

**A COLLATION AND OVERVIEW OF RESEARCH
INFORMATION ON *BOSCIA ALBITRUNCA* (SHEPHERD'S
TREE) AND IDENTIFICATION OF RELEVANT RESEARCH
GAPS TO INFORM PROTECTION OF THE SPECIES**

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TABLE OF CONTENTS

Table of Contents	2
Executive Summary	3
<i>Status of <i>Boscia albitrunca</i></i>	4
Level of protection	4
<i>Source, type and geographical location of threats to the species</i>	4
Species description.....	5
<i>Taxonomy/ Binomial nomenclature</i>	5
<i>Common names</i>	5
<i>General description</i>	5
Distribution and Ecology	5
<i>Seed production, dispersal and germination</i>	6
<i>Seedling establishment and survival</i>	6
<i>Growth rates</i>	6
<i>Demography and mortality with disturbance</i>	<i>Error! Bookmark not defined.</i>
Effects of landuse	6
Effects of fire	7
Effects of harvesting	7
Effects of arboricides	7
Effects of drought	7
Effects of frost	7
Economic value.....	8
<i>Consumptive</i>	8
Fuel	8
Building materials	8
Feed for livestock and game.....	8
Medicinal uses.....	8
Food for human consumption	8
<i>Non-consumptive</i>	9
<i>Contribution to biodiversity</i>	9
Cultural value	9
Tourism/aesthetics	9
Conclusion and recommendations	10
Summary of research gaps	10
References	12

EXECUTIVE SUMMARY

Boscia albitrunca is not a protected tree species in South Africa in terms of section 12 of the National Forests Act, 1998 (Act No. 84 of 1998), but has been proposed for listing by the Department of Water Affairs and Forestry. Protection is to be granted, as it is a keystone species in arid southern Africa, where it primarily provides browse to livestock and game, shade and food and shelter to other animals including invertebrates and birds. The laws of numerous African traditions strictly prohibit destruction of this tree (Coates Palgrave 1983), and the wood is not favoured as a fuelwood (Brundin and Karlsson 1999). The wood has no commercial value, and is not suitable as building material, although it is used in rural areas for making household items such as tables, chairs, spoons and dishes (Palmer and Pitman 1972). This species is under threat, however, owing to intense use of its branches to supplement livestock feed, particularly in times of drought.

The case for including *B. albitrunca* for its keystone role is strong. *B. albitrunca* has high value as a fodder and food source (Palmer and Pitman 1972, Brundin and Karlsson 1999). Its nutritious foliage suggests that this species obtains nutrients from ground water and perhaps also from the concentration of nutrients beneath its canopy because of animal activities. *B. albitrunca* therefore contributes to nutrient cycling in mainly oligotrophic sands, as well as performing other ecological services such as reducing nutrient leaching, mitigating soil degradation, preventing soil erosion, sequestering carbon and replenishing organic matter. In addition, it is often the only available dense shade tree in the hot arid environment of the southwestern regions of its distribution (Bothma 1982). *B. albitrunca*'s usefulness is most apparent in times of drought, of which it is very tolerant (Parry 1989), when branches may be cut to supplement feed domestic livestock.

The seeds of *B. albitrunca* are endozoochorous (Milton and Dean 1995, Dean et al. 1999, Leistner 1967, 1996, van der Walt and le Riche 1999) and non-dormant, with a short life expectancy (Briers 1988). This species is observed to establish beneath other large trees within its environment, primarily *A. erioloba*, which serve as resting and perch sites for animals and birds (Milton and Dean 1995, Dean et al. 1999, Leistner 1967, 1996, Ernst & Tolsma 1990). Recruitment is thus likely favoured by availability of such sites, making the species dependent on large tree species in arid savanna. Therefore, threats to species that provide these microsites (e.g. see Powell 2001) also constitute a threat to *B. albitrunca*. Within the arid Kalahari, indiscriminate removal of camelthorn (*Acacia erioloba*) trees could reduce the availability of suitable germination sites. Under ideal conditions, *B. albitrunca* seeds germinate rapidly compared to other arid zone species, but their rate of germination is low (27.8%) (Briers 1988). Further, the slow growth rate (van Wyk 1984) of this deep-rooted species (Canadell et al. 1996) is likely attributable to extensive investment in establishing and maintaining a deep taproot system, prior to above-ground growth (Cunningham 2002). Therefore, indiscriminate removal of branches to provide fodder could have important consequences for this species, with its short-lived seeds and requirements for recruitment sites.

