, 1982)

Dispersal agent	General adaptation	Modification	Derivation	Comment
Animal	Fleshy nutrient	Aril, pericarp, pulp	Seed coat or floral parts	Vertebrate dispersal
	Chemical attractant	Elaiosome	Seed integument	Ant dispersal

In arid areas, seed dispersal is often linked to the species that nest and/or frequent the specific species. Although seeds contained in fleshy fruit or pulp that attracts frugivorous species can be dispersed by both birds and mammals, birds tend to be the most important seed dispersing fauna species since they tend to be more mobile, lead to increased seed rain under canopies of isolated or tall trees and tend to excel in long-distance dispersals (Holbrook *et al.*, 2002; Howe & Smallwood, 1982; Jordano, 2000; Sekercioglu, 2006; Wenny, 2001). Different dispersers, however, disperse seeds from different parts or canopy levels of the tree to different areas; consequently, they cannot replace one another completely (Clark *et al.*, 2001; Howe &

Smallwood, 1982). In this regard, Jordano (2000) as well as Thompson and Grime (1979) found that frugivorous animals establish a dynamic link between fruiting plants and the seed bank or concentration of viable seeds contained in the upper layer and on the surface of the soil for limited or extended periods in a community.

Fruiting species, such as *B. albitrunca*, are listed as a species prone to directed seed dispersal (Howe & Estabrook, 1977; Thompson & Willson, 1978), especially in arid areas where the trees that attract birds are few and provide microclimates that are favourable for seedling establishment (Sekercioglu, 2006). Directed seed dispersal entails the non-random dispersal of seed to sites where the seedling would have a high survival probability (Wenny, 2001) or the assumption that seeds reach favourable establishment sites due to certain adaptations thereof (Howe & Smallwood, 1982).

The quality and quantity of seed dispersal are affected by the disperser's effectiveness means Schupp (1993) who defines disperser effectiveness as "the contribution a disperser makes to the future reproduction of a plant". Quantity is affected by the number of times the host plant is visited by a disperser as well as the number of seeds the disperser disperse in a single visit, whilst quality is affected by the gut and mouth treatment provided by the disperser and the probability of the seed to survive after dispersal (Schupp, 1983).

According to Chama *et al.* (2013), it still needs to be confirmed whether germination is enhanced by the interactions between the frugivorous species and the seed. The removal of the pulp that inhibits germination is considered to aid germination (Traveset, cited by Chama *et al.*, 2013) and to decrease the seed's risk for fungal and microbial infections (Jackson *et al.*, cited by Chama *et al.*, 2013). Other studies, however, suggest that germination is inhibited by frugivores since abrading of seed coats and the presence of traces of dung on excreted seeds may increase the risk of fungal and microbial infections (Nogales *et al.*, 1999). There are also some researchers (notably Barnea *et al.*, 1992; Chama *et al.*, 2013; Clout & Tilley, 1992; Howe & Vande Kerckhove, 1979) who argue that frugivores are simply the transport agent for the seeds and do not affect the germination probability thereof whatsoever. Regardless of the role of the frugivorous species, Wotton and Kelly (2011) found that a loss of frugivore species negatively affects the recruitment of tree species dependant on these species for seed dispersal.

According to Brooke (cited by Dean *et al.*, 1999), the sandveld of the Kalahari is lacking in numbers of frugivorous birds compared to other sandy areas in southern Africa. Frugivore bird species resident in the southern Kalahari, as observed by Dean *et al.* (1999), include *Agapornis roseicollis* (rosy-faced lovebird), *Tockus leucomelas* (southern yellow-billed hornbill), *Corvus capensis* (cape crow), *Creatophora cinerea* (wattled starling), *Lamprotornis australis* (Burchell's

glossy-starling), *Lamprotornis nitens* (Cape glossy starling) and, following on rain events, *Pycnonotus nigricans* (African red-eyed bulbul) and *Tricholaema leucomelas* (acacia pied barbet).

1.7.2 Propagation from seeds

Boscia albitrunca produces endozoochorous seeds, meaning that its seeds are ingested by fauna as part of the dispersal process (Dean *et al.*, 1999; Van der Walt & Le Riche, 1999). Of interest here is to note that, according to Briers (cited by Alias & Milton, 2003), *B. albitrunca* seeds are non-dormant and have a very limited life expectancy.

Seeds are classified as either transient or persistent (Kos, 2007; Thompson & Grime, 1979). Seeds are transient when viable for a period shorter than one year and persistent when a portion of the seed can remain dormant for longer periods. Kos (2007) correlated seed classification (transient or persistent) with the mass and shape of the seed, as well as its depth distribution and/or how deep the seeds of certain species are buried in the soil seed bank. *B. albitrunca's* seeds have an average mass of 62,427 mg and a 0,020 variance in seed dimensions or shape, resulting in these seeds being classified as transient (Kos, 2007).

Since the seeds of *B. albitrunca* are favoured by numerous fauna species, harvesting seeds for propagation can be challenging given that fallen seeds are mostly predated and no longer viable. However, yellow seeds can be collected by hand-picking (Mans, 2018).

When attempting to propagate *B. albitrunca* from harvested seeds, Mans (2018) pointed out that each fruit or seedpod contains between one and six seeds enclosed within a fleshy endocarp, which inhibits germination. Once harvested, the fleshy endocarp must be removed from the seeds by washing with a damp cloth. Seeds can then be placed in direct sunlight for a limited time to dry after washing, after which they can either be sown directly and/or stored in an airtight container in a fridge.

The processing of seeds after collection affects the quality, viability and life expectancy of the seed (Luna & Wilkinson, 2014). Dry seeds should be stored in paper collection bags for minimal periods until processing for storage, whilst fleshy fruits (as those of *B. albitrunca*) should be stored in plastic bags inside coolers to prevent fermentation (Luna & Wilkinson, 2014). Seeds should not be subjected to direct sunlight or extreme temperatures after collection (Luna & Wilkinson, 2014).

Briers (cited by Alias & Milton, 2003) described *B. albitrunca* as one of the arid zone species that takes the least time to germinate. Mans (2018) recorded the first emerging seedlings after only 11 days. However, other seedlings from the same experiment only emerged after four weeks. During trials using seeds sown in summer immediately post-cleaning, Mans (2018) recorded a

68% germination rate at the past DAFF (now DEFF) state nursery. Seeds stored and sown after winter had an even better germination rate of 85%.

In her study, Mans (2018) sowed seeds into sowing trays and kept them in a hothouse until they germinated. She took care not to sow seeds too deep since, according to her, they only need to be covered lightly. The soil used in her germination trials consisted of 70% red Kalahari dune sand and 30% compost.

Mans (2018) transplanted the seedlings into plastic bags (volumes not specified) within one to two months post-germination to allow more room for root development. According to her, nurturing seedlings in the planting bags proved challenging and after three months, four saplings could be transplanted directly into the ground and hardened gradually. The hardening process is not described in detail, but Mans states that the saplings' watering was reduced to once per month after six months of hardening and irrigation was discontinued after one year.

After three years, a 25% survival rate (i.e. a single sapling) was recorded at the past DAFF (now DEFF) state nursery, and no above-ground growth was evident (Mans, 2018). After approximately three and a half years, the living sapling started showing above-ground growth, and a height difference of more than half a meter was recorded over three months (Mans, 2018).

Mans' (2018) findings support those of Cunningham (2001) who found *B. albitrunca* saplings to be slow growing since the taproot system tends to develop before above-ground growth. According to Mans (2018), the surviving sapling in her trial invested in underground root development during the first three years post transplantation to open ground before starting to invest in above ground growth. Depending on recruitment strategy and soil type, Mans (2018) concluded that *B. albitrunca* saplings will gain no more than 30 cm in height per annum.

Pendota *et al.* (2016) used seeds purchased from Silverhills Seeds in Cape Town. In this trial, the *B. albitrunca* seeds were stored at 10 °C before being subjected to seed viability tests as described by the International Seed Testing Association (ISTA). Accordingly, seeds were soaked in a TTC solution (2, 3, 5-triphenyl tetrazolium chloride) in dark conditions for 24 hours before each seed was dissected and regarded as viable only if the embryo was stained entirely red. Note in this regard that Freeland (cited by Pendota *et al.*, 2016) defines viable seeds as seeds that have a completely red stained embryo after being subjected to the ISTA viability test.

Pendota *et al.* (2016) also conducted seed stratification tests. Both warm (25 °C) and cold (5 °C) stratification were tested for 7, 14 and 21 days respectively. According to the researchers, the stratification tests entailed placing seeds between two sheets of paper towel, concealing the

seeds in plastic bags, and watering them with distilled water by means of a spray bottle. The plastic bags aid the retention of moisture and heat required and serve as an incubator. After incubation, germination tests were conducted at 25 °C under varying light-dark cycles (i.e. 16 hours light and eight hours dark). None of the cold stratification seeds germinated; however, a maximum of 100% germination was recorded for the 14-day warm stratification seeds.

Pendota *et al.* (2016) subjected seeds used in their study to yet another round of germination tests under different temperatures and varying dark-light cycles (16 hours light and eight hours dark). This time, though, the seed coat was removed from half of the seeds since seeds are likely to be scarified when they pass through the digestive system of animals. In this round, a maximum germination of 47% was recorded for the trial conducted at a constant 25 °C on seeds where the seed coat had been removed, as described above.

The water uptake tests conducted by Pendota *et al.* (2016) on *B. albitrunca* seeds indicated an increase in water uptake after seven days, indicating that the seeds had no hard seed coat dormancy. Baskin and Baskin (cited by Pendota *et al.*, 2016) assumed that the difference in germination percentages as obtained during the 2016 warm stratification study of Pendota *et al.* (100%) and an earlier study Briers conducted in 1988 under optimal conditions (27%) could be indicative of “non-deep simple morphophysiological dormancy”.

Furthermore, Pendota *et al.* (2016), found seeds to be photoblastically positive since the germination percentage was poor under dark conditions and enhanced when subjected to alternating dark-light cycles. Interestingly, too, they found the seeds to be smoke responsive; the growth of this species is likely to be promoted when exposed to fire and smoke. Germination tests exhibited longer seedlings for the seeds subjected to smoke-water treatments compared to the control. Seedlings subjected to the low smoke-water concentration of 1:1000 v/v had increased shoot length, produced more leaves and larger leaf areas and had higher shoot weights, both fresh and dry. The root length, root dry weight and root fresh weight results were however not significantly different from the control at the 1:1000 v/v smoke-water concentration. Shoot weights, both fresh and dry, were also significantly different from the control at the higher smoke-water concentration of 1:1500 v/v.

Of particular interest is that Pendota *et al.* (2016) support the view of Wand *et al.* (1999), namely that the growth of seedlings was promoted when they were watered more frequently, which could imply that this species is not as water conserving as its distribution area would imply.

1.7.3 Vegetative propagation

The asexual propagation of plants using vegetative parts rather than seeds have been found to be an easier technique for the propagation of some species (Bidlack & Jansky, 2014). These vegetative parts are referred to as cuttings, which is any portion of a plant that can be planted to develop into a new plant with stems, leaves and roots (Luna & Haase, 2014). Cuttings can be made from different plant parts such as leaves, stems and roots (Bidlack & Jansky, 2014; Luna & Haase, 2014). Stem cuttings needs to produce adventitious roots, whilst root and leaf cuttings must produce both adventitious roots and shoots in order to establish (Bidlack & Jansky, 2014).

The key aspect to successful recruitment from cuttings is the prevention of water loss from the cutting means Bidlack and Jansky (2014). Enclosed containers aid in the prevention of water loss by means of maintaining high humidity and reducing transpiration, hence keeping the tissues of the cutting moist (Bidlack & Jansky, 2014). Frequent misting or fog is commonly used to prevent cuttings from drying out in commercial production systems (Bidlack & Jansky, 2014). Buried stems and/or prostate branches sometimes possess the ability to produce roots in damp or tropical areas (Leakey, 1985).

Vegetative propagation and/or propagation of woody species by means of cuttings varies with regard to the species and genotype, as well as the environment and physiological state of the tree from which these cuttings are collected (Leakey, 1985). The physiological condition of the plant from which cuttings are collected affects the ability of cuttings to form roots, hence the collection season, position of the harvested shoots, tree age and size, and pathogens or viruses may affect results (Hartmann & Kester, 2011). Amri *et al.* (2009) found that cuttings collected from younger plants had better root formation than those collected from more mature plants.

Cuttings collected from basal positions were found to have higher rooting percentages, longer roots and callus formation, which decreased in relation to the cutting position with the lowest rooting percentages and shortest roots recorded for cuttings collected from apical positions (Amri *et al.*, 2009; Leakey, 2004). Cuttings from the base of the parent plant were found to have double the rooting ability of those collected from the middle and apical regions (Zalesny *et al.*, 2003). This is believed to be a result of the increased storage of carbohydrates and a decline in organogenic activity towards the apex of the parent plant (Zalesny *et al.*, 2003).

The propagator further influences the cuttings' ability for root formation with regards to the application of auxins or other growth regulators, physically based on the size of the cuttings and the splitting or wounding of the cutting base and/or by the manipulation of the moisture, light exposure and temperature (Leakey, 1985). IBA is the most commonly used form of synthetic

auxins and can be applied by means of a brief dip of the cutting base or a soak in weakened auxin solutions (Leakey, 1985). Auxins play an important role in the formation of lateral roots, the maintenance of apical dominance as well as adventitious root formation (Hodge *et al.*, 2009). Fungicides are commonly contained in rooting powders and prevents pathogens from entering the wound area (Bidlack & Jansky, 2014).

Leakey (1985) found that the root system formation of cuttings is affected by the slope of the cutting base. The process of root formation can mainly be divided into the following four steps (Leakey, 1985):

1. Dedifferentiation;
2. Formation of root initial cells in the newly meristematic areas;
3. Organization of the cells into root primordia; and
4. The subsequent growth and emergence of roots.

Past research conducted by Perala (1978) found that the length of root cuttings did not aid shoot formation and/or the ability of the cuttings to survive their first winter. Leakey (2004) however states that longer cuttings (specifically stem cuttings) tend to root better. This is due to the increased storage capacity of longer cuttings for assimilates until roots are formed (Leakey, 2004).

Root cuttings of apple cultivars however survived better when collected during winter months when the polysaccharide contents are highest (Robinson & Schwabe, as cited by Leakey, 1985). Other studies indicated that cold storage of roots together with the application of cytokinin and/or applied auxins had better shoot formation (Robinson & Schwabe, as cited by Leakey, 1985). Root cuttings can be planted horizontally or vertically in containers, but it is important to ensure that it is planted with the correct polarity when planting vertically (Luna & Haase, 2014).

Stem cuttings treated with auxins, specifically IBA, had a larger percentage of cuttings with root formation, producing a larger number of roots and longer roots (Amri *et al.*, 2009). Zalesny *et al.* (2003) found that higher rooting percentages are recorded for IBA treated stem cuttings from younger parent plants compared to IBA treated stem cuttings from older or more mature parent plants. Cuttings from mature parent plants however had better callus formation, especially when collected from the basal and middle positions (Amri *et al.*, 2009).

Leafless cuttings rarely form roots during summer, whilst leafless cuttings tend to root well during late winter because of stored reserves during this season (Leakey, 1985). Lux (as cited by Leakey, 1985) also found that hardwood cuttings tend to root better during winter.

Root and callus formation are independent in some species, whilst adventitious roots originate from the callus tissue at the cutting bases in other species (Hartmann & Kester, 2011). Adventitious or nodal roots differentiate from non-root organs of plants, such as stems or rhizomes and initiate at precise locations on these (Hodge *et al.*, 2009).

Cuttings require well-draining soils such as particulate or vermiculite, which are better suited than propagating cuttings in water since these soils maintain oxygen levels better (Bidlack & Jansky, 2014). The temperature at which cuttings are propagated also affects the success thereof (Bidlack & Jansky, 2014). Temperatures should be warm enough to enhance root formation, yet cool enough to minimise growth and transpiration until roots have formed (Bidlack & Jansky, 2014). Post root formation, fertilizer can be applied to stimulate growth (Bidlack & Jansky, 2014).

Even though Venter and Venter (1998) hold that *B. albitrunca* can also be grown successfully from stem- and/or root cuttings, Mans (2018) found the stem-cutting trials conducted by the DAFF state nursery in Upington unsuccessful.

As far as grafting onto mature specimens of the species *Colospermum mopane* and *Combretum imberbe,* only one study – namely that of Wessels and Potgieter conducted in 1997 at the Hobatere Game Lodge in Namibia – reported finding fully grown scions of *B. albitrunca* naturally grafted onto these species. No additional literature on grafting trials could be sourced.

1.7.4 Recruitment challenges

The recruitment success of flora species are dependent on a wide range of factors which include climatic conditions, seed dispersal methods and agents and habitat suitability amongst others (Schupp, 1993).

Seedlings are more susceptible to environmental conditions than adult specimens, therefore the facilitation and competition interactions between plants are most critical during this phase (Grubb, 1977). This is mainly due to the limited access to resources during this stage since seedlings have limited shoot and root tissues (Herms & Mattson, 1992).

Recruitment in the vicinity of the host tree and/or close to other trees of the same species results in the presence of pathogens and herbivores being present which contribute to higher mortalities of juveniles and saplings (Janzen, 1970; Terborgh *et al.*, 2008). Saplings or new recruits are more susceptible to mortalities as a result of predation due to their lower resilience to the loss of shoot tips and leaves compared to adult specimens (Janzen, 1970).

The hypothesis that reproductive adult tree specimens attract pollinators and seed dispersers, as well as species that predate seeds and act as hosts for invertebrate and pathogen species is known as the Janzen-Connell hypothesis (Terborgh *et al.*, 2008; Janzen, 1970) as depicted in Figure 1-5. The seed shadow refers to the recruitment potential or number of seeds that survive beyond germination and the escape curve refers to the impact of enemies in relation to the distance from the host tree (Figure 1-5). Population recruitment curves are derived from these curves which serve as a prediction as to the location where new recruits will establish in relation to the host tree (Figure 1-5).

The Janzen-Connell hypothesis model predicts that recruitment will not occur directly adjacent to or beneath the host tree, allowing other species to establish in this area (Terborgh *et al.*, 2008). These curves are affected by hunting and/or removal of either the seed dispersers (frugivores) or the seed predators (herbivores and pathogens). If frugivores are hunted or removed, the tail of the seed shadow will lower and more seeds will be dispersed with the zone adjacent to the host tree where recruitment success is minimal (Terborgh *et al.*, 2008). On the contrary, if seed predators and herbivores are hunted or removed, the escape curve would be elevated and recruitment would be higher closer to host trees, resulting in overall higher recruitment (Terborgh *et al.*, 2008).

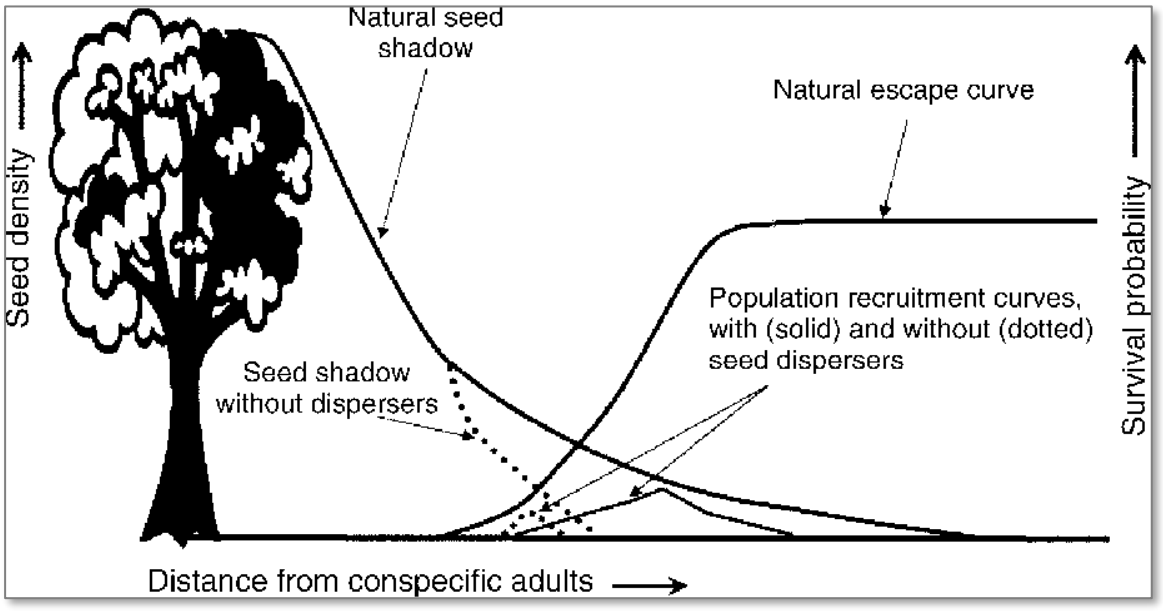

Figure 1-5: The Janzen-Connell hypothesis model as modified by Terborgh *et al.* (2008) with the distance from the host tree on the x-axis and the seed deposition density and proportion of seeds surviving until the mature stage on the y-axis

The study by Marod *et al.* (2004) found that fire and droughts also affect the survival of juvenile specimens specifically in tropical forests. Resprouting or coppicing species, such as *B. albitrunca*, are more likely to survive fire events than non-resprouting species (Marod *et al.*, 2004).

Palatable species often recruit in places which provide refuge from herbivores under the canopy of other plants or near less palatable species (Oesterheld & Oyarzábal, 2004). Growing in close vicinity of a less palatable species positively affects the recruitment of palatable species (Oesterheld & Oyarzábal, 2004). Cipriotti and Aguiar (2005) found that the competition between specimens across species increases with increased grazing pressure. This study further found that the interannual variability increase with a decrease in mean annual precipitation and the survival of palatable species are improved in the vicinity of less palatable species, but the survival of seedlings is constrained (Cipriotti & Aguiar, 2005).

Past research indicates that the recruitment of *B. albitrunca* is threatened by high browsing pressure that results in the trampling of seedlings (Coates Palgrave, 1983; Van der Walt & Le Riche, 1999; Van Rooyen *et al.*, 2016). Due to herbivory, smaller specimens are often subjected to coppicing resulting in new recruits not being able to grow into tall, upright trees (Van der Walt & Le Riche, 1999).

Ungulates affects the composition of tree species due to their increased browsing pressure on specific species and the associated recruitment rates of these species (Candaele *et al.*, 2023). Ungulates can even cause recruitment failure of palatable species directly due to herbivory or indirectly by making the saplings more susceptible to competition and insect defoliation (MacDougall *et al.*, 2010).

Stands of trees from the same species that are of the same age can be regarded as an indication that the species' recruitment is affected by abiotic factors, particularly rainfall (Van der Merwe *et al.*, 2019). Midgley and Bond (2001) observed that stands subjected to past events such as fire or herbivory may also appear to be of the same age.

1.8 Importance of *Boscia albitrunca* as a rehabilitation species

Restoration is defined as the notion to restore a predefined ecosystem with regards to its species diversity before disturbance, whilst rehabilitation is the notion to repair an ecosystem's functions and processes in order to increase its productivity (SER, cited by Aronson *et al.,* 1993).

Restoration is seldom viable due to a lack of historical information and the likelihood of restoring an ecosystem to its original function and species diversity (Aronson *et al.*, 1993). Nevertheless, Jacobs *et al.* (2012) created a conceptual framework for restoration, defining it by means of its

three main divisions or spheres, namely society, technology and ecology. As illustrated in Figure 1-6 below, the area of these spheres indicates the equal value of each with key roles listed inside each sphere as well as in the overlap between these spheres. The degree to which these spheres overlap represents the success probability. This conceptual framework suggests restoration success is more likely if the degree of overlap increases. Moreover, if one of the spheres is not present, the likelihood for success would decrease exponentially.

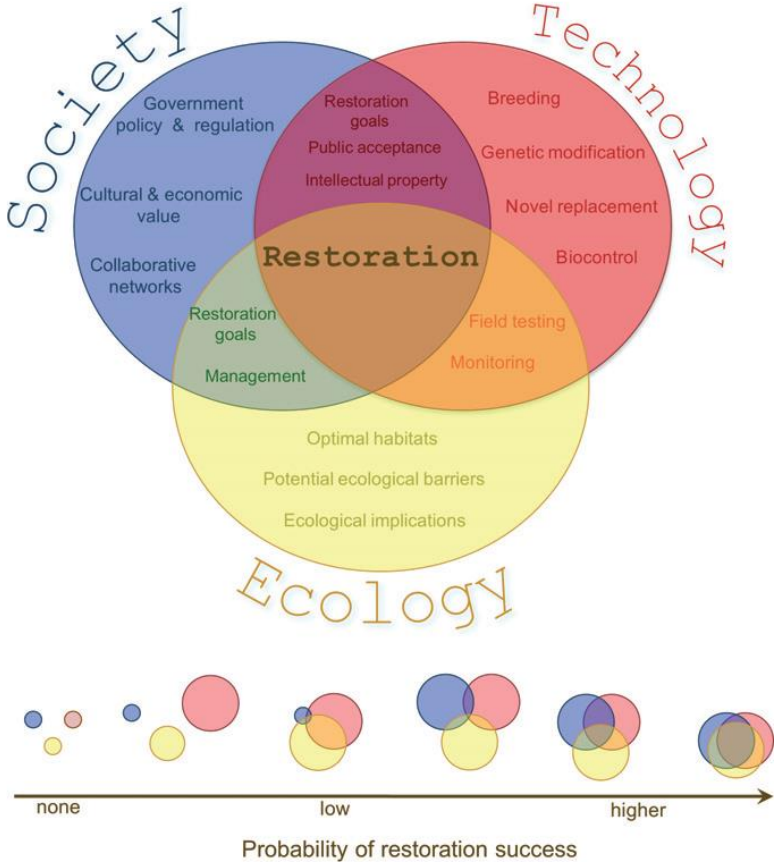

Figure 1-6: The conceptual framework for restoration success (Jacobs *et al.*, 2012)

Note that given the disparity between the concepts of 'restoration' and 'rehabilitation', this researcher opted to use the term rehabilitation throughout.

DeSimone (2011) states that apart from timeframes and funding (the latter often being limited), the variable annual rainfall of arid- and semi-arid areas poses an additional challenge for rehabilitation practices. Moreover, given that rehabilitating arid- and semi-arid environments poses a whole array of unique risks and challenges, the resultant increase in costs that have to be incurred will likely reduce the success rate even further (Milton, 2001). Hence, passive rehabilitation is often more cost-effective should native species have the potential to self-colonise the degraded areas by means of natural recruitment (Rice & Emery, 2003; Zahawi *et al.*, 2014). The latter can be carried out by the application of good management principles, e.g. a reduction

in grazing pressure. Nevertheless, active rehabilitation is often favoured above passive rehabilitation since it is a faster approach and entails the implementation of acceleration techniques instead of simply eliminating the source of the disturbance (DeSimone, 2011).

Passive rehabilitation, though, is highly dependent on the soil seed bank and seed rain within an area and hence also the distance from the source of seed and rainfall events (Guariguata & Ostertag, 2001). It is also a much longer process than active rehabilitation and is often terminated prior to completion (Zahawi *et al.*, 2014) with a higher chance of failure since it is influenced by factors such as the surrounding landscape, the specific ecosystem's resilience, available resources (especially funds and manpower) and past land management practices (Aide *et al*., 2010; Guariguata & Ostertag, 2001; Montagnini, 2008*;* Norden *et al.,* 2015). Other common factors that can contribute to the failure of passive rehabilitation include fire events, competition with pioneer species, soil compaction and erosion, and the absence of or minimal seed dispersers (Aide & Cavalier, 1994; Grau *et al.*, 2010; Holl, 1999; Ortega-Pieck *et al.*, 2011).

Simons and Leakey (2004) postulate that rehabilitation should focus on selecting species with multiple benefits or functions considering the ecological suitability of the area, as well as the preferences of the local community. The reason for the preferences of the local community should be taken into account since multiple species could offer similar benefits (e.g. a source of firewood, fodder or food) (Reubens *et al.*, 2011). Reubens *et al.* (2011) also pointed out that post-rehabilitation, land use and the prevention of erosion should be kept in mind as key functions when selecting species in an attempt to restore degraded areas, noting that a single characteristic such as high risks for disease may render a species unsuitable for rehabilitation.

Woody species aid the recovery potential of an area since their establishment provides perch sites, food and refuge that attract important faunal species and seed dispersers (Montagnini, 2008). However, Chechina and Hamman (2015) emphasised the need to select native tree species for rehabilitation projects based on the following characteristics:

- Unlikely to alter natural habitats and nutrient cycles that will affect native species (Hooper *et al.,* 2002);
- Not as vulnerable to pests and diseases compared to exotic species (Watt *et al.,* 2009 and Wingfield *et al.,* 2001); and
- Having the ability to add value to and to provide benefits for the local community (McElwee, 2008; Mangaoang & Pasa, 2003; Lacuna-Richman, 2002).

Nevertheless, Kardol and Wardle (2010) as well as Roa-Fuentes *et al.* (2013) pointed out, it is critical that both above- and below-ground ecosystem components be considered, and their

linkages assessed before rehabilitation practices are selected and applied. In sum, rehabilitation efforts should focus on re-establishing ecological interactions to ensure long-term sustainability and species conservation (McCann, 2007). Re-establishing the mutualistic relationship between frugivorous fauna (consumers of fleshy fruit) and flora (producers of fleshy fruit) species is particularly important for ecological rehabilitation (Ribeiro da Silva *et al.*, 2015) since this has a direct bearing on the sustainability of ecosystems.

Stanturf *et al.* (2014) described rehabilitation as the opposite process of degradation. They proposed that an increase or decline in certain sustainability attributes should be regarded as a measure of rehabilitation success. These indicators (i.e. forest extent; forest health and vitality; biodiversity; protective functions; and productive functions) are illustrated in the table below.

Table 1-3: Positive indicators of rehabilitation with regards to an increase or decline in certain sustainability attributes on a landscape, stand and species level (Stanturf *et al.*, 2014 as adapted in Stanturf, 2015). Negative indicators should decrease (highlighted in red), whilst positive indicators should increase (highlighted in green)

Sustainability attributes	Rehabilitation indicators	Landscape	Stand	Species
Forest extent	Area maintained	Increase	Increase	
	Area increased	Increase	Increase	
	Crown extent	Increase	Increase	Increase
	Stocking		Increase	Increase
	Species number	Increase	Increase	Increase
	Species diversity	Increase	Increase	Increase
	Structural complexity	Increase	Increase	
	Fragmentation	Decline	Decline	
	Encroachment of non-forest uses	Decline	Decline	
Forest health and vitality	Crown extent	Increase	Increase	Increase
	Growth	Increase	Increase	Increase
	Seed dispersers	Increase	Increase	Increase
	Pollinators	Increase	Increase	Increase
	Mortality	Decline	Decline	Decline
	Stem and root rots		Decline	Decline
Biodiversity	Area designated for habitat conservation	Increase	Increase	Increase
	Richness	Increase	Increase	Increase
	Connectivity	Increase	Increase	
	Species of concern	Increase	Increase	Increase

Sustainability attributes	Rehabilitation indicators	Landscape	Stand	Species
	Genetic diversity within populations	Increase	Increase	Increase
	Dispersal barriers	Decline	Decline	Decline
	Invasive species	Decline	Decline	Decline
Protective functions	Area designated for protective purposes	Increase		
	Surface cover	Increase	Increase	
	Soil loss	Decline	Decline	
	Sediment delivery	Decline	Decline	
Productive functions	Site potential	Increase	Increase	
	Nutrient cycling	Increase	Increase	
	Stocking		Increase	Increase
	Valuable species		Increase	Increase
	Growing stock	Increase	Increase	Increase
	Regeneration	Increase	Increase	Increase
	Wildfire regime	Increase	Increase	
	Invasive species	Decline	Decline	Decline

All positive rehabilitation indicators that are increased or enhanced, and all negative or degradation indicators that decreased on either a local, landscape or species level can be regarded as indicators of rehabilitation success. An increase in productive functions such as nutrient cycling, regeneration and valuable species and a decline in invasive species could, therefore, be regarded as indicators of rehabilitation success on either a landscape or site level (Table 1-3).

In addition to the above indicators of rehabilitation success, several researchers (Claassens *et al.*, 2005; Mummey *et al.*, 2002a; Mummey *et al.*, 2002b; Schloter *et al.*, 2003) are of the opinion that soil quality or health and more specifically, the structure of the soil microbial community should also be considered as a parameter for rehabilitation success. According to Doran and Safley (cited by Schloter *et al.*, 2003:255), the term soil quality refers to the "continued capacity of soil to function as a vital living system, within ecosystem and land use boundaries, sustain biological productivity, to promote the quality of air and water environments, and to maintain plant, animal and human health".

Both *Boscia albitrunca* and *Boscia foetida* offer specific benefits to rehabilitation since these trees are suited for multi-metal phytoextraction of zinc (Zn), lead (Pb) and copper (Cu) (Manyiwa *et al.*,

2021). Furthermore, *B. albitrunca* can absorb silver (Ag), lead (Pb), arsenic (As), tungsten (W) and mercury (Hg) (Mshumi, 2006).

Of importance, though, is that *B. albitrunca* has the ability to reproduce vegetatively from stem and root cuttings (Venter & Venter, 1998), enabling this species to out-perform species that are fully reliant on seedlings, especially where a large seed bank of undesired species is present that could result in higher competition for sunlight and resources (Pywell *et al.,* 2003). Given that this species also tends to establish deep roots during the seedling stage (Cunningham, 2001), its chances to survive in arid environments are increased considerably (Padilla *et al.*, 2009).

Blakesley *et al.* (2000) found that in cases where passive restoration or natural recruitment is low, nursery-grown seedlings can be planted, provided that care is taken to prevent root deformities caused by nursery containers that are too small. Along a similar vein, Milton (2001) postulated that even if specimens do not survive the translocation/transplantation process in rehabilitation efforts, they still contribute to the ecosystem by re-establishing microbes and fungi contained in the soil between their roots, all of which are important for decomposition and symbiotic processes.

As stated in the introduction to this dissertation (see section 1.3), this study set out to determine whether *B. albitrunca* can be used to aid the rehabilitation of previously disturbed areas. Based on a review of pertinent literature, the section to follow will provide a brief overview of the state of land degradation as well as the pressing need to counter this phenomenon in the southern Kalahari in particular.

1.9 Land degradation and rehabilitation in the southern Kalahari

At the time of the Earth Summit held in Rio in 1992, land degradation, along with climate change and changes in biodiversity, were identified as the three components at the heart of global environmental change (Gisladottir & Stocking, 2004). However, as Gisladottir and Stocking pointed out, these components are synergetic, given that a change to one tends to cause changes in the same direction in the others. Along a similar vein, the United Nations have set Sustainable Development Goals (SDGs) as a guideline for global development. Sustainable Development goal (SDG) 15 aims to “protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss” (UNDP, 2015). SDG 15, as Nkonya *et al.* (2016) pointed out, will contribute indirectly to attaining several other goals of the 17 SDGs since addressing land degradation will also address poverty (SDG 1) and zero hunger (SDG 2).

Geist and Lambin (2004) identified four primary causes of desertification:

- Agricultural activities such as livestock and crop production;
- Infrastructure extension, which includes roads for transportation, mining and human settlements;
- Wood extraction or collection of plant and animal materials; and
- Increased aridity which is an indirect impact of a decline in rainfall.

The United Nations Convention to Combat Desertification (UNCCD) is the main organisation that set out to combat desertification on a global scale (Gisladottir & Stocking, 2004). Both the UNCCD and the Millennium Ecosystem Assessment (MEA) commissioned by the UN define land degradation as "the persistent reduction or loss of land ecosystem services" (Le *et al.*, 2016). According to Anderson and Johnson (2016:86), though, Le *et al.* (2016) refined this definition to read as follows: "land degradation is the persistent reduction of the production capacity of a land, which may be manifest through any combination of a number of interrelated processes, such as: soil erosion, deterioration of soil nutrients, loss of biodiversity, deforestation or declining vegetative health" [*sic*]. Moreover, land degradation can be either anthropogenic or natural (Anderson & Johnson, 2016), has a negative effect on food security the world over (Le *et al.*, 2016) and threatens the availability of the natural resources of drylands in particular (Dreber *et al.*, 2014).

Land degradation and desertification are common phenomena in arid systems, such as the southern Kalahari where this study was carried out (Van Rooyen, 1998). According to Rutherford *et al.* (1999), all indications are that global climate change will result in the southern Kalahari becoming even more arid in the decades ahead since more frequent droughts will result in a loss of vegetative cover, resulting in the remobilisation of dunes (Thomas *et al.,* 2005).

As early as 1998, Acocks (1998) found that due to its sparse grass tufts and loose, structureless sands, the Kalahari is particularly vulnerable to increased grazing pressure. Due to a lack of surface water, the Kalahari was not subjected to intensive grazing in the past. However, due to modern water extraction techniques and pipelines that convey water, the availability of surface water has resulted in a significant increase in grazing pressure (Acocks, 1988; Cooke, 1985; Milton & Dean, 2000; Thomas, 2002).

To counter land degradation in the southern Kalahari, Milton and Dean (2000) argued that protecting Kalahari land against grazing altogether would prove to be the best rehabilitation strategy since grazing, combined with periods of drought, could result in ephemeral-dominated landscapes that are less stable than ungrazed, stable perennial grassland landscapes. Not quite

as harsh, but along a similar vein, O'Connor and Roux (cited by Radatz, 2003) suggested that vegetation should be able to re-establish once grazing pressure has been reduced.

Both of the aforementioned rehabilitation strategies would pose numerous challenges given that many inhabitants of the southern Kalahari farms have to secure a livelihood. Total or intermittent disruption of their livelihoods would, thus, reduce the number of households the land can support (Abel & Blaikie, 1989) and the displacement of many (Radatz, 2003). Abel and Blaikie (1989) suggested that grazing should be regulated as alternative to the above. Their proposal involved levying a management fee per animal based on the previous year's rainfall, subsidised market prices and the cost of financing drought-relief schemes. For his part, Dougill (2002) proposed that fire regimes should be reintroduced to control woody elements and to restore grass dominance, while Thomas (2002) suggested the conversion of rangelands to wildlife management areas since native ungulates have lower water requirements than cattle and would minimise the need for boreholes.

As much as the aforegoing rehabilitation strategies might have seemed plausible at the time, Reed (2008) holds that environmental management must be able to adapt to changing circumstances and should embrace a diverse knowledge base, a view supported by Nkonya *et al.* (2016) who hold that traditional knowledge fulfils a crucial role in ensuring the effective outcome of conservation efforts.

In past studies, Fraser *et al.* (2006) and Reed (2008) also emphasised the need to incorporate local or indigenous knowledge and to engage all stakeholders in any attempt aimed at sustainable environmental management. In their study, Fraser *et al.* (2006) found that numerous environmental management errors could have been avoided in the past had local knowledge been incorporated in the decision-making process. Unfortunately, Kos (2007) is of the opinion that human mismanagement is bound to exacerbate and even accelerate land degradation in the Kalahari.

By way of concluding the literary review, this study also set out to determine whether soil amelioration could aid the recruitment of *B. albitrunca.* In the section to follow, pertinent findings pertaining to this aspect will be discussed briefly.

1.10 Soil amelioration

Since their formation can take a hundred to a thousand years, fertile soils are regarded as a non-renewable resource (Lal, cited by Nkonya *et al.*, 2016). Nevertheless, several strategies and

techniques have been applied throughout the years to increase the organic matter contained in soils, the most common being soil amelioration (Ros *et al.*, 2006).

Generally, this strategy involves improving soil quality by means of either physical or chemical soil modification (Taverna-Turisan, 2017). To this end, several techniques can be applied, the most common being composting or the application of eco-friendly fertilizers such as seaweed.

Pascual *et al.* (1997) concur that composting is a cost-effective, organic ameliorant that can promote the microbial activity of the soil and the growth of vegetation. In their study, Ros *et al.* (2006) focused on the effects that the application of different types of compost, mineral fertilizer and a combination of the two have on the soil's chemical, biological and microbiological parameters over a period of 12 years. Their conclusion was that irrespective of the application, an increase in soil organic carbon content was observed and, in instances where fertilizer was applied, also in the nitrogen content of the soil.

According to Yuvaraj and Gayathri (2017) as well as Moller and Smith (cited by Abou El-Yazied *et al.*, 2012), seaweed fertiliser has very limited negative effects since it contains adequate nitrogen, phosphorous and potassium as well as minerals and trace elements in a soluble form, implying that uptake by plants is relatively unencumbered. Furthermore, due to its carbohydrate and organic matter content, seaweed fertilizers are able to enhance the moisture retention capacity of soils (Yuvaraj & Gayathri, 2017), which is probably why Dhargalkar and Pereira (2005) reported that seaweed extracts can promote the germination of seeds and can increase crops' yield abilities.

In sum, Yuvaraj and Gayathri (2017) (citing secondary sources) found seaweed fertilizers to be eco-friendly and capable of offering the following proven advantages to the agricultural sector:

- Soil fertility enhanced due to essential nutrients and minerals (Stephenson);
- Root and shoot development enhanced due to readily available micro-nutrients (Gayathri *et al.*);
- Flowering and fruit production enhanced due to growth-promoting hormones; and
- Harmful organisms repelled due to the crystallisation of inherent salts (Jayaraj).

Furthermore, Verkleij (cited by Yuvaraj & Gayathri, 2017) found that since seaweed serves as a growth medium for microbes, it can fulfil an important role in nutrient cycling and, by inference, the functioning of terrestrial ecosystems (Claassens *et al.*, 2005).

Having reviewed the relevant literature, the aims and objectives for this study to either prove or disprove the hypothesis (i.e., “the cultivation of *Boscia albitrunca* from fresh seeds with limited environmental stress and suitable amelioration methods will improve the recruitment and contribute to the rehabilitation of sustainable populations in previously disturbed areas over the long term in the southern Kalahari”) will be discussed in detail in the next chapter.

CHAPTER 2 INTRODUCTION

2.1 Background and problem statement

According to the Industrial Development Corporation (IDC, 2022), the key industries and sectors supported by the Northern Cape Province are renewable energy, mining, and agriculture. The study area stretches across two local municipal areas: Gamagara and Tsantsabane (Province of the Northern Cape, 2022). Gamagara lists mining, game farming and business services as its main economic sectors (Municipalities of South Africa, 2022a), whilst mining is Tsantsabane's primary economic sector (Municipalities of South Africa, 2022b). Due to the semi-arid nature of the region, large areas that are not mined are mainly used as rangelands for livestock and game farming.

Due to the Northern Cape's rich and diverse geology, numerous minerals are mined in the province and specifically within the study area. The main minerals being mined in the study area are hematite and magnetite of the banded-iron formation of the Northern Cape (Van der Vyver *et al.*, 2009).

According to Mans (2018), almost 35 000 *B. albitrunca* trees were legally removed under Forest Act Licences in the Northern Cape Province and a further 16 351 were conserved due to refusal of licenses. These licences were issued for new developments which included mining, agricultural expansions (plantations and vineyards), renewable energy facilities (solar and wind) and electricity supply powerlines.

Past management practices and overgrazing have led to an increase in the density of woody vegetation (so-called ‘bush encroachment’) in some parts of the province. Eradication of this woody vegetation, specifically *Senegalia mellifera* and *Rhigozum* spp., is often treated with arboricides resulting in losses of other indigenous species. A study conducted by Harmse *et al.* (2016) found that *B. albitrunca* has low sensitivity to the arboricide Tebuthioron in sandy soils of the Molopo region. However, another study conducted by Erasmus (cited by Alias & Milton, 2003) found that mortalities may occur 15 years post application.

The Northern Cape Province is further regarded as the most solar abundant province of South Africa (Van der Merwe & Brent, 2020) and one of the best solar energy resource regions in the world (Uhunamure & Shale, 2021). Solar energy facilities have direct and indirect environmental impacts, which may include the clearance of vegetation, especially tree species, that cause shade and minimise the effectiveness of solar energy generation (Nordberg *et al.*, 2021).

The 2nd Bedrog Reservoir site, which was used for the collection of seeds and cuttings for this study, is another development that resulted in the destruction of this species for water supply infrastructure. The Kgalagadi Pipeline development used as a transplantation site for veld trials in this study is a linear development which further required the removal of this species for upgrading of bulk water supply lines. These developments required total vegetation clearance, hence destroying all *B. albitrunca* trees located directly in the respective development footprints. The locations of these sites where economic development have denuded vegetation within the study area are illustrated in Figure 3-2.

B. albitrunca is a keystone species in the arid parts of southern Africa, which serves as a source of food, shelter and shade to both fauna and humans (Alias & Milton, 2003; Kos, 2007). Due to its high grazing value it is often overutilized by land managers cutting branches to make fodder available to fauna during periods of drought (Van der Walt & Le Riche, 1999). The increased browsing pressure also contributes to the trampling of seedlings (Van der Walt & Le Riche, 1999).

Large quantities of this keystone species is hence lost due to agricultural management practices, economic developments and even climatic factors such as drought periods. Despite being able to recruit *B. albitrunca* from seed or by means of vegetative propagation, there are numerous challenges affecting the success hereof. If these recruitment challenges are better understood the best recruitment strategy can be identified, which is crucial for preserving ecosystem stability, and supporting the overall resilience of the southern Kalahari's unique ecological landscape.

2.2 Aims and objectives

The aim of this dissertation is to assess the recruitment methodology of *B. albitrunca*, by either cuttings or seed or both as well, and whether this species can be used for rehabilitation purposes.

The primary objectives of the study are to determine:

- if soil amelioration improves the recruitment rate of saplings; and
- whether *B. albitrunca* can be better recruited from seed cultivated to saplings or from vegetative cuttings propagated in planting bags.

2.3 Hypothesis

The cultivation of *B. albitrunca* from fresh seeds with limited environmental stress and suitable amelioration methods will improve the recruitment and contribute to the rehabilitation of sustainable populations in previously disturbed areas over the long-term in the southern Kalahari.

2.4 Dissertation structure

Chapter 1 of the study comprises an extensive literature review of existing literature on the species, its conservation importance and threats or challenges that affects its recruitment and survival. Chapter 2 contains the problem statement and background for this study, and sets out its aims, objectives and hypothesis.

Details regarding the location of the study area and an overview description of its climate, pedology, geology and vegetation are presented in chapter 3. Chapter 4 contains a detailed description of the respective methods and materials used as part of this study as well as the experimental design and number of replicates conducted for the respective trials. The methods for data analyses is also included in Chapter 4. The results are summarised in chapter 5 and discussed in chapter 6. Chapter 7 contains the concluding remarks, limitations experienced and recommendations for future studies.

The bibliography follows chapter 7 and contains all references used as part of this dissertation. Finally, additional information and/or data, as well as all relevant permits and licenses applicable to this study are included as annexures.

CHAPTER 3 STUDY AREA

3.1 Study Area

The study was primarily conducted in and around the town Kathu (within a radius of 50 km) within the John Taolo Gaetsewe and ZF Mcgawu districts of the Southern Kalahari region of South Africa's Northern Cape Province (Figure 3-1). The Gamagara River system, as well as the Langberg and Kuruman mountain ranges (West and East respectively) are located within the study area. Coordinates for all study sites are included in Appendix C.

Figure 3-2 illustrates the location of the respective study sites:

- Natural Recruitment areas (Yellow ●)
    - Chertsey Farm
    - Halliford Farm
    - Kgalagadi Offices
    - Gamagara River
- Veld Trial transplantation sites (Pink x)
    - Witleegte River
    - Kgalagadi Offices
    - Kathu Equestrian Club
    - EndemicVision Offices
    - Tamaga Farm/ Nature conservation centre
    - Gamagara River
- Optimal areas with adult stand of *B. albitrunca* (Blue ▼)
    - Marsh Farm
    - Bedrog Farm
    - Edenvale Farm
- Seed collection areas (Green ▲)
    - De Rust Farm
    - Bedrog Farm

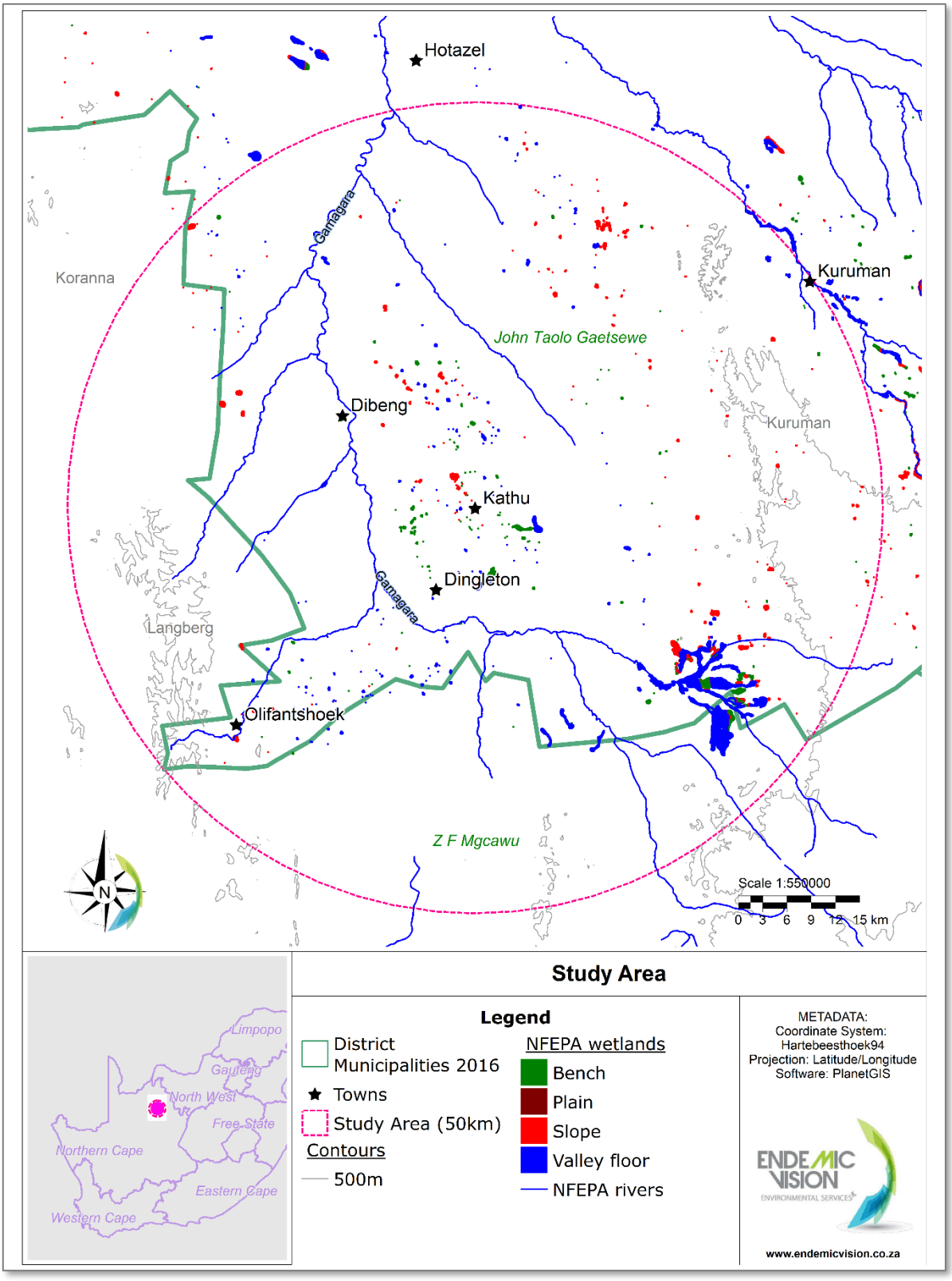

Figure 3-1: **The study area in and around Kathu in South Africa's Northern Cape Province, which partially encompasses the Gamagara perennial river as well as the Langberg (west) and Korannaberg (east) mountain ranges (CSIR, 2011)**

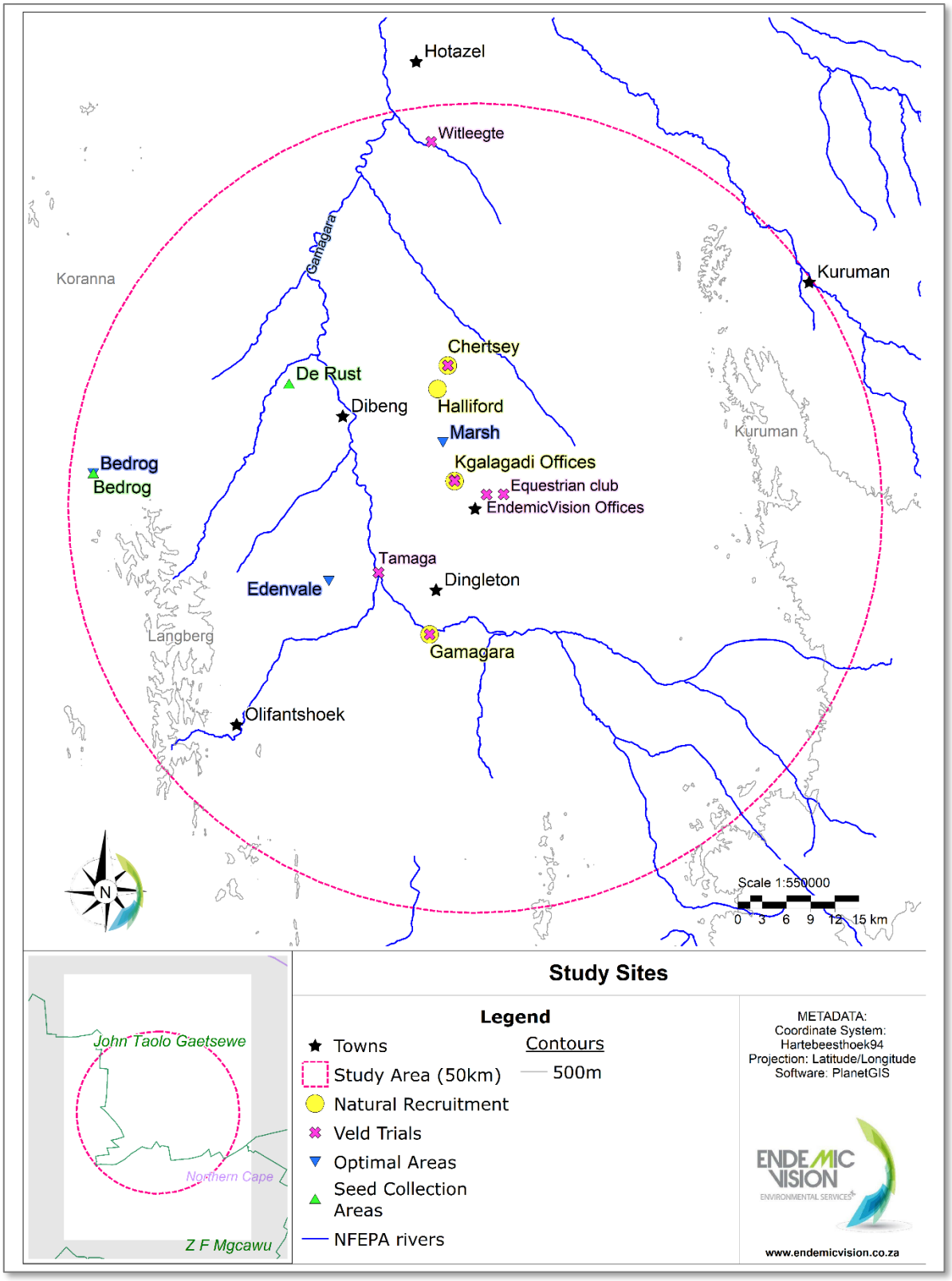

Figure 3-2: **The study sites for the areas with natural recruitment (●); Veld trial transplantation (x); Optimal areas (▼) and Seed Collection (▲)**

3.2 Climate

The climate of Kathu and its surroundings is classified as arid to semi-arid with summer rainfall (Rutherford *et al.*, 2006). The mean annual rainfall of this region ranges between 150 mm in the southwest and 350 mm towards the northeast, as illustrated in Figure 3-3 below, but is unpredictable and can vary from 100 mm to 700 mm per annum at a specific locality (Van Rooyen & Van Rooyen, 2019). Rainfall mostly occurs between October and April and then either in the late afternoon or early morning.

Given that temperatures fluctuate between a minimum of -10°C and a maximum of 45°C, potential evaporation is known to exceed annual precipitation by more than 10 times (Thomas & Shaw, 1991; Porporato *et al.*, 2003). As Porporato *et al.* (2003) and Laio *et al.* (2001) pointed out, dynamic water stress levels as a function of mean rainfall for grasses are maintained at significantly lower levels than those of woody species since grasses have a lower wilting point, making them less susceptible to water deficits, and shallower roots, enabling them to benefit from even light rainfall events that occur more often. Grasses are hence not exposed to such extensive water stress periods as trees. Accordingly, Porporato *et al.* (2003) defined the point of equal plant-water stress as approximately 420 mm between October and April for the central Kalahari region, meaning that this is the rainfall required for both grasses and woody species to flourish. Variability in the interannual rainfall hence results in fluctuations in tree and grass establishment, respectively, enabling both to coexist (Laio *et al.*, 2001; Porporate *et al.*, 2003).

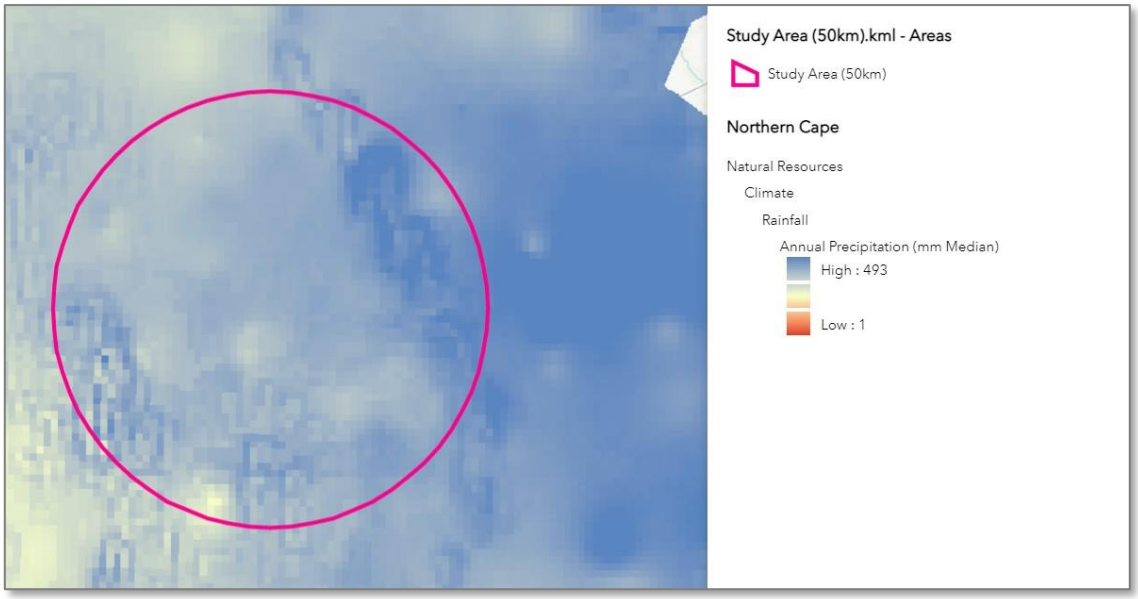

Figure 3-3: Variation in the mean annual precipitation within the Study Area increases in a north eastern direction (DALRRD, 2021)

3.3 Geology, pedology and topography

The Northern Cape's geological formations are mainly comprised of the Griqualand West Super Group, Namaqualand Metamorphic Complex, Dwyka and Ecca Group, Beaufort Group and the Kalahari Group (Council for Geoscience, 2002). The study area is primarily located within the Ecca and Dwyka Groups with the Soutpansberg Group to the west (Figure 3-4).

The mountain ranges in the study area include the Kuruman hills, mainly consisting of banded ironstones, and the quartzitic Olifantshoek Langberg (Van Staden *et al.*, 2020). These form the edges of the Griqualand West Centre of Endemism or Griqualand West Basin (Ghaap Group) and associated Campbell Rand, Schmidtsdrif and Asbestos Hills subgroups (Van Wyk & Smith, 2001).

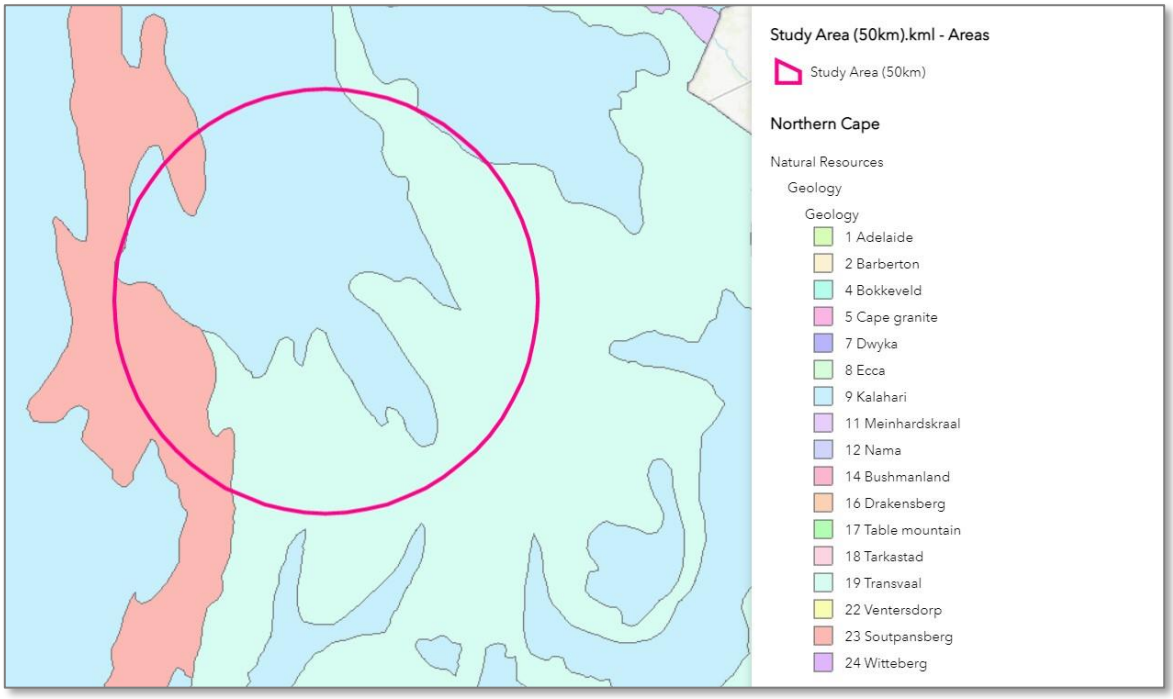

Figure 3-4: The Ecca, Kalahari and Soutpansberg Groups form the geology of the study area (DALRRD, 2021)

The southern Kalahari has two primary land surface types, namely sandy dunes and slightly undulating or flat plains (Van Rooyen & Van Rooyen, 2019). These primary surface types are overlain by structureless, red aeolian sands that reach depths of up to 200 m (Thomas & Shaw, 1991). These Kalahari sands stretch across approximately 2 500 000 km^2 (Leistner & Werger, 1973) and are regarded as infertile due to low nutrient concentrations and a lack of organic materials, resulting in increased water and nutrient stress that impedes plant growth (Horn, 2008; Porporato *et al.*, 2003; Rutherford *et al.*, 2006; Thomas *et al.*, 2002).

The soil patterns present within the study area illustrated in Figure 3-5 include rocky areas (rock with limited soil), red-yellow well drained, massive or weakly structured soils (red soils with high base status), sandy soils with little or no profile development (red and yellow, well drained sandy soils with high base status), and soils with limited pedological development (soils with minimal development, usually shallow, on hard or weathering rock, with or without intermittent diverse soils. Lime generally present in part or most of the landscape).

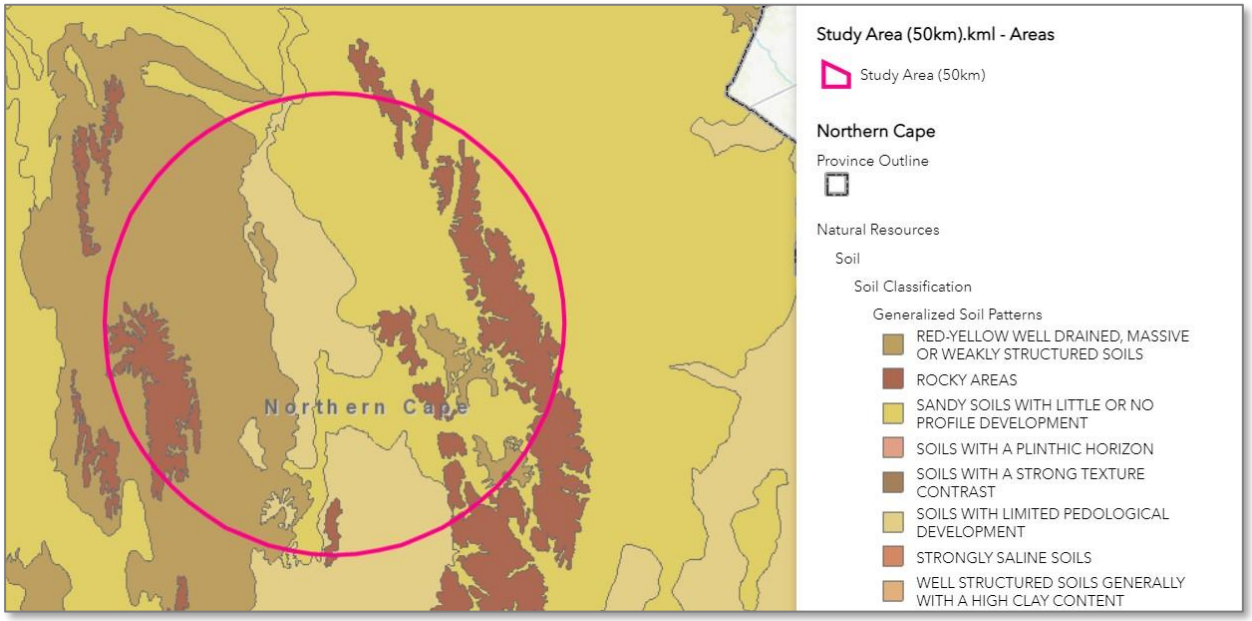

Figure 3-5: The soil patterns present within the study include Rocky areas, red-yellow well drained, massive or weakly structured soils, sandy soils with little or no profile development, and soils with limited pedological development

The southern Kalahari has a relatively flat topography with altitudes ranging between 900 and 1 100 m (Van Rooyen & Van Rooyen, 2019) and a water table that ranges from depths of approximately 25 m to depths exceeding 100 m (Figure 3-6). Jennings (1974) did, however, report a secondary water table at a depth of 20 m in certain shallower areas, especially in the proximity of natural pans and where the Kalahari sands are commonly underlain by types of duricrusts (Nash & McLaren, 2003). For most parts of the southern Kalahari, this duricrust is a calcareous layer or calcretes (Van Rooyen & Van Rooyen, 2019). Biological soil crusts are also common in the southern Kalahari, and these crusts contribute to nutrient cycling in the areas where they occur (Thomas *et al.*, 2002). These crusts consist of cyanobacteria which fixate nitrogen and carbon and help curb soil erosion (Mager, 2010; Thomas *et al.*, 2002).

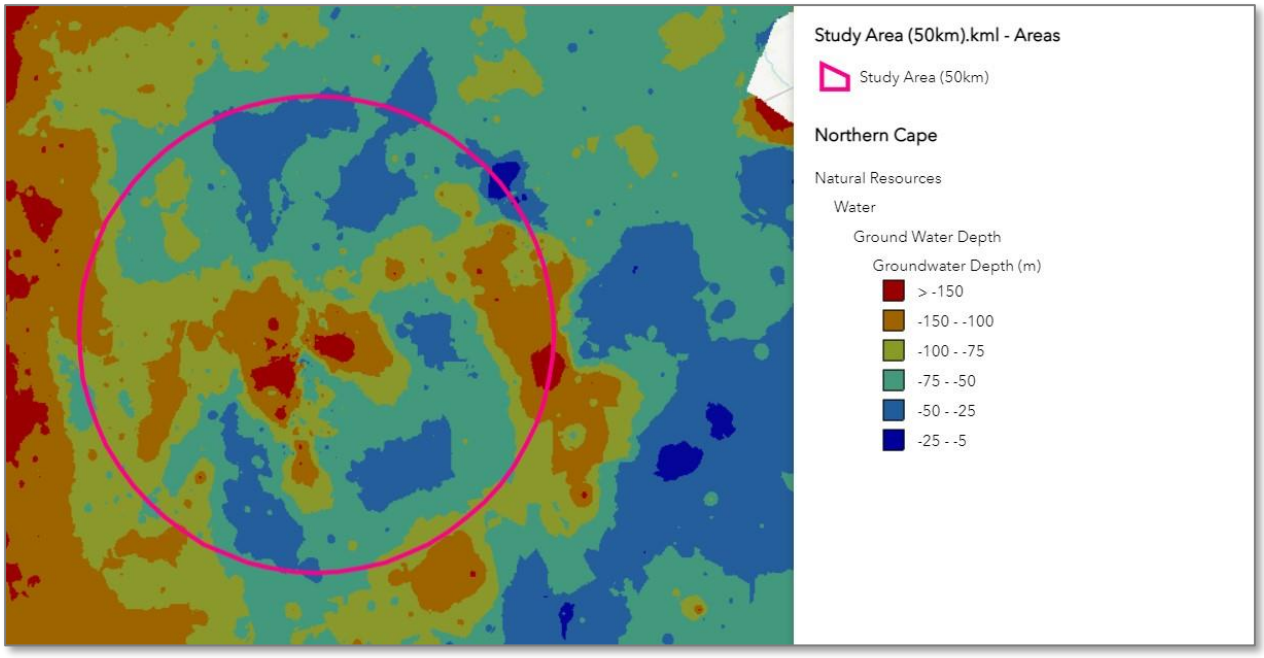

Figure 3-6: Groundwater depths within the study area vary from as shallow as 25 m to depths exceeding 150 m (DALRRD, 2021)

The Gamagara river is the only main river system within the study area flowing towards the Kuruman river to the north of the study area (Figure 3-1). The ephemeral Gamagara river is mainly a dry river system, with short periods of flow after heavy rainfall events (Pietersen and Gaffoor, 2008). This river system has shallow aquifers in its vicinity as well as many ephemeral pans (Pietersen and Gaffoor, 2008; CSIR, 2011). The NFEPA listed wetlands are illustrated in Figure 3-1, although all ephemeral wetlands are not necessarily listed as National Freshwater Ecosystem Priority Areas (NFEPA).

3.4 Vegetation type

3.4.1 Savanna biome

The study area forms part of the savanna biome, which is the most widespread biome in South Africa, covering a total area of 399 600 km^2 that ranges from Zambia to the most southern parts of southern Africa (Fouche, 2017; Rutherford *et al.*, 2006). This biome usually occurs at altitudes lower than 1 500 m but extends to 1 800 m above sea level (Rutherford *et al.*, 2006).

Dominated by a grass layer with scattered individual trees and tree clusters (Rutherford *et al.*, 2006), the savanna biome ranks second in species richness. Note, though, that species richness in the southern Kalahari is relatively low, totalling only 550 recorded species (Cowling *et al.* as cited by Horn, 2008; Gibbs Russell, 1987).

The Kalahari's vegetation varies from dry, open shrublands in the south to deciduous forests in the north with savanna vegetation dominating the central parts (Haddon, 2005; Rutherford *et al.*, 2006). The southern Kalahari is a relatively undisturbed arid savanna with a dense cover of grasses, shrubs and trees (Haddon, 2005; Van Rooyen & Van Rooyen, 2019).

An overview of the main vegetation types depicted in Figure 3-7 is provided in Table 3-1 below, which also gives an overview of the pedology, climate, conservation status and the most important tree taxa of each vegetation type. Excluded from Table 3-1 is the Southern Kalahari Mekgacha, also referred to as dry valleys by Blümel *et al.* (1998), and Southern Kalahari Salt Pans vegetation types also present in the study area (Figure 3-7).

Table 3-1: An overview of the main vegetation types present in the study area indicating the vegetation and landscape features, geology and soils, soil forms, climate, important tree taxa, conservation status, area conserved, and area transformed of each vegetation type (Descriptions adapted from Rutherford *et al.*, 2006.)

VEGETATION TYPE	Gordonia Duneveld	Gordonia Plains Shrubland	Kathu Bushveld	Koranna-Langberg Mountain Bushveld	Kuruman Mountain Bushveld	Kuruman Thornveld	Kuruman Vaalbosveld	Postmasburg Thornveld
Vegetation and landscape features	Parallel dunes < 8 m high and open shrubland with grassland ridges	Mainly plains with open grasslands Almost no dunes	Tree layer with *Vachellia erioloba* and *B. albitrunca*	Rugged mountains with steep slopes and some cliffs to the south (Langberg mountains)	Hills with moderate slopes and open shrubveld	Hills and relatively flat rocky plains Closed shrub layer with *Vachellia erioloba* trees	Open tree layer with limited shrubs comprised of *Vachellia erioloba*, *Vachellia karroo*, *Ziziphus mucronata* and *Searsia lancea* and an open grass layer	Flat areas surrounded by mountains Dense shrub layer with limited grasses and trees
Geology and soils	Silcretes and calcretes overlain by aeolian sands	Calcretes overlain by aeolian sands Namib soils on flat plains	Red aeolian sands and shallow calcretes	Olifantshoek Supergroup quartzite, greywacke and hematite Shallow, rocky sands	Asbestos Hills subgroup banded-iron formation; jaspilite, chert and riebeckite-asbestos of Griqualand West Supergroup	Dolomite of the Campbell Group and Kalahari Group sediments	Vaalian Griqualand West Supergroup carbonates and chert and Kalahari sediments Sandy plains with shallow aeolian sands	Griqualand West Supergroup overlain by red aeolian sands
Soil forms			Hutton, Clovelly		Hutton	Hutton	Hutton, Clovelly, Mispah	Hutton

VEGETATION TYPE	Gordonia Duneveld	Gordonia Plains Shrubland	Kathu Bushveld	Koranna-Langberg Mountain Bushveld	Kuruman Mountain Bushveld	Kuruman Thornveld	Kuruman Vaalbosveld	Postmasburg Thornveld
Climate	Summer and autumn rainfall Frost events during winter	Summer and autumn rainfall Frost events during winter	Summer and autumn rainfall Frost events during winter MAP 220 to 380 mm	Summer and autumn rainfall Frost events during winter MAP 180 to 380 mm	Summer and autumn rainfall Frost events during winter MAP 250 to 500 mm	Summer and autumn rainfall Frost events during winter MAP 300 to 450 mm	Summer and autumn rainfall Frost events during winter MAP 350 to 450 mm	Summer and autumn rainfall Frost events during winter MAP 250 to 350 mm
Important tree taxa	*Vachellia haematoxylon*	*Vachellia haematoxylon*, *Vachellia erioloba*	*Vachellia erioloba*, *B. albitrunca*	*Senegalia mellifera* subsp. *detinens*, *B. albitrunca*, *Ficus cordata*, *Maytenus undata*	*Searsia lancea*	*Vachellia erioloba*, *Senegalia mellifera* subsp. *detinens*, *B. albitrunca*	*Vachellia erioloba*, *Vachellia karroo*, *Ziziphus mucronata*, *Searsia lancea*	*Vachellia erioloba*, *Vachellia karroo*, *Searsia lancea*, *Vachellia tortillis* subsp. *heteracantha*, *Ziziphus mucronata*
Conservation status	Least threatened	Least threatened	Least threatened	Least threatened	Least threatened	Least threatened	Least threatened	Least threatened
Area conserved (statutory conservation areas)	14% in Kgalagadi Transfrontier Park	9% in Kgalagadi Transfrontier Park	0%	0% (Partly conserved in Tswalu Kalahari Reserve)	0%	0%	0%	0%
Area transformed	0%	0%	1% (Sishen Mine)	0%	< 1%	2%	0%	0%

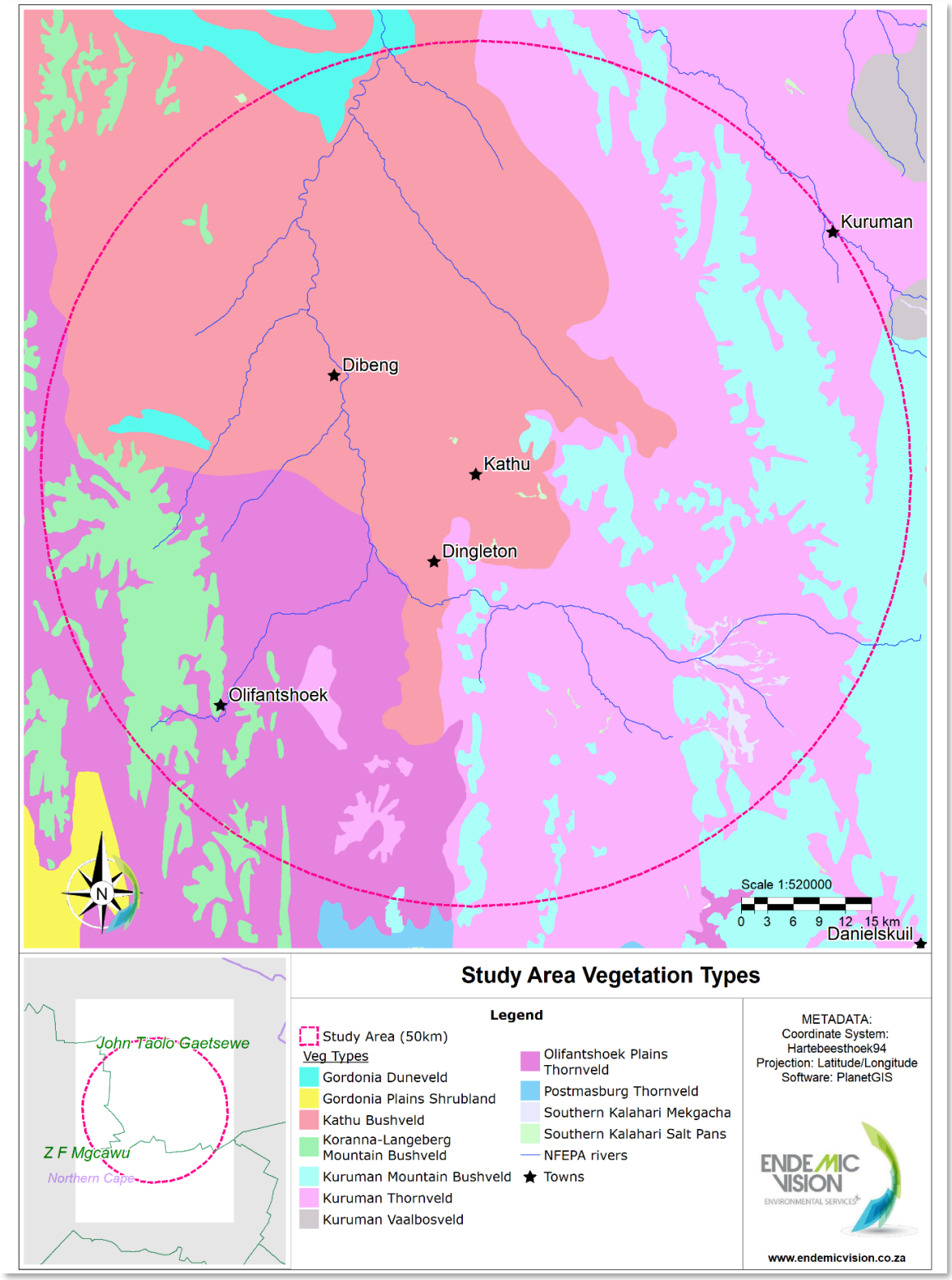

Figure 3-7: **Vegetation types present in the study area include Gordonia Duneveld, Kathu Bushveld, Koranna-Langberg Mountain Bushveld, Kuruman Mountain Bushveld, Kuruman Thornveld, Olifantshoek Plains Thornveld, Southern Kalahari Mekgacha and Southern Kalahari Salt Pans (SANBI, 2018)**

As illustrated in Figures 3-8 and 3-9, the study area is located within the Greater Griqualand West Centre of Endemism as proposed by Frisby (2016) (75 172 km^2) of which Van Staden *et al.* (2020) defined 24 075 km^2 as the Refined Griqualand West Centre of Endemism.

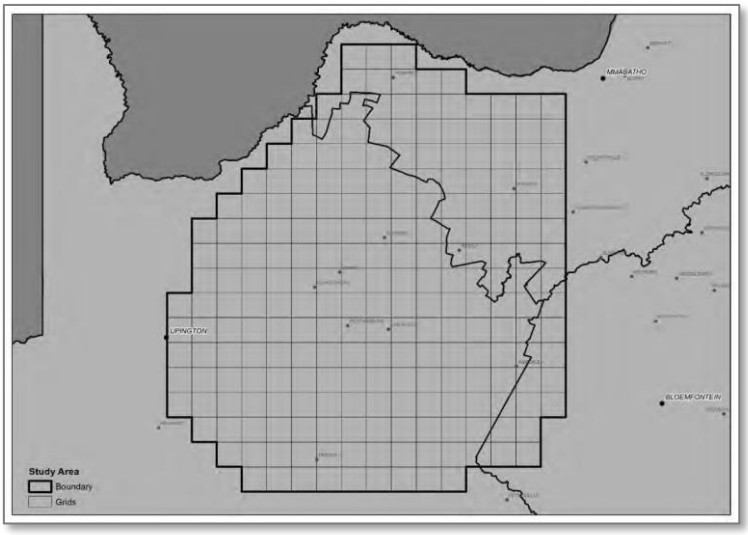

Figure 3-8: The Greater Griqualand West Centre of Endemism as defined by Frisby (2016)

Figure 3-9: The Refined Griqualand West Centre of Endemism as defined by Van Staden *et al.* (2020)

CHAPTER 4 MATERIALS AND METHODS

4.1 Research framework

This study consists primarily of seed and cutting planting bag trials, of which the surviving saplings were hardened and transplanted into the open field as well as degraded areas along the Kgalagadi pipeline servitude where rehabilitation was implemented (field trials) as illustrated in Figure 4-1. Cuttings were also planted directly into the open field as part of field trials.

The study also includes monitoring the newly transplanted saplings in the field trials under natural environmental conditions. Naturally recruiting saplings along the servitude of the Kgalagadi pipeline is also recorded.

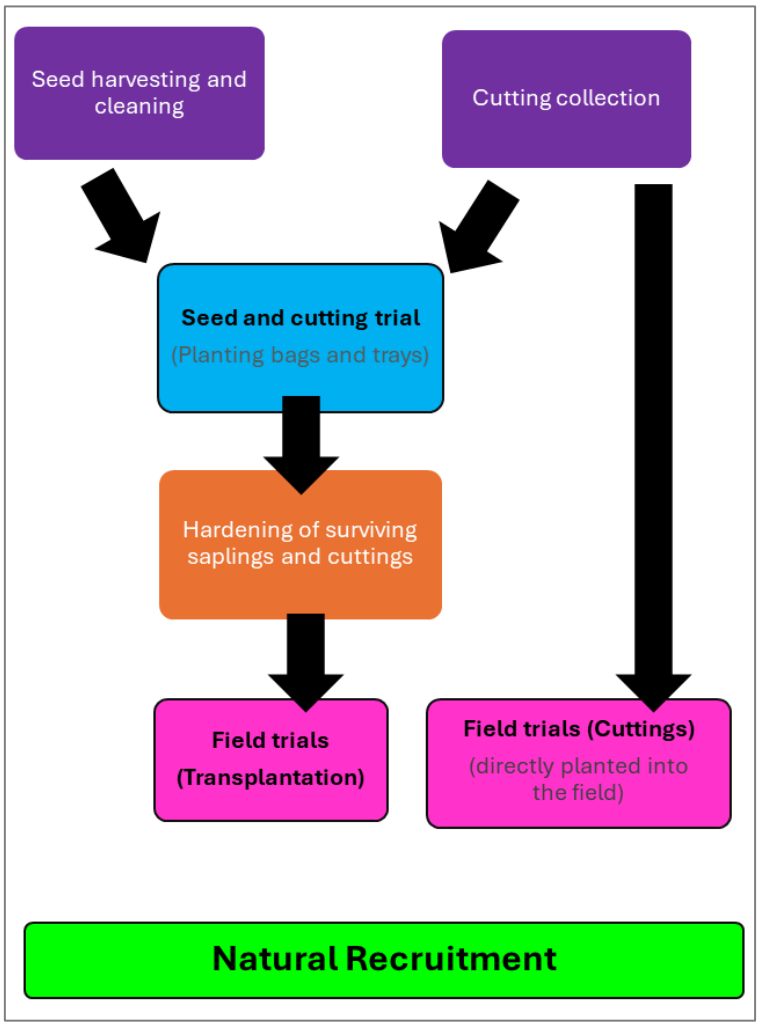

Figure 4-1: Research framework

4.2 Seed harvesting and cleaning

Based on availability and since all trees in the area were not reproducing each year, seeds were collected from two sites [Bedrog (27°39'34.14"S; 22°33'21.80"E) and De Rust (27°33'36.12"S; 22°47'59.64"E)] to the west and northwest of Kathu during November 2019 and from December 2020 to February 2021 respectively (Figure 3-2). Seed collection were done on Bedrog farm in 2019 and on De Rust farm in 2020 and 2021.

Seed collection was based on availability, given that *B. albitrunca* seeds do not ripen simultaneously, as illustrated in Figure 4-2. Still, the conditions of the flora harvesting permit (Permit No. FLORA 0011/2020, which can be found in Annexure B) were followed during all harvesting. This permit was given to EndemicVision Environmental Services (Pty) Ltd in line with the National Environmental Management: Biodiversity Act of 2004.

This permit authorises the collection of seeds from *B. albitrunca* in the John Taolo Gaetsewe District Municipality and the Tsantsabane Local Municipality of the ZF Mcgawu District Municipality. The permit further states that seeds may only be collected from healthy plants to ensure good quality seedlings and only from populations with a moderate quantity of mature seed crop distributed uniformly. These populations should be further alternated annually, and no damage may be caused by the harvesting or seed collection techniques.

Figure 4-2: A single *B. albitrunca* tree can bear both ripe (yellow) and unripe (green) seeds simultaneously

In keeping with the provisos outlined above, seeds in this study were harvested by hand with the aid of a step ladder in order to cause minimal harm to the trees. Post-collection, seeds were transported in plastic bags within coolers as prescribed by Luna and Wilkinson (2014). Seeds were further stored in cool conditions (< 20 ˚C) for a maximum of seven days before they were cleaned by hand using lukewarm water and a textured cloth to ensure adequate removal of the fruit, which inhibits germination (Figure 4-3). This method of seed collection and cleaning was

agreed upon following a telephonic interview with Jacoline Mans, author of the article “Growing shepherd’s trees from seed" (2018), in April 2020.

Fleshy fruited seeds should be harvested when seeds are ripe, since dried seeds prove much harder to clean (Luna & Wilkinson, 2014). After cleaning, the seeds were laid out in shallow trays indoors and dried in indirect sunlight for a period of three to five days for the Bedrog trial and up to 30 days for all other trials before being stored in a cold (< 6˚C) place until sowing. Seeds were then stored in brown paper bags to prevent exposure to sunlight.

Figure 4-3: Cleaning harvested *B. albitrunca* seeds with a textured cloth to ensure adequate removal of the fruit after soaking in water

During the cleaning process, seeds showing signs of predation (mostly caused by Lepidoptera and/ or Coleoptera larvae, ants and small black beetles (Coleoptera) feeding on seeds) were discarded (Figure 4-3).

Figure 4-4: Signs of *B. albitrunca* seeds being predated by Lepidoptera and/ or Coleoptera larvae

4.3 Collection of root and stem cuttings

Cuttings were sourced from the farm Bedrog (27°39'34.14"S; 22°33'21.80"E), where *B. albitrunca* trees were to be destroyed to make way for the construction of the Kalahari East Water Users Association's second Bedrog reservoir (Figure 3-2). The construction of this reservoir was authorised under Environmental Authorisation Permit 17/2020 (Ref. NC/BA/34/ZFM/DAW/UPI2/2019) and Licence NCU 11041020 as issued by the then Department of Agriculture, Forestry and Fisheries. This licence authorised the destruction of seven *B. albitrunca* trees and it is from those trees that both root and stem cuttings were collected prior to and during site clearance and/or removal for the purpose of this study.

During the cutting collection run, both stem and root cuttings of varying sizes were collected from the Bedrog farm during October and November 2020. Root cuttings were collected immediately after the soil was disturbed and damaged by a bulldozer that was used to clear the area in preparation for the construction of the second Bedrog reservoir (Figure 4-4). Care was taken to ensure root cuttings are transported with the correct polarity to ensure correct planting as prescribed by Luna and Haase (2014).

All cutting edges were sealed using a commercial plant sealer[1] during collection. Cuttings were cut to size (small, medium or large) prior to planting and the cutting wounds were resealed for all sealed trials or left unsealed or exposed for the unsealed cutting trials as detailed in section 4.4 and 4.6 below.

[1] A commercial plant sealer or fungicidal pruning wound paste were used to seal cutting wounds or cutting edges to reduce the infection of pruning wounds and cut surfaces from certain fungi.

Figure 4-5: Collection of *B. albitrunca* root cuttings immediately post removal of adult trees at the farm Bedrog

4.4 Seed and cutting trial experimental design

The seed and cuttings collected as described above were sown and/or planted in planting bags[2] or trays in the case of the hothouse trials to conduct the planting bag and tray trials summarised in Figure 4-5 and Table 4-1 below.

This trial consisted primarily of cuttings and seed planted in outdoor planting bags, or hothouse planting trays as was the case for the very old seed trial. The planting bag trial consisted of a total of 228 outdoor plastic (polythene) planting bags with a volume of 6 000 ml each and a surface area diameter of approximately 200 mm, as well as four plastic hothouse planting trays with a volume of 12 000 ml each and a surface area of approximately 45 x 25 cm.

The cutting trials consisted of both root and stem cuttings, of which all root cutting planting bags (n = 12) contained sealed medium-sized cuttings, and stem cutting planting bags (n = 120) contained either small or medium-sized cuttings (Figure 4-5 and Table 4-1). The 72 planting bags for the medium sized cuttings had 60 planting bags containing sealed cuttings and 12 containing unsealed cuttings (Figure 4-5 and Table 4-1). Ten small cuttings and three medium cuttings were planted per planting bag, regardless of whether root or stem cuttings.

[2] Planting bags are black plastic bags with a volume of approximately 6000 ml used for the propagation of plants.