Although the nature of threats is known, their severity and geographical location requires further investigation. High browsing pressure, cutting of branches for browse, and trampling of seedlings are important threats to recruitment, establishment and overall survival of this species. Browsing, branch removal or the cutting of entire crowns as fodder supplement during severe droughts can transform specimens into flat, multi-stemmed shrubs (Van der Walt and Le Riche 1999). The effects of intensive removal of branches for fruit and seed production are also not known. Frequent pruning, and pruning too low down the main stem, increases the probability of the tree dying (Van der Walt and Le Riche 1999). Furthermore, the extent to which subsequent herbivory of coppice growth can be tolerated is unknown.

There is a dearth of information regarding recruitment success and the influence of stocking rates on the species. High stocking rates of livestock and game are considered a primary cause for low densities of *B. albitrunca* trees in rangelands (Brundin and Karlsson 1999). In Etosha National Park (Namibia), more than 70% of trees were less than 1m tall, with plants less than 2m tall exhibiting high browsing pressure (Nott and Stander 1991).

The influences of water extraction from ground water sources on *B. albitrunca* is also not known, with mortality likely to result from significant lowering of the water table. In areas where large

amounts of water to be extracted, monitoring may be necessary to detect any negative effects on *B. albitrunca* and other important species. Although *B. albitrunca* appears to survive fires better than *Acacia species* (Skarpe 1980), fire can transform *B. albitrunca* trees into multi-stemmed shrubs because of coppice growth from the basal parts following crown damage (Skarpe 1980, Van der Walt and Le Riche 1999).

Studies conducted in the 1980s indicated that *B. albitrunca* was not immediately affected by arboricides such as Tebuthiuron, applied to rid the area of encroaching species such as *Acacia mellifera* (Moore et al. 1985). There are now reports of large-scale mortality of *B. albitrunca* in areas treated over 15 years ago (H. Erasmus, *pers. comm.*), and no doubt requires urgent investigation, particularly as arboricides are still in widespread use today to clear bush-encroached areas.

Extensive clearance of tracts of land for cultivation poses another threat to *B. albitrunca*, although generally, conservation authorities try to ensure that *B. albitrunca* specimens are left standing.

In order to establish the status of *B. albitrunca* and its population across its range, studies of its size class distributions are needed, across various climate and management regimes, particularly with reference to use as a source of fodder. This will give an indication of the distribution of size-classes as affected by browsing and branch removal, which will highlight both size-specific mortality and the status of a population. Coupled with simple matrix population modelling, it may be possible to better understand population dynamics and effects of harvesting (Cunningham 2001), to make informed management decisions to ensure protection of the species. The importance of suitable microsites for establishment also require investigation, in light of threats to large trees beneath which this species establishes in the Kalahari savanna.

STATUS OF BOSCIA ALBITRUNCA

LEVEL OF PROTECTION

According to Palmer and Pitman (1972), *B. albitrunca* is protected provincially in the Free State and in number different districts, including Barkley West, Hay, Herbert, Kimberley, Kuruman, Mafeking, Taung, and Vryburg in the Cape. Under this protection, the tree may not be cut except for domestic purposes. *B. albitrunca* has recently been proposed for inclusion on a National list, to be protected in terms of section 12 of the National Forests Act, 1998 (Act No. 84 of 1998). This law states that "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." The act does not distinguish between dead and live trees, making removal of dead trees without a permit illegal.

THREATS TO THE SPECIES: SOURCE, TYPE AND GEOGRAPHICAL LOCATION

B. albitrunca's general usefulness has led to its destruction in certain areas, particularly in very arid areas where it has been stripped of foliage for fodder, or has been dug up for human food (Palmer and Pitman 1972). The demand for the wood itself is low, being used primarily to make household utensils on small scale (Izak van der Merwe, *pers. comm.*). Superstitions surrounding the tree prohibit cutting or burning the wood of this species (Coates Palgrave 1983).