The seed trials, which consisted of four hothouse planting tray trials and 96 outdoor planting bag trials, had four respective seed age classes with varying quantities of planting bags or trays per class as summarised in Table 4-1 below. Ten seeds were planted per planting bag and 60 per planting tray.

Table 4-1: Seed and cutting planting bag trial description and number of replicates per trial

Trials	Description	Trial ID	Nr of planting bags/ trays	Planting bag/ - tray volume (ml)	Nr of seeds / cuttings per bag	Total nr of seed/ cuttings
Seed germination	Young/ Fresh seed (harvested within 1 month from seeding)	G*	24	6 000	10	**240**
	Old seed (harvested within 6 months from seeding)	B*	48	6 000	10	**480**
	Very old seed (harvested within 9 months from seeding)	G*	24	6 000	10	**240**
	Extra old seed **hothouse trial** (harvested >12 months from seeding)	HH*	4	12 000	60	**240**
Stem cuttings	Unsealed medium cuttings measuring approximately 3-5 cm in diameter and 30 cm in length	UC*	12	6 000	3	**36**
	Sealed small cuttings measuring approximately 1 cm in diameter and 15 cm in length	S*	48	6 000	10	**480**
	Sealed medium cuttings measuring approximately 3-5 cm in diameter and 30 cm in length	C*	60	6 000	3	**180**
Root cuttings	Sealed root cuttings measuring approximately 3-5 cm in diameter and 30 cm in length	R*	12	6 000	3	**36**
Total nr of planting bags		**228**				
Total nr of planting trays		**4**				

G Trial ID: Planting bags for young/fresh seed were numbered 1-6, whilst planting bags for very old seed were numbered 7-12. Both trial ID's start with the letter 'G.'*

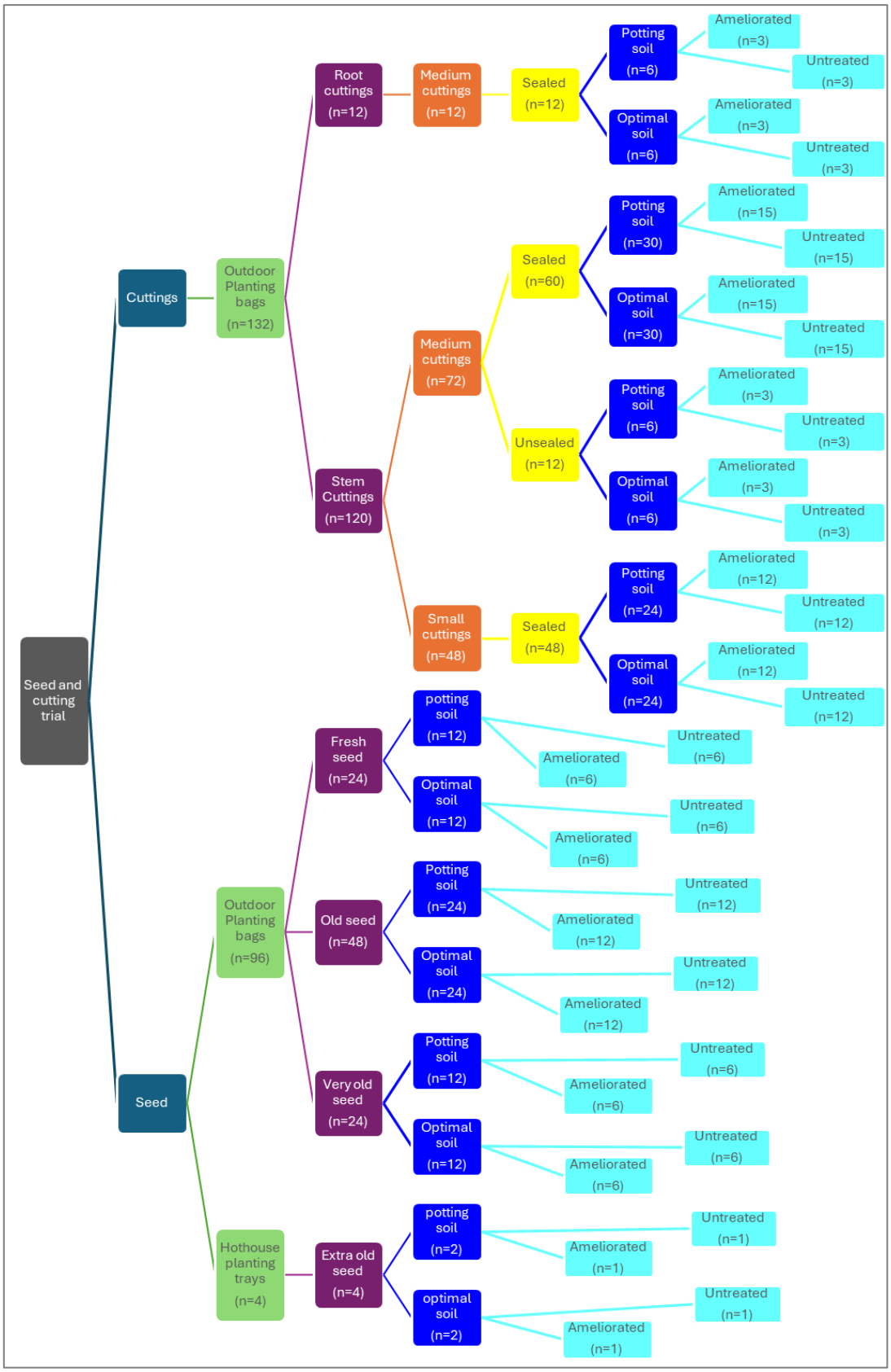

Figure 4-6: **Seed and cutting trial experimental design ('n =' indicates the number of planting bags or -trays)**

Each of the respective trials were subjected to two soil types, optimal and potting soil, of which 50% were ameliorated and 50% left untreated. Commercially sourced potting soil was used as the control soil type. The assumption is that potting soil will not have any plant available nutrient deficiencies. Hence deficiency variables are removed for germination and/or establishment. The soil referred to as optimal soil is topsoil sourced from Bedrog farm, where dense stands of adult *B. albitrunca* specimens were growing. Amelioration entailed the addition of 150 g compost and 100 g bonemeal per planting bag or tray.

Each trial were subjected to equal replicates of the following four variations in soil:

- Potting soil (referred to as CTRL soil type)
    - Sourced from a local nursery
- Ameliorated potting soil (referred to as CTRL soil type)
    - Potting soil ameliorated with 150 g compost and 100 g bonemeal per planting bag
- Optimal soil (referred to as OPTI soil type)
    - Soil collected from habitats where *B. albitrunca* is abundant, restricted to topsoil layer (< 30 cm), is mainly collected under the canopy of adult trees
- Ameliorated optimal soil (referred to as OPTI soil type)
    - Optimal soil ameliorated with 150 g compost and 100 g bonemeal per planting bag

Planting bags and planting trays were filled with the respective soil mixes until 20 mm from the upper brim to allow for watering. Amelioration was applied in the upper 50 mm of the soil profile after filling the planting bag or planting tray with the relevant soil.

The planting bag ID's are a combination of the trial name, soil type and treatment (Table 4-2). The letter "O" is assigned where optimal soil is used as growth medium or soil type and the letter "P" where potting soil is used. A letter "A" or "U" is further applied to indicate amelioration design: ameliorated or untreated.

Table 4-2: Seed and cutting trial planting bag ID's, soil types and amelioration design

Trial	Description	Planting bag ID	Soil type/ Growth medium	Amelioration design
Seed germination	Young/ Fresh seed	GAO*	Optimal	Ameliorated
		GAP*	Potting soil	Ameliorated
		GUO*	Optimal	Untreated
		GUP*	Potting soil	Untreated
	Old seed (Bedrog)	BOA*	Optimal	Ameliorated
		BPA*	Potting soil	Ameliorated
		BOU*	Optimal	Untreated
		BPU*	Potting soil	Untreated
	Very Old seed	GAO*	Optimal	Ameliorated
		GAP*	Potting soil	Ameliorated
		GUO*	Optimal	Untreated
		GUP*	Potting soil	Untreated
	Extra old seed hothouse trial	HHOA*	Optimal	Ameliorated
		HHPA*	Potting soil	Ameliorated
		HHOU*	Optimal	Untreated
		HHPU*	Potting soil	Untreated
Stem cuttings	Unsealed medium cuttings	UCOA*	Optimal	Ameliorated
		UCPA*	Potting soil	Ameliorated
		UCOU*	Optimal	Untreated
		UCPU*	Potting soil	Untreated
	Sealed small cuttings	SOA*	Optimal	Ameliorated
		SPA*	Potting soil	Ameliorated
		SOU*	Optimal	Untreated
		SPU*	Potting soil	Untreated
	Sealed medium cuttings	COA*	Optimal	Ameliorated
		CPA*	Potting soil	Ameliorated
		COU*	Optimal	Untreated
		CPU*	Potting soil	Untreated
Root cuttings	Sealed root cuttings	RSOA*	Optimal	Ameliorated
		RSPA*	Potting soil	Ameliorated
		RSOU*	Optimal	Untreated
		RSPU*	Potting soil	Untreated

4.4.1 Seed

4.4.1.1 Outdoor planting bag seed trials

The outdoor seed trials involved sowing locally harvested seeds in bags as follows:

1. Seeds harvested from De Rust Farm during February 2021 were sown in March of the same year (Young seed trial [YOUNG]);

2. Seeds harvested from Bedrog Farm in late November 2019 were sown in June 2020 after being stored for approximately six months (Old seed trial [OLD]); and

3. Seeds harvested from De Rust farm during December 2020 were sown in August 2021 after being stored for approximately nine months (Very old seed trial [V_OLD])

Each of the trials mentioned above (1-3) entailed the sowing of ten seeds per bag in 6 000 ml planting bags with a diameter of approximately 200 mm. Seeds were sown at a maximum depth of 5 mm and were evenly distributed along the edge of the planting bag (Figure 4-7). Immediately post-planting, seeds were watered with approximately 2 000 ml of water or until the planting bag showed signs of draining to ensure the entire bag had been watered thoroughly.

Figure 4-7: Cleaned and dried *B. albitrunca* seeds evenly distributed in a planting bag filled with optimal soil during the planting process

4.4.1.2 Hothouse planting tray seed trial

A single hothouse seed trial was conducted during March 2022 using seeds collected in February 2021 from the farm De Rust. These seeds were stored for approximately 12 months (Extra old seed trial [X_OLD]).

The same soil variations explained above (4.4) were applied to this trial. In this case, though, seedling trays were used and placed indoors to eliminate the negative impact frost might have on germination.

The size of the trays were 12 000 ml, each containing 60 seeds. These trays, however, had a larger surface area (approximately 45 x 25 cm) although they were shallower than planting bags used for outdoor seed trials. The saplings propagated during this trial were not used in field trials. Seeds were again sown at a maximum depth of 5 mm and were evenly distributed throughout the planting tray (Figure 4-8). Immediately post-planting, seeds were watered with approximately 2 000 ml of water or until the planting bag showed signs of draining to ensure the entire bag had been watered thoroughly.

Figure 4-8: Cleaned and dried *B. albitrunca* seeds evenly distributed in a planting tray filled with potting soil during the hothouse trial planting process

The conditions in the hothouse were limited to natural light exposure during daytime hours, with no artificial lighting applied. The hothouse was covered with durable and weatherproof roofing that prevented direct sunlight from entering. Solid brick walls were present on the western and eastern sides, with glass panels on the northern and southern sides. The recorded temperatures at various intervals throughout the day varied between 3˚ C and 29˚ C.

4.4.2 Cuttings

Both root and stem cuttings were sealed in field during collection to prevent water loss during transportation and freshly cut to size prior to planting. After cutting the cuttings to size, all above

ground cutting edges and wounds were either sealed using a commercial plant sealer (Figure 4-9) or left unsealed based on the respective trial. The edges of vegetative cuttings were angled at approximately 45 degrees to optimize absorption surface area, especially for the bottom parts to be planted.

Figure 4-9: Sealed small *B. albitrunca* cuttings ready for planting as part of the planting bag trials

Three trials were conducted using stem cuttings of two varying size classes (see section 4.4 above). The first trial entailed medium-sized stem cuttings of which cutting edges and/or wounds were not sealed, whilst the second and third trials involved small- and medium-sized stem cuttings sealed using a commercial sterilising plant sealer.

A fourth cutting trial was conducted using medium-sized root cuttings sealed using a commercial sterilising plant sealer. No unsealed root cuttings were planted during planting bag trials.

The two size classes of cuttings planted in planting bags are as follows:

- Medium cuttings measuring approximately 3-5 cm in diameter and 30 cm in length; or
- Small cuttings measuring approximately 1 cm in diameter and 15 cm in length.

All cuttings were treated at the base of the cutting with either an organic liquid bio-fertiliser[3] or root stimulating hormone powder[4], both of which contained auxins. Treatment was applied by briefly dipping the freshly cut base into either the liquid bio-fertiliser or the root stimulating hormone powder up to a depth of 50 mm. No dilution of either was done. These impacts were not specifically tested for correlation with recruitment success as part of the results in chapter 5.

Ten small or three medium cuttings were planted per planting bag (Figure 4-10) and no leaves were removed prior to planting.

Figure 4-10: Sealed medium-sized stem cuttings planted in planting bags

Outdoor planting bag trials were conducted in Kathu town under tree canopies to minimise direct sunlight. Planting bags were packed in a random pattern using Excel's random tiles package (Version 3 of 2001) (Figures 4-11 and 4-12).

[3] The organic liquid bio-fertiliser used is rich in both micro and macronutrients, as well as several amino acids. It is further claimed to accelerate photosynthesis, respiration and transpiration and improve resilience during times of climatic stress.

[4] The root stimulating hormone powder contains 4-Indole-3-Butyric Acid [IBA] as active ingredient and stimulates root formation of cuttings.

Figure 4-11: ***B. albitrunca*** **planting bag trials for seeds and medium-sized cuttings respectively packed according to Random tiles layout**

Number of tiles in width	6
Number of tiles in height	4
Total needed	*24*

	Tiles available	Fill colour	*Tiles used*
Medium Cutting - Ameliorated Optimal Soil	6		*6*
Medium Cutting - Ameliorated Potting Soil	6		*6*
Medium Cutting - Optimal Soil	6		*6*
Medium Cutting - Potting Soil	6		*6*

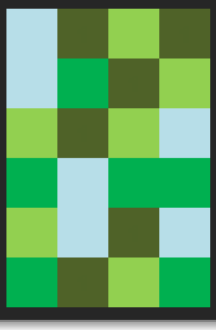

Figure 4-12: **Random tiles used to determine cutting layout (right) for the 24 planting bag trials of the four respective soil mediums used for medium cuttings. The layout is illustrated on the right using the colours in the legend (left)**

Only fifty percent of the unsealed medium stem cuttings collected from Bedrog farm were used for planting bag trials. The remaining fifty percent were planted as part of the field trials detailed

in section 4.6 below. Fifty percent of the sealed root cuttings were also transplanted directly into the ground as part of field trials and were not used for planting bag trials (refer to section 4.6 below).

4.5 Hardening of saplings and cuttings

Once seedlings have produced leaves other than the cotyledons (seed leaves), they were perceived as saplings and considered ready for hardening. This was usually after approximately 12-16 weeks. Saplings were hardened for 60 days prior to being transplanted into the natural veld as part of field trials. The hardening process entailed gradual exposure of the seedlings to full sunlight for approximately half a day and fortnightly watering for 30 days. During the final 30 days of this hardening process, saplings were exposed to full sun all day and the watering frequency decreased to once in four weeks.

The same hardening process was followed for cuttings established during the planting bag trials. No cuttings survived the hardening process and hence no propagated cuttings were transplanted as part of the field trials.

4.6 Field trials

All saplings grown in the seed and cutting trial were subjected to hardening as described above, whereafter all surviving saplings were transplanted as part of the field trials together with cuttings planted directly as part of field trials and not in planting bags (Figure 4-13). These cuttings were not propagated in planting bags first and were not subjected to hardening.

A total of 58 saplings survived hardening and were transplanted to the Equestrian club (n = 22) and Tamaga (n = 36) respectively (locations indicated with ▼ in Figure 4-14). No additional treatment or amelioration was applied during transplantation.

An additional 193 saplings grown under the supervision of Ms Mans and sourced from the then Department of Agriculture, Forestry and Fisheries' (DAFF) nursery were also transplanted as part of the field trials due to the large number required as part of the Kgalagadi pipeline's protected tree permit and were simultaneously monitored (locations indicated with ◄ in Figure 4-14). All of

these saplings were also subjected to hardening prior to transplantation and planted with the addition of water retention hydrogel[5] to aid moisture retention.

The sapling ID's assigned for field trials, as well as the number of saplings per planting hole, the planting areas and the number of replicates per planting area are summarised in Table 4-3 below.

Table 4-3: Field trial sapling design descriptions and number of replicates per trial

Sapling Type	Planting Area	Sapling ID	Nr of planting holes (n)	Nr of saplings per planting hole	Total nr of saplings per planting area
Sourced	Witleegte	WIT*	20	1	**20**
	Chertsey	CHER*	15	1	**15**
	EndemicVision Offices	KAT* / EVOF*	18	1	**18**
	Kathu Pan	KPN*	80	1	**80**
	Gamagara	GAM*	50	1	**50**
	Kgalagadi Offices	KPOF*	10	1	**10**
Grown in planting bag trials	Equestrian Club	KPK*	22	1	**22**
	Tamaga	TAM*	36	1	**36**
Total nr of planting holes			**251**		
Total nr of planting areas			**8**		

A further 28 stem cuttings of varying sizes and 12 medium sized root cuttings were planted at two respective locations as part of the field trials (Figure 4-13).

A total of 28 unsealed stem cuttings, 12 medium and 16 large, as well as 12 sealed medium root cuttings were planted directly into the ground as part of field trials. All cuttings were transplanted individually, one cutting per planting hole.

Cuttings were directly planted at EndemicVision offices and Gamagara river sites respectively.

[5] The water retention hydrogel is a hydrogel that increases the water holding capacity of soils for several years, improves root development and increase soil aeration.

The cutting ID's assigned for field trials, as well as the description (size and sealed/unsealed) number of cuttings per planting hole, the planting areas and the number of replicates per planting area are summarised in Table 4-4 below.

Table 4-4: Field trial cutting design descriptions and number of replicates per trial

Cutting type	Description	Cutting ID	Nr of planting holes (n)	Nr of cuttings per planting hole	Planting Area	Total nr of cuttings
Stem cuttings	Unsealed medium cuttings measuring approximately 3-5 cm in diameter and 30 cm in length	UC*	12	1	EndemicVision	**12**
	Unsealed large cutting measuring approximately 10 cm in diameter and 150 cm in length	SL*	16	1	Gamagara	**16**
Root cuttings	Sealed root cuttings measuring approximately 3-5 cm in diameter and 30 cm in length	R*	12	1	EndemicVision	**12**
Total nr of planting holes		**40**				
Total nr of planting areas		**2**				

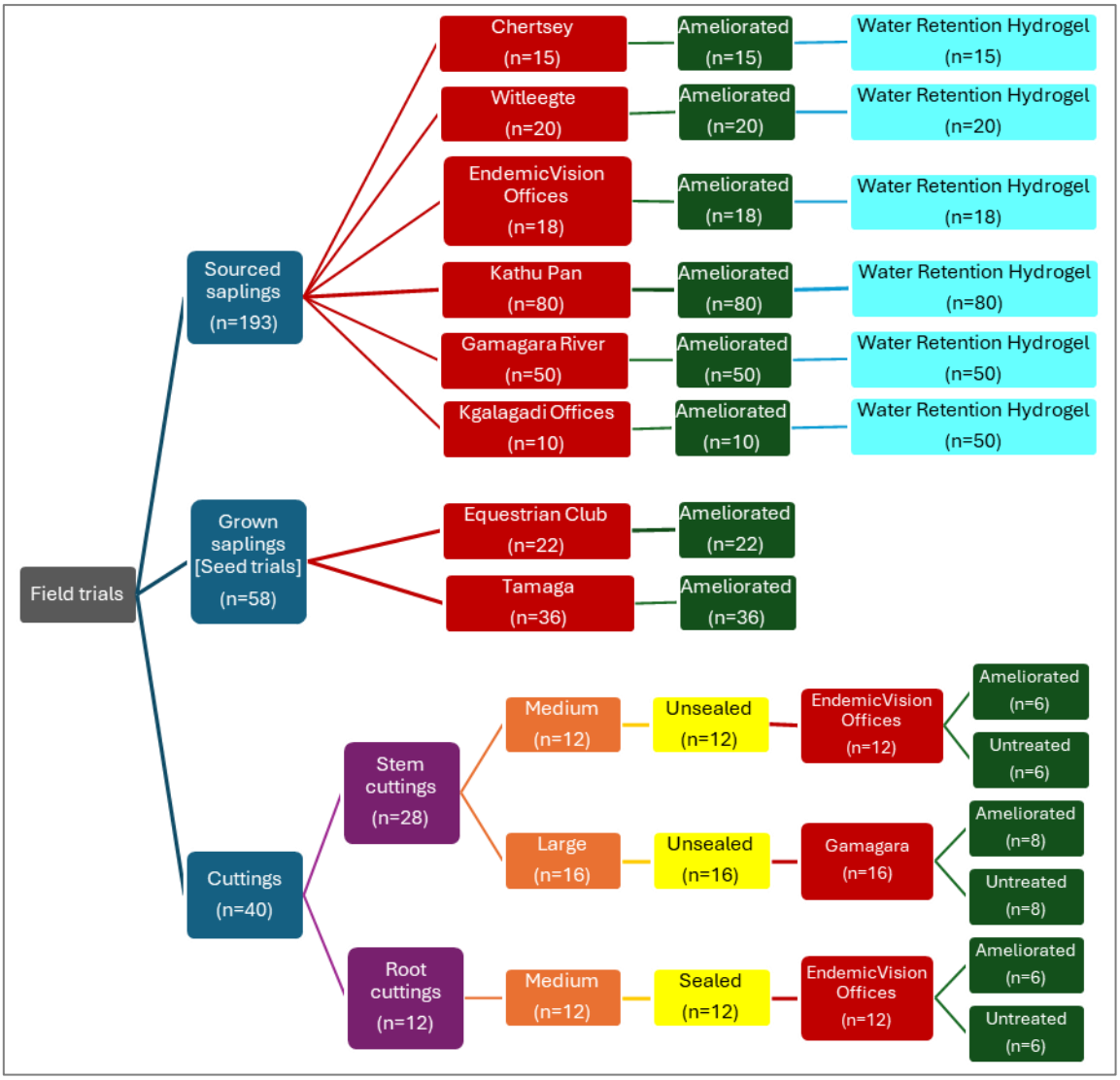

Figure 4-13: **Field trial experimental design ('n =' indicates the number of planting holes and/or saplings or cuttings since all saplings and cuttings were transplanted or planted individually)**

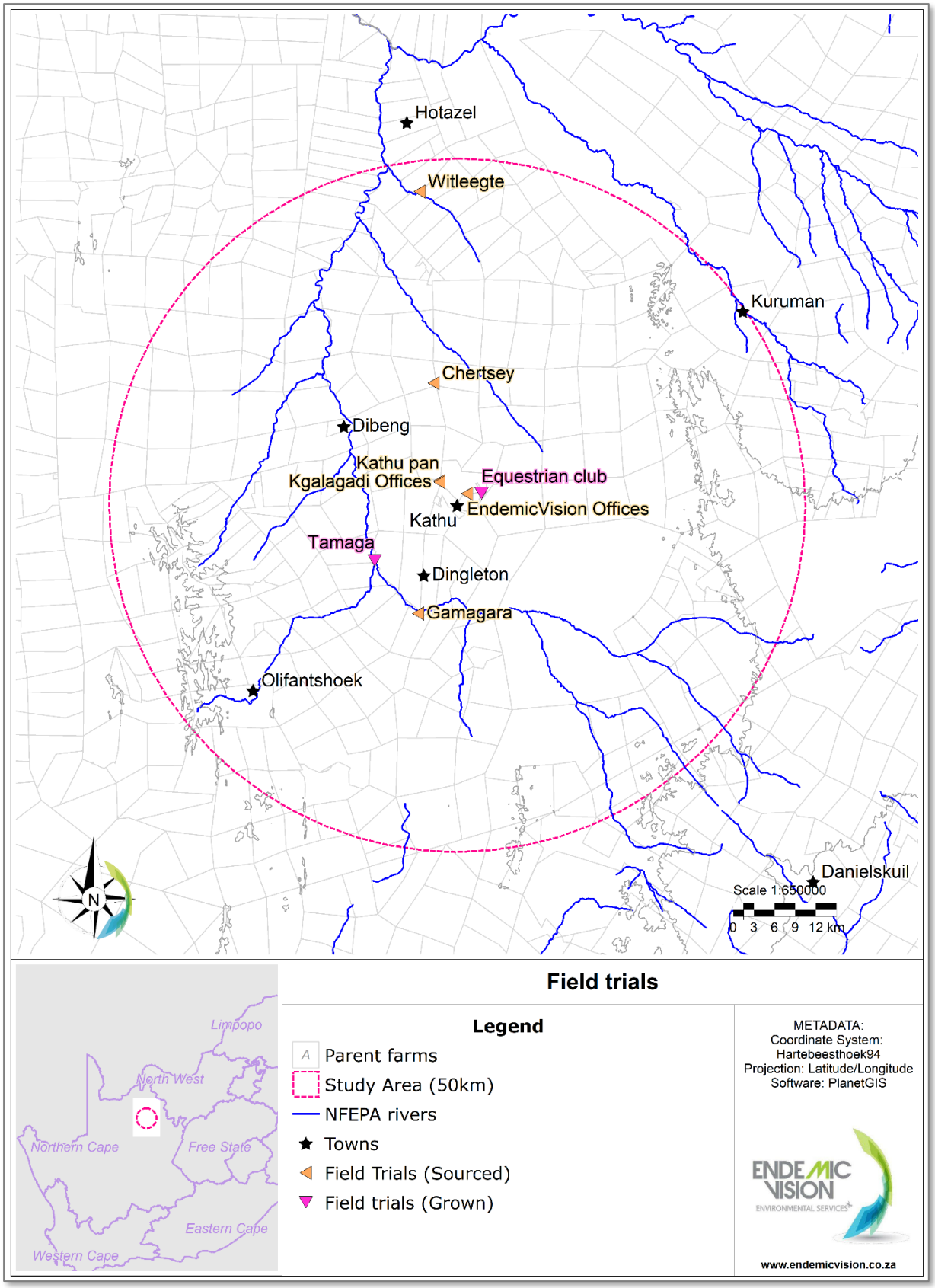

Figure 4-14: **Placement of field trials within the study area: Sourced saplings are indicated in orange (◄) and grown saplings in pink (▼)**

4.6.1 Saplings

The same transplantation method was followed for all repetitions which entailed the transplantation of saplings in a hole 30 cm deep and 40 cm wide with angled edges. The planting holes were watered and ameliorated with 100 g bonemeal and 100 g compost prior to transplantation. Care was taken not to disturb the roots of the sapling during transplantation, and 50 g compost was applied to the planting hole after transplantation (Figure 4-15). To protect saplings from browsing by livestock and/or game, woody branches from deciduous species with spines were used as cover (brush packing).

In the case of sourced saplings transplanted as part of the Kgalagadi pipeline rehabilitation project, 60 g water retention hydrogel was applied to the bottom of the planting holes with compost and bonemeal. This is a powdered gel that reacts with moisture to form a gel substance resulting in prolonged water storage in dryland rehabilitation. No water retention hydrogel was added to saplings propagated during this study's planting bag trials transplanted to the Tamaga and Kathu Equestrian Club sites.

Figure 4-15: Planting of sapling grown in planting bag trial. Care was taken not to disturb the roots of saplings during transplantation

4.6.2 Cuttings

The unsealed large stem cuttings (n = 16) of the first trial and 50% of the unsealed medium stem cuttings (n = 12) of the same trial were planted directly into the ground as part of the field trials and were not grown in planting bags. In addition, 50% of the root cuttings (n = 12) were planted directly into the ground as part of field trials. The large stem cuttings (measuring approximately 10 cm in diameter and 150 cm in length) were planted to the Gamagara river site, whilst all others were planted into the ground on EndemicVision's premises in Kathu (Figures 4-13).

Amelioration was applied to 50% of all cutting field trials using the same concentrations listed for soil variations (see section 4.4 above). 150 g compost and 100 g bonemeal were hence applied per planting hole with the letter “A” in its label/ID and planting holes with the letter “U” were left untreated (see Annexure A).

No planting bag cuttings, sealed or unsealed, survived the hardening process and hence no cuttings were transplanted from planting bags as part of the field trials.

4.7 Natural recruitment

Saplings naturally recruited along the servitude of the Kgalagadi Pipeline were also recorded as part of this study in areas where adult *B. albitrunca* trees were removed for the construction of the pipeline. These naturally recruited saplings were monitored, and recruits were recorded for up to 18 months post-completion of the construction along the entire extent of the servitude.

Monitoring entailed georeferencing by means of a handheld GPS device, scale photographing with a measuring device, as well as recording the sapling parameters listed under section 4.9.3 below and was conducted on a six monthly frequency.

Naturally recruited saplings were recorded to determine whether *B. albitrunca* can be naturally recruited post disturbance, as well as the optimal method for natural recruitment (root or stem cuttings or seedlings) and the growth rate of these dryland recruited specimens compared to transplanted saplings.

4.8 Soil sampling

A single soil sample was collected at each field trial site, and for each of the respective soil mediums used as part of the planting bag trials (Table 4-5 [List of samples also included in Annexure A]). The commercially sourced potting soil was sampled as the control.

Soil samples (n = 15) were collected to a depth of approximately 15 cm and consisted of a composite five point sample per site. Soils used in planting bags were sampled similarly with potting soil sample being the composite of five random potting soil bag samples. The five subsamples were mixed in the field to form the composite sample sent for laboratory analysis.

All soil samples were collected under dry conditions and stored in sealed plastic bags for transportation. The composite samples were subsampled into 400 g samples, once again contained in plastic bags, and send to Van's Laboratory (Pty.) Ltd in Bloemfontein, Free State Province, for analyses. A full list of all soil samples is included in Appendix A.

4.8.1 Soil analysis

The following physical and chemical parameters were assessed as part of the soil analyses (as derived from Soil and Plant Analysis Council, 1999):

- Soil texture (Particle size classes)
    - Coarse sand (>0,50 mm)
    - Medium sand (>0,25 mm)
    - Fine sand (>0,125 mm)
    - Silt (>0,0039 mm)
    - Clay (>0,0002 mm)
- Soil chemistry
    - Electrical conductivity (EC)
    - pH in KCl
    - Macronutrients (Ca, Mg)
    - Potassium (K)
    - Sodium (Na)

Soil texture data obtained were further analysed to determine the soil texture class for each soil sample using the USDA-NRCS (2014) trilinear diagram for soil textural classes.

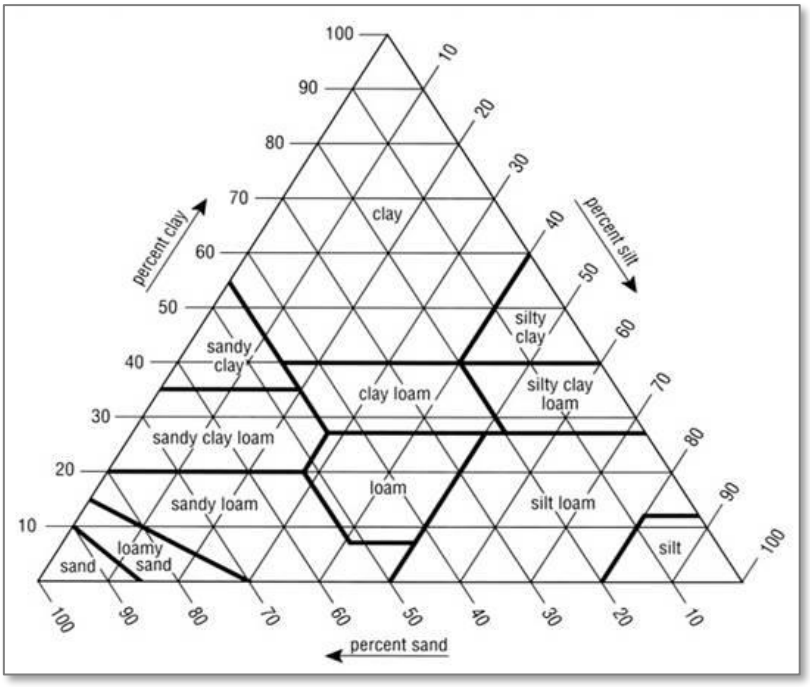

Figure 4-16: Trilinear diagram used for the classification of soil textural classes (USDA-NRCS, 2014)

4.8.2 Soil categorization

The respective study sites and their correlating soil samples are further categorized based on their ecosystem or habitat type as terrestrial or aquatic. Aquatic sites include all pans and riverine areas, whilst all other sites are considered terrestrial. The potting soil (CTRL) and Gamagara River 1 (GRV1) samples are uncategorized since these are neither terrestrial nor aquatic but rather artificially modified. GRV1 was modified during the construction of the Kgalagadi pipeline development, regardless of its riverine location.

Table 4-5: Soil samples and their habitat/ecosystem categorization

Soil Sample/ Field Trial Site Name	Habitat/ Ecosystem Categorization
GRV1	Uncategorized
HAL1	Terrestrial
HAL2	Terrestrial
KPAN	Aquatic
TAMA	Aquatic
WITL	Aquatic
GRV2	Terrestrial

Soil Sample/ Field Trial Site Name	Habitat/ Ecosystem Categorization
KPK1	Terrestrial
KGOF	Aquatic
MARS	Aquatic
EVOF	Terrestrial
EDEN	Terrestrial
CHER	Terrestrial
OPTI	Terrestrial
CTRL	Uncategorized

4.9 Monitoring and data collection

4.9.1 Cuttings

The growth of cuttings was monitored every 14 days in bag trials to record any new leaves being formed. Monitoring included soil pH and soil moisture content monitoring to determine watering requirements. A handheld soil moisture meter was used for monitoring.

4.9.2 Seedlings

Seeds planted in planting bag trials were monitored daily for the first month to determine the germination rate. After germination, these seedlings were monitored with regards to their soil pH and soil moisture content to determine watering requirements using a handheld soil moisture meter.

4.9.3 Saplings

Saplings were monitored every 14 days for the planting bag trials and once per season for the field trials. Planting bag trial saplings were monitored with regards to their soil pH and soil moisture content to determine watering requirements using a handheld soil moisture meter.

The following parameters were recorded for each sapling transplanted as part of the field trials:

- Height of sapling
- Width of sapling canopy
- Height of first leaves
- Leaf shedding (as percentage)
- Number of stems at ground level

- Condition (health) of the sapling on a scale of 1-5 [5 = good / 1 = poor]
- Evidence of predation and/or browsing (insect or fauna) on a scale of 1-5 [5 = slight / 1 = severe]

4.10 Statistical Data analysis

Data for the respective trials undertaken as part of this study were consolidated in a database (Excel spreadsheet). PCOrd version 7.10 was used for statistical analyses using two-way dendrograms and matrix coding to show the hierarchical relationship between the soil types used. Principal Component analyses (PCA) were used to indicate associations between the weekly germination of seeds and the soil types, amelioration applied, seed age and the sowing season. A PERMANOVA supported this PCA to compare the difference in germination success with regards to amelioration, soil type and seed age as well as the interactions between these. p-values below 0,05 are regarded as significant.

A Sorenson distance measure or Non-metric Multidimensional Scaling (NMS) were used to determine significant regression and correlation for the survival monitoring dataset of all cuttings and saplings in field trials by Week 20. This was preceded by a Multi-Response Permutation Procedure (MRPP) used to address imbalances in the datasets. While data representation with NMS stress values below 20 on its scree plot is still regarded as useful, values below 10 is regarded as a good representation.

CHAPTER 5 RESULTS

5.1 Introduction

This chapter presents the findings and results obtained during this study. As stated, the hypothesis is that the cultivation of *B. albitrunca* from fresh seeds with limited environmental stress and suitable amelioration methods will improve the recruitment and contribute to the rehabilitation of sustainable populations in previously disturbed areas over the long-term in the southern Kalahari.

5.2 Soil properties

5.2.1 Soil texture

Soil analysis for soil texture was conducted with regards to the particle distribution sizes listed in section 4.8. The respective soil samples analysed were grouped into four groups (Table 5-1). The soil group named Nat_Rec comprises samples collected at sites along the dryland rehabilitation of servitude where *B. albitrunca* saplings were naturally recruited after removal for the construction of the Kgalagadi pipeline; S&C_Tr comprises samples used in planting bags and -trays of the seed and cutting trials; and Veld_Tr samples analysed for sites where saplings cultivated as part of the planting bag trials and additional sourced saplings were transplanted after hardening (i.e., field trials). Soil collected from areas/sites with dense natural stands of mature *B. albitrunca* within the study area is regarded as part of the Optimal soil group (Optimal).

Table 5-1: Abbreviations used for soil groups based on the respective trials undertaken (soil sample abbreviations/names listed in Appendix A)

Abbreviation	Description
Nat_Rec (Δ)	Natural recruitment
Optimal (▲)	Optimal areas/sites
Veld_Tr (▼)	Field trials
S&C_Tr (∇)	Seed and Cutting trials

The mean and standard deviation of the soil groups are summarized in Table 5-2 and Table 5-3. The OPTI soil sample forms part of the optimal soil group (Optimal) as well as the seed and cutting trial (S&C_Tr) soil group (as illustrated by the blue box in Figure 5-3) since this soil type was also used as base material in planting bag trials.

All soil groups consisted of a mean of more than 80% total sand, between 8,89% and 11,51% clay and less than 6,17% silt (Table 5-2). Similar mean silt percentages were recorded for the natural recruitment (Nat_Rec) and seed and cutting trial (S&C_Tr) groups. These groups also had the highest silt content among all groups. A very high variability in the Fine sand fraction of the S&C_Tr soils were recorded.

With regards to the colour coded groups, the natural recruitment (Nat_Rec) group's HAL1 and HAL2 samples were most similar, with the GRV1 sample in the same group having almost 10% more clay than these samples. The samples of the seed and cutting trial (S&C_Tr) group were distinct from each other. The CTRL sample had more than 20% clay and 32% fine sand compared to the 7% clay and 56% fine sand of the OPTI sample, hence this group's high standard deviation of 9,62 for clay content and 23,55 for fine sand content respectively (Table 5-2). No clear grouping of soil types with regards to the predefined four soil groups could be identified. This was expected, given that in a study area covering almost 800 000 ha, soils are bound to differ based in textural composition.

Looking at the soil samples, the predominant component in all samples were sand, comprising more than 70% of each sample, with clay particles following, and a smaller proportion of silt particles (Table 5-3).

Soil of the KGOF and EVOF sites were found to have the coarsest soil textures with 24% coarse sand particles (> 0,5 mm). All soil samples had more than 70% total sand content, with a varying ratio of fine (> 0,125 mm) to coarse (> 0,5 mm) sand particles (Table 5-3). The highest clay contents were observed for the Gamagara River (GRV1) and Control (CTRL) soil samples, equating to almost a fifth of their particle size distribution (Table 5-3).

Table 5-2: **Mean and standard deviation of the soil texture classes per colour coded soil group**

		Clay	Silt	Coarse Sand	Medium Sand	Fine Sand	TOTAL SAND
Nat_Rec	**Mean**	11,51	6,17	9,33	18,46	54,56	82,34
	Standard Deviation	5,51	0,74	6,02	9,99	7,13	6,27
Veld_Tr	**Mean**	9,86	4,78	12,55	21,95	51,03	85,53
	Standard Deviation	3,27	3,03	7,16	6,44	9,97	6,13
Optimal	**Mean**	8,89	3,93	13,38	18,13	56,31	87,82
	Standard Deviation	1,95	1,72	5,06	0,90	7,53	4,58
S&C_Tr	**Mean**	13,79	6,17	14,12	19,13	48,26	81,51
	Standard Deviation	9,62	5,80	6,51	1,34	23,55	15,77

Table 5-3: **Soil texture results indicating particle size distribution per soil sample. Soil groups are colour coded. Data bars compare percentage per site and not per texture class.**

Nat_Rec | Optimal | S&C_Tr | Veld_Tr

ID	% clay	% Silt	% fine sand	% medium sand	% coarse sand
GRV1	18	7	63	8	4
HAL1	8	6	50	28	8
HAL2	8	6	51	19	16
KPAN	14	7	49	22	9
TAMA	11	5	48	25	10
WITL	6	3	63	22	6
GRV2	14	11	52	15	8
KPK1	9	3	45	33	10
KGOF	11	4	36	25	24
EVOF	5	2	49	21	24
CHER	10	2	67	13	9
MARS	11	6	53	19	11
EDEN	9	4	51	17	19
OPTI	7	2	65	18	10
CTRL	21	10	32	20	19

The trilinear diagram or soil textural triangle illustrates the percentage distribution of soil fractions silt, sand and clay on the three axes to classify each sample according to their soil textural class. A total of three (3) samples were classified as sand (WITL, EVOF and OPTI), eight (8) as loamy

sand (HAL1, HAL2, TAMA, KPK1, KGOF, MARS, EDEN and CHER), three (3) as sandy loam (GRV1, KPAN and GRV2) and one (1) as sandy clay loam (CTRL) (Figure 5-1).

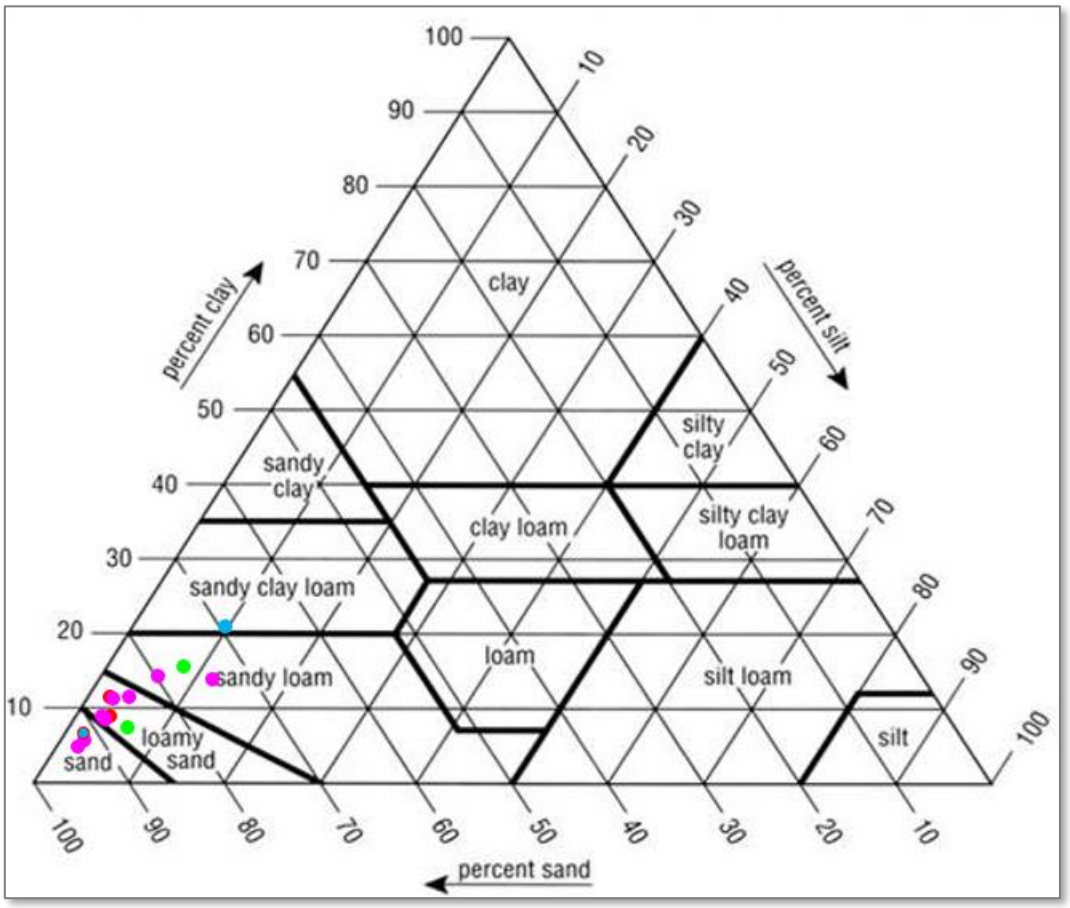

Figure 5-1: **Soil textural triangle (USDA-NRCS, 2017) or trilinear diagram of the 15 soil samples colour-coded according to the four soil groups: Pink = Veld_Tr; Green = Nat_Rec; Red = Optimal; Blue = S&C_Tr and OPTI soil sample as blue with a red border since it can be classified as both Optimal and S&C_Tr**

5.2.2 Soil chemistry

Results regarding soil chemistry are presented per parameter: pH and electrical conductivity (EC). Electrical conductivity is expressed as millisiemens per metre (mS/m) and pH as numerical values. All results are presented in relation to the parameter ranges for arid area vegetation establishment as defined by van Deventer (as cited by Neethling, 2016) (Table 5-4).

Table 5-4: Chemical analysis parameter ranges for arid area vegetation establishment (Van Deventer as cited by Neethling, 2016)

pH	EC (mS/m)
5,0 - 8,5	< 200

5.2.2.1 Acidity/ alkalinity (pH)

The pH of the soil samples for the 15 samples analysed ranged between 6,0 and 8,3; with a standard deviation of 0,6 and a mean pH of 7,5. These soils hence consist of slightly acidic to slightly alkaline soils, all within 1,5 logarithms of the optimal pH range for vegetation establishment.

Given their pH values of 6,96; 6,97 and 5,96 respectively, CHER, OPTI and EDEN soil samples were the only samples within the optimal pH range (pH 5,5 – pH 7,0) for vegetation establishment (Figure 5-2).

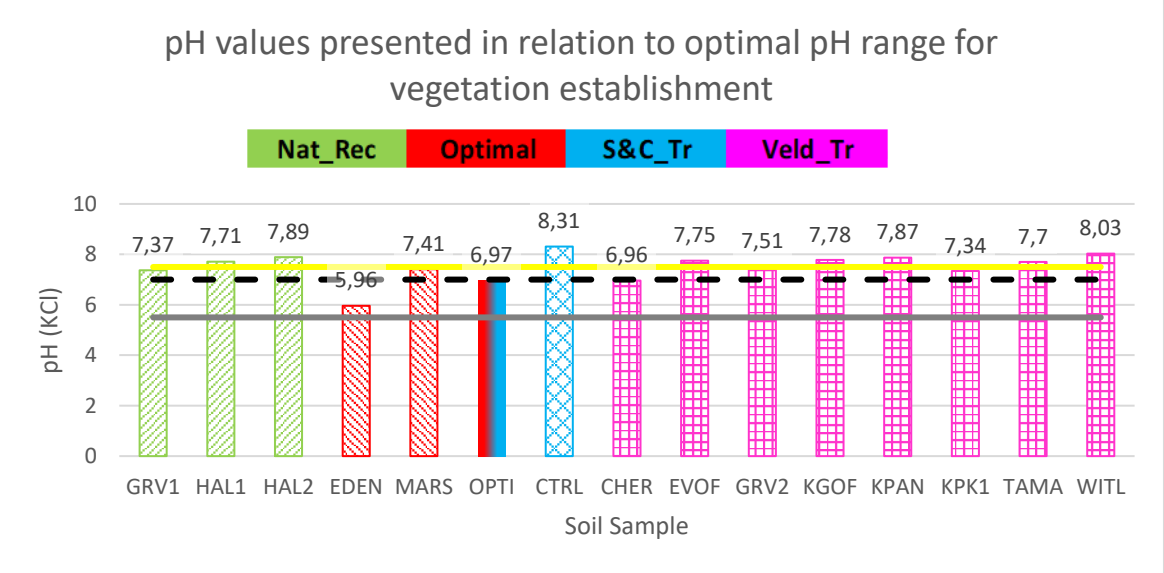

Figure 5-2: pH values presented in relation to optimal pH range for vegetation establishment (5,5 to 7): The maximum arid area plant production threshold value is indicated with the dashed black line, minimum with the grey solid line and the mean (7,5) of all samples with the yellow line

5.2.2.2 Electrical conductivity (EC)

Electric conductivity is the ability of soils to conduct an electrical current (Brady & Weil, 2014) and is generally below 200 mS/m for plant production in arid areas (Neethling, 2016). The CTRL sample is the only sample exceeding the maximum EC threshold for vegetation establishment by 585 mS/m (Figure 5-3).

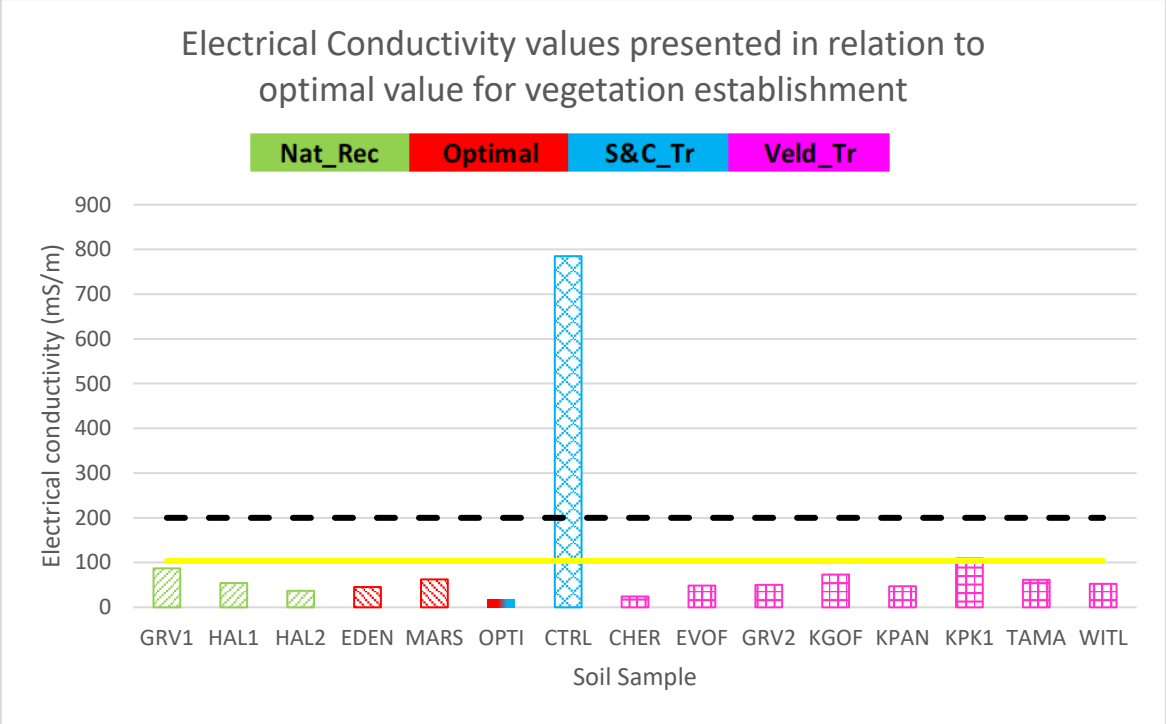

Figure 5-3: Electrical conductivity values presented in relation to the maximum value (dashed line) for optimal vegetation establishment (200 mS/m) and the mean of all soil samples (103 mS/m) in yellow

5.2.3 Soil nutrients

Results regarding soil chemistry are presented per soil nutrient: Calcium (Ca) and Magnesium (Mg), Potassium (K) and Sodium (Na). All nutrients are expressed as mg/kg with organic carbon expressed as percentage. All results are presented in relation to the parameter ranges for arid area vegetation establishment as defined by van Deventer (as cited by Neethling, 2016) (Table 5-5).

Table 5-5: Soil nutrient parameter ranges for arid area vegetation establishment (Van Deventer as cited by Neethling, 2016)

K	Ca	Mg	Na	Org C
(mg/kg)				%
> 50	> 200	> 50	< 25	> 0,5

5.2.3.1 Potassium (K)

All soil samples exceeded the minimum arid area plant production target value of 50 mg/kg with the exception of the EVOF sample (Figure 5-4). Soils of the GRV1 and CTRL samples had the highest Potassium content, with the CTRL sample exceeding 25 000 mg/kg.

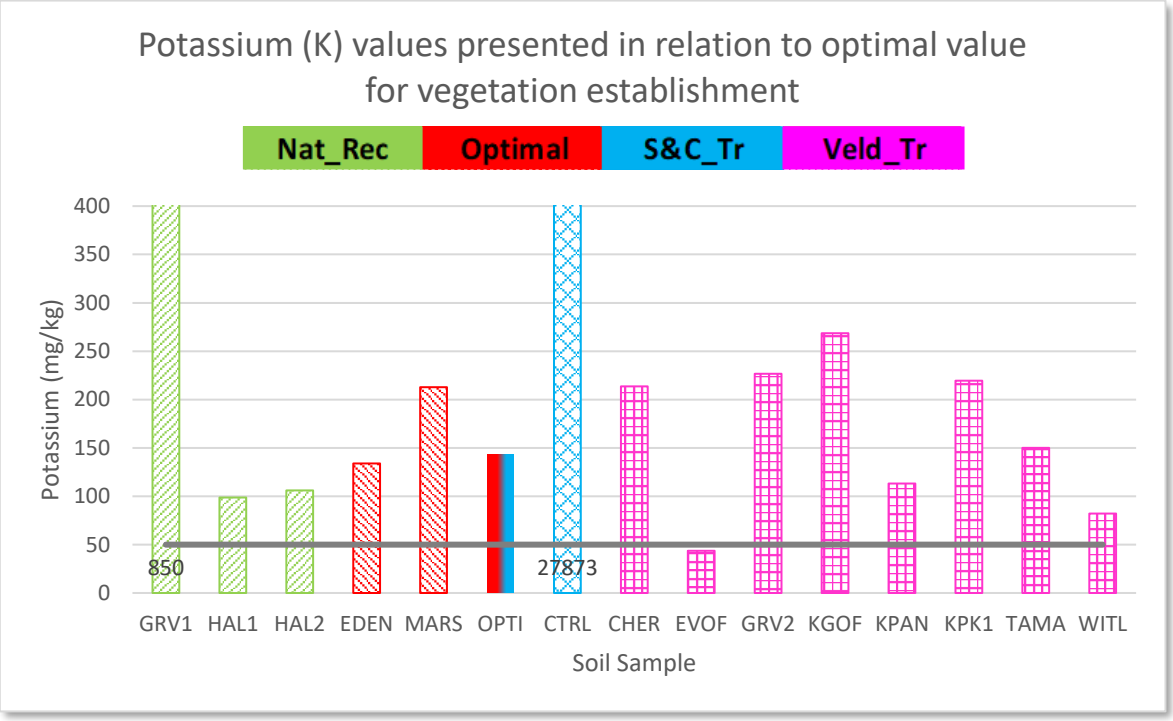

Figure 5-4: Potassium (K) content presented in relation to arid area plant production target value for optimal vegetation establishment (50 mg/kg) indicated by the solid grey line (mean of all soil samples = 2 049 mg/kg)

5.2.3.2 Calcium (Ca)

The calcium concentration of all soil samples was above the minimum required concentration of 200 mg/kg with a mean value of 3 848 mg/kg (Figure 5-5). No calcium deficiencies were hence recorded for any of the samples, despite the optimal (Optimal) as well as the seed and cutting trial (S&C_Tr) colour coded groups having calcium concentrations relatively low compared to the mean of all samples.

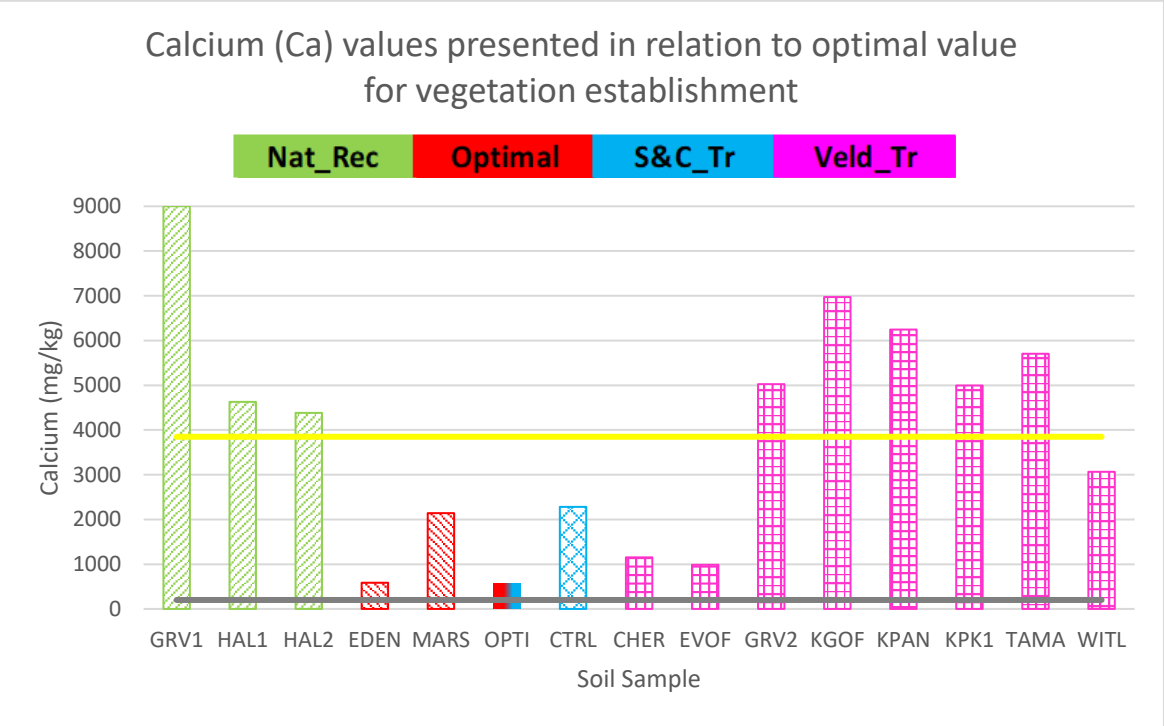

Figure 5-5: Calcium (Ca) content presented in relation to the minimum value for optimal vegetation establishment (200 mg/kg) indicated by the solid grey line and the mean of all soil samples (3 848 mg/kg) indicated by the yellow line

5.2.3.3 Magnesium (Mg)

Magnesium content of the samples ranged between 4 mg/kg and 1730 mg/kg. The EVOF soil sample was the only sample with magnesium content below the prescribed arid area plant production target of 50 mg/kg, with a deficiency of 46 mg/kg (Figure 5-6).

All soil groups besides the optimal group (Optimal) had at least one sample that exceeded the mean magnesium content. The optimal soil group had the lowest mean magnesium content of 144 mg/kg.

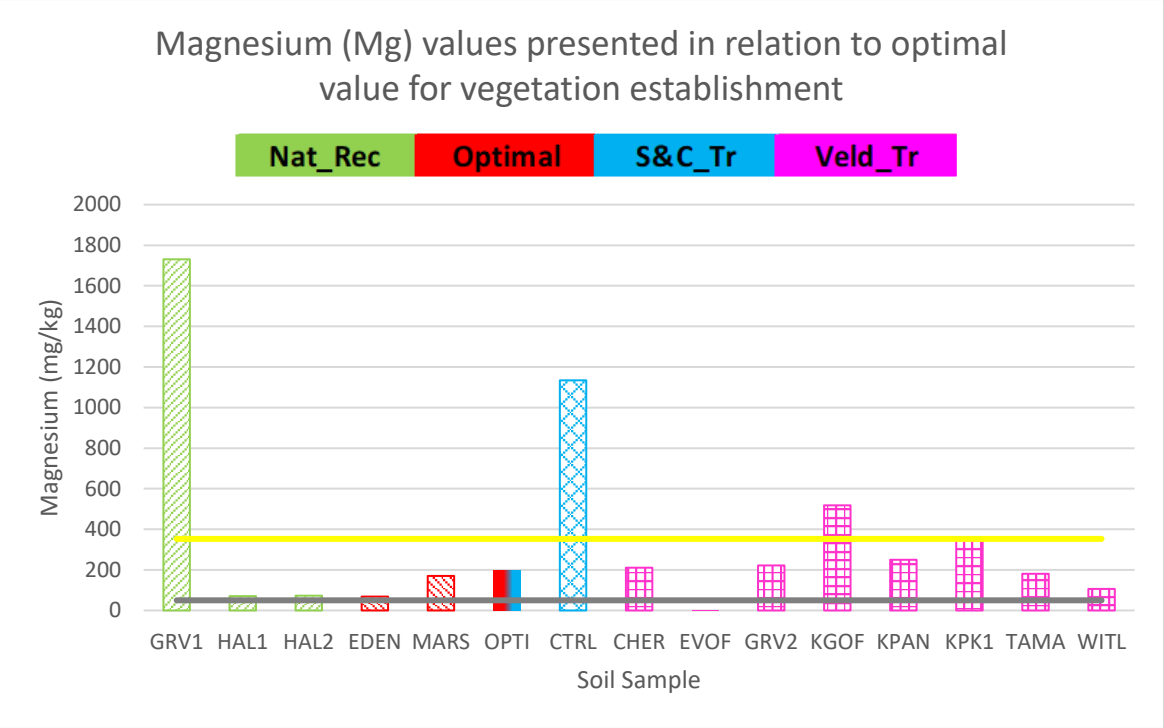

Figure 5-6: **Magnesium (Mg) content presented in relation to arid area plant production target (50 mg/kg) for optimal vegetation establishment indicated by the solid grey line and mean of all soil samples (353 mg/kg) indicated by the yellow line**

5.2.3.4 Sodium (Na)

Sodium levels recorded ranged between 1 mg/kg and 8 578 mg/kg, with soil samples GRV1, OPTI, CTRL and CHER significantly exceeding the arid area plant production target threshold of 25 mg/kg (Figure 5-7).

Exceedances above the maximum plant production target value of 25 mg/kg was recorded across all soil groups, with both samples of the seed and cutting trial (S&C_Tr) group exceeding this target value.

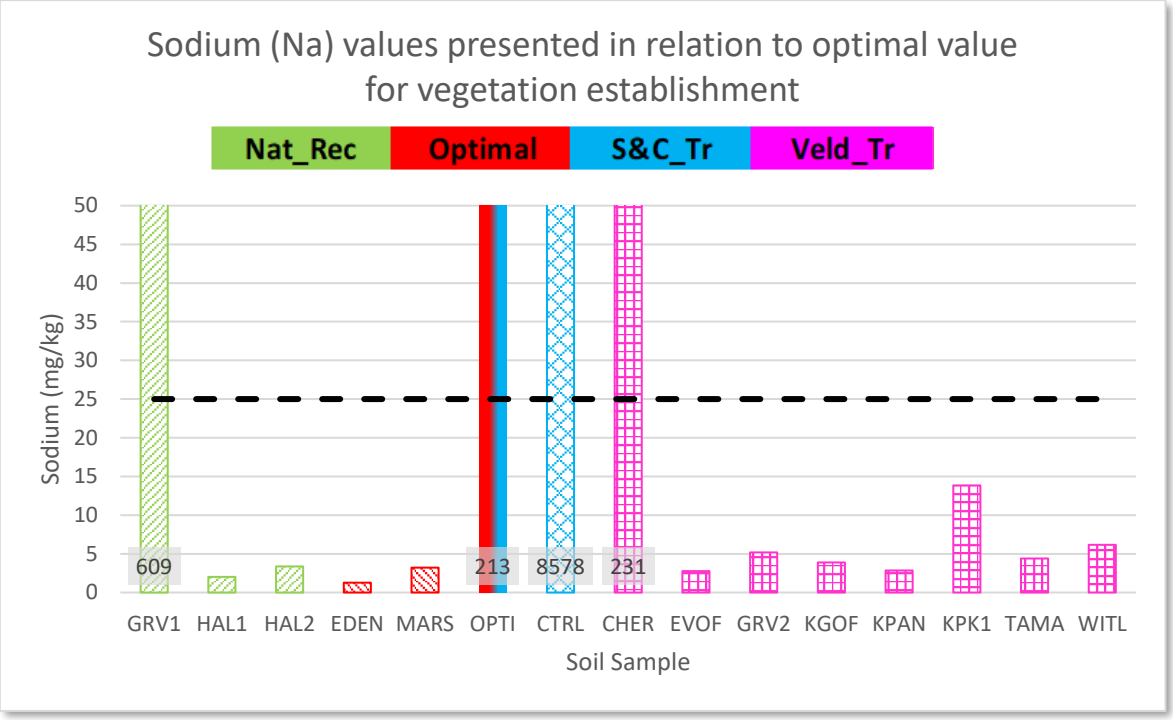

Figure 5-7: **Sodium (Na) content presented in relation to arid area plant production target (< 25 mg/kg) for optimal vegetation establishment indicated by the dashed black line (mean of all soil samples = 645 mg/kg)**

5.2.4 Summary of soil chemical, nutrient and textural properties

The soil chemistry and textural classes were compared for all 16 soil samples collected based on 17 variables which include five textural classes, 2 chemical components and 10 soil nutrients. The means and standard deviations of these variables are summarised in Table 5-6 below.

Very high heterogeneity are found among groups with regards to their calcium, sodium and potassium contents. Samples are further heterogeneous with regards to their magnesium and sulphur content, as well as their electrical conductivity.

Highlighting important plant macro nutrients, calcium content ranges between 564 mg/kg and 9001 mg/kg, whilst magnesium content ranges between 4 mg/kg and 1730 mg/kg (Table 5-6). The highest mean calcium content was recorded for the soils of the natural recruitment (Nat_Rec) group, and the highest magnesium content for the seed and cutting trial (S&C_Tr) group's soils. The latter further had the highest sodium and potassium contents.

Sodium ranges were between 1,27 mg/kg and 8578,46 mg/kg with a standard deviation of more than 2200. The veld trial (Veld_Tr) group has the lowest mean sodium of 33 mg/kg compared to the seed and cutting trial (S&C_Tr) group's maximum sodium content of 4395 mg/kg.

Organic carbon is moderate (mean %OC = 1,48) across all sites, with a standard deviation of 1,64. The moderate mean is mainly due to the KGOF, CTRL and KPAN samples having above average values, increasing the mean of the sample set.

Table 5-6: Means, standard deviation and range per chemical and textural variable (focus variables listed in section 4 are indicated in bold)

Variable	Mean	Standard deviation	Minimum	Maximum
NO3	7,43	6,46	1,00	20,80
Ca	3848,30	2562,87	564,76	9001,66
Mg	352,72	470,06	4,01	1730,58
Na	645,35	2200,85	1,27	8578,46
K	2049,03	7146,62	43,63	27873,42
S	198,75	494,00	2,78	1525,11
pH (KCl)	7,50	0,56	5,96	8,31
Ca: Mg	22,12	37,29	1,23	150,02
Mg:K	3,52	2,12	0,13	7,07
%OC	1,48	1,64	0,35	6,21
%OM	2,54	2,83	0,60	10,71
EC	103,60	189,89	16,59	785,00
Clay	10,72	4,30	4,90	20,60
Silt	5,25	2,75	2,00	11,20
C_Sand	12,48	6,28	4,30	24,00
M_Sand	20,35	6,20	8,00	33,20
F_Sand	51,50	10,02	31,60	66,80

The two-way dendrogram in Figure 5-8 (bottom left) graphically display the hierarchical relationships among soil samples. The dendrogram depict the 16 soil samples, colour coded according to the four (4) soil groups with the 17 variables associated with each sample.

The two-way dendrogram (Figure 5-8) on the bottom left consists of leaves (horizontal lines) and clades (vertical lines) connecting multiple leaves, with longer leaves indicating greater differences between the soil samples.

The cumulative variance of data was 65% with 35% data remaining which provided sufficient definition of clades for interpretation. Six distinct clades were visible:

1. GRV1;
2. HAL1 and HAL2;
3. KPAN, TAMA, WITL, KGOF, GRV2, CHER, EVOF and KPK1;
4. EDEN and OPTI;
5. MARS; and
6. CTRL.

None of the colour coded groups were found distinctly similar to the samples within the group with regards to their textural, nutrient or chemical properties.

The CTRL, MARS and GRV1 samples in clades 1, 5 and 6 are on their own leaves at 65% information remaining or simplicifolius, meaning that these samples are substantially different and hence considered distinct from all other soil clades with regards to their soil chemical and textural classes.

Whether the trial were undertaken in terrestrial or aquatic habitats (Terres and Aqua) does not reflect in the colour coded soil groups (Nat_Rec; Optimal; S&C_Tr and Veld_Tr) or in the clades identified at 65% data remaining (clades 1-6 listed above).

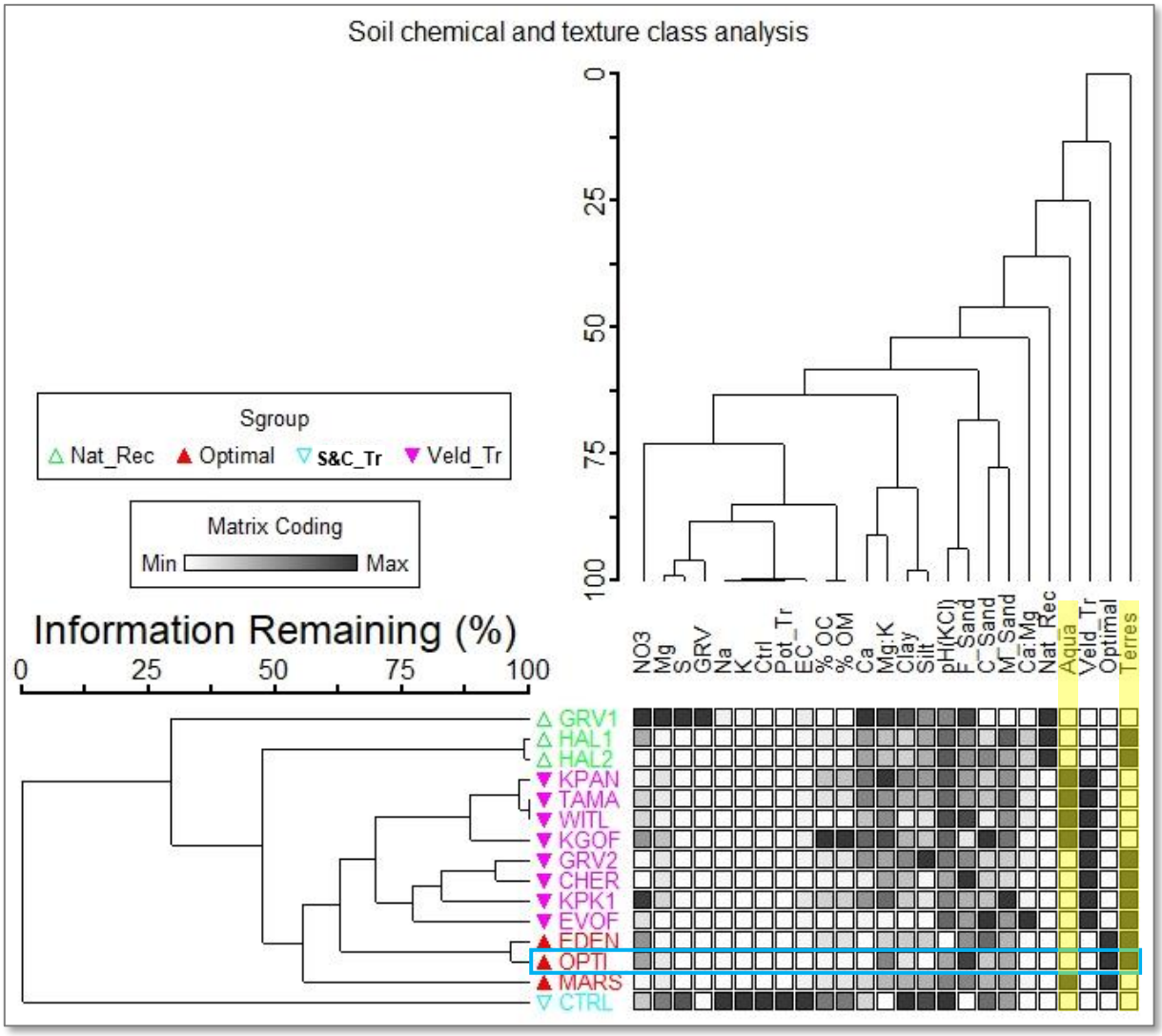

Figure 5-8: **Two-way dendrogram showing the hierarchical relationships among soil samples: All soil samples are colour-coded according to the four soil groups (Sgroup) with OPTI that can be grouped as part of both the Optimal and S&C_Tr group (as indicated by the blue box). Greyscale matrix coding (bottom right) indicate values from high (black) to low (white). Vertical lines indicate group associations and horizontal lines show the distinctiveness of the groups. Aquatic (Aqua) or terrestrial (Terres) grouping based on the habitat samples were collected from is indicated in Yellow**

5.3 Germination of *Boscia albitrunca* seeds

Germination success of *B. albitrunca* seeds were tested to evaluate the influence of amelioration, seed age, soil type and sowing season. *Boscia albitrunca* seeds took a minimum of six to nine weeks to germinate, except for a single seedling recorded emerging during week 4 in an ameliorated planting bag with potting soil (BPA10) of the Bedrog fermented trials. Bedrog' fermented trial (Old seed trial [OLD]) had no seeds that germinated during weeks 6 to 21 and are hence excluded from Table 5-7 (mean seed germination = 0).

Table 5-7 was supported by multivariate analyses (PCA's) (Figure 5-9 to Figure 5-12). Amelioration, seed age, soil type and sowing season were used as the grouping variables to evaluate the germination results. The germination results were the germination percentage per week (n = 16) of all seed planting bag trials (n = 96) and all seed planting tray trials (n = 24 with the 4 planting trays divided into ten seeds each for data correlation). The first two ordination axes accounts for 100% of the variability in the data (97% on axis 1 and 3% on axis 2). The PCA is statistically significant, and the distribution of germination results is greater than what would be expected by chance (p = 0,001).

Planting bags and trays (n = 120) are illustrated as dots or circles in the multivariate space, and weeks as lines in an anti-clockwise order around the graph centroid. Zero is truly zero and not a replacement for blank or missing data. Environmental variables not accounted for (e.g., predation and drought) are potential variables that may affect the results.

The first assessment assessed whether **amelioration** improved seed germination by testing two amelioration designs: untreated and ameliorated. Ameliorated and untreated planting bags had no clear groups in the ordination space with most of the seed germination occurring close to the graph centroid (Figure 5-9). Both amelioration designs had similar mean seed germination (Ameliorated=13,43; Untreated=12,20) and standard deviation from the mean (Ameliorated=8,37; Untreated=8,36) (Table 5-7).

The second assessment assessed whether **sowing season** affects germination. The PCA ordination graph presents germination values per week according to three sowing seasons: early spring (EarlSpr), early summer (EarlSum) and late summer (LateSum) (Figure 5-10).

Sowing conducted during the early summer season (EarlSum) used the fermented Bedrog seeds (Old seed trial [OLD]) and hence had no germination between weeks 6 and 21 and is therefore not visible in the ordination space.

A small overlap in ordination space was evident for early spring (EarlSpr) and late summer (LateSum) close to the PCA centroid. The planting bag trials conducted during late summer (LateSum) had a larger germination dispersal and variance along Axis 1 than those conducted during early spring (EarlSpr). Early spring (EarlSpr) germination were similar for all planting bags while late summer germination varied for different planting bags. The two sowing seasons, early spring (EarlSpr) and late summer (LateSum) had high variation in mean germination (EarlSpr=4,08; LateSum=17,19) and standard deviation from the mean (EarlSpr=6,44; LateSum=9,33) indicating high variability in mean germination with regards to sowing season (Table 5-7).

The third assessment assessed whether **seed age** improved germination. The PCA ordination graph presents germination values per week according to four seed ages (Figure 5-11):

- OLD (split into OLDa and OLDb)
    - Seeds stored for approximately six months (Bedrog fermented seed trial)
- YOUNG
    - Seeds stored for approximately one month
- V_OLD
    - Seeds stored for approximately eight months
- X_OLD
    - Seeds stored for approximately 11 months

OLD seeds are illustrated as OLDa and OLDb to ensure a balanced dataset since this specific seed age trial had double the amount of planting bags (n = 48). No germination was however recorded for this trial (Bedrog fermented seed trial) and hence no dots are visible in the ordination space.

X_OLD and V_OLD seed ages were clustered closer to the data set' mean, with YOUNG dispersed along a gradient, further from any other age. A larger dispersal of the YOUNG seed age along Axis 1 indicates higher variation in the germination of this seed age, followed by the X_OLD seed age. The planting bag trials of the YOUNG seed age had more variety with regard to the number of seeds germinating weekly, than those of the V_OLD and X_OLD seed ages. Higher mean germination was recorded for seeds stored for approximately one month (YOUNG) in the CTRL soil type compared to seeds stored for approximately nine months (V_OLD) and twelve months (X_OLD) which had higher mean germination in the OPTI soil type. This relates to the significant interaction between the soil type and seed age (PERMANOVA p-value of 0,0026).

The high variability of the seed age results can be seen in the PCA (Figure 5-12) where no distinct groups between the different seed ages were found. This is confirmed by the high standard deviation value of 16,57 for YOUNG seeds (Table 5-7). V_OLD and X_OLD seeds were more similar to each other, but not significantly different from young seeds.

The highest mean germination was found using seeds stored for the shortest period of one month (YOUNG) (mean = 29,97) (Table 5-7).

The fourth assessment assessed whether **soil sample** improved germination. The PCA ordination graph presents germination values per week according to two soil types: CTRL and OPTI (Figure 5-11).

The overlap in multivariate ordination space indicates similarities between optimal soil (OPTI) and the control, potting soil (CTRL). All planting bags that are not overlapping in the ordination space are trials that used seeds stored for less than one month (YOUNG), regardless of the soil type.

No obvious separation of groups with regards to the soil sample emerged as both samples are well dispersed throughout the ordination space.

Table 5-7: Mean germination and standard deviation per germination trial type for weeks 6 to 21

Variable	Name	Mean	Standard deviation	Minimum	Maximum
Amelioration	Untreated	12,20	8,36	0,20	21,27
	Ameliorated	13,43	8,37	0,20	20,61
Sowing season	LateSum	17,19	9,33	0,20	23,39
	EarlSpr	4,08	6,44	0,20	16,03
Seed age	YOUNG	29,97	16,57	0,20	41,03
	V_OLD	4,08	6,44	0,20	16,03
	X_OLD	4,41	2,08	0,20	5,74
Soil sample	OPTI	10,90	7,86	0,20	19,91
	CTRL	14,73	8,87	0,20	21,96

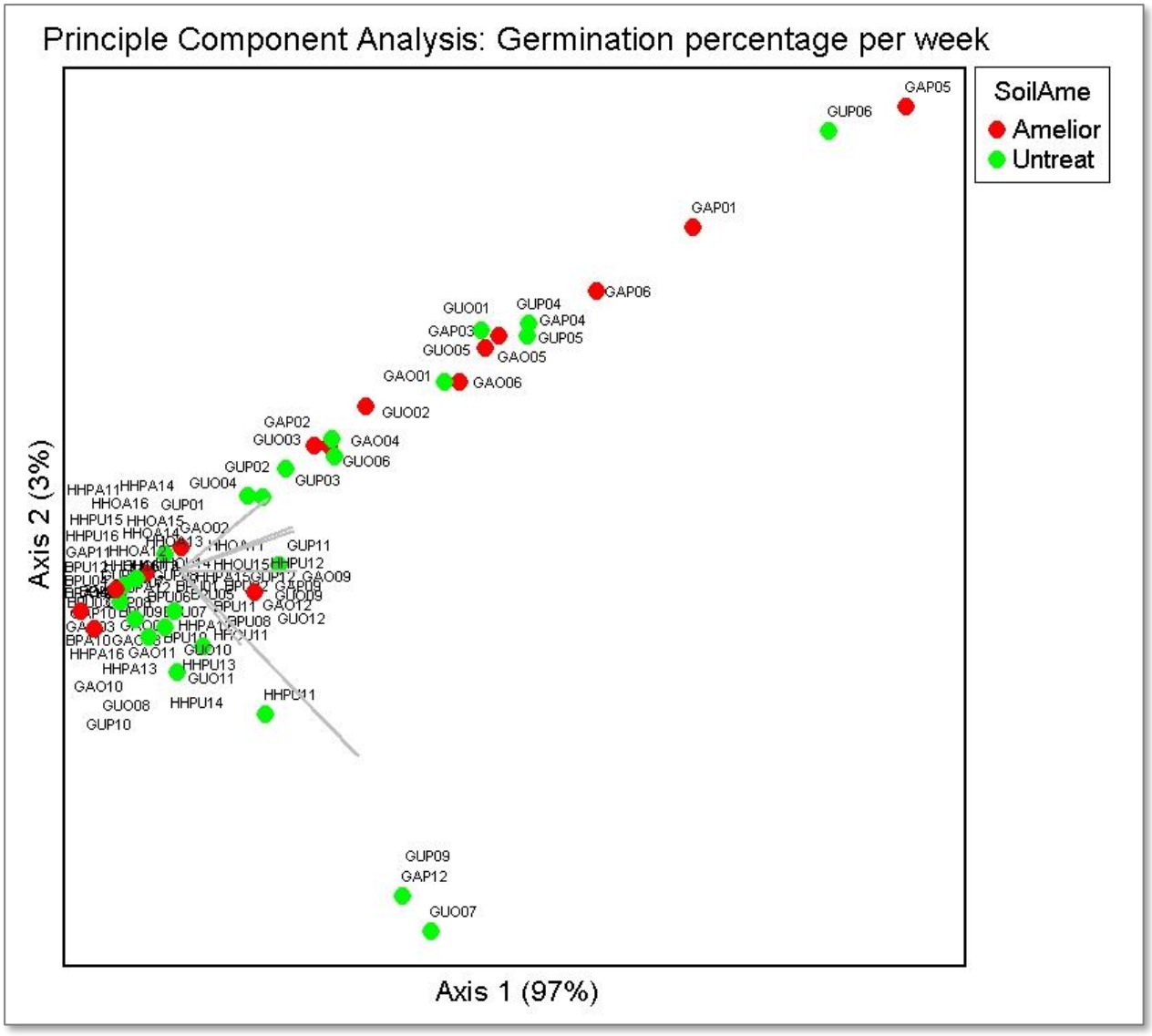

Figure 5-9: **Principal component analysis (PCA) ordination diagram of germination percentage with regards to soil amelioration. Weekly germination percentage is indicated per planting bag/tray. Different soil amelioration designs are indicated by different coloured dots and weeks by grey lines.**

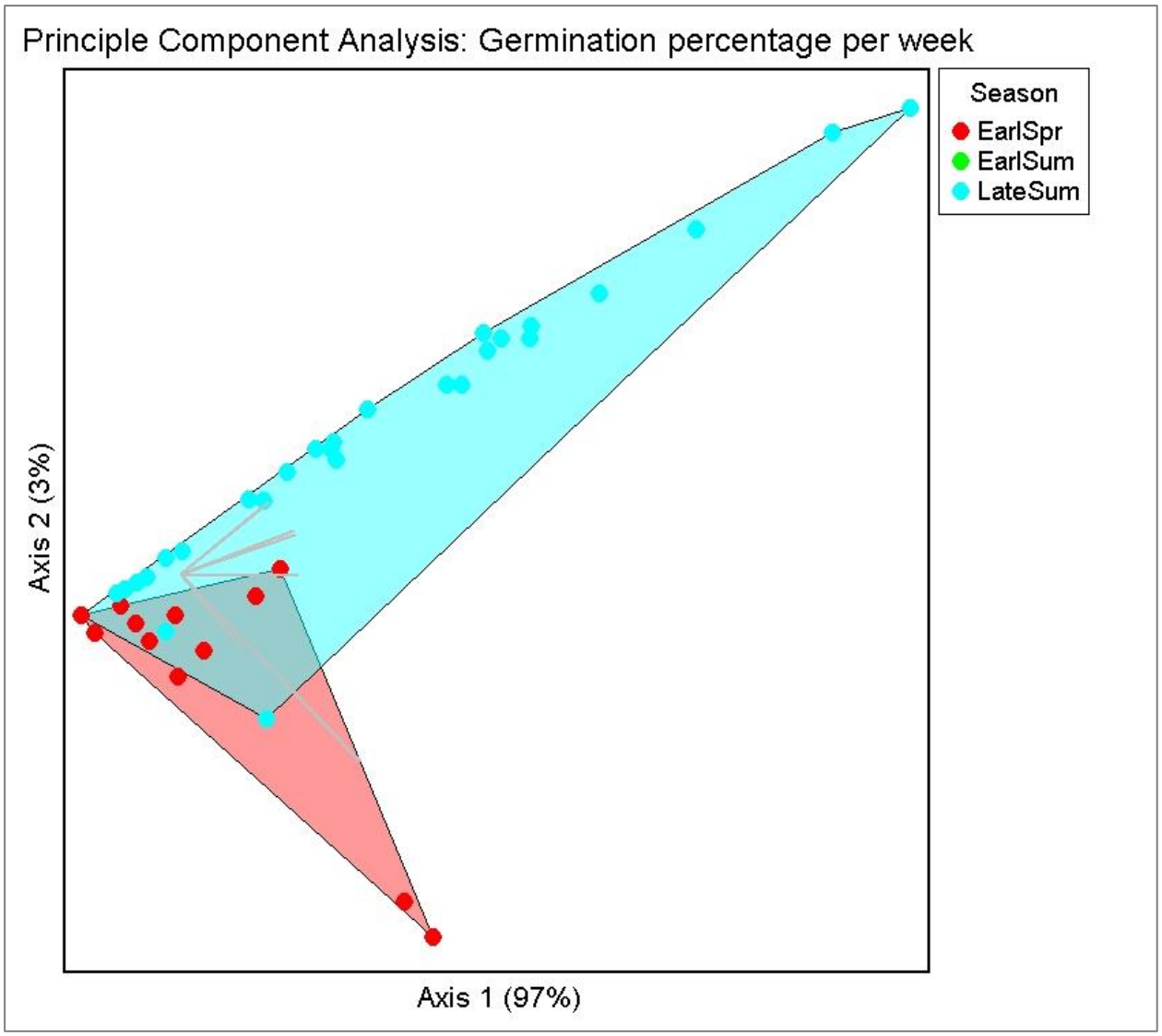

Figure 5-10: **Principal component analysis (PCA) ordination diagram of germination percentage per sowing season. Weekly germination percentage is indicated per planting bag/tray. Different seasons are indicated by different coloured dots and weeks by grey lines.**

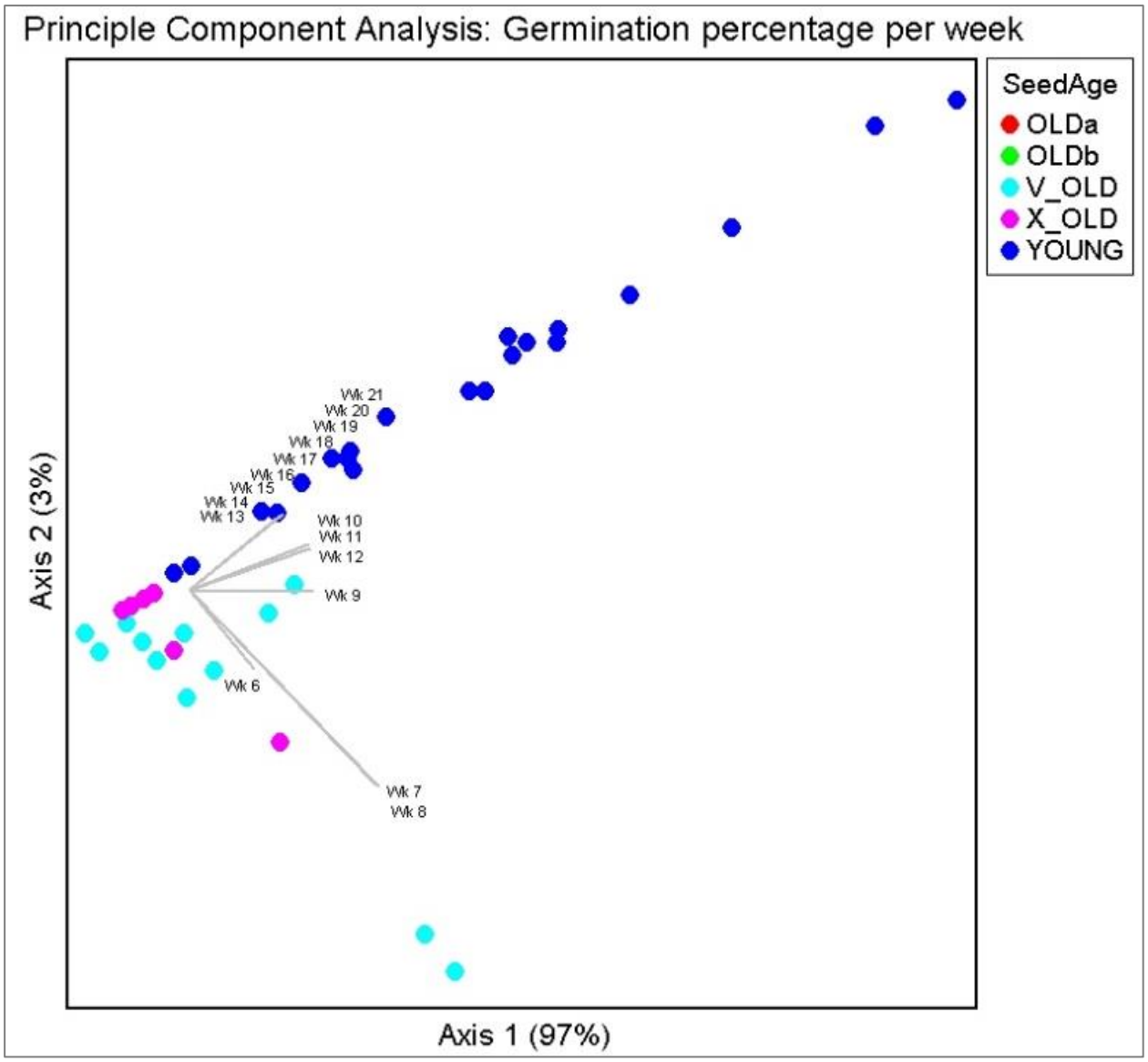

Figure 5-11: **Principal component analysis (PCA) ordination diagram of germination percentage per seed age. Weekly germination percentage is indicated per planting bag/tray. Different seed ages are indicated by different coloured dots and weeks by grey lines.**

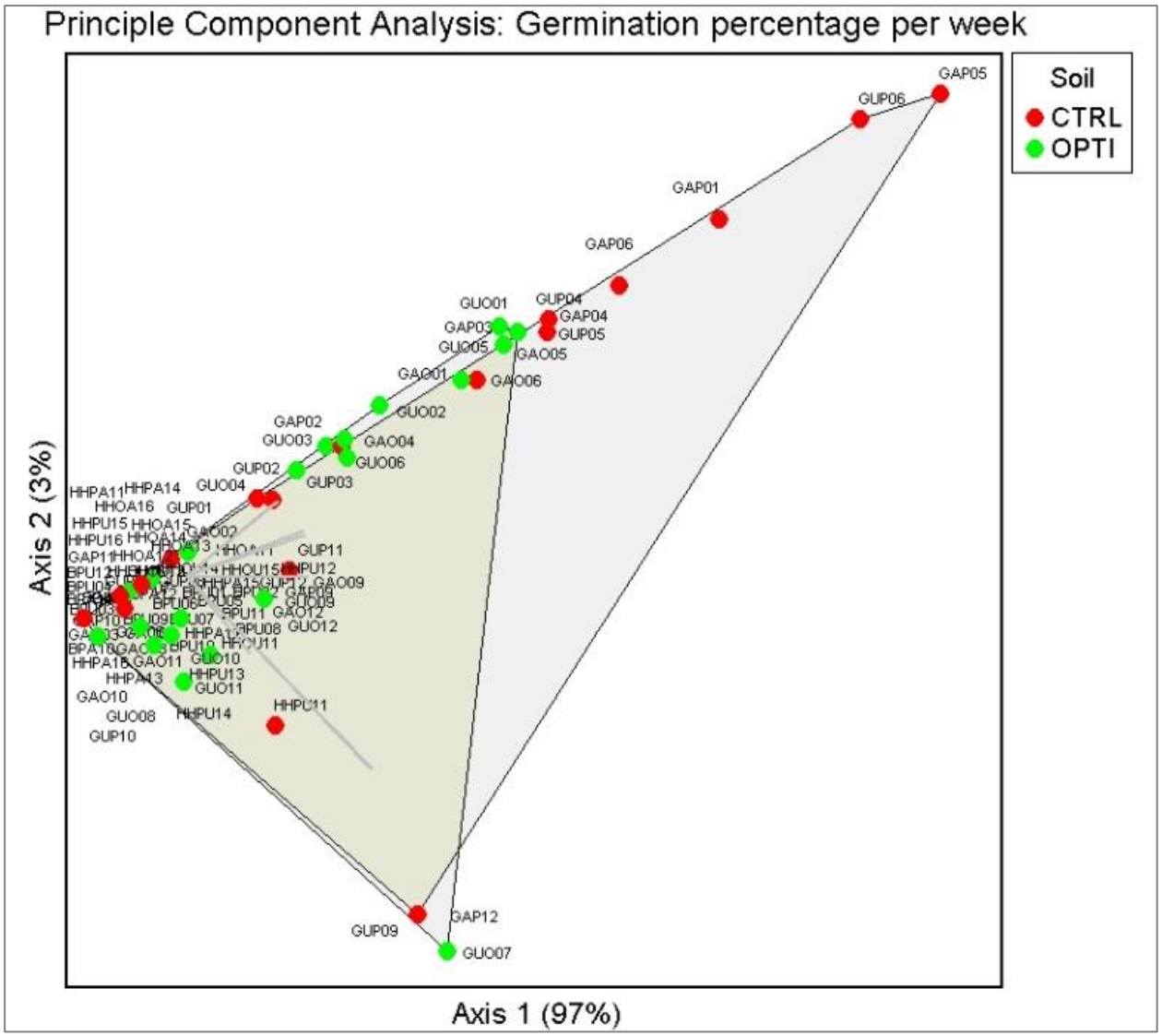

Figure 5-12: Principal component analysis (PCA) ordination indicating germination percentage per soil samples used in planting bags/trays. Weekly germination percentage is indicated per planting bag/tray. Different soil samples are indicated by different coloured dots and weeks by grey lines.