Although not in demand for its wood, this species is favoured as a browse tree by livestock (Brundin and Karlsson 1999). Stock farmers therefore often cut branches out of livestock's reach to supplement feeding, particularly in times of drought or when grazing and browsing is poor (Izak van der Merwe, *pers. comm.*). In Namibia, farmers sometimes cut partially through the tree trunk, so that it can be bent such that the leaves are within reach of browsing livestock (Coates Palgrave 1983). Occasionally, these trees are also destroyed while land is being cleared for agriculture (Izak van der Merwe, *pers. comm.*). The tree is also a source of food, with the roots being used to make porridge and as a substitute for coffee. There may, therefore, also be pressure to harvest this species for sustenance of both livestock and humans in times of drought. Although the nature of threats is known, their severity and geographical location requires further investigation. We do not know if soil erosion through trampling, wind and water is a threat to this species in degraded landscapes, and this requires further investigation.

B. albitrunca has been included on the list of protected species because it is an essential keystone species in the arid parts of South Africa, where it not only provides browse, but shade and microhabitat for other biota, and also because of its great cultural importance and potential uses (Izak van der Merwe, *pers. comm.*).

SPECIES DESCRIPTION

TAXONOMY/ BINOMIAL NOMENCLATURE

This species belongs to the Cappariaceae Family, Order Cappariales. The name 'Boscia' refers to Louis Bosc, a French professor of agriculture, while Burchell first used the term 'albitrunca' (Bothma 1982). The genus *Boscia* is restricted to Africa, except for one species that occurs in southern Arabia (Palmer, 1981).

COMMON NAMES

Shepherd's Tree, White-stem Tree, and Coffee Tree (English); Witgat, Witstamboom Matoppie (Afrikaans); umGqomogqomo (Xhosa); umFithi (Zulu); molthopi (Tswana); mohlopi (North Sotho); muvhombwe (Venda) and omutenderereti (Herrero) (Palmer and Pitman 1972).

GENERAL DESCRIPTION

B. albitrunca is a stocky evergreen tree that may reach heights of 5-7 m (Palmer and Pitman 1972), although much larger specimens occur near Vorstershoop, where they occasionally reach a height of 11 m or more (C. Seymour *pers. obs.*). In the Ghanzi area of western Botswana it reaches a height of between 3-4 m in a low tree and shrub savanna, together with lower shrubs of *Acacia mellifera* sub sp. *Detinens* and *Grewia flava* (Cole and Brown 1976). It usually has a well-rounded crown and owing to its nutritional value to livestock, often has a clear 'browse line' (Coates Palgrave 1983). The stem is light in colour and often folded, seamed and sometimes pitted with holes, and when viewed from a distance appears to have been whitewashed (Van Wyk 1984, Coates Palgrave 1983). The wood is hard, heavy, short-fibred and tough, and not readily used (Van Wyk 1984, Palmer and Pitman 1972, Coates Palgrave 1983).

The foliage of this tree is evergreen, although some leaves are shed around flowering time. The leaves are flat, elliptic and variable in size, but are generally 40 x 10 mm in dimension, with rounded tips (Van Wyk 1984). They have a smooth margin, are tough and leathery and may be slightly hairy (Palmer and Pitman 1972), with a colouring of grey-green to green above and below (Coates Palgrave 1983). The petiole ranges in size from 1 – 10 mm, with the leaves attached in bunches of four or five simple leaves which are clustered on older branches, although they tend to be alternate on new growth (Coates Palgrave 1983).

The flowering period extends from August to November (Venter & Venter 1996), or after rain (Coates Palgrave 1983). The flowers are small and inconspicuous, star-shaped and without petals (Coates Palgrave). They are characterised by a heavily scented central mass of yellowish stamens (Venter & Venter 1996). The fruit is round and berry-like, yellow with a reddish flesh (Venter & Venter 1996), measuring 10-15 mm in diameter (Van Wyk 1984, Coates Palgrave 1983).

DISTRIBUTION AND ECOLOGY

Of the eight *Boscia* species occurring in southern Africa, *B. albitrunca* is the most widespread (Bothma 1982). It occurs from the arid parts of KwaZulu Natal, Transvaal, Free State, across to Botswana and the Northern Cape (Venter & Venter 1996). It also occurs in Mozambique, Zambia, Zimbabwe and Namibia (Anon 1984). This species is widespread in dry, open woodland and bushveld. It is especially characteristic in semi-desert vegetation of the Kalahari/ Karoo-Namib transition, but also extends northwards into various Zambesian woodlands and shrublands (Anon 1984). *B. albitrunca* favours sandy, loamy and calcrete soils (Venter & Venter 1996).