This dataset was further subjected to PERMANOVA testing, which found significance (p-value of 0,0026) for the effect of seed age and the interaction between certain seed ages and soil types. Seed age was the overarching influence affecting germination (p = 0,0002).

Based on the pairwise comparison, comparing the respective seed ages, the following comparisons were significant:

- OLDa vs YOUNG (p = 0,0002);
- OLDa vs V_OLD (p = 0,0002);
- OLDa vs X_OLD (p = 0,0002);
- OLDb vs YOUNG (p = 0,0002);
- OLDb vs V_OLD (p = 0,0002);
- OLDb vs X_OLD (p = 0,0002);
- YOUNG vs V_OLD (p = 0,0002);
- YOUNG vs X_OLD (p = 0,0002); and
- V_OLD vs X_OLD (p = 0,0002).

The only pairwise comparison for seed age that was not significant (p = 1) is OLDa vs OLDb, which both had no germination.

5.4 Seedling and cutting establishment in planting bag trials

A non-metric multidimensional scaling (NMS) using the Sorenson distance measure to determine significant regression and correlation of the dataset (70 planting bags/trays for 12 groups or trials x weekly survival results over 5 weeks) were conducted of percentage survival for both cuttings and seedlings from the seed and cutting trial (Figure 5-13). The period assessed were weeks 4 to 20, in four weekly intervals. To validate the NMS, stress was assessed at different dimensions by means of a Scree plot and Monte Carlo test. Note, though, that seedlings are compared with regards to planting trays (HH*) and planting bags (G*) and not seed age (Figure 5-13). All planting bags and trays with no survival during the assessment period are further excluded from the dataset.

A final stress (cut-off point where a test of the association between points is strong enough to allow a model to be displayed between the two axes) of 0,07 (7%) was recorded over 50 iterations for a 2-dimensional display and interpretation. NMS stress values above 0,20 (20%) on its scree plot should not be used, since they are regarded as invalid (Clarke, 1993). Clarke (1993), however regards a stress between 0,05 (5%) and 0,10 (10%) as viable interpretable results.

The NMS were evaluated to determine which variable (soil amelioration, soil type, sowing season and timeframe) had the most influence on the plant establishment results. The weeks since sowing or planting had the greatest influence on establishment of all variables tested.

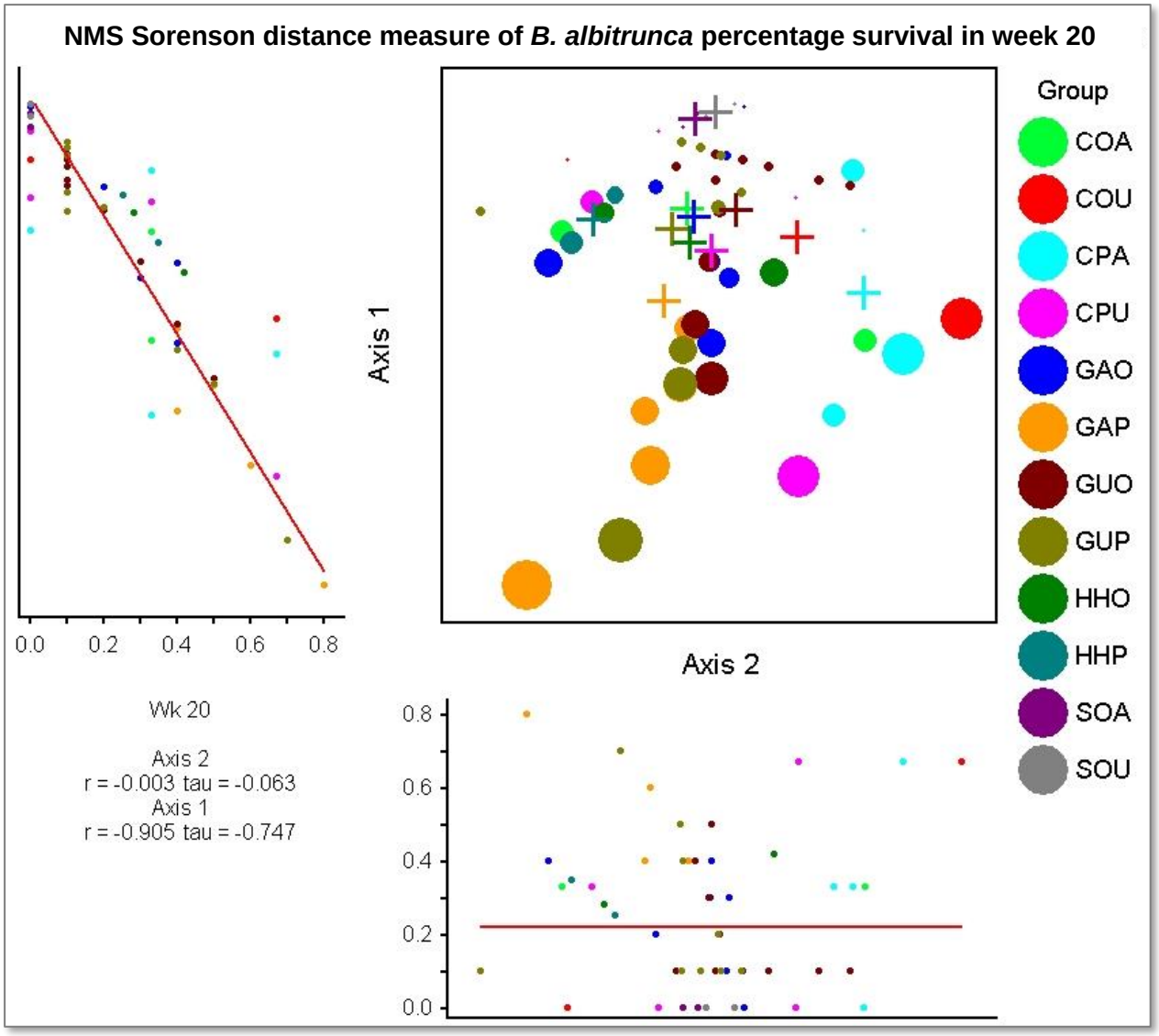

Figure 5-13: **NMS (Sorensen distance measure) of establishment for the seed and cutting trial in Week 20. Pearson's correlation coefficient (r-value) of -0.905 for Axis 1. The line graph on the left illustrates the regression line for the tau-values and r-values at Week 20 (Wk 20). Groups are indicated by distinct colours. Circle sizes indicate percentage establishment (smaller circles have a lower percentage and larger circles have a higher percentage). Group mean is indicated with a cross (+)**

The survival of germinated seedlings and establishing cuttings are respectively illustrated in Figure 5-14 and Figure 5-15 which indicates their survival per planting bag or tray for the seed and cutting trial in monthly intervals. No cuttings from the unsealed stem cutting trial (UC*) or sealed root cutting trial (R*) established or survived in planting bags; hence these are excluded

from the results. Bedrog fermented seed trial (OLD seed age) results are also excluded due to the limited survival of the single seedling that established.

A significantly lower establishment was recorded for small sealed cuttings compared to medium sized cuttings (Figure 5-14). No small cuttings survived past week 16.

Figure 5-14: Average cutting survival per four-week period over five months. Unsealed cuttings are excluded from these results [see Annexure A for a detailed list of trial abbreviations and planting bag names]

The highest survival was recorded for seed stored for the shortest period (YOUNG), although the oldest seed sown in the hothouse planting trays (X_OLD) had higher survival than the seed which was stored for an intermediate period (V_OLD). The oldest seeds sown in hothouse trials (X_OLD) germinated in the shortest period since sowing.

Fluctuation with regards to seedling (and later sapling) survival was lower than that of cuttings (Figure 5-14 and Figure 5-15).

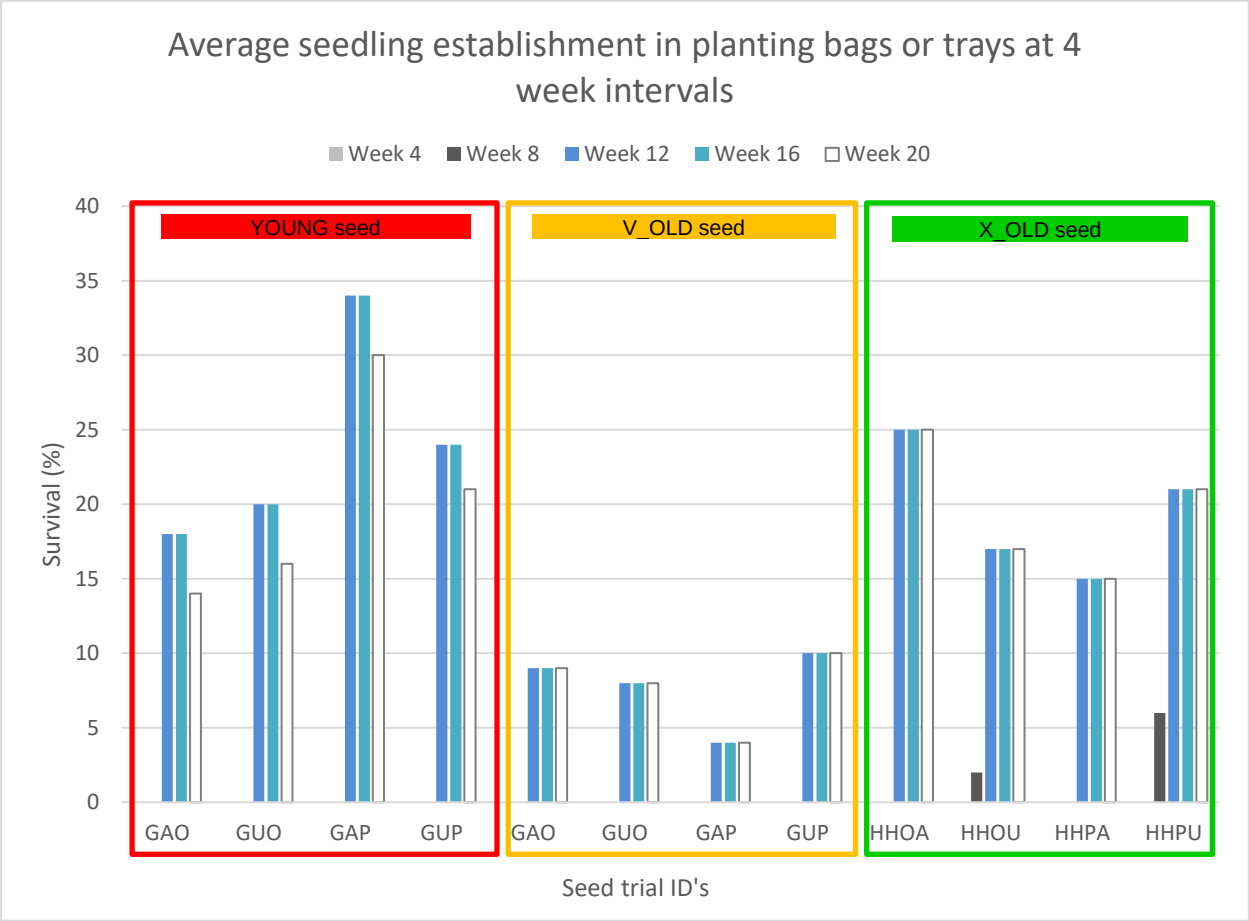

Figure 5-15: Average seedling (and later sapling) survival per four-week period over five months. Fermented seeds are excluded from these results [see Annexure A for a detailed list of trial abbreviations]

Sealed cuttings that produced no leaves and/or lacked any signs of above ground growth still had what appeared to be root development during the monitoring period prior to hardening (Figures 5-16 and 5-17). These structures are regarded as adventitious roots since they lack callus tissue and develop from stem nodes. Cuttings planted during the unsealed cutting trial had no signs of growth or root development (Figure 5-18).

Figure 5-16: **Adventitious root development of sealed cutting after 16-week monitoring period prior to hardening: This cutting showed no signs of above-ground growth although adventitious roots were starting to form below ground**

Figure 5-17: **Growth of a sealed cutting of which all wounds or cutting edges were sealed prior to planting after 6 weeks**

Figure 5-18: Unsealed cuttings of the first cutting planting bag trial removed after 20 weeks showed no signs of growth and/or root formation

5.5 Field trials

Saplings from seed and cuttings trials was transplanted to field trials after hardening. No cuttings were transplanted from the seed and cutting trials since no cuttings were able to survive hardening. Cuttings were however planted directly as part of field trials. These cuttings planted directly into the ground, irrespective of whether the wounds or cutting edges were sealed or left unsealed, showed no signs of growth, hence these cuttings were excluded from the results.

A total of 251 saplings were transplanted to eight different planting areas after hardening. All transplantations was done during winter season. After 18 months of monitoring, the highest percentage survival was found at area Chertsey (CHER). Chertsey's survival exceeded the mean survival of 21% by more than 60%. This site received below average number of saplings (32 average planted per site) but had an above average survival rate. Tamaga (TAMA) had the second highest survival rate which exceeded the mean survival by more than 50%, despite not having any water retention hydrogel applied. The highest mortality rate was recorded at the Kathu Pan site (KPAN) where no saplings survived the 18 month period.

The application of the water retention hydrogel did not enhance the survival of saplings after transplantation (Figure 5-19). A total of 50% survival was obtained for cultivated saplings transplanted in field trials without the addition of the water retention hydrogel compared to the 12% survival of sourced saplings which had the addition of the hydrogel.

These results are inconclusive and could not be statistically analysed because of the total number of saplings varying amongst the eight sites (range between 10 and 80). It could therefore not be directly compared in a T-test.

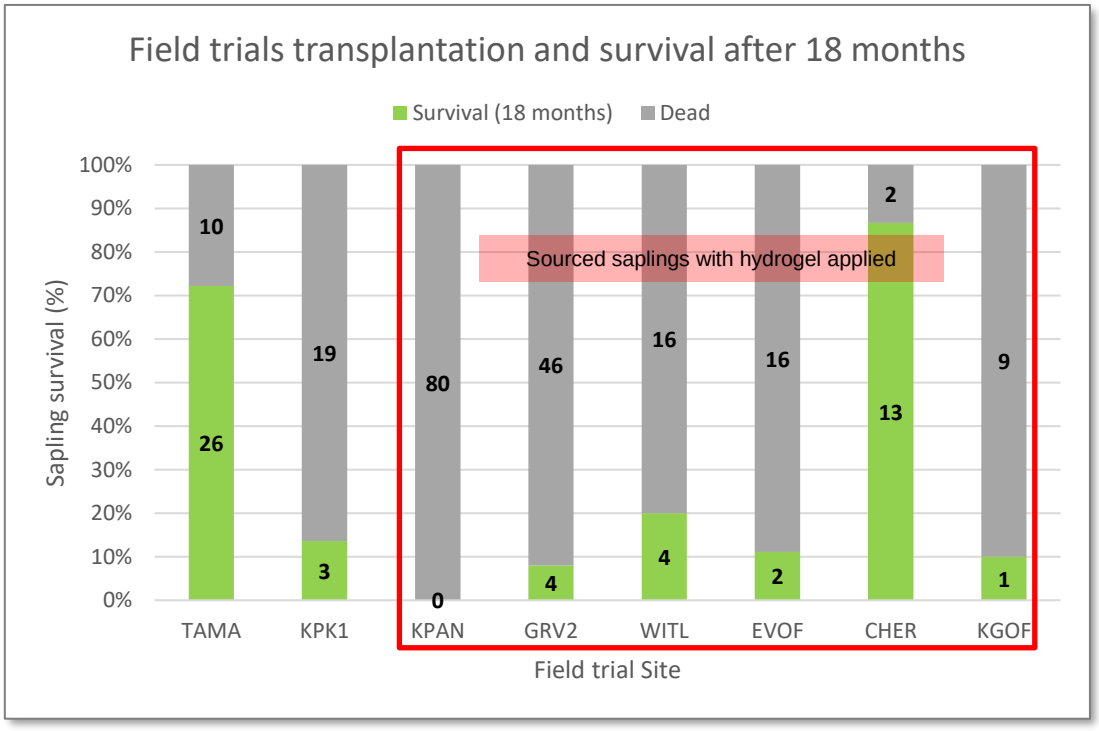

Figure 5-19: **Sapling survival (lime) and mortality (grey) percentage after 18 months per planting area. Field trials using sourced saplings to which hydrogel was applied during transplantation are boxed in red. Numbers on the histogram bars indicate number of saplings.**

Interestingly, contradictory growth results were observed between the sites. All of the sites had <5cm growth in height over 18 months whilst the Witleegte (WITL) saplings more than doubled in height in the same period.

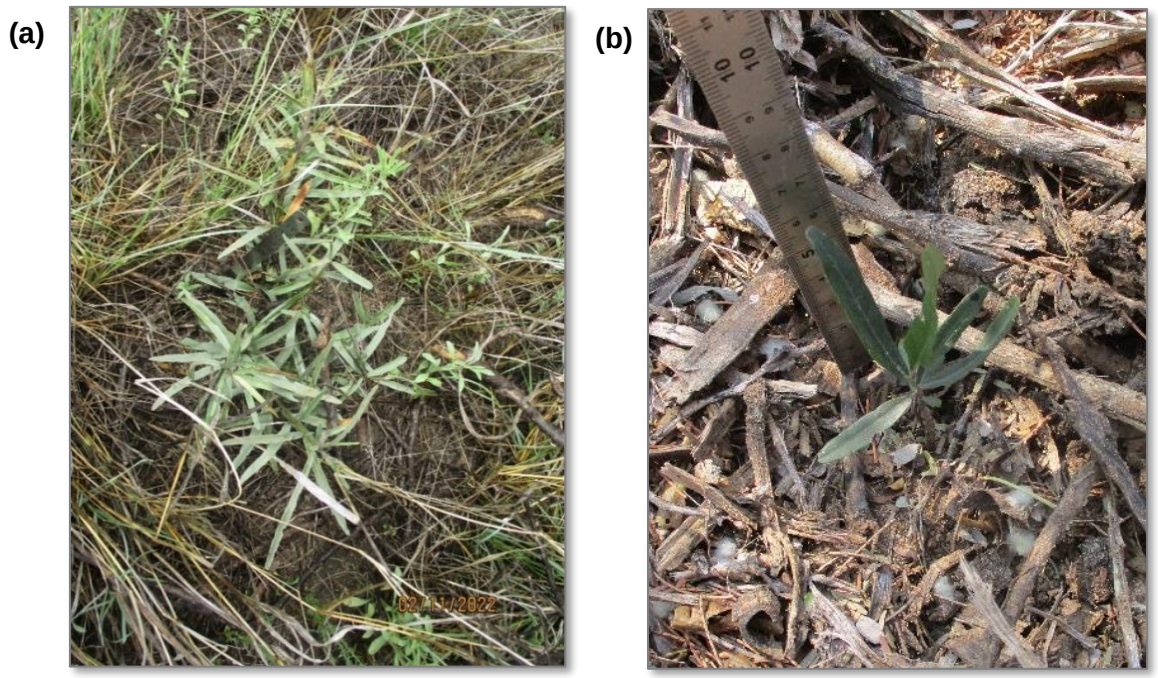

Figure 5-20: Sapling condition and size of (a) Witleegte (WITL) and (b) Kathu Equestrian Club (KPK1) sapling after 18 months (ruler used for size reference)

In addition to the above finding, a three-year growth of a single *B. albitrunca* sapling planted at the GRV2 site (Figure 5-21) remained stunted for three years. Measurements of the height and width over three years (2020-2022), as shown below, highlight the slow growth rate of this species (Figure 5-21). Below-ground growth was, however, not verified.

Figure 5-21: Growth of a single sourced sapling at field trial site GRV2 over three years (2020-2022)

5.6 Natural recruitment

A total of 77 naturally recruited *B. albitrunca* saplings were recorded along the linear extent of the constructed Kgalagadi pipeline where *B. albitrunca* saplings were also transplanted during field trials as part of the restoration effort (Figure 5-21). This was done to determine whether *B. albitrunca* will recruit naturally after disturbance, as well as to compare natural recruitment to the reintroduction of *B. albitrunca* by means of sapling transplantation to compensate for disturbance impact and determine whether the replacement ratios (number of saplings to be planted in order to compensate for the destruction of specimens of the same species) required in protected tree removal licences are adequate to ensure the survival of this species.

On initial observation it seemed that natural recruitment occurred above expectation regardless of impact. The transplanted saplings surviving within the Kgalagadi Pipeline servitude in which natural recruitment was also recorded was a limited 22 across the Kathu Pan (KPAN), Gamagara River (GRV2), Witleegte (WITL), Chertsey (CHER) and Kgalagadi Office (KGOF) sites (Figure 5-19). The naturally recruited survival after 18 months exceeded the sapling survival of field trials within the same assessment area by almost 30%.

Compared to the transplanted saplings, the naturally recruited saplings are fast growing and mainly multi-stemmed based on the observations made 18 months post-construction (Figure 5-22).

Upon investigation, it was found that natural recruitment did not take place and all the specimens recorded were coppices from root and stem remnants. These trees were able to coppice due to the superficial impact of the development on the trees (topsoil clearing) that did not destroy the root base. It appears that a lot of *B. albitrunca* specimens growing as shrubs is really coppicing *B. albitrunca*. This was confirmed by other field monitoring results on a property with no grazing within the study area where the rootstock of the coppice was exposed by a burrowing animal (Figure 5-22).

Figure 5-22: A naturally coppicing *B. albitrunca* specimen recorded approximately 18 months post construction as part of this study along the Kgalagadi pipeline with its roots exposed up to 15 cm

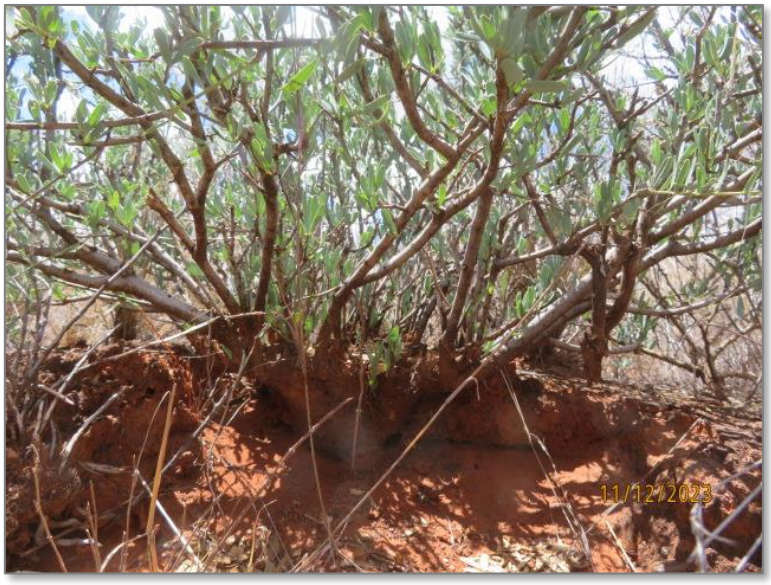

Figure 5-23: A naturally coppicing *B. albitrunca* specimen recorded within the study area of which the rootstock was exposed by fauna burrowing

The results obtained in this study will be discussed in the next chapter with regards to the respective trials undertaken.

CHAPTER 6 DISCUSSION

6.1 Soil properties

Soil properties are discussed with reference to the soil groups defined in section 5.2 and whether the soil sample was taken in terrestrial or aquatic habitats (section 4.8.2). Soil texture, soil chemistry and soil nutrients are discussed separately.

6.1.1 Soil texture

All of the soils used in this study's soil texture correlates with Venter and Venter (1998) who broadly stated that *B. albitrunca* are commonly found in sandy to loamy calcrete soils. The naturally recruiting *B. albitrunca* were found in soils with these same characteristics (In slight contrast to this, the optimal areas where adult specimens of *B. albitrunca* were recorded were classified as more sandy (loamy sand to sandy soils). Sandier soils are preferred for the establishment of cuttings (Bidlack & Jansky, 2014).

The potting soil (CTRL) sample were distinct from all the other soils with regards to properties. In conclusion, we propose that high sand particle content or sandy soil textural characteristics are most suitable for *B. albitrunca*.

6.1.2 Soil chemistry

6.1.2.1 Acidity / Alkalinity (pH)

Neethling (2016) found that vegetation growth and/or recruitment is primarily affected by soil properties such as pH, clay content and nutrient content/deficiencies as well as soil's water holding capacity. Soil pH is defined as "the negative logarithm of the hydrogen ion concentration (H_+)" and is referred to as either acidic (pH < 7), neutral (pH = 7) or alkaline (pH > 7) based on the soil's unique pH value (McCauley *et al.*, 2009).

The pH of the soil can be used to predict the chemical activities that occur within the soil and is considered a useful tool to determine which plants are able to grow at a certain location, what soil pH modification is required and/or which nutrients are available in the soil (Mylavarapu *et al.*, 2020). According to McCauley *et al.* (2009), the pH of soil also has a direct bearing on the decomposition of organic matter and the availability of essential nutrients.

McCauley *et al.* (2009) hold that phosphorus in soils is most available for vegetation at a pH range of 6 to 7 and macronutrients such as potassium, calcium and magnesium at a pH range between

6,5 and 8, noting that most micronutrients are more available between soil pH values of 5 and 7. Nevertheless, McCauley *et al.* (2009) also found that lower amounts of these nutrients were available outside these optimal pH ranges, pointing out that base cations (Ca, K, Mg) are more prone to leaching from the soil at low pH values.

Van Deventer (as cited by Neethling, 2016) found that the optimum pH range for vegetation establishment in arid areas is between 5,5 and 7. Only three of the soil samples (CHER, OPTI and EDEN) were within this optimal pH range. All sites were however within a relatively small pH range within 1,5 logarithms of the optimal range. Hence, pH was not found to negatively affect the germination or establishment of *B. albitrunca* seedlings.

6.1.2.2 Electrical conductivity (EC)

Electrical conductivity is defined as a measure of the charge mobility in response to an applied electric field (Klein & Santamarina, 2003) or the soil's capacity "to conduct or transmit electrical current" (Brady & Weil, 2014). Electrical conductivity strongly correlates with the particle size distribution and cation exchange capacity (CEC) of soils, whereas sands tend to have lower conductivity and clays higher conductivity (Neethling, 2016). In addition, electrical conductivity (EC) tends to be higher in soils with more ions (salts) present and vice versa (Brady & Weil, 2014).

Neethling (2016) found that for vegetation to establish, the optimal soil EC should be below 200 mS/m. The potting soil (CTRL) sample is the only soil sample that exceeds this optimal range. With an exceedance of almost four times the optimal range defined, this sample (CTRL) was expected to affect the germination of seedlings negatively. However, the excessive EC values were not found to negatively affect germination and establishment of *B. albitrunca*.

6.1.3 Soil nutrients

6.1.3.1 Potassium (K)

Potassium (K), after nitrogen and phosphorus, is the third most common essential element that can limit plant growth and, for this reason, forms part of the composition of most fertilizers (Brady & Weil, 2014). According to the latter, potassium activates more than 80 important enzymes required for both plant and animal processes, such as photosynthesis, protein synthesis, starch formation and the fixation of nitrogen for legumes. Fleshy fruited plants, such as *B. albitrunca*, tend to be limited in distribution with regards to soil available potassium and, to a lesser extent, nitrogen (Milewski, 1982; Hughes *et al.,* 1993*)*.

Brady and Weil (2014) hold that potassium is crucial for plants to survive environmental stresses associated with drought, winter frost events, fungal diseases and infestations by insect pests, adding that it also enhances the flavour and colour of fruits and vegetables, as well as the quality and quantity of flowers. The minimum arid area plant production target value for soil potassium content is 50 mg/kg (Neethling, 2016); hence only the EndemicVision office (EVOF) site lacked potassium content with a 6 mg/kg deficiency. Brady and Weil (2014) however states that potassium values between 30 000 and 50 000 mg/kg, as was the case for potting soil (CTRL), is not uncommon.

Potassium is found in relatively high concentrations in most soils but tend to be lower in soils with a texture of mainly quartz sand particles (Brady & Weil, 2014). The higher Potassium content of the Gamagara river (GRV1) and potting soil (CTRL) samples correlates with the higher clay content of these samples.

The EndemicVision office (EVOF) soil sample was sampled in Kathu town, in close proximity to the declared Kathu *Vachellia erioloba* forest (Anderson & Anderson, 2007). *V. erioloba* trees have been found to increase the soil's nitrogen, phosphorous and potassium concentrations underneath their canopy (Dean *et al.*, 1999) contradictory to the potassium concentration found in the EndemicVision office (EVOF) sample. Unknown past management practices such as overgrazing and the development of Kathu town might have contributed to the depletion of this site's potassium concentration (Neethling, 2016).

6.1.3.2 Calcium (Ca)

Calcium (Ca) and Magnesium (Mg) are soil cations and/or macronutrients that can aid vegetation's ability to overcome environmental stress (Brady & Weil, 2014). A terrestrial ecosystem's productivity and species composition largely depends on its soil calcium status, which specifically aids root development and buffers the soil pH (Brady & Weil, 2014). All sites possess sufficient amounts of calcium and exceed the minimum calcium content (200 mg/kg) required for optimal vegetation establishment that Neethling (2016) prescribed.

6.1.3.3 Magnesium (Mg)

Magnesium (Mg) is utilised in lesser quantities than calcium by plants. Nevertheless, Brady and Weil (2014) pointed out that this macronutrient plays a very important role in plant photosynthesis, adding that it is also important for oil and protein synthesis and to activate the enzymes required for energy metabolism.

Brady and Weil (2014) stated that many agriculturists agree that an exchangeable Ca:Mg ratio of 6:1 is required for optimal plant growth and soil tilth and/or suitability for vegetation establishment. The highest Ca:Mg ratio of 5:1 was recorded for the GRV1 soil sample. The arid area plant production target value for soil magnesium content is 50 mg/kg (Neethling, 2016), implying that only the EVOF site is lacking in magnesium content with a deficiency of 46 mg/kg (Figure 5-7).

6.1.3.4 Sodium (Na)

According to Neethling (2016), sodium (Na) is not essential for plant establishment and should be below 25 mg/kg for optimal plant growth. High sodium values contribute to soil erosion potential since a sodium contribution higher than 5% to the cation exchange capacity can cause soils to become dispersive (Neethling, 2016; Brady & Weil, 2014).

Soil samples GRV1, OPTI, CTRL and CHER exceeded the arid area plant production target value for sodium up to 300 times. The sodium values of soils in Neethling's (2016) study within the same area ranged between 1 mg/kg and 29 mg/kg contradicting the excessive sodium contents found in the Gamagara river (GRV1), optimal (OPTI) and Chertsey (CHER) soil samples of this study's field trials. Neethling (2016) assumed that mining dust deposition was the reason for the elevated sodium content, but the Chertsey (CHER) soil sample is not located within close proximity to any mines.

6.1.4 Summary of soil chemical, nutrient and texture properties

The texture of all soil samples analysed correlated with Venter and Venter's (1998) finding that *B. albitrunca* prefer sandy to loamy calcrete soils. All soil samples with the exception of potting soil (CTRL) had high sand particle content, with total silt and clay particles below 30%. Surface calcretes are also present throughout the study area.

The majority of the soil samples were within the arid area plant production target values with regard to their soil chemistry and soil nutrients. The EndemicVision office (EVOF) sample had deficiencies with regards to its potassium and magnesium content, whilst the Gamagara river (GRV1), optimal (OPTI), potting soil (CTRL) and Chertsey (CHER) samples had excessive sodium content.

Considering the preferred soil characteristics for *B. albitrunca* establishment found in this study, we believe potting soil (CTRL) was not the most suitable control for this study and optimal soil (OPTI) would have been more suited as control.

6.2 Germination of *Boscia albitrunca* seeds

Boscia albitrunca seeds took a minimum of six to nine weeks to germinate, with the hothouse trial seeds (HH*) which had the oldest seed (X_OLD) germinating in the shortest period. This study's minimum germination rate exceeded the two weeks period after which seedlings emerged during Mans' (2018) trials. Other seedlings only emerged after four weeks in Mans' (2018) trials, with the majority of seeds in this study germinating between weeks 9 and 10 regardless of amelioration, sowing season or seed age. Hothouses as used for germination trials by Mans (2018) and during the X_OLD seed trial of this study were therefore found to accelerate germination of *B. albitrunca* seeds within the southern Kalahari. It is anticipated that the expected germination period in field will take even longer than the timeframes recorded, due to the exposure to environmental variables over longer periods.

Seeds harvested from Bedrog farm were harvested and cleaned according to the method described in section 4.2 but were not dried adequately prior to storage and hence started fermenting or rotting. The importance of correct seed handling, storage and cleaning is iterated by Luna and Wilkinson (2014) since this affects the quality, viability and life expectancy of the seeds. The low viability is confirmed by the single seed germinating in this trial. Seed cleaning methods by Mans (2018) were proven successful in this study, although the drying period must be adhered to or lengthened.

Amelioration was not found to significantly influence germination of seeds. This corresponds with Bidlack and Jansky's (2014) statement that fertilizer should be applied post root development to stimulate growth.

Younger seeds (YOUNG) had higher mean germination than older seeds (V_OLD and X_OLD). The highest mean germination was recorded for younger seeds stored for the shortest period of time (YOUNG). The older seeds stored for approximately 12 months (X_OLD) had a mean germination of 4,41 compared to the mean germination of 29,97 obtained for seeds stored for only one month. This confirms that *B. albitrunca* seeds lose fecundity over time, although the seeds are still viable after one year of storage which contradicts the very limited life expectancy thereof referred to by Briers (cited by Alias & Milton, 2003).

Higher mean germination and higher variability in the germination percentages were recorded for the late summer (LateSum) sowing season compared to early spring (EarlSpr). *B. albitrunca* bears seed between November to April (Venter & Venter, 1998) and natural recruitment from seed is hence expected to take place within the same season or the following season since seeds are believed to have very limited life-expectancies (Briers, as cited by Alias & Milton, 2003).

A maximum germination of 100% were recorded during warm (25 °C) stratification tests for *B. albitrunca* conducted by Pendota *et al.* (2016). This correlates with the day temperatures of both the late summer and early spring season within the study area, since summer temperatures can exceed 40 °C. The optimal sowing season identified in this study is in contrast to the findings of Mans (2018) who recorded higher germination percentages after winter during early spring. Mans (2018) conducted trials in a hothouse which may have influenced the germination season.

The old seed trial (OLD [OLDa and OLDb]) using seeds stored for approximately six months had no seed germination from week five onwards and hence had significantly worse germination than all their respective pairwise companions (YOUNG, V_OLD, X_OLD). The pairwise companion between seeds stored for approximately one month (YOUNG) and seeds stored for approximately nine months (V_OLD) indicated that the seeds stored for approximately one month (YOUNG) had better germination by more than double that of those stored for approximately nine months (V_OLD). The seeds stored for the shortest period of approximately one month (YOUNG) and the seeds stored for the longest period of approximately twelve months (X_OLD) had a more similar germination, although the seeds stored for the longest period (X_OLD) started germinating earlier than the seeds stored for the shortest period (YOUNG). Finally, the pairwise companion of seeds stored for approximately nine months (V_OLD) against seeds stored for approximately twelve months (X_OLD) indicated that the ones stored for approximately nine months (V_OLD) had less germination than those stored for longer periods (X_OLD), although the ones stored for approximately nine months (V_OLD) germinated earlier.

6.3 Seedling and cutting establishment in the seed and cutting trial

The key aspect to successful plant establishment from cuttings is the prevention of water loss from the cutting means Bidlack and Jansky (2014). This is confirmed since no cuttings of which the cutting edges were left unsealed were able to establish. In damp or tropical areas buried stems and/or prostate branches sometimes produce roots (Leakey, 1985), but no literature confirms the possibility hereof for arid areas although a single adult specimen was observed producing roots from a fallen branch within the Bedrog farm's population from which cuttings and seeds were collected for this study.

Besides the loss of water, several other factors such as the position from which cuttings were collected on the parent tree, the collection season and the temperature ranges during establishment influence the establishment of cuttings (Amri *et al.*, 2009; Robinson & Schwabe, as cited by Leakey, 1985; Bidlack & Jansky, 2014). All of these variables' influences can be reduced by hothouse trials and to some extent by increased cutting sizes.

The small, sealed stem cutting SO* (SOA, SOU) trials had the lowest establishment and long-term survival and died back entirely after week 16. This corroborates the discovery by Leakey (2004) that longer cuttings possess an enhanced capacity for assimilate storage, which aids in sustaining the plant until roots are established and assimilates can be acquired from the growth medium.

No root cuttings established, regardless of the wound edges being sealed in contrast to Venter and Venter's (1998) statement that this species can be easily propagated from either root or stem cuttings.

Weeks since sowing was the most significant variable for establishment of *B. albitrunca*. The strongest regression was found at week 20 (second last week of monitoring) with Axis 1 (Pearson coefficient [r-value] of 0,905) indicating that this week was most significant for establishment from seed. The rate of establishment exhibited a continuous increase, peaking between weeks 16 and 20. This suggests that a more extended period of establishment is crucial for *B. albitrunca*. The fact that *B. albitrunca* saplings are known to be slow growing (Mans, 2018; Cunningham, 2001), highlights the necessity for prolonged monitoring. Longer establishment periods means that exposure periods to predators and other threats are longer in natural environments which may negatively affect the establishment in field compared to nursery trials and therefore very poor natural establishment is expected.

6.4 Field trials

No cuttings planted as part of field trials showed any signs of above ground growth. Saplings transplanted as part of these trials had a 21% survival after 18 months, with an average of 12% surviving saplings which had the application of water retention hydrogel, and 50% surviving saplings to which no water retention hydrogel was applied. Hydrogel was not proven to aid survival of *B. albitrunca* in dryland rehabilitation. The too shallow application of the hydrogel did cause soil cracking at the surface and possibly disturbed the upper roots of the saplings which may have detrimentally affected sapling survival. Hydrogel application must be done below the root zone of saplings for roots to grow into it and since hydrogel may not be exposed to direct sunlight. The benefit of hydrogel cannot be seen from this study and should be tested in further studies since *V. erioloba* saplings transplanted within the study area were able to survive high summer temperatures between December and January without watering (personal observation).

The Witleegte River crossing site (WITL) had only 20% survival after 18 months but showed significant above ground growth of saplings with regards to its physical measurements (height and width). Studies by Pendota *et al.* (2016) and Wand *et al.* (1999) found that growth of *B.*

albitrunca was promoted by more frequent watering. The field trials were not watered post transplantation and hence the rainfall for this study site might have improved the growth on this site. Rainfall data was however not recorded for this study.

The stunted growth of the transplanted saplings observed in this study was confirmed by Mans (2018). However, according to the trial conducted by Mans (2018), this species grow underground to establish its roots for several years before starting to grow above ground which was not verified.

The reason for this above ground growth is still inconclusive since the planting methodology, planting team, sapling selection and hardening processes were similar for all field trials. This site's soil texture, chemistry and nutrients was further not found significantly different.

6.5 Natural recruitment

Natural recruitment refers to the potential of native species to self-colonise degraded areas (Rice & Emery, 2003; Zahawi *et al.*, 2014). During bi-annual post construction monitoring, *B. albitrunca* specimens were observed within the impact footprint. We started monitoring these as we thought it to be important for this study. Upon further investigation it was found to be adult *B. albitrunca* resprouting or coppicing and not saplings.

The pre-clearance population of *B. albitrunca* for the natural recruitment sites are not known with regards to exact locations and densities, hence recruitment could not be correlated with the original population density and/or exact locations of past specimens to confirm whether these saplings are resprouting or coppicing from undisturbed roots and stumps below ground.

The basal coppicing ability of *B. albitrunca,* as suggested by Mans (2018) is confirmed. *B. albitrunca* has the ability to recover by means of coppicing after the removal of superficial topsoil by means of dozing to limited depths (<30 cm) and the replacement of topsoil within 12 months.

The multi-stemmed nature and faster above-ground growth compared to the growth of the transplanted saplings correlates with the ability of resprouts to regenerate and recover biomass quickly after disturbance (Kelley *et al.*, 2014). Resprouting species also tend to resprout in the form of multi-stemmed shrubs (Pausas & Keeley, 2017).

To counter land degradation in the southern Kalahari, Milton and Dean (2000) as well as O'Connor and Roux (cited by Radatz, 2003) suggested that vegetation should be able to re-establish once grazing pressure has been reduced. This is confirmed since coppicing was restricted to areas with no grazing impacts for a minimum period of 18 months after completion of the Kgalagadi pipeline construction.

In the interest of similar future studies, the key findings, limitations identified, and recommendations are summarised in the next chapter, with additional observations included for future reference.

CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

Even though this study only partially met its aim to determine the best recruitment methodology for *Boscia albitrunca*, its results will contribute to a better understanding of the most viable methodologies to recruit *B. albitrunca* for restoration purposes.

The primary aim of this study was to determine (Chapter 2):

- whether soil amelioration would improve the recruitment rate of *B. albitrunca* saplings; and
- whether *B. albitrunca* can be better recruited from seed cultivated to saplings or from vegetative cuttings propagated in planting bags.

The hypothesis that the cultivation of *B. albitrunca* from fresh seeds with limited environmental stress and suitable amelioration methods will improve recruitment success and contribute to the rehabilitation of sustainable populations in previously disturbed areas over the long term in the southern Kalahari is rejected. No significant difference was found between the recruitment of ameliorated and untreated planting bag trials when compared to seed age or soil type, or the interaction with these. No significant difference hence exists between the recruitment of ameliorated and untreated planting bag trials.

The study involved seed and cutting nursery trials in planting bags and trays, field trials, as well as an assessment of natural recruitment in areas where adult *B. albitrunca* trees were removed for the construction of the Kgalagadi pipeline. Fermentation due to incorrect cleaning and storage of seeds negatively affected germination success. This led to the conclusion that seed germination is mainly influenced by the cleaning and storing of seeds prior to planting. Correctly cleaned and stored seeds were however proven to remain viable for up to 12 months, and hothouse conditions were found to shorten germination periods.

The highest mean germination was recorded for seeds stored for the shortest period, although trends could not be defined since seeds stored for approximately twelve months had higher germinated than seeds stored for a shorter period of nine months.

Correlations between the sowing season and germination success indicated that late summer is better than early spring for the sowing of *B. albitrunca* seeds.

The coppicing ability of *B. albitrunca* is confirmed based on the multi-stemmed specimens that grew significantly faster than seedlings and saplings which were recorded in previously disturbed areas where soil clearance activities were conducted for construction.

Based on the areas where *B. albitrunca* was found naturally occurring, soil textures consisted of more than 70% sand particles, less than 20% clay particles and less than 10% silt particles.

The conclusion, thus, is that *B. albitrunca* can be propagated from seeds, provided that the seed is cleaned correctly and dried adequately prior to storage. This species can also be recruited from stem cuttings where all wounds have been sealed to prevent drying out. Sealed stem cuttings will, however, require longer planting bag periods to build resilience before being transplanted into the veld as part of restoration projects. In this regard, when comparing small and medium cuttings it is evident that the larger medium cuttings have more stored resources to successfully establish given that small cuttings had much lower establishment and no overall survival even prior to hardening, hence indicating that larger sized cuttings have higher resilience. Cuttings transplanted directly into the ground as field trials proved to be unsuccessful as a recruitment technique for *B. albitrunca*. Root cuttings also proved unsuccessful regardless of their edges being sealed or unsealed. Cuttings further require longer establishment periods before being subjected to hardening.

Evidently, soil amelioration does not significantly affect the recruitment success of *B. albitrunca,* irrespective of whether from seed or cuttings. Younger or fresher seeds further have the highest germination percentage and sealed stem cuttings the best establishment.

7.2 Recommendations and observations

Having analysed the results of this study in depth and in the interest of future studies, the researcher proposes the following recommendations with regards to the recruitment of *B. albitrunca* for rehabilitation purposes:

7.2.1 Recommendations for the recruitment of *Boscia albitrunca*

- During seed cleaning, care must be taken to ensure that the fruity flesh that inhibits germination is removed entirely and that seeds are dried for adequate periods prior to storage to ensure their viability.

- The cutting edges and wounds of cuttings must be sealed when vegetative cultivation is done for this species to prevent cuttings from drying out before establishing.

7.2.2 Observations regarding the establishment and preservation of *Boscia albitrunca*

- Even though *Boscia albitrunca* specimens seem to tolerate and have the ability to establish in a wide variety of soils with varying textures and chemistry, site clearance should take coppicing into account by minimising topsoil clearance in all areas that will not be subjected to hard surfacing. This will encourage resprouting from intact root systems.

- The illegal removal of *B. albitrunca* specimens due to a lack of knowledge should be addressed by sharing information on all platforms to ensure land occupants and developers are aware of the tree's protection status.

- The replacement ratio of *B. albitrunca* in protected tree permits is too low to ensure the sustainability of this species. Replacement ratios must be maximised due to this species' very low survival rates when transplanted in dryland rehabilitation efforts.

- Offsets where pristine natural stands of this species can be conserved should be considered where large numbers are cleared.

- The effect of arboricides applied for bush eradication should be quantified for *B. albitrunca* to ensure that informed land-management decisions can be made with regard to the conservation of this species.

- This species is believed to survive for very long periods, although very limited data is available. A carbon dating study should be undertaken where trees are to be cleared for new developments to determine adult specimens' ages and confirm their longevity.

7.3 Limitations of this study

A number of limitations were recorded for this study, which should be considered in similar or follow-up studies. These include:

- Given that *Boscia albitrunca* is a slow-growing species, long-term monitoring is required to determine survival success after transplantation.

- Germination trials should be conducted for all seasons and not limited to the optimal seasons described in literature.

- Large cuttings should also be grown in planting bags and not only transplanted directly into the ground since planting bag establishment seemed to work best for larger cuttings with higher inherent resilience.

- Cuttings should be subjected to periods of up to 12 months in planting bags before being subjected to hardening to determine the timeframe required to achieve adequate resilience required for restoration.

- The role companion or host plants fulfil in ‘nursing’ the establishment and growth of *B. albitrunca* was not assessed in this study. Should it be found that host or companion trees such as *Vachellia erioloba* will aid their survival, field trial saplings ought to be planted under such trees in future.

- Naturally recruiting saplings post-construction should be assessed and excavated in order to determine if these are established from root- or stem cuttings.

- Rainfall data should be collected as part of the field trials to determine if rainfall can be assessed as an environmental stress factor influencing the survival of this species.

- Three replicates of each habitat type (e.g. pans, rivers, deep aeolian sands) for the respective transplantation sites should be assessed for improved statistical analyses and comparisons.

- Potting soil differs from all other soil samples relevant to the study area to such an extent that an alternative control soil should be identified for future studies.

- The natural recruitment potential of *B. albitrunca* should be further assessed by recording all naturally recruiting species in development areas and correlating these with the method and depth of topsoil clearance as well as the impact period.

To conclude, significant knowledge gaps still need to be addressed before *B. albitrunca* can be successfully recruited for rehabilitation in the southern Kalahari. Even though the recruitment of this species proves challenging, given that *B. albitrunca* is referred to as “the tree of life”, its high ecological value justifies every effort to ensure the conservation and protection of this species.

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ANNEXURE A: ABBREVIATIONS AND ACRONYMS USED IN PLANTING BAG AND FIELD TRIALS

Soil Sample/ Field Trial Site Name	Description of Area	Habitat/ Ecosystem Categorization
GRV1	Gamagara River 1	Uncategorized
HAL1	Halliford Farm 1	Terrestrial
HAL2	Halliford Farm 2	Terrestrial
KPAN	Kathu Pan	Aquatic
TAMA	Tamaga Farm	Aquatic
WITL	Witleegte River	Aquatic
GRV2	Gamagara River 2	Terrestrial
KPK1	Kathu Perdeklub/ Equestrian Club	Terrestrial
KGOF	Kgalagadi Pipeline Offices	Aquatic
MARS	Marsh Farm	Aquatic
EVOF	EndemicVision Offices	Terrestrial
EDEN	Edenvale Farm	Terrestrial
CHER	Chertsey Farm	Terrestrial
OPTI	Bedrog Farm	Terrestrial
CTRL	Control (Potting Soil)	Uncategorized

Soil Group	Description
Nat_Rec	Natural Recruitment
Optimal	Optimal Areas/ sites
Veld_Tr	Veld Trials
S&C_Tr	Seed and Cutting Trials

Seed Age	Description
OLD	Old seeds stored for approximately 6 months
V_OLD	Very old seeds stored for approximately 9 months
X_OLD	Extra old seeds stored for approximately 12 months
YOUNG	Fresh seeds stored for <1 month

Planting bag / tray ID	Trial type/description	Soil Type	Amelioration design
*UCOA	Unsealed medium stem cuttings	Optimal Soil	Ameliorated
*UCOU	Unsealed medium stem cuttings	Optimal Soil	Untreated
*UCPA	Unsealed medium stem cuttings	Potting Soil	Ameliorated
*UCPU	Unsealed medium stem cuttings	Potting Soil	Untreated
COA	Medium, sealed stem Cuttings	Optimal Soil	Ameliorated
COU	Medium, sealed stem Cuttings	Optimal Soil	Untreated
CPA	Medium, sealed stem Cuttings	Potting Soil	Ameliorated
CPU	Medium, sealed stem Cuttings	Potting Soil	Untreated
GAO	Outdoor Seed Germination	Optimal Soil	Ameliorated
GAP	Outdoor Seed Germination	Potting Soil	Ameliorated
GUO	Outdoor Seed Germination	Optimal Soil	Untreated
GUP	Outdoor Seed Germination	Potting Soil	Untreated
HHOA	Hothouse Seed Germination	Optimal Soil	Ameliorated
HHOU	Hothouse Seed Germination	Optimal Soil	Untreated
HHPA	Hothouse Seed Germination	Potting Soil	Ameliorated
HHPU	Hothouse Seed Germination	Potting Soil	Untreated
SOA	Small, sealed stem Cutting	Optimal Soil	Ameliorated
SOU	Small, sealed stem Cutting	Optimal Soil	Untreated
*SPA	Small, sealed stem Cutting	Potting Soil	Ameliorated
*SPU	Small, sealed stem Cutting	Potting Soil	Untreated
BOA	Bedrog (Fermented) seed germination	Optimal Soil	Ameliorated
BOU	Bedrog (Fermented) seed germination	Optimal Soil	Untreated
BPA	Bedrog (Fermented) seed germination	Potting Soil	Ameliorated
BPU	Bedrog (Fermented) seed germination	Potting Soil	Untreated
*RSOA	Medium, sealed root Cuttings	Optimal Soil	Ameliorated
*RSOU	Medium, sealed root Cuttings	Optimal Soil	Untreated
*RSPA	Medium, sealed root Cuttings	Potting Soil	Ameliorated
*RSPU	Medium, sealed root Cuttings	Potting Soil	Untreated

*Data not included in Dissertation results due to no recruitment recorded

Outdoor seed germination trials (G) planting bags are numbered 1 to 6 for Young or Fresh seeds stored for <1 month and 7 to 12 for Very old seed stored for approximately 9 months.*

Field ID	Trial type/description	Planting Area / Site	Amelioration design
*UCOA	Unsealed stem cuttings	EndemicVision	Ameliorated
*UCOU	Unsealed stem cuttings	EndemicVision	Untreated
*SLOA	Unsealed stem cuttings	Gamagara	Ameliorated
*SLOU	Unsealed stem cuttings	Gamagara	Untreated
*RSOA	Medium, sealed root Cuttings	EndemicVision	Ameliorated
*RSOU	Medium, sealed root Cuttings	EndemicVision	Untreated

*Data not included in Dissertation results due to no recruitment recorded

ANNEXURE B: PERMITS AND LICENCES

- **EndemicVision Flora Harvesting Permit (FLORA 0011/2020)**

ODB Number: **0016/2020** Permit No: **FLORA 0011/2020** Application ID: **41296**

Biodiversity

Northern Cape Province

Integrated Competence

Permit

Ordinary

Flora - Harvesting

None

Issued in terms of the provisions of:
National Environmental Management: Biodiversity Act 10 of 2004

Issued in terms of the provisions of:
Northern Cape Nature Conservation Act, 9 of 2009

SPECIES AND NUMBERS, RESTRICTED ACTIVITIES AND PERMIT CONDITIONS AS PER ADDENDUM 1 AND PAGES ATTACHED

Authorising Entity / Institute / Company
Endemic Vision

Chrizette Deons Neethling - ID or Passport 7503050036082 - Farm name: - Physical Address: 15 Kokkewiet Street, - Kathu - Northern Cape Province - 8446

Postal address: PO Box 2061, Kathu, Northern Cape, 8446

Contact details: Office: 0537231379 - Home: 0537232106 - Cell: +27826586078 - Fax: 0865907261 - E-mail: cdn@endemicvision.co.za

Region in which restricted activity will take place

Northern Cape Province

Address / Place / Fixed Property where restricted activity will be carried out, conducted or take place

Natural environment in both the Bushmanland and Kalahari Regions within the municipal boundaries as stipulated in the additional conditions

Digital signature of verifier

MD Smit

Digitally signed by MD Smit
DN: C=ZA, E=msmit@ncpg.gov.za, O=Department of Nature Conservation and Environment, OU=Permit Administration, CN=MD Smit
Location: Kimberley
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(Kuruman) Tel: 053-712 0702 Fax: 053-712 0936 *(Upt) Tel: 054-3322885 Fax: 054-3311155*

ODB Number: **0016/2020** Permit No: **FLORA 0011/2020** NNO 1/10/3/ **41296**

ADDENDUM 1

PRESCRIBED FEES
The prescribed fees paid for the issuing of this document shall not be refunded

Tariff: All unspecified - Amount currently owed: R50 - Debit amount: R50 on 19/03/2020 with receipt number: FLORA/ENDEMICVISION

SPECIES AND NUMBERS PERMITTED

Live, Abutilon austro africanum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Abutilon pycnodon, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Acacia burkei, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Acacia galpinii, , Apiesdoring - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Acacia haematoxylon, Vaalkameeldoring, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Acacia hebeclada, Trassiebos, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Acacia karoo (Vachellia karroo), Sweet thorn, Soetdoring - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Acacia karroo, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Acacia mellifera, Swarthaak/Gnoibos/Blackthorn, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Acacia mellifera_detinens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Acacia tortillis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Acanthopsis annual, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Acanthopsis hoffmannseggiana, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Acanthospermum hispidum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Achyranthes aspera aspera, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Acrotome inflata, Acrotome, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Adenogramma sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Adromischus alstonii, Bulbees, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Adromischus diabolicus, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Adromischus marianiae "hallii ovate", , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Adromischus nanus, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aizoon asbestinum, -----, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Albuca spiralis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Albuca tortuosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Aloe dichotoma, Quiver Tree, Kokerboom - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aloe gariepensis, Oranjerivieraalwyn, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aloe microstigma, Kamiesbergaalwyn, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Alternanthera pungens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Amaranthus argentea, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Amaranthus cruentus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Amaranthus praetermissus, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Amaranthus spinosus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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Live, Amaranthus thunbergii, Misbredie, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Amaranthus viridis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Amellus tridactylus subsp. Tridactylus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ammocharis coranica, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Amphiglossa thuja, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Amphiglossa triflora, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Amsinckia retrorsa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Anacampseros baeseckei, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Anacampseros filamentosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Anacampseros karasmontana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Anacampseros subnuda, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Anacapseros bayeriana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Andropogon chinensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Anthemis cotula, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Anthephora pubescens, Wool grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Antherothamnus pearsonii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Anthospermum spathulatum subsp. Spathulatum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aptosimum albomarginatum, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Aptosimum annual, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aptosimum elongatum, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Aptosimum indivisum, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aptosimum lineare, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Aptosimum macra, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Aptosimum marlothii, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Aptosimum spinescens, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aptosimum spinescens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Arctotis cf. leiocarpa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Arctotis sp1, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Argemone ochroleuca, White Flowered Mexican Poppy, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Argyrolobium argenteum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Aridaria cf. serotina, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aridaria noctiflora subsp. Noctiflora, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aridaria noctiflora subsp. straminea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aristida adscensionis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Aristida adscensionis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Aristida canescens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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Live, Aristida congesta barbicolis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Aristida congesta subsp. Congesta, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Aristida congesta, Tassel Three awn, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Aristida diffusa burkei, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Aristida meridionalis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Aristida sp, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Aristida stipitata robusta, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Aristida stipitata, Long-awned three awn, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Aristida vestita, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Asparagus bechuanicus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Asparagus capensis, Katdoringwortel, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Asparagus capensis, Katdoringwortel, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Asparagus cf. laricinus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Asparagus cooperi, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Asparagus laricinus, Katdoring, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Asparagus nelsii, Katdoring, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Asparagus retrofractus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Asparagus retrofractus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Asparagus sp., ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Asparagus suaveolens, Katdoring, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Atriplex semibaccata, Kruipsoutbos, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Augea capensis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Avonia albissima, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Avonia papyracea subsp. Papyracea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Avonia quinaria subsp. Alstonii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Avonia recurvata subsp. Minuta, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Avonia recurvata subsp. Recurvata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Avonia ruschii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Azima tetracantha, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Babiana bainesii, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Babiana hypogea, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Barleria rigida, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Barleria rigida, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Berkheya canescens, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Berkheya spinosissima subsp. Spinosissima, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Bidens bipinnata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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ADDENDUM 1

Live, Bidens pilosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Blepharis marginata, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Blepharis micra, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Blepharis mitrata, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Boerhavia repens var repens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Boophone disticha, Gifbol, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Boscia albitrunca var. albitrunca, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Boscia albitrunca, Shepherd tree, Witgatboom - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Boscia foetida subsp. Foetida, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Boscia foetida supsp. foetida, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Brachiaria marlothii, Creeping grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Brachiaria nigropedata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Brachiaria serrata, Velvet signal grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Brownanthus ciliatus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Brunsvigia comptonii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Brunsvigia sp. nov.1, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Brunsvigia sp. nov.2, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Buddleja saligna, Olive beddleja, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Buddleja salviifolia, Sagewood, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Bulbine namaensis, Katstert, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Bulbine striata, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Bulbostylis hispidula, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Bulbostylis hispidula, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Bulbostylis humilis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Cadaba aphylla, Leafless cadaba, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Cadaba aphylla, Leafless cadaba, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Catophractes alexandri, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Cenchrus ciliaris, Buffelgras, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Centropodia glauca, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Cephalophyllum fulleri, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Cephalophyllum sp. nov. (2014), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ceraria fruticulosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ceraria namaquensis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ceterach cordatum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Chamaesyce inaequilatera, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Chascanum garipensis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

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ADDENDUM 1

Live, Chascanum pinnatifidum pinnatifidum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Chascanum pumilum, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cheilanthes deltoidea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Cheilanthes namaquensis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Chenopod sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Chenopodium album, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Chenopodium carinatum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Chenopodium murale, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Chironia sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Chloris virgata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Chlorophytum sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Chrysocoma ciliata, Bitter Karoo, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Chrysocoma ciliata, Bitter Karoo, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Chrysocoma microphylla, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Chrysocoma obtusata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Chrysocoma sparsifolia, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Cineraria alchemilloides, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Cirsium vulgare, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cissampelos capensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cissampelos capensis, Dawid wortel, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Citrullus lanatus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Clematis brachiata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cleome angustifolia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cleome cf. oxyphylla, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Cleome rubella, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Coccinia rehmanni, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Coccinia sessilifolia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Codon royenii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Commelina africana, Commelina, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Commiphora gracilifrondosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Conophytum angelicae (Pofadder form), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Conophytum angelicae subsp. angelicae (Plateau form), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Conophytum calculus subsp. vanzylii "dwarf form", , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Conophytum fulleri, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Conophytum limpidum (diploid form), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Conophytum marginatum var. karamoepense, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

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ADDENDUM 1

Live, Conophytum maughanii subsp. maughanii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Conophytum praesectum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Conophytum ratum (dwarf or plateau form), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Conophytum ratum (plains form), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Convolvulus ocellatus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Convolvulus sagittatus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Conyza bonariensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Corallocarpus dissectus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Corchorus pinnatipartitus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Coronopus integrifolius, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Coronopus integrifolius, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Corrigiola litoralis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Cortaderia selloana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Cotula coronpifolia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Cotula microglossa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Cotyledon orbiculata subsp. orbiculata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula alstonii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula brevifolia subsp. brevifolia, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula columnaris subsp. prolifera, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula corallina subsp. macrorrhiza, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula deceptor, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula deltoidea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula exilis subsp. Sedifolia, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula garibina, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula mesembrianthemopsis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula muscosa var. muscosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula namaquensis subsp. namaquensis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula sericea var. sericea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula sericea var. velutina, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula subaphylla subsp. Subaphylla, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crassula tomentosa var. glabrifolia, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Crinum bulbispermum, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Cucumis africanus, Wilde/Sprigbokkomkommer, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Cucumis heptadactylus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Cucumis rigidus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Cymbopogon caesius, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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ADDENDUM 1

Live, Cymbopogon pospischilii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cynanchum orangeanum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cynodon dactylon, Kweekgras, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cynodon hirsustus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cyperus bellus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Cyperus congestum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cyperus indecorus namaquensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cyperus laevigatus, Sedge, Biesie - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cyperus maginatus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cyperus margaritaceus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Cyperus marginatus, Matjiesgoed, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Cyperus squarrosus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Dactyloctenium aegyptioum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Dactyloctenium giganteum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Datura ferox, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Datura stramonium, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Dianthus namaensis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Dichilus gracilis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Dichilus lebeckioides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Dicoma capensis, Wild karmedik, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Dicoma capensis, Wild karmedik, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Dicoma schinzii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Didelta carnosa var. carnosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Digitaria argyrograpta, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Digitaria diagonalis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Digitaria eriantha, Gewone vingergras, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Digitaria eriantha, Gewone vingergras, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Digitaria pentzii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Digitaria polyphylla, Finger grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Dinteranthus microspermus subsp. Puberulus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Diospyros lycioides, Bloubos / Red star-apple, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Diospyros lycioides, Bloubos / Red star-apple, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Diospyros ramulosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Dischisma sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Dodonaea angustifolia, Toube / Ysterhoutkoppe, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Drimia sp., ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

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ADDENDUM 1

Live, Drosanthemum cf. breve, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Drosanthemum godmaniae, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Drosanthemum hispidum, Fyn t'nouroebos, skaapvygie, dew vygie, --- - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Drosanthemum karooense, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Dyerophytum africanum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ebracteola fulleri, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ehretia rigida, Deurmekaarbos / Puzzle bush, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ehretia rigida, Deurmekaarbos / Puzzle bush, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Ehrharta calycina, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Elephantorrhiza elephantina, Eland's bean, Elandsboontjie - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Elionurus muticus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Emex australis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Enneapogon cenchroides, Nine awn grass, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Enneapogon cenchroides, Nine awn grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Enneapogon desvauxii, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Enneapogon desvauxii, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Enneapogon scaber, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Enneapogon scaber, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis annualata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis annulata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eragrostis barbinodis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis bicolor, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis biflora, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis chloromelas, Kruiblaar, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis curvula, Oulandsgras, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eragrostis curvula, Oulandsgras, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis echinochloidea, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis lehmanniana, Knietjiesgras, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis nindensis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eragrostis nindensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis obtusa, Dew grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis pallens, Broom love grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis porosa, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis rigidior, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis rotifer, Pearly love grass, Reengras - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis tef, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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ADDENDUM 1

Live, Eragrostis trichophora, Hairy love grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis truncata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eragrostis viscosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eriocephalus africanus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eriocephalus ambiguus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eriocephalus aspalathoides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eriocephalus brevifolius, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eriocephalus ericoides griquensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eriocephalus merxmuelleri, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eriocephalus microphyllus var. pubescens, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eriocephalus pauperrimus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eriocephalus scariosus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eriocephalus sp., ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eriospermum bakerianum subsp. Bakerianum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eriospermum cordiforme, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eriospermum flagelliforme, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Eriospermum pusillum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euclea crispa ovata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Euclea undulata, Thicket euclea, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euclea undulata, Thicket euclea, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Euphorbia avasmontana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euphorbia braunsii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euphorbia decussata, Soetmelkbos, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euphorbia gariepina, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euphorbia gregaria, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euphorbia guerichiana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euphorbia inaequilatera inaequilatera, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Euphorbia mauritanica, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euphorbia rectirama, ----, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euphorbia spinea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Euphorbia wilmaniae, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Euryops subcarnosus subsp. Vulgaris, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Eustachys paspaloides, Fan grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Evolvulus alsinoides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Exomis microphylla axyrioides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Fagonia capensis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

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ADDENDUM 1

Live, Felicia cf. clavipilosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Felicia fascicularis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Felicia filifolia, Bloudraaibos, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Felicia hirsuta, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Felicia muricata, Blue flower karoo, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Felicia muricata, Blue flower karoo, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Felicia namaquana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Felicia sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ficus cordata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ficus cordata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Ficus ilicina, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Fingerhuthia africana, Vingerhoedgras, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Flaveria bidentis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Fockea comaru, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Forsskaolea candida, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Foveolina albida, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Galenia africana, Kraalbos, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Galenia africana, Kraalbos, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Galenia cf. meziana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Galenia fruticosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Galenia fruticosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Galenia sarcophylla, Beslyn, porselyn, t'gouboedana, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Gazania krebsiana, Botterblom, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gazania lichtensteinii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Geigeria filifolia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Geigeria ornativa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Geigeria vigintisquamea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Gisekia africana africana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gisekia pharnacioides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gladiolus saccatus, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Gnidia polycephala, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gomphocarpus fruticosus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gomphocarpus tomentosus tomentosus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gomphrena globosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gorteria corymbosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Grewia flava, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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Live, Grielum humifusum parviflorum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Grielum humifusum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Guilleminea densa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gymnosporia buxifolia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gymnosporia heterophylla, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Gymnosporia szyszylowiczii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Harpagophytum procumbens, Devil's Claw, Duiwelsklou - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Haworthia venosa subsp. tessellata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Hebenstretia namaquensis, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Helichrysum arenicola, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Helichrysum argyrosphaerum, Hottentos tea, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Helichrysum herniarioides, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Helichrysum pentzioides, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Helichrysum pumilio subsp. Pumilio, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Helichrysum pumilio, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Helichrysum zeyheri, Everlasting, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Helichrysum zeyheri, Everlasting, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Heliophila arenaria var. arenaria, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Heliophila cf. acuminata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Heliophila deserticola, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Heliophila suavissima, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Heliophila trifurca, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Heliotropium ciliatum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Heliotropium lineare, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Hereroa bergeriana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Hereroa puttkameriana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Hermannia burchellii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Hermannia cernua, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Hermannia cf. coccocarpa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Hermannia cococarpa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Hermannia comosa, Dolls rose, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Hermannia desertorum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Hermannia disermifolia, Jeukbos, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Hermannia garlepina, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Hermannia jacobeifolia, Dolls rose, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Hermannia macra, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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Live, Hermannia minutiflora, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hermannia spinosa, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hermannia stellulata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Hermannia stricta, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hermannia stricta, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Hermannia tomentosa, Dolls rose, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Hermbstaedtia fleckii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Hermbstaedtia glauca, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hermbstaedtia odorata odorata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Hesperantha rupicola, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Heteropogon contortus, Spear grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Hibiscus engleri, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hibiscus pusillus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Hirpicium alienatum, Haarbos, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hirpicium cf. gazanioides, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hirpicium echinus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hoodia alstonii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hoodia gordonii, Hoodia, Ghaap - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hoodia gordonii, Hoodia, Ghaap - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Hordeum capense, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Huernia campanulata subsp. ingeae, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hydnora africana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hypertelis bowkeriana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Hypertelis salsoloides, Hassuuring, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Hypertelis salsoloides, Hassuuring, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Ihlenfeldtia excavata, T'noutsiama, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ihlenfeldtia vanzylii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Indigastrum argyroides, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Indigofera alternans, Indigo, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Indigofera aspera, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Indigofera auricoma, Ear Indigo, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Indigofera cf. auricoma, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Indigofera charlieriana charlieriana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Indigofera daleoides, Indigo, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Indigofera exigua, Alternate Indigo, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Indigofera filipes, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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ADDENDUM 1

Live, Indigofera flavicans, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Indigofera heeterotricha, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Indigofera heterotricha, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Indigofera sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ipomoea bolusiana, Morning glory, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Ipomoea magnusiana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Jamesbrittenia aridicola, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Jamesbrittenia atropurpurea, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Jamesbrittenia integerrima, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Juncus krausii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Justicia thymifolia, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Kedrostis africana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Kedrostis crassirostrata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Kleinia cephalophora, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Kleinia longiflora, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Kohautia caespitose brachyloba, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Kohautia cynanchica, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Kohautia sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Kyllinga alba, White Sedge, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Kyllinga alba, White Sedge, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Lachenalia giessii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Laggera decurrens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Lampranthus sauvissimus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Lantana rugosa, Birds brandy, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Lapeirousia plicata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Lavrania cactiformis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Lavrania marlothii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Lebeckia macrantha, Ganna, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Lebeckia spinosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ledebouria luteola, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Ledebouria sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ledebouria undulata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Lepidium africanum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Lessertia brachypus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Lessertia frutescens (Sutherlandia frutescens), Kankerbos, Cancer Bush - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Leucas capensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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ADDENDUM 1

Live, Leucosphaera bainesii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Leysera tenella, Teebossie, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Limeum aethiopicum subsp. namaense var. lanceolatum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Limeum aethiopicum, Koggelmandervoet Karoo, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Limeum arenicola, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Limeum argute carinatum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Limeum fenestratum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Limeum sulcatum sulcatum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Limeum viscosum transvaalense, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Limeum viscosum, Lizard foot, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Limeum viscosum, Lizard foot, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Lithops julii subsp. fulleri var. fulleri, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Lithops olivacea var. olivacea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Lophiocarpus polystachyus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Lopholaena cneorifolia, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Lotononis calycina, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Lotononis densa gracilis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Lotononis falcata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Lotononis falcata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Lotononis furcata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Lotononis platycarpa, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Lotononis rabenaviana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Lycium bosciifolium, Slapkriedoring, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Lycium cf. bosciifolium, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Lycium cinereum, Kriedoring, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Lycium cinereum, Kriedoring, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Lycium hirsutum, River Honey Thorn, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Lycium prunus-spinosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Lycium pumilum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Malva parviflora, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Manulea nervosa, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Manulea sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Mariscus cf. aristatus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Medicago sp, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Megaloprotachne albescens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Melhania burchellii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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ADDENDUM 1

Live, Melhania didyma, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Melhania rehmannii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Melhania virescens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Melia azedarach, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Melinis repens grandiflora, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Melinis repens repens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Melolobium calycinum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Melolobium candicans, Honeybush, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Melolobium candicans, Honeybush, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Merremia verecunda, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Merxmeullera dura, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Mesembryanthemum guerichianum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Mesembryanthemum inachabense, Soutslaai, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Mesembryanthemum longistylum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Microloma incanum, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Mollugo cerviana var. cerviana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Momordica balsamina, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Monechma divaricatum, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Monechma genistifolium australe, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Monechma incanum, Perdebos / Skaapbloubossie/Vallbossie, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Monechma spartioides, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Monsonia angustifolia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Monsonia parviflora, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Montinia caryophyllacea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Moraea fugax, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Moraea pallida, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Nemesia sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Nenax microphylla, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Neurada procumbens, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Neuradopsis austro africana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Nicandra physalodes, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Nicotiana glauca, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Nidorella resedifolia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Nolletia arenosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Nuxia gracilis, —, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Nymania capensis, Chinese lantern, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

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Live, Ochna pulchra, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Ocimum americanum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Oenothera indecora, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Olea europaea africana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Ophioglossum polyphyllum, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ophioglossum polyphyllum, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Orbea knobelii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Ornithogalum glandulosum, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ornithogalum montanum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Ornithogalum pruinosum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ornithogalum sp., Tjienkerietjee, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ornithoglossum viride, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Oropetium capense, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Oropetium capense, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Orthanthera jasminiflora, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Osteospermum armatum, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Osteospermum pinnatum var. breve, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Osteospermum pinnatum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Osteospermum scariosum, Bietou/Sagte Bietou, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Othonna abrotanifolia, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Othonna auriculifolia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Othonna cf. cuneata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Othonna floribunda, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Othonna pavonia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Othonna protecta, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Othonna quercifolia (caudiform), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Othonna quercifolia (shrub), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Othonna sedifolia, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Othonna sp. nov. (PGD 2342), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Othonna sp. nov. (PGD 3728), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Oxalis annae, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Oxalis commutata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Oxalis eckloniana var. eckloniana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Oxalis lawsonii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Oxalis obtusa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Oxalis pes caprae, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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Live, Oxalis pulchella, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Oxalis semiloba, Bolila, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Ozoroa dispar, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Panicum arbusculum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Panicum coloratum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Panicum kalaharense, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Panicum maximum, Guinea grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pappea capensis, Indaba tree, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pappea capensis, Indaba tree, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Parkinsonia africana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pavonia senegalensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pegolettia retrofracta, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pelargonium cf. carnosum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pelargonium crithmifolium, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pelargonium sp., Malva, --- - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pelargonium spinosum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pelargonium xerophyton, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Peliostomum leucorrhizum, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Peliostomum leucorrhizum, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pellaea calomelanos, Bergaving, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pennisetum setaceum, Fountain grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pentarrhinum insipidum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pentatrichia petrosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pentzia argentea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pentzia calcarea, Meerkat bush, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pentzia incana, Karoobossie, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pentzia lanata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pentzia viridis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pergularia daemia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pharnaceum sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Phragmites australis, Fluitjiesriet, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Phragmites australis, Fluitjiesriet, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Phyllanthus angolensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Phyllanthus maderaspatensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Phyllanthus parvulus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Phyllobolus latipetalus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

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Live, Phyllobolus lignescens, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Physalis viscosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Piaranthus decorus subsp. cornutus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Piaranthus geminatus, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Picris echioides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Platycarpha carlinoides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Plinthus cryptocarpus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Plinthus karooicus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Plinthus sericeus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pogonarthria squarrosa, Herringbone Grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pollichia campestris, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Polygala seminuda, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Polygala seminuda, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pomaria burchellii burchellii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Portulaca collina, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Portulaca kermesina, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Portulaca oleracea, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Portulaca pilosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Prepodesma orpenii, ---, -- - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Prosopis glandulosa, Mesquite, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Prosopis glandulosa, Mesquite, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Psilocaulon articulatum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Psilocaulon coriarium, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Psilocaulon subnodosum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pteronia acuminata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pteronia adenocarpa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Pteronia cf. unguiculata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pteronia ciliata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pteronia glauca, Sage, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pteronia leucoclada, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pteronia mucronata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pteronia sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Pupalia lappacea, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Putterlickia saxatilis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Quaqua mammillaris, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Requienia sphaerosperma, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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(Kuruman) Tel: 053-712 0702 Fax: 053-712 0936 *(Upt) Tel: 054-3322885 Fax: 054-3311155*

ADDENDUM 1

Live, Rhigozum trichotomum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Rhigozum trichotomum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Rhus incisa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Rhus undulata, Kuni-bush, Sandrapuis - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Rhynchosia totta totta, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Ricinus communis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Rogeria longiflora, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Rosenia humilis, ---, --- - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ruschia aff. divaricata (PGD 3764), , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ruschia barnardii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ruschia divaricata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ruschia griquensis, Brillant Ruschia, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ruschia inclusa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ruschia muricata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Ruschia robusta, Swart t'nouroebos, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Salsola aphylla, Lye ganna, Rivierganna - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Salsola aphylla, Lye ganna, Rivierganna - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Salsola kali, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Salsola kali, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Salsola sp.2, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Salvia stenophylla, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Salvia verbenaca, Sage, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Sansevieria aethiopica, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Sansevieria aethiopica, ---, --- - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Sarcocaulon crassicaule, Boesmankers, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Sarcocaulon salmoniflorum, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Sarcostemma pearsonii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Sarcostemma viminale, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Schinus molle, Pepper tree, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Schizobasis sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Schizocarphus nervosus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Schkuhria pinnata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Schmidtia kalahariensis, Kalahari suurgras, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Schmidtia kalihariensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Schmidtia pappophoroides, Sand quick, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Schoenoplectus cf. erectus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

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ADDENDUM 1

Live, Schoenoplectus muricinux, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Schoenoplectus muricinux, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Schwantesia pillansii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Schwantesia ruedebuschii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Scirpoides burkei, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Searsia burchellii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Searsia ciliata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Searsia lancea, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Searsia pendulina, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Searsia pyroides, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Searsia tenuinervis, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Searsia tridactyla, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Searsia undulata, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Selago densiflora, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Selago namaquensis, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Senecio bulbinifolius, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Senecio burchellii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Senecio radicans, Bobbejaantoontjies, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Senecio sarcoides, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Senecio sisymbriifolius, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Senna italic arachoides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Septulina glauca, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Sericocoma avolans, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Sericocoma avolans, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Sericocoma avolans, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Sericocoma pungens, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Sericorema remotiflora, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Sericorema sericea, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Sesamum capense, ---, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Sesamum capense, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Sesamum triphyllum, ---, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Setaria verticillata, Bur Bristle grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Sisyndite spartea, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Solanum burchellii, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region
Live, Solanum burchellii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region
Live, Solanum capense, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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ADDENDUM 1

Live, Solanum giftbergense, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Solanum incanum, Poisen apple, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Solanum nigrum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Solanum nigrum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Solanum supinum, Tandpynbos, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Sonchus oleraceus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Sorghum bicolor, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Sporobolus discosporus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Sporobolus fimbriatus, Fynvleigras, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Sporobolus nervosus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Sporobolus rangei, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Stachys rugosa, Boesmantee, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stapelia similis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis aff. Namaquensis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis anomala, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis brevifolia, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis cf. uniplumis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis ciliata, Langbeenbosmangras, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis ciliata, Langbeenbosmangras, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Stipagrostis ciliata, Langbeenbosmangras, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Stipagrostis hirtigluma, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Stipagrostis namaqensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Stipagrostis namaquensis, Steekwiet, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis obtusa, Kortbeen-boesmangras, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis obtusa, Kortbeen-boesmangras, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Stipagrostis sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis uniplumis neesii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Stipagrostis uniplumis var. uniplumis, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Stipagrostis uniplumis, Silky bushman grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Sutera halimifolia, Snapdragon, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Sutera ramosissima, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Sutera tomentosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Suterlandia fruticosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tagetes minuta, Khaki bush, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tagetes minuta, Khaki bush, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tamarix unseoides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

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Live, Tamarix usneoides, Wild tamarix, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tapinanthus oleifolius, Mistletoe (Lighting matches), - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Taraxacum officinale, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tarchonanthus camphoratus, Wild camphor bush, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tarchonanthus obovatus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tephrosia dregeana dregeana, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tephrosia dregeana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Terminalia sericea, Silver cluster leaf, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tetragonia reduplicata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tetragonia spicata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Themeda triandra, Red grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Thesium hystrix, Kleinswartstorm, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Thesium lineatum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Titanopsis hugo-schlechteri var. hugo-schlechteri, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Trachyandra cf. jacquiniana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Trachyandra saltii, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Trachyandra sp. nov., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tragus berteronianus, Common carrot seed grass, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tragus racemosus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Trianthema parvifolia parvifolia, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Trianthema parvifolium, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tribulus cf. zeyheri, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tribulus cristatus, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tribulus terrestris, Devils thorn, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tribulus zeyheri, Devils thorn, - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Trichodesma africanum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Trichodesma africanum, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Trichodiadema obliquum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Trichoneura grandiglumis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tripteris microcarpa subsp. Microcarpa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tripteris pinnatilobata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tripteris sinuata, Skaapbos, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Triraphis andropogonoides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Tritonia karooica, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tylecodon paniculatus, Botterboom, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tylecodon reticulatus subsp. Phyllopodium, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

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Live, Tylecodon rubrovenosus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tylecodon sulphureus var. sulphureus, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Tylecodon wallichii, Krimpsiekbos, --- - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Urochloa panicoides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Ursinia nana, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Vachellia erioloba [Acacia erioloba], Camel Thorn, Kameeldoring - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Vachellia erioloba [Acacia erioloba], Camel Thorn, Kameeldoring - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Vahlia capensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Vangueria infausta, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Verbena basilensis, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Verbesina encelioides encelioides, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Viscum capense, Voelent, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Viscum rotundifolium, Red berried Mistletoe, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Wahlenbergia cf. nodosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Wahlenbergia nodosa, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Wahlenbergia oxyphylla, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Wahlenbergia prostrata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Wahlenbergia sp., , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Walafrida cf. geniculata, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Waltheria indica, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Whiteheadia bifolia, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Withania somnifera, , - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Zaluzianskya cf. villosa, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Ziziphus mucronata, Buffalo-thorn, Haakdoring - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Ziziphus mucronata, Buffalo-thorn, Haakdoring - -Species sex: Not applicable, Seeds to be collected in the Kalahari region

Live, Zygophyllum cf. decumbens, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Zygophyllum cf. meyeri, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Zygophyllum cf. microphyllum, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Zygophyllum retrofractum, Hondepisbos, - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

Live, Zygophyllum simplex, , - -Species sex: Not applicable, Seeds to be collected in the Bushmanland region

STANDARD RESTRICTED ACTIVITIES AND METHODS PERMITTED

Gathering, collecting, picking or plucking by using approved collection methods as stipulated under "species and numbers permitted" and under "additional conditions".

SPECIAL RESTRICTED ACTIVITIES AND METHODS PERMITTED

None

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ADDENDUM 1

ADDITIONAL RESTRICTED ACTIVITIES AND METHODS PERMITTED

GENERAL PERMIT CONDITIONS APPLICABLE

1) This permit is not transferable to any individual person or any other legal identity.

2) Any alterations to this permit shall immediately render it invalid.

3) This permit is deemed valid only:
a) in the original format as issued by the Director.

b) for the period as specified on the permit.

c) once the signature of the holder thereof has been endorsed thereon in ink.

4) The Director reserves the right to amend, withhold, withdraw or cancel any permit at any time.

5) This permit shall lapse / be deemed invalid when it is lost or destroyed and no copy thereof shall be issued.

6) This permit, unless otherwise stated, is valid only within the boundaries of the Northern Cape Province and then specifically only for the property as specified on the permit.

7) This permit does not grant the permit holder automatic access to any Protected area, National Park, Provincial Nature Reserve or privately owned land. Any other / further conditions or restrictions that the manager / landowner may stipulate at his / her discretion must also be adhered to.

8) The permit holder must at all times while performing any restricted activity have the permit and all relevant documentation in his / her possession.

9) Permits must be made available upon request of any authorized person. This person must also be allowed access onto the property at any reasonable time for any inspection needed and can remain on such property as long as it is needed to do the inspection.

10) If applicable, the permit holder must within 21 days after performing the restricted activity furnish the Director with a written return as prescribed, with feedback on the results of the activity conducted.

11) If applicable, the permit holder shall apply for the renewal of the permit to the Director, on the appropriate application form, at least 3 months prior to the expiry date thereof.

12) The holder of this permit shall return the original to The Director: Permit Administration, Private Bag X6102, Kimberley, 8300, within fourteen days from the date of expiry thereof.

13) No new permit applications will be processed prior to the return of the original permit, once it has been used or once it has expired.

14) This permit is subject to the provisions of any law in force, during the period of validity of the permit, in respect of the specific area to which the permit applies.

15) This permit is subject to any applicable norms and standards in existence at the time of issuance of this permit.

16) It is the permit holder's responsibility to obtain information on any other legislation or changes thereto and any specifications or permit requirement that may be needed or required from any other department / organization / institute, for any activity as authorized by this permit.

17) It should be noted that any transgression, failure to render the required reports and or the return of the original permit, can jeopardize any future applications by the permit holder.

18) If the holder of this permit contravenes or fails to comply with any permit condition or requirement to which this permit is subject, he or she shall be guilty of an offence.

STANDARD PERMIT CONDITIONS APPLICABLE

1) The permit holder will be responsible for the supervision during the harvesting process.

2) The weight mentioned on this permit is the maximum authorized to be harvested.

Abrahams

Signature of Issuing Authority

20/03/2020

Date of Signature

Signature of Permit Holder

Department of Environment and Nature Conservation - 90 Long Street - Private Bag X 6102, Kimberley 8300

(HQ - Kby) Tel: 053-807 7430 Fax: 086 5151 769 *(Cal) Tel: 027-341 1779 Fax: 027-341 1718* *(De Aar) Tel: 053-6310 601 Fax: 053-6310 343*

(Kuruman) Tel: 053-712 0702 Fax: 053-712 0936 *(Upt) Tel: 054-3322885 Fax: 054-3311155*

ADDENDUM 1

3) Detailed records of harvesting and trade must be supplied to the Director: Private Bag X6102, Kimberley 6300, upon expiry of this permit on the register provided.

SPECIAL PERMIT CONDITIONS APPLICABLE

None

ADDITIONAL PERMIT CONDITIONS APPLICABLE

1.The permit is only valid for the collection of seeds from the natural environment in both the Bushmanland and Kalahari Regions within the following municipal boundaries:

a.Tsantsabane Local Municipality in the ZF Mcgawu District Municipality,
b.the entire John Taolo Gaetsewe District Municipality &
c.the Khâi-Ma Local Municipality in the Namakwa District Municipality.

2.The list permitted for collection contains endemic species: if these species are collected for rehabilitation purposes then they should be re-planted in their specific ranges only.

3.The collection of seeds for species listed as Endangered, Near Threatened, Vulnerable, Critically Rare, etc. as well as NEMBA: ToPS Protected species should be limited to include not more than 5% of the seeds from a single population for harvesting purposes.

4.NCNCA 9 of 2009 listed species:
a.Not more than 20% of the seeds from and individual tree / plant should be harvested.
b.Not more than 5% of the seeds from a single population should be harvested.

5.Seeds should only be harvested from healthy, vigorous plants – to ensure good quality seedlings and plants.

6.Seeds should only be collected from 2 weeks on after the seed crop has been set / established.

7.Seeds should only be collected from a population with a mature seed crop of moderate quantity.

8.When selecting populations for harvesting, ensure that the target species are uniformly distributed; do not collect from plants located in close proximity of each other.

9.Areas / populations harvested from should be alternated annually.

10.Seeds may only be collected from the species listed in the permit.

11.Wasteful harvesting of seeds is prohibited – harvest only the amount of seeds needed for cultivation purposes.

12.Do not harvest from plants stressed due to drought or other environmental / anthropogenic impacts.

13.Harvesting of whole plants is prohibited.

14.Plants should not be unnecessarily damaged when seeds are harvested.

15.Damage to the natural environment should be avoided at all costs when seeds are harvested.

16.Should a report, publication, article, thesis or any other form of dissemination arise from this research, an acknowledgement to the DENC should be included.

17.A copy of all completed reports, publications, articles, theses, or any other forms of dissemination that arise from this research should be submitted to the Deputy Director: Research & Development Support, the DENC, free of charge.

18.The identification of new species within the Province should be communicated with the DENC (Deputy Director: Research & Development Support).

19.The DENC has no jurisdiction within National Parks and permission is needed for collection on National Reserves.