This species' deep rooting system is particularly suited to arid, sandy areas (van der Walt and le Riche 1999), perhaps because it is easier to extend deep roots into sand. It also grows against the dune slopes of the inner veld, but tends to grow as a shrubby, tangled thicket in these areas, as it has difficulty anchoring itself in the loose sands (van der Walt and le Riche 1999).

SEED PRODUCTION, DISPERSAL AND GERMINATION

The seeds are endozoochorous, with the main dispersal agents being birds and mammals (Milton and Dean 1995, Dean et al. 1999, Leistner 1967, 1996, van der Walt and le Riche 1999). This method of dispersal ensures that the seeds are transported to suitable sites for germination and establishment, and seedlings are therefore commonly found beneath perch sites such as *Acacia* trees (Milton and Dean 1995, Dean et al. 1999, Leistner 1967, 1996, Ernst & Tolsma 1990). Animal digestion and dispersal appear to be vitally important to this species, as the flesh of the fruit surrounding the seed contains a growth inhibitor (Venter & Venter 1996).

Seeds appear to be non-dormant with a short life expectancy (Briers 1988). Seeds of a related species (*B. senegalensis*) are cold sensitive and best stored at 15 degrees C (Danthu et al. 1999). *B. albitrunca* seeds were found to have a low germination rate (27.8%) under ideal conditions (Briers 1988), although these seeds were not pre-treated and germination rates may be higher for treated seeds, particularly as this is an endozoochorous species. Germination occurred quite rapidly, however, with almost all of the seeds that germinated emerging within the first 20 days (Briers 1988). Venter & Venter (1996) report germination taking place within 7 – 14 days. Of those that germinated and established in Brier's (1988) study, over 97% did so within the first 20 days of planting (Briers 1988). Briers (1988) thus characterised *B. albitrunca* as a species that germinates relatively quickly compared to other species from the arid environments in which it occurs. The seeds of this species only survive one or two seasons in the soil, however (Briers 1988).

There is little available information in the literature about seed parasitism and predation, although Venter & Venter (1996) report that seeds found on the ground are usually parasitised.

SEEDLING ESTABLISHMENT AND SURVIVAL

There is little information available on establishment and survival rates of *B. albitrunca* seedlings. When cultivating this species, seedlings need to be transplanted directly into open ground, as growth tends to stop if planted in nursery bags (Venter & Venter 1996), no doubt because its tap root then has no room to grow.

GROWTH RATES

Growth rates of seedlings depend on the amount of moisture available in the soil (Venter & Venter 1996). Venter & Venter (1996) record this species to be fast growing in the first five years, but do not specify conditions under which such fast growth occurs. Other authors record this species as being slow growing (van Wyk 1984), presumably in reference to post seedling growth rates. This could be attributed to this species' deep rooting behaviour, with roots extending to a depth of 68 m (Canadell et al. 1996). Saplings likely expend considerable time and resources in establishing and maintaining a deep taproot before investing in above ground growth.

This species has also been found to be not particularly conservative in its use of water (Wand *et al.* 1999), which may be because its taproot enables it to be less economical in this aspect.

EFFECTS OF LANDUSE

Browsing and cutting of branches or entire crowns as a fodder supplement during severe droughts, can transform specimens of this species into flat, multi-stemmed shrubs (Van der Walt and Le Riche 1999). *B. albitrunca* appears to occur at lower densities in areas of high stocking rates, in response to browsing pressure (Brundin and Karlsson 1999). In the Central Kalahari Game Reserve in Botswana, Kalikawa (1990) found that *B. albitrunca* occurred at a density of 69 individuals/ha around an artificial watering point. Kalkawa (1990) postulates that densities of this species may decrease with increasing browsing pressure. Similarly, a study of density and height structure of *B. albitrunca* in Etosha National Park (Namibia), found that more than 70% were less than 1 m tall, and plants less than 2 m exhibited high browsing pressure (Nott and Stander 1991). In addition, the authors believed the survival of *B. albitrunca* in the 3-6 m height category was precarious, owing to severe browsing by giraffe (*Giraffa camelopardalis*) (Nott and Stander 1991). Livestock traditionally seen as grazers (e.g. cattle) also sometimes browse *B. albitrunca*: Skarpe (1990)

records some browsing mainly on *B. albitrunca* of all the species in her study area. Thus, although direct damage is not brought about by human activities on the tree itself, high browsing pressure and trampling may present a considerable challenge to recruitment and establishment of this species. More information is required regarding the success of recruitment episodes and the influence of stocking rates on these.