20.The applicant should, on an annual basis, submit a report-back (summary) to the DENC (Deputy Director: Research & Development Support at DENCPermitReports@gmail.com) of the species collected and their localities should be mapped.

21.The applicant should, at all times, obtain private landowner's permission prior to the collection of seeds. Proof of this should be kept on record at all times.

Signature of Issuing Authority

20/03/2020

Signature of Permit Holder

Date of Signature

Department of Environment and Nature Conservation - 90 Long Street - Private Bag X 6102, Kimberley 8300

(HQ - Kby) Tel: 053-807 7430 Fax: 086 5151 769 *(Cal) Tel: 027-341 1779 Fax: 027-341 1718* *(De Aar) Tel: 053-6310 601 Fax: 053-6310 343*

(Kuruman) Tel: 053-712 0702 Fax: 053-712 0936 *(Upt) Tel: 054-3322885 Fax: 054-3311155*

- **EndemicVision seed harvesting Consent Letter (Bedrog)**

19 November 2019

Hiermee gee ek,

Naam & Van: FREDERICK DANIËL MARITZ

ID: 6307045111088

magtiging aan:

EndemicVision Environmental Services (Pty) Ltd
Reg No: 201300324507

om saad te oes/versamel van die volgende spesies:

Boscia albitrunca

op die eiendom:

Porsie 1 van plaas Shrewsbury 496
LPI kode: C04100000000049600001

Bemagtigde:

Voorletters & van: F D MARITZ

Getuie:

Voorletters & van: E. Cronjé

Geteken te Oliphantshoek op hierdie 19 dag van November 2019

EndemicVision Environmental Services (Pty) Ltd
Company Reg No. 201300324507 • VAT Reg No. 49302634/07
PO Box 2061, Kathu, 8446 • 15 Kokkewiet Street, Kathu, 8446, South Africa
T: +27 53 723 1379 • **F:** +27 86 590 7261 • **E**: info@endemicvision.co.za
W: www.endemicvision.co.za

- **EndemicVision seed harvesting consent letter (De Rust)**

ENDEMIC VISION

ODB Nr: 0016/2020

Permit No: 0011/2020

18/ 12/ 2020

Hiermee gee ek, HENDRIK J C WESSELS <Volle name en Van> (ID: 661124 5008 089),

magtiging en/of permissie aan **EndemicVision Environmental Services (Pty) Ltd (Reg No: 201300324507)** om saad te versamel op die eiendom:

PLAAS DERUST <Naam van eiendom>

DIBENG <Naam van eiendom>

8463 <Pos kode>.

Slegs saad van die onderstaande spesie(s) mag versamel word:

Boscia albitrunca (Shepherd's Tree / Witgat)

Grondeienaar:

HENNIE WESSELS

<Voorletters & Van>

Getuie:

K WESSELS

<Voorletters & Van>

Geteken te DIBENG <Plek> op 19 <DD> dag van DESEMBER <Maand> 20 <YY>.

EndemicVision Environmental Services (Pty) Ltd
Company Reg No. 201300324507 • VAT Reg No. 49302634/07
PO Box 2061, Kathu, 8446 • 15 Kokkewiet Street, Kathu, 8446, South Africa
T: +27 53 723 1379 • F: +27 86 590 7261 • E: info@endemicvision.co.za
W: www.endemicvision.co.za

- **Kalahari East Water Users Association (Licence NCU 11041020)**

environment, forestry & fisheries
Department: Environment, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

Approved 19/10/20

Enquiries: J. Mans
E-mail: JacolineMa@daff.gov.za
Contact: 060 973 1660
Ref: NCU 11041020

LICENCE
NCU 11041020

TO AUTHORISE CUT, REMOVE & DAMAGE OR DESTROY a) *INDIGENOUS TREES* IN *NATURAL FORESTS*, AND/OR b) *PROTECTED TREES*, OR THE ACQUISITION OR DISPOSAL IN ANY MANNER OF SUCH TREES OR THEIR PRODUCTS
[SECTIONS 7(1) AND 15(1) OF ACT NO. 84 OF 1998, REGULATION 20(1) AND 21(1)]

This Licence:

- Grants authority under National Forests Act (Act No. 84 of 1998), as amended, to carry on one or more of the activities, upon such conditions, and for such a period, as specified in more details below;
- Does not exempt the licensee from adhering to the provisions of any other law
- Must be renewed at nearest Forestry office after expiry of the specified period if still required
- Is valid for the period **15 October 2020** to **15 October 2022**

A	PARTICULARS OF LICENSEE		
Institution	Kalahari East Water Users Association – 2nd Bedrog Reservoir		
Surname	Nel		
First Names	Jacobus Cornelius		
ID Number	670104 5014 088		
Postal Address	P.O. Box 1331, Upington, 8800		
Residential Address	20 Van Coppenhagen Street, Upington, 8801		
Contact Details	**Tel: (054) 337 8100**	**Cell: N/A**	**Fax: (054) 332 3932**
E-mail address	Kobus@nelenvennote.co.za; cc ec@endemicvision.co.za; cc vandermerwekotie@gmail.com		
Name and Number of property	Portion 1 of Farm *Shrewsburry* 496, Olifantshoek District		
Location of property	Tsantsabane Local Municipality, Z.F. Mgcawu District Municipality, Northern Cape Province		

In respect of protected trees:

B	LICENSED ACTIVITIES	
1	***Cut / Destroy / Damage / Disturb:*** A maximum of 7 *Boscia albitrunca,* 119 *Vachellia erioloba* and 2 *Vachellia haematoxylon* distributed over an area of ± 2.9 ha.	
2	***Possess / Transport:*** Timber from the trees specified in number 1 above; it can be donated to the landowner, used on site for domestic purposes (firewood) or transported to the nearest registered landfill or municipal dumping site. It may not be sold.	
3	Cutting of live trees according to approved sustainable management plan.	**DENC Ref: NC/BA/34/ZFM/DAW/UPI2/2019 (Permit 17/2020)**
4	***Sizes and numbers of tree species:*** Seven (7) *Boscia albitrunca* 119 *Vachellia erioloba* and two (2) *Vachellia haematoxylon* distributed over an area of ± 2.9 ha. All size classes.	
5	***Condition of trees:*** Healthy, vigorous trees. Dead trees may also be encountered.	
6	***Estimated quantity:*** A maximum of 7 *Boscia albitrunca,* 119 *Vachellia erioloba* and 2 *Vachellia haematoxylon.*	
7	***Origin:*** Portion 1 of Farm *Shrewsburry* 496, Olifantshoek District, Northern Cape Province.	
8	***Destination:*** As in number 7 above or the nearest registered landfill/municipal dumping site.	

9	*Specifications, prescriptions and remarks*	1. This license permits the felling of a maximum of seven (7) *Boscia albitrunca,* 119 *Vachellia erioloba* and two (2) *Vachellia haematoxylon* distributed over an area of ± 2.9 ha for construction of the 2nd Bedrog Dam, adjacent to the existing reservoir on Portion 1 of Farm *Shrewsburry* 496, Olifantshoek District. See final approved layout map with GPS Coordinates on page 3 of this license. 2. The affected trees hampering construction of the fence and those in the laydown area and reservoir footprints can be felled. All other protected trees must be barricaded and safeguarded during construction, to avoid accidental damage. 3. The trees may only be felled shortly prior to construction of the reservoir. If the trees are felled and the facility is not constructed, it will be deemed as unnecessary removal of protected trees and non-compliance with Act 84/1998. 4. Records must be kept of the actual number of trees destroyed under this license and a report-back provided to the Forestry Office in Upington by the expiry date of this license. The report must contain photographic evidence of protected trees retained on site. Permitted numbers may not be exceeded. If numbers will be exceeded, an additional license must be applied for and obtained. 5. Trees with active bird nests may not be disturbed without a valid Fauna Permit from the provincial Department of Environment and Nature Conservation (DENC) under the Northern Cape Nature Conservation Act, Act 9 of 2009 (NCNCA), if affected. 6. If the Licensee is not the landowner, **written permission must be obtained from the affected landowner(s), prior to commencement or entry onto private property.** Affected landowner(s) may personally supervise tree removal / pruning on their properties, should they wish to do so. 7. The Licensee or appointed Environmental Control Officer shall supervise all personnel who undertake activities under this license to avoid unnecessary destruction and damage to protected trees, based on a lack of knowledge.

C	LICENCE CONDITIONS

1. General license rules

This licence is –

(a) Not transferable (you cannot pass it on to another person), and

(b) Only valid for the period it was issued for.

2. Showing this license

(a) You must produce this licence on demand to any forest officer or police officer.

(b) The person moving or transporting timber or other products must at all times be in possession of a certified / stamped copy of this license.

Any further conditions	**Officials from the Department of Environment, Forestry and Fisheries may at any time conduct a site inspection to monitor compliance. Removal of protected trees not specified in this license and/or non-compliance with a license condition may result in the immediate cancellation of the license and criminal prosecution, which may include a fine or imprisonment or both such a fine and imprisonment.**

DATE STAMP

19 Oct 2020

……
DIRECTOR-GENERAL

NCU 11041020

License NCU 11041020 permits the felling of seven (7) *Boscia albitrunca*, 119 *Vachellia erioloba* and two (2) *Vachellia haematoxylon* distributed over an area of ± 2.9 ha for construction of the 2nd Bedrog Dam, adjacent to the existing reservoir on Portion 1 of Farm *Shrewsburry* 496, Olifantshoek District. All other protected trees present on site must be conserved.

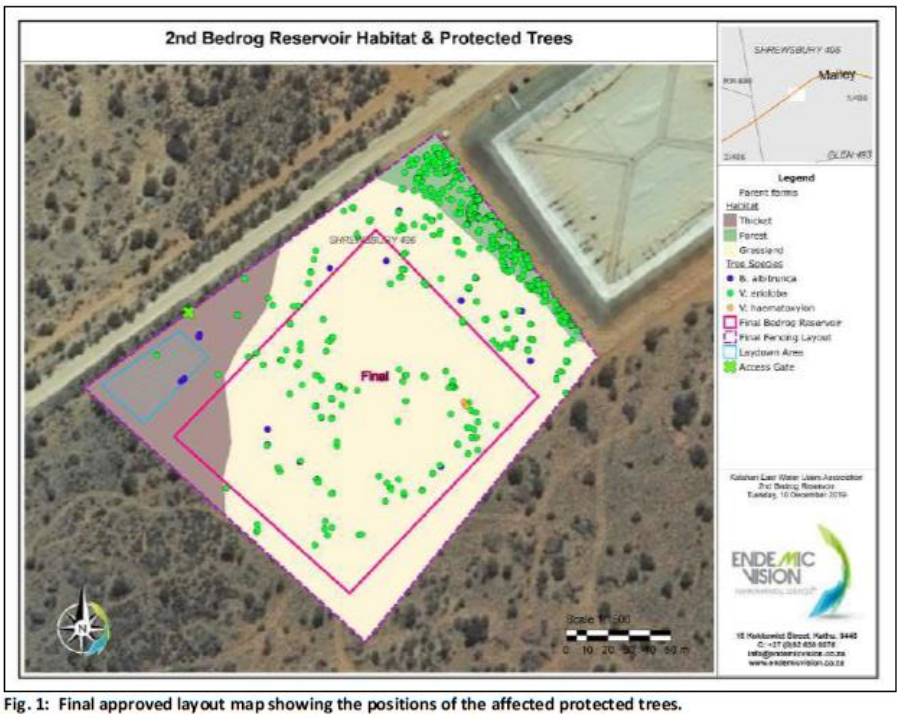
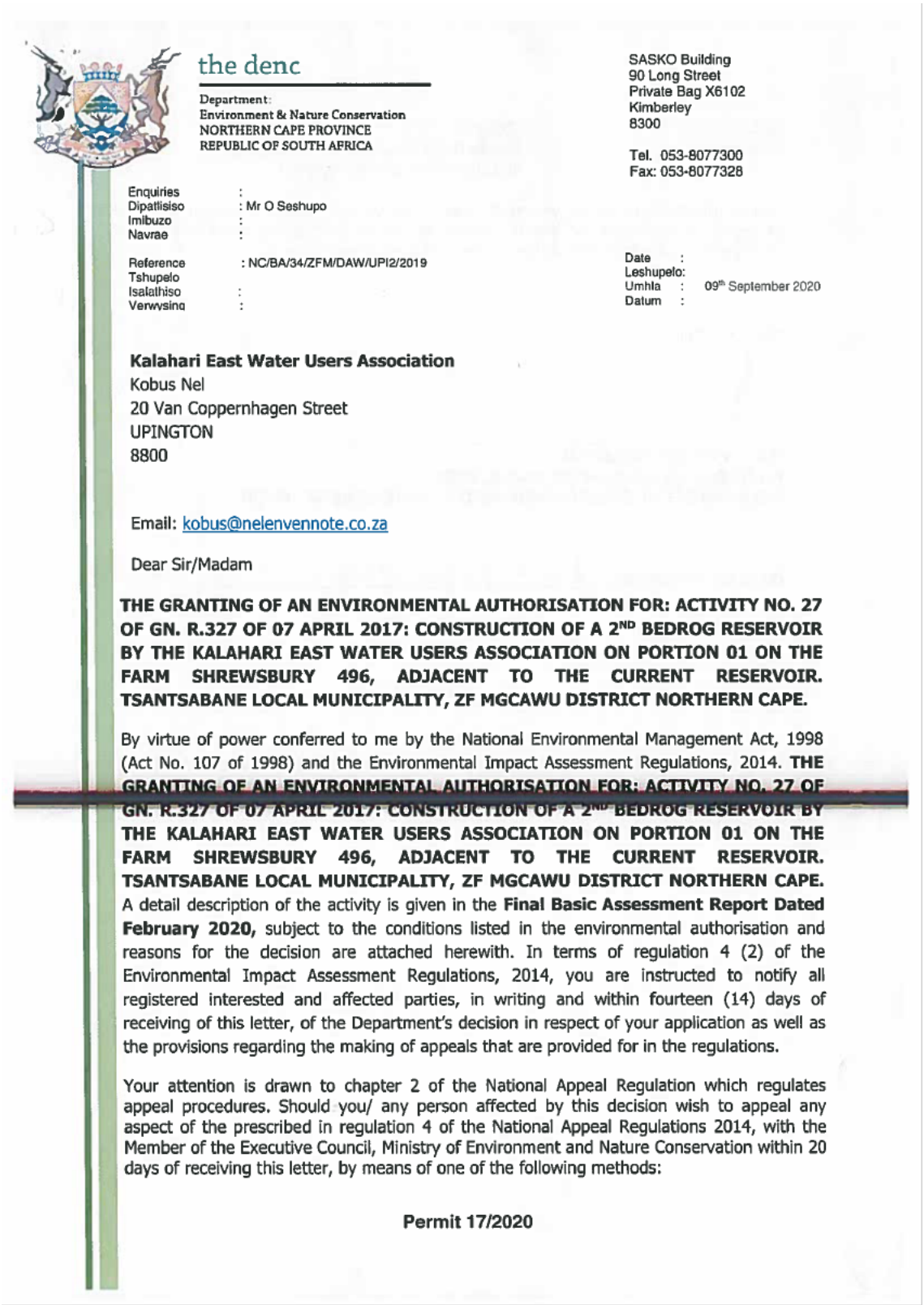


Fig. 1: Final approved layout map showing the positions of the affected protected trees.

GPS Coordinates of final approved layout plan:

Final fencing layout:		Final Reservoir:		Final laydown area:	
East:	South:	East:	South:	East:	South:
22° 33' 20.15"	27° 39' 30.64"	22° 33' 15.63"	27° 39' 35.30"	22° 33' 14.38"	27° 39' 34.51"
22° 33' 22.98"	27° 39' 34.07"	22° 33' 18.68"	27° 39' 37.72"	22° 33' 15.11"	27° 39' 35.10"
22° 33' 18.92"	27° 39' 38.46"	22° 33' 31.93"	27° 39' 34.68"	22° 33' 16.23"	27° 39' 34.07"
22° 33' 14.09"	27° 39' 34.55"	22° 33' 19.11"	27° 39' 32.11"	22° 33' 15.72"	27° 39' 33.67"

- **Kalahari East Water Users Association (Environmental Authorisation NC/BA/34/ZFM/DAW/UPI2/2019)**



the denc

Department:
Environment & Nature Conservation
NORTHERN CAPE PROVINCE
REPUBLIC OF SOUTH AFRICA

SASKO Building
90 Long Street
Private Bag X6102
Kimberley
8300

Tel. 053-8077300
Fax: 053-8077328

Enquiries :
Dipatlisiso : Mr O Seshupo
Imibuzo :
Navrae :

Reference : NC/BA/34/ZFM/DAW/UPI2/2019
Tshupelo
Isalathiso :
Verwysing :

Date :
Leshupelo:
Umhla : 09th September 2020
Datum :

Kalahari East Water Users Association
Kobus Nel
20 Van Coppernhagen Street
UPINGTON
8800

Email: kobus@nelenvennote.co.za

Dear Sir/Madam

THE GRANTING OF AN ENVIRONMENTAL AUTHORISATION FOR: ACTIVITY NO. 27 OF GN. R.327 OF 07 APRIL 2017: CONSTRUCTION OF A 2ND BEDROG RESERVOIR BY THE KALAHARI EAST WATER USERS ASSOCIATION ON PORTION 01 ON THE FARM SHREWSBURY 496, ADJACENT TO THE CURRENT RESERVOIR. TSANTSABANE LOCAL MUNICIPALITY, ZF MGCAWU DISTRICT NORTHERN CAPE.

By virtue of power conferred to me by the National Environmental Management Act, 1998 (Act No. 107 of 1998) and the Environmental Impact Assessment Regulations, 2014. **THE GRANTING OF AN ENVIRONMENTAL AUTHORISATION FOR: ACTIVITY NO. 27 OF GN. R.327 OF 07 APRIL 2017: CONSTRUCTION OF A 2ND BEDROG RESERVOIR BY THE KALAHARI EAST WATER USERS ASSOCIATION ON PORTION 01 ON THE FARM SHREWSBURY 496, ADJACENT TO THE CURRENT RESERVOIR. TSANTSABANE LOCAL MUNICIPALITY, ZF MGCAWU DISTRICT NORTHERN CAPE.** A detail description of the activity is given in the **Final Basic Assessment Report Dated February 2020,** subject to the conditions listed in the environmental authorisation and reasons for the decision are attached herewith. In terms of regulation 4 (2) of the Environmental Impact Assessment Regulations, 2014, you are instructed to notify all registered interested and affected parties, in writing and within fourteen (14) days of receiving of this letter, of the Department's decision in respect of your application as well as the provisions regarding the making of appeals that are provided for in the regulations.

Your attention is drawn to chapter 2 of the National Appeal Regulation which regulates appeal procedures. Should you/ any person affected by this decision wish to appeal any aspect of the prescribed in regulation 4 of the National Appeal Regulations 2014, with the Member of the Executive Council, Ministry of Environment and Nature Conservation within 20 days of receiving this letter, by means of one of the following methods:

Permit 17/2020

By facsimile:	(053) 8077328
By post:	Private Bag X 6102, Kimberley, 8300 or
By hand:	90 Long Street, Kimberley, 8300

Should you decide to appeal, you must serve a copy of your notice of intention to appeal on all registered interested and affected parties as well as a notice indicating where, and for what period, the appeal submission will be available for inspection.

Yours Faithfully

MR. B FISHER: DIRECTOR
ENVIRONMENTAL QUALITY MANAGEMENT
DEPARTMENT OF ENVIRONMENT AND NATURE CONSERVATION

DATE OF DECISION: 16 September 2020

CC: ENDEMIC VISION ENVIRONMENTAL SERVICES
cdn@endemicvision.co.za

Northern Cape Province

DEPARTMENT OF ENVIRONMENT & NATURE CONSERVATION

Profensi Ya Kapa Bokone

LEFAPHA LA TIKOLOGO LE TSHOMARELO YA THLAGO

ENVIRONMENTAL AUTHORISATION

in terms of National Environmental Management Act, 1998 (Act No. 107 of 1998) and the Environmental Impact Assessment Regulations, 2014

Authorisation Register Number:	**Permit 17/2020**
Reference Number:	**NC/BA/34/ZFM/DAW/UP12/2019**
Last Amended:	**N/A**
Holder of Authorisation:	**Kalahari East Water Users Association**
Location of activity:	**Portion 01 of the farm Shrewsbury 496, Tsantsabane Local Municipality, ZF Mgcawu District Municipality.**

DEFINITIONS

"Activity" means an activity identified in any notice published by the Minister or MEC in terms of section 24D (1) (a) of the Act as a listed activity or specified activity;

"Proponent" means a person intending to submit an application for environmental authorisation and is referred to as an applicant once such application for environmental authorisation has been submitted;

"Application" means an application for an -

(a) environmental authorization in terms of Chapter 4 of the 2014 Environmental Impact Assessment regulations;

(b) amendment to an environmental authorisation in terms of Chapter 5 of the 2014 Environmental Impact Assessment regulations;

(c) amendment to an EMPr in terms of Chapter 5 the 2014 Environmental Impact Assessment regulations;

(d) amendment of a closure plan in terms of Chapter 5 of the 2014 Environmental Impact Assessment regulations;

"Basic Assessment Report" means a report contemplated in regulation 19 of the 2014 Environmental Impact Assessment regulations;

"Environmental Impact Assessment Report" means a report contemplated in regulation 23 of the 2014 Environmental Impact Assessment regulations;

"Plan of Study for Environmental Impact Assessment" means a study contemplated in regulation 22 which forms part of a scoping report and sets out how an environmental impact assessment will be conducted;

"Scoping Report" means a report contemplated in regulation 21 of the 2014 Environmental Impact Assessment regulations;

"EAP" means an Environmental Assessment Practitioner as defined in section 1 of the Act;

"EMPr" means an environmental management programme contemplated in regulations 19 and 23 of the 2014 Environmental Impact Assessment regulations;

"Registered Interested and Affected Party" in relation to an application, means an interested and affected party whose name is recorded in the register opened for that application in terms of regulation 42;

"Public Participation Process" means the process in which potential interested and affected parties are given an opportunity to comment on, or rare issues relevant to specific activity;

"Department" means the Northern Cape Department of Environment and Nature Conservation; and

"The Act" means the National Environmental Management Act, 1998 (Act No. 107 of 1998).

DECISION

The Department is satisfied, on the basis of information available to it and subject to compliance with conditions of this environmental authorisation, that the applicant should be authorised to undertake the activity specified below.

Details regarding the basis on which the Department reached this decision are set out in Annexure 1.

ACTIVITIES AUTHORISED

By virtue of the powers conferred on it by the National Environmental Management Act, 1998 (Act No. 107 of 1998) and the Environmental Impact Assessment Regulations, 2014 the Department hereby authorises –

Kalahari East Water Users Association

with the following contact details –

Kobus Nel

20 Van Coppenhagen street

Upington

Tel: (054) 337 8100

Fax: (054) 332 3932

Cell: N/A

Email: kobus@nelenvennote.co.za

to undertake the following activities (hereafter referred to as "the activity")

Construction of a 2nd Bedrog reservoir by the Kalahari East Water Users Association on portion 01 on the farm Shrewsbury 496, adjacent to the current reservoir. Tsantsabane Local Municipality, Northern Cape.

Activity No. 27 of GNR. 327 of April 2017

The clearance of an area of 1 hectare or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for-

(i) the undertaking of a linear activity; or

(ii) maintenance purposes undertaken in accordance with a maintenance management plan.

The project will be located on Portion 01 of the farm Shrewsbury, adjacent to the current Bedrog Reservoir located 31km from Deben and 35km from Olifantshoek towns respectively. Which falls under the jurisdiction of the Tsantsabane Local Municipality, ZF Mgcawu District Municipality Northern Cape Province. with the following co-ordinates;

(Latitude (S) 27° 39' 30.369" N, Longitude (E) 22° 33' 21.718")

(Latitude (S) 27° 39' 34.070" N, Longitude (E) 22° 33' 22.961")

(Latitude (S) 27° 39' 38.458" N, Longitude (E) 22° 33' 18.940")

(Latitude (S) 27° 39' 34.549" N, Longitude (E) 22° 33' 14.080")

(Latitude (S) 27° 39' 30.639" N, Longitude (E) 22° 33' 20.171)

Hereafter referred to as "the property".

The granting of this Environmental Authorisation is subject to the conditions set out below.

CONDITIONS

Scope of authorisation:

1. Authorisation of the activity is subject to the conditions contained in this authorisation, which conditions form part of the environmental authorisation and are binding on the holder of the authorisation.

2. The holder of the authorisation **must** be responsible for ensuring compliance with the conditions by any person acting on his or her behalf, including but not limited to, an agent, sub-contractor, employee or person rendering a service to the holder of the authorisation.

3. The activities which are authorised **must** only be carried out at the property indicated above.

4. Any changes to, or deviations from, the project description set out in this authorisation must be approved, in writing, by the Department before such changes or deviations may be effected. In assessing whether to grant such approval or not, the Department may request such information as it deems necessary to evaluate the significance and impacts of such changes or deviations and it may be necessary for the holder of the authorisation to apply for further authorisation in terms of the regulations.

5. This authorisation does not negate the holder of the authorisation's responsibility to comply with any other statutory requirements that may be applicable to the undertaking of the activities.

General conditions:

6. A copy of this authorisation must be kept at the property where the activities will be undertaken. The authorisation must be produced to any authorised official of the Department who requests to see it and must be made available for inspection by any employee or agent of the holder of the authorisation who works or undertakes work at the property.

7. Where any of the applicant's contact details change, including the name of the responsible person, the physical or postal address and/ or telephonic details, the applicant must notify the Department as soon as the new details become known to the applicant.

8. The holder of the authorisation must notify the Department, in writing and within 24 (Twenty-Four) hours, if condition 16 of this authorisation cannot be or is not adhered to. In all other cases, the holder of the authorisation must notify the Department, in writing, within seven (7) days if any condition of this authorisation is not adhered to. Any notification in terms of this condition must be accompanied by reasons for the non-compliance.

9. Non-compliance with a condition of this authorisation may result in criminal prosecution or other actions provided for in the National Environmental Management Act, 1998 and the regulations.

10. This authorization is subject to the approval by the relevant local authorities i.e. in terms of any relevant legislation administered by those local authorities.

11. The activities **must** not commence without the necessary permits/licenses/approvals and/or service agreements, where it is relevant, from or with the relevant regulatory authorities whether national, provincial or local (these include but are not limited to National Department of Environmental Affairs , National Department of Agriculture, Forestry and Fisheries, Department of Housing & Local Government, Department of Water and Sanitation, Department of Mineral Resources, Department of Transport, Roads & Public Works, Department of Sports, Arts & Culture, South African Heritage Resources Agency, South African Civil Aviation Authority).

12. The activities, including site preparation, may not commence before the thirty (30) day appeal period expires or until such time as the Department has considered any appeals that have been lodged.

    a. **Seven (7) days** written notice must be given to the Department before commencement

    b. Such notice shall make clear reference to the site location details and the reference number given above.

    c. The said notice must also include proof of compliance with the following condition described herein:

        i. Condition: 11

13. The applicable conditions of this authorization must form part of all contractors' and sub-contractors' conditions of contract. A performance-based requirement with regard to environmental impact management must be included in all contracts related to any aspect of this authorization.

14. The applicant must carry out regular environmental audits to establish compliance with the conditions of this authorization and contracts.

15. Environmental Management Inspectors employed by the Department shall be given access to the property as described above (see detailed description of the activities) for the purposes of assessing and/or monitoring compliance with the conditions contained in this Environmental Authorization. Where the activity is located on a third party's property the applicant shall be responsible to arrange access for departmental officials.

16. This Department may add to, change and/or amend any of the conditions in this authorization if, in the opinion of the Department, the addition, change of amendment is environmentally justified. In event that such impacts exceed its significance as predicted in the independent consultant's basic assessment report and supporting documentation, the authorization may be withdrawn after proper procedures were followed.

17. In the event of any dispute concerning the significance of a particular impact, the opinion of this department in respect of its significance will prevail.

18. This Department and any national department, provincial department, local authorities or committees appointed in terms of the conditions of this application or any other public authority or organization shall not be held responsible for any damage of losses suffered by the applicant or his successor in title in any instance where construction or operation subsequent to construction be temporarily or permanently stopped for reasons of non-compliance by the applicant with the conditions of approval as set out in this document or any other subsequent document emanating from these conditions of approval.

19. The applicant shall be responsible for all costs necessary to comply with the above conditions unless otherwise specified.

20. The applicant must apply the principle of best practicable environmental option for all technologies used/ implemented during construction and operation phase.

Appeal of authorisation:

21. In terms of Regulation 4(2) of the Environmental Impact Assessment Regulations, 2014 (the Regulations), you are instructed to notify all registered interested and affected parties, in writing and within 14 (fourteen) days of the date of the Department decision in respect of the amendment made as well as the provisions regarding the submission of appeals that are contained in the Regulations.

22. Your attention is drawn to Chapter 2 of Government Notice No. R993, which prescribes the appeal procedure to be followed.

Management of activity:

25. The Environmental Management Programme ("EMPr") submitted as part of the application for environmental authorisation must be implemented. (Alternatively, if further changes are required to the EMPr as a result of the authorisation, this condition must be modified).

26. Ensure that all "NO-GO" areas are clearly defined and adequately demarcated.

27. All works to be conducted in an environmentally sensitive manner and in accordance with the EMPr and conditions of this authorization.

Monitoring

28. The EMPr must be strictly enforced during all phases of the project.

29. Changes to the EMPr, which are environmentally defendable, must be submitted to this Department for acceptance before such changes are effected.

30. The Department reserves the right to amend the EMPr should any impacts that were not anticipated or covered in the Basic Assessment Report.

31. A spillage plan must be implemented and strictly enforced during construction phase.

Environmental Control Officer (ECO) and Duties

32. The holder of this authorisation must appoint an independent Environmental Control Officer (ECO) with experience or expertise in the field for the construction phase of the development. The ECO will have the responsibility to ensure that the conditions referred to in this authorisation are implemented and to ensure compliance with the provisions of the EMPr.

33. The ECO must be appointed before commencement of any authorised activity.

34. The ECO must meet with the contractors to discuss the conditions of the **Environmental Authorisation** and the contents of the EMPr prior to commencement of activities.

35. Once appointed, the name and contact details of the ECO must be submitted to the Director: Compliance Monitoring of the Department.

36. The ECO must keep record of all activities on site, potential impacts, problems identified, transgressions noted and a task schedule of tasks undertaken by the ECO.

37. The ECO must remain employed until all rehabilitation measures, as required for implementation due to construction damage, are completed and the site is ready for operation.

38. Records relating to monitoring and auditing must be kept on site and made available for inspection to any relevant and competent authority in respect of this development.

39. Photographs must be taken (before, during and immediately after construction as a visual reference).

Recording and Reporting to the Department

40. The holder of this authorisation must keep all records relating to monitoring and auditing on site and make it available for inspection to any relevant and competent authority in respect of this development.

41. Records relating to compliance or non-compliance with any condition of this authorization must be kept in good order. Such records must be made available to any Official from Monitoring Compliance and Enforcement section of the Directorate: Environmental Management within seven (7) days of written request by the said Officer.

42. Any complaints regarding the said development must be brought to the attention of the Department within 24 hours after receiving the complaints; register must be kept up to date for inspection by the Department. Where any of the applicant's contact details change, including the name of the responsible person, the physical or postal address and/ or telephonic details, the applicant must notify the Department as soon as the new details become known to the applicant.

Environmental audit report

43. The holder of the authorization must submit an environmental audit report to the Department within 30 days of completion of the construction phase and within 30 days of completion of rehabilitation activities.

44. The Environmental audit report must:

- Be compiled by an independent environmental auditor;
- Indicate the date of the audit, the name of the auditor and the outcome of the audit in terms of compliance with the environmental authorisation conditions as well as the requirements of the EMPr.
- Include measures to be implemented to attend to any non-compliances.
- Include copies of any approvals granted by other authorities relevant to the department for the reporting period.
- Highlight any outstanding environmental issues that must be addressed, along with recommendations for ensuring that they are appropriately addressed.
- Include evidence of adherence to the conditions of this authorisation and the EMPr where relevant such as training records.

Operation of the activity

45. Seven (7) days written notice must be given to the Department that the activity will commence. Commencement for the purposes of this condition includes site preparation. The notice must include a

46. Any waste generated during construction and operation phase must be disposed of at a waste disposal site licensed for such waste.

47. No on-site burning or burying of solid waste is permitted.

48. The construction area must be demarcated, no construction or dumping activities should be allowed outside the proposed footprint.

49. The Holder of this Environmental Authorisation must ensure construction and operation adheres to the National Water Act; Part 4 Section 19: Pollution Prevention and Part 5 Section 20 Emergency Incidents.

50. The Holder of this Environmental Authorisation must ensure construction and operation adheres to Government Notice No. 36784; No. R. 634: Department of Environmental Affairs; National Environmental Management Waste Act; 2008 (Act No.59 of 2008); Waste Classification and Management Regulations.

51. The Holder of this Environmental Authorisation must ensure that all activities associated with the proposed project take into account Integrated Environmental Management by ensuring that development is socially, environmental and economically sustainable.

52. The holder of this authorization must carry out regular inspections to detect leakages from the fuel tanks.

53. Any spillages of diesel and oil must be reported and cleared up immediately. In the event of oil or diesel spills, the contaminated soil must be placed in a waste skip and disposed-off at a licensed land fill site for such material.

54. The holder of this Environmental Authorization must ensure that soil compaction is limited to the proposed footprint of the activity.

55. Dust control measures must be implemented during clearing phase and must comply with the dust regulations promulgated under the Air Quality Act, 2004 (Act 39 of 2004).

56. If any new evidence of archaeological sites or artefacts, paleontological fossils, graves or other heritage resources is found during development or construction, SAHRA and an archaeologist and/or palaeontologist, depending on the nature of the resources found, must be alerted immediately.

57. Vegetation clearing must be limited to the required footprint.

58. Proper measures to prevent/reduce the risk of erosion and the invasion of alien species must be strictly implemented.

59. The protected trees occurring on site must not be destroyed but they must be incorporated within the development layout plan.

60. The destruction/ or disturbance of individual protected trees must be avoided during the construction of the proposed development. Alternatively, a permit for the removal of any protected species must be applied for and granted by the relevant authority.

61. The necessary flora permits must be applied for and granted by the Northern Cape Department of Environment and Nature Conservation for all plant species protected under the Northern Cape Nature Conservation Act, 2009 (Act No. 9 of 2009) should they be found existing on site.

62. The spreading of declared weedy and alien invasive plant species must be controlled and monitored at all times.

63. Cleared alien vegetation must not be dumped on adjacent intact vegetation during clearing but must be temporarily stored in a demarcated area.

64. All areas of disturbed soil must be reclaimed using only indigenous grass and shrubs. Reclamation activities shall be undertaken according to the rehabilitation plan to be included in the final EMPr.

65. Topsoil from all excavations and construction activities must be salvaged and reapplied during reclamation.

66. All mitigation measures detailed in the Environmental Management Programme report must be implemented.

Site Closure and Decommissioning:

67. Should the proposed activity ever cease or become redundant, the applicant must undertake the required actions as prescribed by legislation at the time and comply with all relevant legal requirements administered by any relevant and competent authority.

68. All areas disturbed by the project must be rehabilitated to their original or better condition.

DURATION AND PERIOD OF VALIDITY

This activity(s) must commence within a period of ten (10) years from the date of issue. If commencement of the activity(s) does not occur within that period and the intention is to extend the validity period of the authorization, an application for amendment to extend the validity period must be launched at least three (3) months prior to the expiry date of the validity period. If commencement of the activity does not occur within that period, the authorisation lapses and a new application for environmental authorisation must be made in order for the activity to be undertaken.

APPEAL

An appellant must submit an appeal to the appeal administrator, and a copy of the appeal to the applicant, any registered interested and affected party and any organ of state with interest in the matter within 20 days from the date that the notification of the decision was sent to the applicant by the competent authority.

Appeals must be submitted in writing to:

The Member of the Executive Council
Ministry of Environment & Nature Conservation
Private Bag X6102
Kimberley
8300
Fax: (053) 832 1026

Please note that in terms of section 43(7) of the National Environmental Management Act, 1998, an appeal under section 43 of that Act will suspend the environmental authorisation or any provision or condition attached thereto. In the instance where an appeal is lodged, you may not commence with the activity until such time that the appeal is finalised.

MR. B. FISHER

DIRECTOR: ENVIRONMENTAL QUALITY MANAGEMENT

DEPARTMENT OF ENVIRONMENT & NATURE CONSERVATION

DATE OF ENVIRONMENTAL AUTHORISATION: 16 September 2020

ANNEXURE 1: REASONS FOR DECISION

1. Background

The applicant **Kalahari East Water Users Association** applied for authorization to carry on the following activity –

Construction of a 2nd Bedrog reservoir by the Kalahari East Water Users Association on portion 01 on the farm Shrewsbury 496, adjacent to the current reservoir. Tsantsabane Local Municipality, Northern Cape.

Activity No. 27 of GNR. 327 of April 2017

The clearance of an area of 1 hectare or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for-

(i) the undertaking of a linear activity; or

(ii) maintenance purposes undertaken in accordance with a maintenance management plan.

The project will be located on Portion 01 of the farm Shrewsbury, adjacent to the current Bedrog Reservoir located 31km from Deben and 35km from Olifantshoek towns respectively. Which falls under the jurisdiction

following co-ordinates;

(Latitude (S) 27° 39′ 30.7404″ Longitude (E) 22° 33′ 20.0916″)

(Latitude (S) 27° 39′ 34.1028″ Longitude (E) 22° 33′ 22.9284″)

(Latitude (S) 27° 39′ 37.4832″ Longitude (E) 22° 33′ 17.8128″)

(Latitude (S) 27° 39′ 34.0668″ Longitude (E) 22° 33′ 14.9076″)

Hereafter referred to as "the property".

The applicant appointed Endemic Vision Environmental Services (Pty) Ltd to undertake an Environmental Impact Assessment process. Basic Assessment process was followed.

2. Information considered in making the decision

In reaching its decision, the Department took, *inter alia,* the following into consideration –

a) The Environmental Assessment Practitioner complied with Regulation 19 of April 2017.

b) Public participation followed is in line with Regulation 41 of April 2017 and proof was submitted together with the Final Basic Assessment report in 24th February 2020.

c) The information contained in the Basic Assessment process submitted in 24th February 2020. by Chrizette Neethling (Endemic Vision Environmental Services (Pty) Ltd).

d) The comments received from interested and affected parties as included in the Basic Assessment report.

e) The objectives and requirements of relevant legislation, policies and guidelines, including section 2 and 23 of the National Environmental Management Act, 1998 (Act No. 107 of 1998), The Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) and the Northern Cape Conservation Act, 2009 (Act No. 9 of 2009).

f) Date and accompanying official/s for conducting the site visit.

3. Key factors considered in making the decision

All information presented to the Department was taken into account in the Department's consideration of the application. A summary of the issues which, in the Department's view, were of the most significance is set out below.

a) The EAP who prepared the report has the expertise to carry out the Basic Assessment procedures.

b) Impacts of the proposed activity on the receiving environment were described in terms of geographical, physical, biological, social, economic and cultural aspects.

c) Basic Assessment identified all legislation and guidelines it considered in preparing the report.

d) The EAP took into account comments from interested and affected parties and incorporated them into making the Basic Assessment report.

e) The need and desirability for the proposed activity.

4. Findings

After consideration of the information and factors listed above, the Department made the following findings -

a) The identification and assessment of impacts are detailed in the Basic Assessment Report dated 24th February 2020.

b) The proposed mitigation of impacts identified and assessed adequately curtails the identified impacts.

c) The procedure followed for impact assessment is adequate for decision-making process.

d) All issues emanating from interested and affected parties were fully addressed.

In view of the above, the Department is satisfied that, subject to compliance with the conditions contained in the environmental authorization, the proposed activity will not conflict with the general objectives of integrated environmental management laid down in Chapter 5 of the National Environmental Management Act, 1998 and that any potentially detrimental environmental impacts resulting from the proposed activity can be mitigated to acceptable levels. The application is accordingly granted.

- **Kgalagadi pipeline Flora Harvesting Permit (FLORA 0108/3/2016)**

ODB Number: **2470/3/2016** Permit No: **FLORA 0108/3/2016** Application ID: **38433**

Biodiversity

Northern Cape Province

Integrated Competence

Permit

Ordinary

Flora Harvesting - Development

None

Issued in terms of the provisions of:
National Environmental Management: Biodiversity Act 10 of 2004

Issued in terms of the provisions of:
Northern Cape Nature Conservation Act, 9 of 2009

SPECIES AND NUMBERS, RESTRICTED ACTIVITIES AND PERMIT CONDITIONS AS PER ADDENDUM 1 AND PAGES ATTACHED

Authorising Entity / Institute / Company
Sedibeng Water

Ian Michael Hasenjager - ID or Passport 5705045120085 - Farm name: - Physical Address: Protea Street Balkfontein - Bothaville - Free State Province - 9660

Postal address: Private Bag X5, Bothaville, Free State, 9660

Contact details: Office: 0565150200 - Home: - Cell: +27828068624 - Fax: 0565150369 - E-mail: ihasenjager@sedibengwater.co.za

Region in which restricted activity will take place

Kgalagadi (John Taolo) - Northern Cape Province

Address / Place / Fixed Property where restricted activity will be carried out, conducted or take place

Proposed upgrade of sections of the Vaal Gamagara Bulk Water Supply Scheme from Roscoe Reservoir (Olifantshoek turn-off) to Blackrock Reservoir, John Taolo Gaetsewe District Municipality, Northern Cape Province.

Digital signature of verifier

MD Smit

Digitally signed by MD Smit
DN: C=ZA, E=msmit@ncpg.gov.za, O=Department of Environment and Nature Conservation, OU=Permit Administration, CN=MD Smit
Location: Kimberley
Reason: This document has been verified as correct according to departmental legislation, policy and prescripts and I attest to the accuracy and integrity of the document.
Contact Info: 053-8077485
Date: 2019.01.30 14:55:44+02'00'

Issuing authority

VALIDITY PERIOD
FROM 31/01/2019 TO 31/01/2021

Stamp if applicable

Permit holder / Dealer

Signature of Issuing Authority

01/02/2019
Date of Signature

Signature of Permit Holder

Department of Environment and Nature Conservation - 90 Long Street - Private Bag X 6102, Kimberley 8300

(HQ - Kby) Tel: 053-807 7430 Fax: 086 5151 769 *(Cal) Tel: 027-341 1779 Fax: 027-341 1718* *(De Aar) Tel: 053-6310 601 Fax: 053-6310 343*

(Kuruman) Tel: 053-712 0702 Fax: 053-712 0936 *(Upt) Tel: 054-3322885 Fax: 054-3311155*

ODB Number: **2470/3/2016** Permit No: **FLORA 0108/3/2016** NNO 1/10/3/ **38433**

ADDENDUM 1

PRESCRIBED FEES
The prescribed fees paid for the issuing of this document shall not be refunded

Tariff: Amendment - Amount currently owed: R200 - Debit amount: R200 on 12/12/2018 with receipt number: Flora/ I Hasenjager / I HASENJAGER

SPECIES AND NUMBERS PERMITTED

Live, Boophone disticha, Gifbol, - -Species sex: Not applicable, All specimens found within the development footprint may be removed/translocated/transplanted on a suitable habitat outside the development footprint on the same property.

Live, Harpagophytum procumbens, Devil's Claw, Duiwelsklou - -Species sex: Not applicable, All specimens found within the development footprint may be removed/translocated/transplanted on a suitable habitat outside the development footprint on the same property.

Live, Indigenous Flora (Protected and Specially Protected), , - -Species sex: Not applicable, All specimens found within the development footprint may be removed/cut/damaged/destroyed.

Live, Invasive & Alien flora (Schedule 6), , - -Species sex: Not applicable, All specimens found within the development footprint may be removed/cut/damaged/destroyed.

STANDARD RESTRICTED ACTIVITIES AND METHODS PERMITTED

Gathering, collecting or plucking by using approved collection methods as stipulated under "species and numbers permitted" and under "additional conditions".

SPECIAL RESTRICTED ACTIVITIES AND METHODS PERMITTED

None

ADDITIONAL RESTRICTED ACTIVITIES AND METHODS PERMITTED

None - by using the following prohibited method and/or instrument namely: None

GENERAL PERMIT CONDITIONS APPLICABLE

1) This permit is not transferable to any individual person or any other legal identity.

2) Any alterations to this permit shall immediately render it invalid.

3) This permit is deemed valid only:
a) in the original format as issued by the Director.

b) for the period as specified on the permit.

c) once the signature of the holder thereof has been endorsed thereon in ink.

d) while the Commitment Letter is being implemented by the permit holder

4) The Director reserves the right to amend, withhold, withdraw or cancel any permit at any time.

5) This permit shall lapse / be deemed invalid when it is lost or destroyed and no copy thereof shall be issued.

6) This permit, unless otherwise stated, is valid only within the boundaries of the Northern Cape Province and then specifically only for the property as specified on the permit.

7) This permit does not grant the permit holder automatic access to any Protected area, National Park, Provincial Nature Reserve or privately owned land. Any other / further conditions or restrictions that the manager / landowner may stipulate at his / her discretion must also be adhered to.

8) The permit holder must at all times while performing any restricted activity have the permit and all relevant documentation in his / her possession.