The effect of water extraction from ground water sources on *B. albitrunca* is not known, but we surmise that considerable lowering of the water table could result in large-scale mortality. In areas where large amounts of water are to be extracted, monitoring may be needed to ascertain negative effects on *B. albitrunca* and other important species.

EFFECTS OF FIRE

Fire can transform a *B. albitrunca* tree into a multi-stemmed shrub, because the tree coppices from the basal parts after crown damage (Skarpe 1980, Van der Walt and Le Riche 1999). Although her sample size was small, Skarpe (1980) found *B. albitrunca* survived fires better than *Acacia* species in the Kalahari, and cites their presence in areas that experience repeated fires in the Eastern Kalahari in support of this.

EFFECTS OF HARVESTING

If pruned too frequently, or too low down the stem, the probability of a tree dying is increased (Van der Walt and Le Riche 1999). Where roots have been cut for making porridge, the severed area generally coppices, providing a valuable food source to livestock (Coates Palgrave 1983). Although *B. albitrunca* is capable of resprouting, the coppicing elicited becomes vulnerable to herbivory. It is uncertain what intensity of subsequent herbivory by livestock can be tolerated by this species.

EFFECTS OF ARBORICIDES

Tebuthiuron was applied to farms in the Molopo area to clear expansive areas of heavy infestation by bush encroaching species, primarily *Acacia mellifera*. The arboricide was initially found to be effective at killing target species, while *B. albitrunca* was not affected (Moore et al. 1985). Recently, reports of *B. albitrunca* mortality are emerging, thus subsequent mortality of non-target species needs to be ascertained through a follow-up study (H. Erasmus pers comm.2003).

EFFECTS OF DROUGHT

B. albitrunca has been found to be among the most drought-tolerant species during the drought preceding 1960 although specimens smaller than 50cm either died or were resprouting from the base after aerial parts had dried up (Leistner 1967). In the continuous drought of 1981-1987 in Botswana, most other species suffered mortality, but even in areas where the drought was extreme, all mature specimens survived (Parry 1989). During dry periods, the tree remains evergreen, retaining its leaves (Coates Palgrave 1983). No doubt this contributes further to the tree's value as a fodder species.

EFFECTS OF FROST

There is no record in the literature of frost tolerance, but frost and drought are believed to dictate floral composition of the Kalahari (Miller 1946), and presence of *B. albitrunca* in areas with frequent frost indicates tolerance, although we do not know if this tolerance extends to all size classes.

EFFECTS OF CLIMATE CHANGE

Tyson & Crimp (1998) predict a greater frequency of extreme events (i.e. droughts and floods) in the southern Kalahari, with a doubling of atmospheric CO₂. Woody species are expected to be able to use water more efficiently with increased CO₂ (Bond et al. 2002). Knowledge of how *B. albitrunca* responds to drought, floods and how important water use efficiencies will be to this species are needed to predict the importance of climate change.

ECONOMIC VALUE

CONSUMPTIVE

FUEL

Generally, *B. albitrunca* is not used or harvested as fuel. Thus the demand for firewood from this species is very low, owing to its cultural importance and the superstitions associated with it (Bothma 1982). Commercial farmers also do not harvest this tree from rangelands.

BUILDING MATERIALS

The wood is not suitable for construction, although it is used in rural areas for a variety of household items such as tables, chairs, spoons and dishes (Palmer and Pitman 1972). The sustainability of such harvesting is unknown.