9) Permits must be made available upon request of any authorized person. This person must also be allowed access onto the property at

Signature of Issuing Authority

01/02/2019

Signature of Permit Holder

Date of Signature

Department of Environment and Nature Conservation - 90 Long Street - Private Bag X 6102, Kimberley 8300

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(Kuruman) Tel: 053-712 0702 Fax: 053-712 0936 *(Upt) Tel: 054-3322885 Fax: 054-3311155*

ADDENDUM 1

any reasonable time for any inspection needed and can remain on such property as long as it is needed to do the inspection.

10) If applicable, the permit holder must within 21 days after performing the restricted activity furnish the Director with a written return as prescribed, with feedback on the results of the activity conducted.

11) If applicable, the permit holder shall apply for the renewal of the permit to the Director, on the appropriate application form, at least 3 months prior to the expiry date thereof.

12) The holder of this permit shall return the original to The Director: Permit Administration, Private Bag X6102, Kimberley, 8300, within fourteen days from the date of expiry thereof.

13) No new permit applications will be processed prior to the return of the original permit, once it has been used or once it has expired.

14) This permit is subject to the provisions of any law in force, during the period of validity of the permit, in respect of the specific area to which the permit applies.

15) This permit is subject to any applicable norms and standards in existence at the time of issuance of this permit.

16) It is the permit holder's responsibility to obtain information on any other legislation or changes thereto and any specifications or permit requirement that may be needed or required from any other department / organization / institute, for any activity as authorized by this permit.

17) It should be noted that any transgression, failure to render the required reports and or the return of the original permit, can jeopardize any future applications by the permit holder.

18) If the holder of this permit contravenes or fails to comply with any permit condition or requirement to which this permit is subject, he or she shall be guilty of an offence.

STANDARD PERMIT CONDITIONS APPLICABLE

1) The permit holder will be responsible for the supervision during the harvesting process.

2) The number of plants and weight of seeds mentioned on this permit is the maximum authorized to be harvested.

3) Detailed records of harvesting and trade must be supplied to the Director: Private Bag X6102, Kimberley 6300, upon expiry of this permit on the register provided.

4) The permit holder will be responsible for semester reporting to the Director: Private Bag X6102, Kimberley 6300 as per Commitment Letter agreement.

5) A summary, upon lapsing / renewal of this permit, should be submitted to the Permit Unit and Scientific Manager Gr B: Research and Development Support (cc dencpermitreports@gmail.com), DENC, on the following:

a) The GPS coordinates of the original location of the protected species as well as the GPS coordinates of the new location,
b) Detailed explanations of the methods used to remove and transplant the plants,
c) Photo(s) of the transplanted plants,
d) Current health status of plants (i.e. how well did the plants acclimatize after being transplanted),
e) GPS coordinates of plants and details of methods used to transplant the plant.

SPECIAL PERMIT CONDITIONS APPLICABLE

None

ADDITIONAL PERMIT CONDITIONS APPLICABLE

1) The following properties/farms will be traversed:

a) Portion 0 of Mukulu No. 265
b) Portion 9 of N'Chwaning No. 267
c) Portion 0 of York No. 279
d) Portion 0 of Hotazel No. 280
e) Portion 0 of Kipling No. 271
f) Portion 0 of East No. 270
g) Portion 1 of Gloria No. 266
h) Portion 0 of Perth No. 276
i) Portion 0 of Devon No. 277
j) Portion 0 of Smartt No. 314

Signature of Issuing Authority

Signature of Permit Holder

01/02/2019

Date of Signature

Department of Environment and Nature Conservation - 90 Long Street - Private Bag X 6102, Kimberley 8300

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(Kuruman) Tel: 053-712 0702 Fax: 053-712 0936 *(Upt) Tel: 054-3322885 Fax: 054-3311155*

ADDENDUM 1

k) Portion 4 of Adams No. 328
l) Portion 9 of Goold No. 329
m) Portion 0 of Moab No. 700
n) Boshof No. 300

2) The pipeline is divided into 2 areas:

AREA 1 has 2 sections:
- No vegetation clearance has been done on this area prior to the issuing of this permit.
- Search and rescue must still be done on area 1.

AREA 2 has 3 sections:
- Bush clearance has already been done in area 2; total vegetation clearance has not been done yet.
- Search and rescue have been done in this area.

GPS locations for Areas 1 & 2 with their respective sections are as follow:

Area 1: Search and rescue not done

Section 1: Start 27°8'57,6139"S - End 27°10'25,9331"S
Start 22°52'7,0237"E - End 22°55'1,5017"E

Section 2: Start 27°17'38,3467"S - End 27°20'49,6428"S
Start 22°58'46,632"E - End 22°59'25,7705"E

Area 2: Search and rescue done, not cleared

Section 1: Start 27°8'7,139"S - End 27°8'57,6139"S
Start 22°50'24,9256"E - End 22°52'7,0237"E

Section 2: Start 27°10'26,3064"S - End 27°17'38,3467"S
Start 22°55'4,4364"E - End 22°58'46,632"E

Section 3: Start 27°20'49,6428"S - End 27°23'59,5594"S
Start 22°59'25,7705"E - End 22°59'40,033"E

4) It is advised that the 'Search and Rescue' operation be conducted by a suitable qualified horticultural / botanical contractor prior to construction with regard to the relocation of the species that will be transplanted.

5) At least 75% of all viable protected species found that are transplantable (e.g. geophytes / bulbous plants, succulents, etc.) should be rescued and transplanted soon after removal to avoid/minimize dieback of species.

6) Topsoil should be kept separate for rehabilitation.

7) For Compliance Purposes: this permit is coupled with a DAFF licence that has the following reference:
NCU 8951118.

8) Indigenous trees protected under the Northern Cape Nature Conservation Act (Act No. 9 of 2009) should, under all circumstances, only be disturbed / trimmed if it is necessary.

9) Vegetation clearance should be restricted to the 25 meter servitude area. The whole servitude width of the new pipeline need not be cleared of all indigenous and protected species.

10) If the crowns of indigenous trees protrude into buffer areas, the tree crowns may be trimmed back. Not more than 50% of a tree crown should be trimmed.

11) Proper pruning requires that branches be removed as close to the branch forks as possible.

12) For areas containing a high concentration of species protected under the Northern Cape Nature Conservation Act (Act No. 9 of 2009), clearance should preferably be restricted to a 12 meter clearance buffer zone.

Signature of Issuing Authority

01/02/2019

Signature of Permit Holder

Date of Signature

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ADDENDUM 1

13) Revegetation should be done with the species normally found in the area of interest.

14) Seeds should be collected from Boscia trees which will be destroyed; seeds should be donated to the Forestry branch of the DAFF, Upington.

a) A donation letter should be submitted to Elsabé Swart before expiry of the permit at elsabe.dtec@gmail.com as proof.
b) The Environmental Authorization reference and DENC permit reference should be on the donation letter.

15) Disturbance to indigenous flora should be kept to a minimum as far as possible.

16) A nursery permit should be applied for if plants are to be kept on site.

17) Only indigenous species may be used for restoration.

18) Collect viable seeds within the proposed construction site prior to construction for sowing during restoration; store under appropriate cool, dry, pest-free conditions.

19) Plant establishment should be monitored on a six month basis prior to construction (i.e. every sixth month) until sufficient plant cover and diversity is obtained.

20) A report-back should be provided to DENC upon the expiry of the permit with a complete species list and numbers of protected species removed and/or relocated. List should contain monitoring information (i.e. health status of plants) and all information (but not restricted to) as set in table attached. Report back should also contain detailed information on methods used to transplant transplantable species as well as survival rate of the species that was transplanted.

21) Cumulative species removal will be considered for future permit applications for any development pertaining to Sedibeng Water. It is envisaged that future off-sets will be triggered under the DAFF.

22) Indigenous vegetation and the grass layer should be kept intact as far as possible to prevent / mitigate erosion to an extensive degree.

23) Intermittent follow-up enquiries on plant survival of transplanted protected species can be done by the DENC.

24) No indigenous plants/shrubs/bird's nests in trees may be disturbed or removed without the necessary DENC permits.

25) Fauna permits should be applied for if any faunal species are to be disturbed or removed, this includes bird nests, snakes, ground squirrels, etc.

26) This permit is only permissible for the activities authorised under the DENC Environmental Authorization with reference: NC/BA/34/JTG/GAM/SED1/2014 (amendment).

27) This permit replaces previous Permit No. 0108/2/2016 issued under ODB 2470/2/2016.

Signature of Issuing Authority

01/03/2019

Signature of Permit Holder

Date of Signature

Department of Environment and Nature Conservation - 90 Long Street - Private Bag X 6102, Kimberley 8300

(HQ - Kby) Tel: 053-807 7430 Fax: 086 5151 769 *(Cal) Tel: 027-341 1779 Fax: 027-341 1718* *(De Aar) Tel: 053-6310 601 Fax: 053-6310 343*

(Kuruman) Tel: 053-712 0702 Fax: 053-712 0936 *(Upt) Tel: 054-3322885 Fax: 054-3311155*

- **Kgalagadi pipeline Protected Tree Licence (NCU 6981216)**

agriculture, forestry & fisheries

Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

Approved 13/12/2016

Enquiries: J. Mans
E-mail: JacolineMa@daff.gov.za
Telephone: 054 338 5909
Ref: NCU 6981216

LICENCE
NCU 6981216

TO AUTHORISE CUT, REMOVE & DAMAGE OR DESTROY a) *INDIGENOUS TREES* IN *NATURAL FORESTS*, AND/OR b) *PROTECTED TREES*, OR THE ACQUISITION OR DISPOSAL IN ANY MANNER OF SUCH TREES OR THEIR PRODUCTS.
[SECTIONS 7(1) AND 15(1) OF ACT NO. 84 OF 1998, REGULATION 20(1) AND 21(1)]

This licence:

- Grants authority under National Forests Act (Act No. 84 of 1998), as amended, to carry out one or more of the activities, upon such conditions, and for such a period, as specified in more details below;
- Does not exempt the licensee from adhering to the provisions of any other law
- Must be renewed at nearest Forestry office after expiry of the specified period if still required
- Is valid for the period **13 December 2016** to **13 December 2018**

A	PARTICULARS OF LICENSEE		
Institution	**Royal Haskoning DHV representing Sedibeng Water**		
Surname	Hasenjager		
First Names	Ian Michael		
ID Number	570504 5120 085		
Postal Address	Private Bag X5, Bothaville, 9660		
Residential Address	Protea Street, Balkfontein, Bothaville, 9660		
Contact Details	**Tel: (056) 515 0200**	**Cell: 082 806 8624**	**Fax: (056) 515 0369**
E-mail address	ihasenjager@sedibengwater.co.za; cc Johannesburg@rhdhv.com Sibongile.Gumbi@rhdhv.com; cc Owen.Munyaradzi@rhdhv.com; cc Joubert.Tulleken@rhdhv.com; cc Willem.Vorster@rhdhv.com; cc Johan.Blignaut@rhdhv.com; cc cdn@endemicvision.co.za		
Name and Number of property	**Upgrade the Vaal Gamagara Bulk Water Supply** Scheme as per Locality Map provided to the Department. The 80 km water pipeline traverses numerous properties, from Roscoe (vicinity of Olifantshoek) via Kathu and Hotazel to Black Rock Reservoir. Main roads close to the pipeline include the N14, R325 and the R380. The 43 affected property / farm names were provided to the Department of Agriculture, Forestry and Fisheries.		
Location of property	Joe Morolong and Gamagara Local Municipalities; John Taolo Gaetsewe District Municipality; Northern Cape Province.		

In respect of protected trees:

B	LICENSED ACTIVITIES
1	***Cut / Destroy / Damage / Disturb:*** Approximately 59 *Boscia albitrunca;* ± 4 844 *Acacia (Vachellia) erioloba* and ± 3 549 *Acacia (Vachellia)haematoxylon* for upgrading of the Vaal Gamagara Bulk Water Supply. The servitude width that may be cleared of protected trees is 25m, but efforts must be made to retain large protected trees in the servitude or to reduce the width of the area cleared for installation of the pipeline. The pipeline stretches over a distance of 80 km, thus clearing a width of 25 m would result in total vegetation clearance of ± 200 ha. See number 9 below for special conditions.
2	***Possess / Transport:*** Timber derived from protected trees specified in number 1 above can be destroyed on site or donated to the respective landowners. If requested by the affected landowners, timber may be removed and transported to the appointed site or nearest registered landfill site.

3	Cutting of living protected trees done according to approved sustainable management plan.	**DENC Ref: NC/BA/34/JTG/GAM/SED1/2014 (Amended); Permit 42/2015 (Amendment1)**
4	***Sizes and numbers of tree species:*** All size classes	
5	***Condition of trees:*** Healthy, vigorous trees. Dead trees may also be encountered.	
6	***Estimated quantity***: Approximately 59 *Boscia albitrunca;* ± 4 844 *Acacia (Vachellia) erioloba* and ± 3 549 *Acacia (Vachellia) haematoxylon.*	
7	***Origin*:** From Roscoe (vicinity of Olifantshoek) via Kathu and Hotazel to Black Rock Reservoir.	
8	***Destination*:** As in number 7 above or municipal dumping sites or other registered landfill sites.	
9	***Specifications, prescriptions and remarks***	1. This license replaces **NCU 6931116 which is hereby officially cancelled** and must be destroyed or returned to the Forestry Office in Upington. 2. This license allows for felling of protected trees in the 25 m wide servitude along the 80 km water pipeline to upgrade the Vaal Gamagara Bulk Water Supply Scheme (Phase 1 of the project) as per locality map provided to the Department. The upgrade is divided in two sections: (1) From Roscoe to Sishen Western Expansion Project (SWEP); (2) From Kathu Reservoir to Mamatwane Reservoir to Hotazel Reservoir and ending at Blackrock Reservoir. 3. Vegetation clearance must be restricted to the 25 m servitude. Adjustments should be made where possible, to avoid larger protected trees since most of the large trees fall outside the original 12 meter clearance area, but inside the 25 m clearance area. To minimize impacts on protected trees, Sedibeng Water must try to conserve the ± 124 tall Camel thorn trees (with heights > 4 m) recorded in the servitude, as far as possible. Zone 2 (as per map supplied by Endemic Vision) is a dense area where all three NFA listed protected tree species occur and it is less than 10% of the application area. In zone 2 all possible efforts should be made to restrict vegetation clearance to a width of 12 m to reduce impacts on protected trees. 4. For the purpose of this license, the position of a tree or seedling is marked by the base of its trunk. Tree trunks are commonly accepted to denote the position of a tree. 5. Where tree crowns protrude into the servitude, trees may be trimmed back but the whole tree cannot be removed. Proper pruning requires that branches be removed as close to branch forks as possible, and this may result in more of the tree crown removed than the part protruding into the servitude. 6. Protected trees with significant biodiversity features such as Sociable weaver nests or nests of raptors and vultures may not be disturbed without a Fauna Permit from the provincial Department of Environment and Nature Conservation (DENC) under the Northern Cape Nature Conservation Act 9 of 2009 (NCNCA), if these would be affected by construction activities. 7. A Flora Permit must be obtained from the DENC for removal of the dually protected *B. albitrunca* and other indigenous vegetation not covered under the National Forests Act, Act 84 of 1998. **8.** The License holder **must attain written permission from the affected land owners prior to commencement or entry onto private land, and must liaise with such owners beforehand to determine trees of special significance, in which case such trees shall be conserved.** Affected landowner(s) may personally supervise pruning / vegetation removal on their properties, should they wish to do so. 9. The Licensee or appointed Environmental Control Officer (ECO) shall train and supervise all personnel who undertake activities under this license to avoid unnecessary destruction and damage to protected trees, based on a lack of knowledge. The ECO shall clearly demarcate the construction site and/or 25 m wide servitude. Tree removal must be restricted to the permitted areas.

		10. If fresh, ripe seeds are found on affected *Boscia albitrunca* specimens, it must be harvested prior to destruction of such trees and given to the DAFF. 11. To aid in rehabilitation, Sedibeng Water must place at least double the amount of prepared seed (± 16 904 seeds) consisting of a mixture of *A. (V.) erioloba; A. (V.) haematoxylon* and *B. albitrunca* on the rehabilitation areas after construction, but before the first rainy season. For advice on seed pre-sowing treatments such as scarification, contact the Forestry Office in Upington. 12. Sedibeng Water must implement a greening project as mitigation to compensate for the loss of thousands of protected trees. Normally a ratio of 3:1 (plant three trees for every protected tree destroyed) is used, but due to the large number of trees to be felled, 2000 trees must be procured and planted on site or donated to communities, institutions and individuals in need of trees, in the John Taolo Gaetsewe District (species to be determined in consultation with the DAFF). If trees are planted on site, it must be protected against browsers, watered regularly until it is well established and if planted seedlings die within a year after planting, it must be replaced. Keep records of the GPS coordinates of planted seedlings. If trees are donated, the duty of care is the responsibility of the recipient. For tree donations, the following must be recorded: Recipient Name and Surname, I.D. number, physical address where trees would be planted, date and signature of recipient, tree species and number of trees donated. These records must be supplied to the DAFF in the form of a greening report by the expiry date of this license. 13. Sedibeng Water must note that **the Department of Agriculture, Forestry and Fisheries (DAFF) will assess cumulative impact(s) on protected trees and additional phases affecting protected trees may trigger a biodiversity offset.** The destruction of ± 8 452 protected trees is significant and exceeds the threshold value upon which an offset may be requested by the DAFF. Offset negotiations are time consuming and Sedibeng Water must not wait until construction of further phases to consult with the DAFF and DENC as it may delay the issuing of further licenses.

C	LICENCE CONDITIONS

1. General license rules

This licence is –

(a) Not transferable (you cannot pass it on to another person), and

(b) Only valid for the period it was issued for.

2. Showing this license

(a) You must produce this licence on demand to any forest officer or police officer.

(b) The person moving or transporting timber or other products must at all times be in possession of a certified / stamped copy of this license.

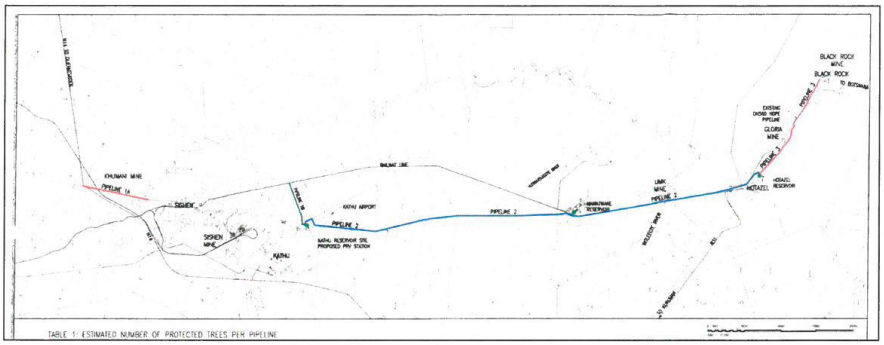
Any further conditions	**The Department of Agriculture, Forestry and Fisheries (DAFF) may at any time conduct a site inspection to monitor compliance. Non-compliance or removal of protected trees outside the 25 m servitude may result in the immediate cancellation of this license and criminal prosecution, which may include a fine and imprisonment or both such a fine and imprisonment.**

DATE STAMP 13/12/16

.....
DIRECTOR-GENERAL

DEPT. VAN LANDBOU, BOSBOU & VISSERY
NORTHERN CAPE REGION
2016 -12- 13
PO BOX 2782, UPINGTON 8800
TEL: 054 338 5908/09/10 FAX: 054 334 0030
DEPT. OF AGRICULTURE, FORESTRY & FISHERIES

The locality map showing the pipeline route from Roscoe to Black Rock Reservoir.



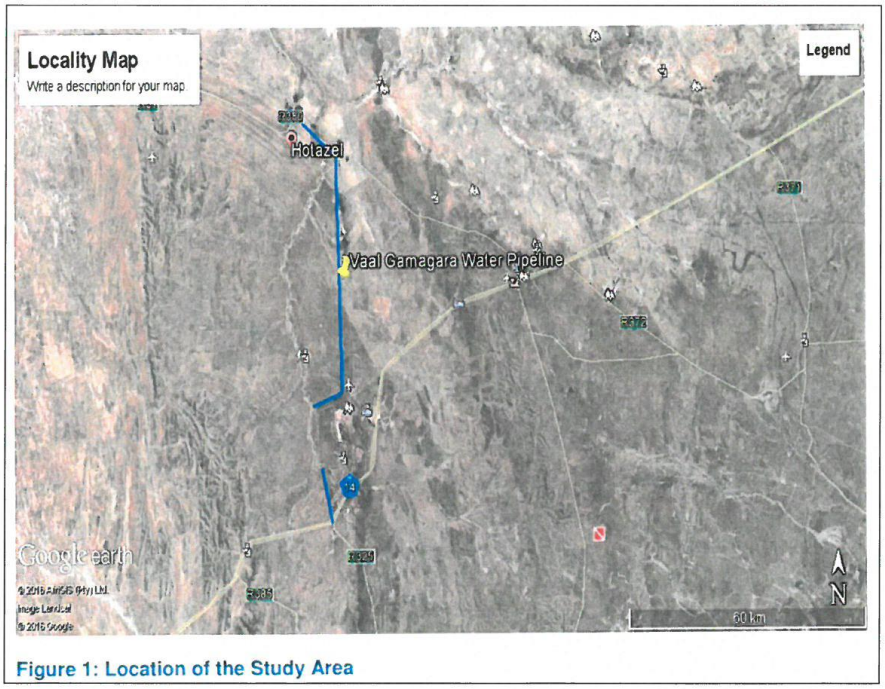


Figure 1: Location of the Study Area

ANNEXURE C: COORDINATES FOR FIELD TRIALS AND NATURAL RECRUITMENT

- **Field Trials**

Field Trial	Soil Sample / Field Trial Site	Sapling ID	Easting	Northing
Kathu Equestrian Club	KPK1	KPK01	23,064676	-27,674303
Kathu Equestrian Club	KPK1	KPK02	23,064701	-27,674293
Kathu Equestrian Club	KPK1	KPK03	23,06469	-27,674223
Kathu Equestrian Club	KPK1	KPK04	23,064701	-27,674194
Kathu Equestrian Club	KPK1	KPK05	23,06465	-27,674144
Kathu Equestrian Club	KPK1	KPK06	23,06462	-27,674094
Kathu Equestrian Club	KPK1	KPK07	23,064596	-27,674117
Kathu Equestrian Club	KPK1	KPK08	23,06457	-27,674081
Kathu Equestrian Club	KPK1	KPK09	23,064537	-27,674095
Kathu Equestrian Club	KPK1	KPK10	23,064507	-27,674079
Kathu Equestrian Club	KPK1	KPK11	23,064486	-27,674088
Kathu Equestrian Club	KPK1	KPK12	23,064433	-27,674088
Kathu Equestrian Club	KPK1	KPK13	23,064382	-27,674105
Kathu Equestrian Club	KPK1	KPK14	23,06433	-27,674153
Kathu Equestrian Club	KPK1	KPK15	23,064335	-27,674208
Kathu Equestrian Club	KPK1	KPK16	23,064321	-27,674239
Kathu Equestrian Club	KPK1	KPK17	23,064313	-27,674312
Kathu Equestrian Club	KPK1	KPK18	23,064321	-27,674319
Kathu Equestrian Club	KPK1	KPK19	23,064357	-27,674353
Kathu Equestrian Club	KPK1	KPK20	23,064414	-27,674388
Kathu Equestrian Club	KPK1	KPK21	23,064679	-27,674272
Kathu Equestrian Club	KPK1	KPK22	23,064673	-27,674161
Tamaga Farm	TAMA	TAM01	22,912691	-27,770088
Tamaga Farm	TAMA	TAM02	22,91272	-27,769931
Tamaga Farm	TAMA	TAM03	22,912824	-27,769939
Tamaga Farm	TAMA	TAM04	22,913074	-27,769957
Tamaga Farm	TAMA	TAM05	22,913089	-27,77017
Tamaga Farm	TAMA	TAM06	22,913329	-27,77021
Tamaga Farm	TAMA	TAM07	22,913617	-27,77023
Tamaga Farm	TAMA	TAM08	22,914214	-27,76983
Tamaga Farm	TAMA	TAM09	22,912487	-27,769947
Tamaga Farm	TAMA	TAM10	22,911852	-27,770189
Tamaga Farm	TAMA	TAM11	22,911219	-27,770561
Tamaga Farm	TAMA	TAM12	22,909416	-27,770516
Tamaga Farm	TAMA	TAM13	23,089454	-28,299361
Tamaga Farm	TAMA	TAM14	22,909857	-27,769818
Tamaga Farm	TAMA	TAM15	22,909991	-27,769565

Field Trial	Soil Sample / Field Trial Site	Sapling ID	Easting	Northing
Tamaga Farm	TAMA	TAM16	22,913656	-27,770179
Tamaga Farm	TAMA	TAM17	22,913541	-27,770221
Tamaga Farm	TAMA	TAM18	22,913564	-27,770231
Tamaga Farm	TAMA	TAM19	22,913506	-27,770237
Tamaga Farm	TAMA	TAM20	22,913458	-27,770237
Tamaga Farm	TAMA	TAM21	22,91343	-27,770227
Tamaga Farm	TAMA	TAM22	22,913385	-27,770215
Tamaga Farm	TAMA	TAM23	22,913258	-27,770196
Tamaga Farm	TAMA	TAM24	22,913205	-27,770186
Tamaga Farm	TAMA	TAM25	22,913005	-27,770112
Tamaga Farm	TAMA	TAM26	22,912911	-27,770036
Tamaga Farm	TAMA	TAM27	22,91279	-27,769952
Tamaga Farm	TAMA	TAM28	22,91184	-27,76927
Tamaga Farm	TAMA	TAM29	22,911947	-27,768813
Tamaga Farm	TAMA	TAM30	22,911658	-27,76845
Tamaga Farm	TAMA	TAM31	22,911322	-27,768633
Tamaga Farm	TAMA	TAM32	22,911056	-27,769046
Tamaga Farm	TAMA	TAM33	22,911089	-27,769218
Tamaga Farm	TAMA	TAM34	22,910801	-27,770944
Tamaga Farm	TAMA	TAM35	22,91355	-27,770309
Tamaga Farm	TAMA	TAM36	22,911151	-27,769062
Gamagara River Crossing	GRV2	GAM01	22,974575	-27,838949
Gamagara River Crossing	GRV2	GAM02	22,974628	-27,838943
Gamagara River Crossing	GRV2	GAM03	22,974654	-27,838907
Gamagara River Crossing	GRV2	GAM04	22,974605	-27,838876
Gamagara River Crossing	GRV2	GAM05	22,974643	-27,838821
Gamagara River Crossing	GRV2	GAM06	22,974683	-27,838861
Gamagara River Crossing	GRV2	GAM07	22,974719	-27,838869
Gamagara River Crossing	GRV2	GAM08	22,974704	-27,838923
Gamagara River Crossing	GRV2	GAM09	22,974784	-27,838823
Gamagara River Crossing	GRV2	GAM10	22,974762	-27,8388
Gamagara River Crossing	GRV2	GAM11	22,974748	-27,838774
Gamagara River Crossing	GRV2	GAM12	22,9748	-27,838743
Gamagara River Crossing	GRV2	GAM13	22,974831	-27,838707
Gamagara River Crossing	GRV2	GAM14	22,974884	-27,838711
Gamagara River Crossing	GRV2	GAM15	22,974922	-27,838734
Gamagara River Crossing	GRV2	GAM16	22,974992	-27,838793
Gamagara River Crossing	GRV2	GAM17	22,974962	-27,838825
Gamagara River Crossing	GRV2	GAM18	22,974902	-27,838812
Gamagara River Crossing	GRV2	GAM19	22,974878	-27,838835
Gamagara River Crossing	GRV2	GAM20	22,974847	-27,838912
Gamagara River Crossing	GRV2	GAM21	22,974943	-27,838899
Gamagara River Crossing	GRV2	GAM22	22,975024	-27,83887
Gamagara River Crossing	GRV2	GAM23	22,975105	-27,838863

Field Trial	Soil Sample / Field Trial Site	Sapling ID	Easting	Northing
Gamagara River Crossing	GRV2	GAM24	22,974983	-27,838952
Gamagara River Crossing	GRV2	GAM25	22,974906	-27,83897
Gamagara River Crossing	GRV2	GAM26	22,974901	-27,839012
Gamagara River Crossing	GRV2	GAM27	22,974864	-27,839024
Gamagara River Crossing	GRV2	GAM28	22,974815	-27,839007
Gamagara River Crossing	GRV2	GAM29	22,974591	-27,838837
Gamagara River Crossing	GRV2	GAM30	22,974615	-27,838783
Gamagara River Crossing	GRV2	GAM31	22,974563	-27,838752
Gamagara River Crossing	GRV2	GAM32	22,974557	-27,838725
Gamagara River Crossing	GRV2	GAM33	22,97461	-27,83873
Gamagara River Crossing	GRV2	GAM34	22,974614	-27,8387
Gamagara River Crossing	GRV2	GAM35	22,974777	-27,838691
Gamagara River Crossing	GRV2	GAM36	22,974057	-27,83857
Gamagara River Crossing	GRV2	GAM37	22,974096	-27,838538
Gamagara River Crossing	GRV2	GAM38	22,974104	-27,838496
Gamagara River Crossing	GRV2	GAM39	22,974165	-27,838523
Gamagara River Crossing	GRV2	GAM40	22,974152	-27,838556
Gamagara River Crossing	GRV2	GAM41	22,974137	-27,838593
Gamagara River Crossing	GRV2	GAM42	22,974134	-27,838637
Gamagara River Crossing	GRV2	GAM43	22,974199	-27,838569
Gamagara River Crossing	GRV2	GAM44	22,974216	-27,838517
Gamagara River Crossing	GRV2	GAM45	22,974226	-27,838502
Gamagara River Crossing	GRV2	GAM46	22,974265	-27,838531
Gamagara River Crossing	GRV2	GAM47	22,974281	-27,838573
Gamagara River Crossing	GRV2	GAM48	22,974318	-27,838558
Gamagara River Crossing	GRV2	GAM49	22,974326	-27,83852
Gamagara River Crossing	GRV2	GAM50	22,974363	-27,838512
EndemicVision Offices	EVOF	KAT01	23,0459663	-27,6832567
EndemicVision Offices	EVOF	KAT02	23,0458858	-27,6833713
EndemicVision Offices	EVOF	KAT03	23,0459603	-27,6834232
EndemicVision Offices	EVOF	KAT04	23,0457617	-27,6830453
EndemicVision Offices	EVOF	KAT05	23,0458054	-27,6830788
EndemicVision Offices	EVOF	KAT06	23,0457221	-27,6831014
EndemicVision Offices	EVOF	KAT07	23,0456856	-27,683169
EndemicVision Offices	EVOF	KAT08	23,0457441	-27,6831954
EndemicVision Offices	EVOF	KAT09	23,045774	-27,6831335
EndemicVision Offices	EVOF	KAT10	23,0459815	-27,6830901

Field Trial	Soil Sample / Field Trial Site	Sapling ID	Easting	Northing
EndemicVision Offices	EVOF	KAT11	23,0459647	-27,6831434
EndemicVision Offices	EVOF	KAT12	23,0458249	-27,6828984
EndemicVision Offices	EVOF	KAT13	23,045885	-27,6829248
EndemicVision Offices	EVOF	KAT14	23,045936	-27,6828702
EndemicVision Offices	EVOF	KAT15	23,0458694	-27,6828395
Chertsey Farm	CHER	CHER01	23,000279	-27,538204
Chertsey Farm	CHER	CHER02	23,000277	-27,538381
Chertsey Farm	CHER	CHER03	23,000314	-27,538542
Chertsey Farm	CHER	CHER04	23,000347	-27,538734
Chertsey Farm	CHER	CHER05	23,00035	-27,53892
Chertsey Farm	CHER	CHER06	23,000256	-27,538016
Chertsey Farm	CHER	CHER07	23,000486	-27,540009
Chertsey Farm	CHER	CHER08	23,000485	-27,539897
Chertsey Farm	CHER	CHER09	23,000496	-27,539765
Chertsey Farm	CHER	CHER10	23,000457	-27,539633
Chertsey Farm	CHER	CHER11	23,000401	-27,539452
Chertsey Farm	CHER	CHER12	23,000386	-27,539269
Chertsey Farm	CHER	CHER13	23,000387	-27,539092
Chertsey Farm	CHER	CHER14	23,000534	-27,540291
Chertsey Farm	CHER	CHER15	23,000529	-27,540126
Kgalagadi pipeline offices	KGOF	KPOFF01	23,0069792	-27,667587
Kgalagadi pipeline offices	KGOF	KPOFF02	23,006503	-27,668056
Kgalagadi pipeline offices	KGOF	KPOFF03	23,006522	-27,668176
Kgalagadi pipeline offices	KGOF	KPOFF04	23,006543	-27,668113
Kgalagadi pipeline offices	KGOF	KPOFF05	23,006502	-27,668193
Kgalagadi pipeline offices	KGOF	KPOFF06	23,006442	-27,667351
Kgalagadi pipeline offices	KGOF	KPOFF07	23,005785	-27,667174
Kgalagadi pipeline offices	KGOF	KPOFF08	23,005674	-27,667171
Kgalagadi pipeline offices	KGOF	KPOFF09	23,006059	-27,668486
Kgalagadi pipeline offices	KGOF	KPOFF10	23,006001	-27,668432
Kathu Pan	KPAN	KPN01	23,001197	-27,661766
Kathu Pan	KPAN	KPN02	23,001232	-27,661903
Kathu Pan	KPAN	KPN03	23,001289	-27,661899
Kathu Pan	KPAN	KPN04	23,001296	-27,661981
Kathu Pan	KPAN	KPN05	23,001349	-27,661976
Kathu Pan	KPAN	KPN06	23,001328	-27,662048
Kathu Pan	KPAN	KPN07	23,0013863	-27,6627594
Kathu Pan	KPAN	KPN08	23,001405	-27,662038
Kathu Pan	KPAN	KPN09	23,001381	-27,662127

Field Trial	Soil Sample / Field Trial Site	Sapling ID	Easting	Northing
Kathu Pan	KPAN	KPN10	23,001496	-27,662177
Kathu Pan	KPAN	KPN11	23,001439	-27,662219
Kathu Pan	KPAN	KPN12	23,001532	-27,66225
Kathu Pan	KPAN	KPN13	23,001492	-27,662313
Kathu Pan	KPAN	KPN14	23,001574	-27,662352
Kathu Pan	KPAN	KPN15	23,001596	-27,662412
Kathu Pan	KPAN	KPN16	23,001024	-27,661909
Kathu Pan	KPAN	KPN17	23,000979	-27,661977
Kathu Pan	KPAN	KPN18	23,001018	-27,662044
Kathu Pan	KPAN	KPN19	23,001056	-27,66201
Kathu Pan	KPAN	KPN20	23,001096	-27,66206
Kathu Pan	KPAN	KPN21	23,001061	-27,662113
Kathu Pan	KPAN	KPN22	23,001133	-27,662133
Kathu Pan	KPAN	KPN23	23,001085	-27,662175
Kathu Pan	KPAN	KPN24	23,001174	-27,662192
Kathu Pan	KPAN	KPN25	23,00113	-27,662259
Kathu Pan	KPAN	KPN26	23,001242	-27,662286
Kathu Pan	KPAN	KPN27	23,001173	-27,662309
Kathu Pan	KPAN	KPN28	23,001206	-27,662377
Kathu Pan	KPAN	KPN29	23,001278	-27,662363
Kathu Pan	KPAN	KPN30	23,001358	-27,662496
Kathu Pan	KPAN	KPN31	23,001307	-27,662431
Kathu Pan	KPAN	KPN32	23,001546	-27,662506
Kathu Pan	KPAN	KPN33	23,00162	-27,662684
Kathu Pan	KPAN	KPN34	23,001639	-27,662687
Kathu Pan	KPAN	KPN35	23,001655	-27,662775
Kathu Pan	KPAN	KPN36	23,001684	-27,662838
Kathu Pan	KPAN	KPN37	23,001735	-27,662919
Kathu Pan	KPAN	KPN38	23,001791	-27,663013
Kathu Pan	KPAN	KPN39	23,001537	-27,662764
Kathu Pan	KPAN	KPN40	23,001488	-27,662701
Kathu Pan	KPAN	KPN41	23,001451	-27,662579
Kathu Pan	KPAN	KPN42	23,001713	-27,662565
Kathu Pan	KPAN	KPN43	23,00173	-27,662688
Kathu Pan	KPAN	KPN44	23,00175	-27,662793
Kathu Pan	KPAN	KPN45	23,001815	-27,662923
Kathu Pan	KPAN	KPN46	23,001863	-27,663029
Kathu Pan	KPAN	KPN47	23,001919	-27,663122
Kathu Pan	KPAN	KPN48	23,001858	-27,663168
Kathu Pan	KPAN	KPN49	23,001819	-27,663096
Kathu Pan	KPAN	KPN50	23,001902	-27,663266
Kathu Pan	KPAN	KPN51	23,001964	-27,663218
Kathu Pan	KPAN	KPN52	23,00196	-27,663345
Kathu Pan	KPAN	KPN53	23,002005	-27,663439

Field Trial	Soil Sample / Field Trial Site	Sapling ID	Easting	Northing
Kathu Pan	KPAN	KPN54	23,002064	-27,663547
Kathu Pan	KPAN	KPN55	23,002084	-27,663655
Kathu Pan	KPAN	KPN56	23,002115	-27,66375
Kathu Pan	KPAN	KPN57	23,00214	-27,663844
Kathu Pan	KPAN	KPN58	23,002134	-27,663937
Kathu Pan	KPAN	KPN59	23,001345	-27,662697
Kathu Pan	KPAN	KPN60	23,001421	-27,662868
Kathu Pan	KPAN	KPN61	23,001483	-27,662931
Kathu Pan	KPAN	KPN62	23,001528	-27,663019
Kathu Pan	KPAN	KPN63	23,001602	-27,66294
Kathu Pan	KPAN	KPN64	23,001658	-27,663034
Kathu Pan	KPAN	KPN65	23,00157	-27,663116
Kathu Pan	KPAN	KPN66	23,001696	-27,663136
Kathu Pan	KPAN	KPN67	23,00164	-27,66319
Kathu Pan	KPAN	KPN68	23,001737	-27,663239
Kathu Pan	KPAN	KPN69	23,001665	-27,663279
Kathu Pan	KPAN	KPN70	23,00179	-27,663337
Kathu Pan	KPAN	KPN71	23,001714	-27,663407
Kathu Pan	KPAN	KPN72	23,001831	-27,663418
Kathu Pan	KPAN	KPN73	23,00186	-27,663501
Kathu Pan	KPAN	KPN74	23,001887	-27,663588
Kathu Pan	KPAN	KPN75	23,001907	-27,66367
Kathu Pan	KPAN	KPN76	23,001923	-27,663757
Kathu Pan	KPAN	KPN77	23,001936	-27,66385
Kathu Pan	KPAN	KPN78	23,001946	-27,663945
Kathu Pan	KPAN	KPN79	23,002058	-27,663383
Kathu Pan	KPAN	KPN80	23,002022	-27,663289
Witleegte river crossing	WITL	WIT01	22,980374	-27,294757
Witleegte river crossing	WITL	WIT02	22,980308	-27,294713
Witleegte river crossing	WITL	WIT03	22,98034	-27,294665
Witleegte river crossing	WITL	WIT04	22,980279	-27,294624
Witleegte river crossing	WITL	WIT05	22,980338	-27,294587
Witleegte river crossing	WITL	WIT06	22,980269	-27,294534
Witleegte river crossing	WITL	WIT07	22,980322	-27,294497
Witleegte river crossing	WITL	WIT08	22,980263	-27,294448
Witleegte river crossing	WITL	WIT09	22,980323	-27,294411
Witleegte river crossing	WITL	WIT10	22,9803699	-27,2952833
Witleegte river crossing	WITL	WIT11	22,980472	-27,29527
Witleegte river crossing	WITL	WIT12	22,980432	-27,295208
Witleegte river crossing	WITL	WIT13	22,980419	-27,295131
Witleegte river crossing	WITL	WIT14	22,980382	-27,295079
Witleegte river crossing	WITL	WIT15	22,980413	-27,29504
Witleegte river crossing	WITL	WIT16	22,980352	-27,294986

Field Trial	Soil Sample / Field Trial Site	Sapling ID	Easting	Northing
Witleegte river crossing	WITL	WIT17	22,980396	-27,294941
Witleegte river crossing	WITL	WIT18	22,980337	-27,294887
Witleegte river crossing	WITL	WIT19	22,980383	-27,294841
Witleegte river crossing	WITL	WIT20	22,980325	-27,294799
EndemicVision Offices - Parking	EVOF	EVO01	23,0460675	-27,6829419
EndemicVision Offices - Parking	EVOF	EVO02	23,0460509	-27,682975
EndemicVision Offices - Parking	EVOF	EVO03	23,0460095	-27,6830527

- **Natural Recruitment**

Trial	Soil sample / Field trial site	Sapling_ID	# of Surviving saplings (18_mths)	Easting	Northing
Natural Recruitment	HAL2	NAT01	2	23,006353	-27,564411
Natural Recruitment	HAL2	NAT02	2	23,007437	-27,568449
Natural Recruitment	HAL2	NAT03	1	23,007438	-27,568464
Natural Recruitment	HAL2	NAT04	1	23,008049	-27,569805
Natural Recruitment	HAL2	NAT05	1	23,008692	-27,572176
Natural Recruitment	HAL2	NAT06	1	23,008693	-27,572130
Natural Recruitment	HAL2	NAT07	1	23,008722	-27,572268
Natural Recruitment	HAL2	NAT08	1	23,008809	-27,572587
Natural Recruitment	HAL2	NAT09	1	23,009255	-27,574227
Natural Recruitment	HAL2	NAT10	1	23,009294	-27,575090
Natural Recruitment	HAL2	NAT11	1	23,009506	-27,575208
Natural Recruitment	HAL2	NAT12	1	23,009564	-27,575335
Natural Recruitment	HAL2	NAT13	1	23,009624	-27,575602
Natural Recruitment	HAL2	NAT14	5	23,009688	-27,575819
Natural Recruitment	HAL2	NAT15	1	23,010094	-27,577340
Natural Recruitment	HAL2	NAT16	2	23,010099	-27,577374
Natural Recruitment	HAL2	NAT17	2	23,010147	-27,578253
Natural Recruitment	HAL2	NAT18	1	23,010162	-27,578235
Natural Recruitment	HAL1	NAT19	1	23,010997	-27,581531
Natural Recruitment	HAL1	NAT20	1	23,011030	-27,581638
Natural Recruitment	HAL1	NAT21	1	23,011293	-27,581706
Natural Recruitment	HAL1	NAT22	1	23,011385	-27,582162
Natural Recruitment	HAL1	NAT23	1	23,011319	-27,582734

Trial	Soil sample / Field trial site	Sapling_ID	# of Surviving saplings (18_mths)	Easting	Northing
Natural Recruitment	HAL1	NAT24	1	23,011580	-27,583702
Natural Recruitment	HAL1	NAT25	1	23,011724	-27,584255
Natural Recruitment	HAL1	NAT26	1	23,013271	-27,589041
Natural Recruitment	HAL1	NAT27	1	23,013238	-27,588933
Natural Recruitment	HAL1	NAT28	5	23,014578	-27,594607
Natural Recruitment	HAL1	NAT29	1	23,014785	-27,594765
Natural Recruitment	HAL1	NAT31	3	23,011879	-27,617562
Natural Recruitment	HAL2	NAT32	1	23,000073	-27,537505
Natural Recruitment	CHER	NAT33	1	23,000051	-27,537364
Natural Recruitment	CHER	NAT34	1	23,000042	-27,537284
Natural Recruitment	CHER	NAT35	4	22,999990	-27,537064
Natural Recruitment	CHER	NAT36	1	22,999926	-27,536641
Natural Recruitment	CHER	NAT37	1	22,999772	-27,535411
Natural Recruitment	CHER	NAT38	1	22,999734	-27,535158
Natural Recruitment	CHER	NAT39	2	22,999723	-27,535002
Natural Recruitment	CHER	NAT40	1	23,000313	-27,539718
Natural Recruitment	CHER	NAT41	3	23,000335	-27,539955
Natural Recruitment	CHER	NAT42	1	23,000394	-27,540517
Natural Recruitment	CHER	NAT43	1	22,998831	-27,527402
Natural Recruitment	CHER	NAT44	1	22,998980	-27,528629
Natural Recruitment	CHER	NAT45	1	22,998987	-27,529251
Natural Recruitment	CHER	NAT46	1	22,999039	-27,529595
Natural Recruitment	CHER	NAT47	1	22,999146	-27,530294
Natural Recruitment	CHER	NAT48	1	22,999207	-27,531096

Trial	Soil sample / Field trial site	Sapling_ID	# of Surviving saplings (18_mths)	Easting	Northing
Natural Recruitment	CHER	NAT49	1	22,999797	-27,534503
Natural Recruitment	HAL2	NAT50	1	23,004412	-27,557114
Natural Recruitment	HAL2	NAT51	1	23,005768	-27,562329
Natural Recruitment	HAL2	NAT52	1	23,006165	-27,562892
Natural Recruitment	KGOF	NAT53	1	23,004996	-27,670340
Natural Recruitment	KGOF	NAT76	1	23,004996	-27,670332
Natural Recruitment	KGOF	NAT77	1	23,004996	-27,670332
Natural Recruitment	KGOF	NAT78	1	23,004378	-27,669564
Natural Recruitment	KGOF	NAT79	1	23,004389	-27,669552
Natural Recruitment	KGOF	NAT80	1	23,003405	-27,667821