FEED FOR LIVESTOCK AND GAME

The roots provide a valuable food source for both animals and humans (Coates Palgrave 1983), although the leaves and twigs are the preferred source of forage for livestock (Brundin and Karlsson 1999). The mature leaves and twigs have a crude protein value of 9.04% (Aganga and Adolga-Bessa 1999), and are high in vitamin A (Coates Palgrave 1983/2002). The leaves also contain high quantities of calcium ($2 \pm 0.8\%$, $n = 43$), phosphorus (1321 ± 424 parts/ 10^6 , $n = 43$), potassium ($1.05 \pm 0.46\%$, $n = 19$) and sodium (102 ± 66 parts/ 10^6 , $n = 19$), similar to other important browse species such as *Grewia flava* and *Acacia mellifera* (Cole and Brown 1976). There is no difference in nutritional value of browse at different heights on the tree (Woolnough & du Toit 2001), and the protein and phosphorous levels vary little across season (Bonsma 1942). Ludeman (1966) found, however that only when leaves and twigs were ground to a finer texture, were they sufficient to sustain cattle. It is also an important source of fodder for game species. For example, in the Kalahari, red hartebeest and porcupine are known to feed on the bark of *B. albitrunca*, while the flowers are also eaten by a number of different game species (Bothma 1982).

In Namibia, farmers partially cut through the trunk so that it may be bent down and the leaves brought within the reach of browsing animals (Coates Palgrave 1983, Palmer & Pitman 1972). In times of drought when there is a shortage of grazing, farmers often remove the branches to feed their sheep and cattle (Palmer & Pitman 1972).

The fruits of *B. albitrunca* are edible, although not very tasty to humans. Green fruits, crushed and mixed with milk, are eaten as a vegetable by the Korana people (Bothma 1982). The fruits are favoured by birds, primates and elephants (van der Walt and le Riche 1999). They may also be eaten and dispersed by bat-eared fox (*Otocyon megalotis*) and jackal (*Canis mesomelas*).

MEDICINAL USES

B. albitrunca is an important medicinal species. The green fruit is used to treat epilepsy (van der Walt & le Riche 1999). A cold fusion of the leaves is applied to the inflamed eye of cattle and an extract of the roots provides a treatment for haemorrhoids (Coates Palgrave 1983).

FOOD FOR HUMAN CONSUMPTION

B. albitrunca has been used as a source of food during droughts and famine. The roots are sometimes eaten either raw or cooked in water and then concentrated to make syrup (van der Walt and le Riche 1999), and the dry, unroasted root kernel can also be important for making porridge (Coates Palgrave 1983). This porridge was considered tasty because it was free of tannin, as this is associated with a bitter taste (Bothma 1982). The roots are most commonly used to provide a drink called "witgatkoffie" (van der Walt and le Riche 1999). The process of making witgatkoffie is discussed in detail in Bothma (1982) and van der Walt & le Riche (1999). The flower buds can be used in place of capers (Coates Palgrave 1983).

In Botswana, the old hollow trunks are used a to hold water that is tapped out by the Basarwa (Coates Palgrave 1983).

The powered roots have preservative qualities and local tribes use this powder to preserve butter fat. This was tested and proved by a number of experiments carried out by the CSIR (Bothma 1982). Milk was found to remain fresh for 24 hours when 0.5 percent of the ground freeze-dried root was added to the milk at 30°C (Bothma 1982). Butter remained fresh for 19 days under the same conditions, compared with butter made from untreated cream, which became rancid after only 3 days (Bothma 1982). Further experiments showed that the powered root also prevents mould forming on oranges, tomatoes, bread and potatoes (Bothma 1982). These uses could be explored further if they can be carried out sustainably and for use to uplift local communities.

NON-CONSUMPTIVE

CONTRIBUTION TO BIODIVERSITY

The shepherd's tree is a valuable source of shade especially in arid areas such as the Kalahari, where trees are rare. The low-spreading tree shepherd's tree is mainly found on the crest of the dunes in the Kalahari (Bothma 1982).

By day, the Kalahari's larger mammals species in particular rest in the shade of various tree species in the area but show a preference for a shrub-like dense shepherd's tree with pendant branches reaching the ground (Bothma, 1982). Research by Bothma (1982) and Eloff (1979) on lions (*Panthera leo*) and leopards (*Panthera pardus*), found that both species preferred to rest beneath *B. albitrunca* during the heat of the day. Daytime temperatures beneath this tree have been found to be as much as 21°C cooler than that of open unprotected sand (Bothma 1982). According to Bothma (1982), in the hot arid environment of the southwestern range of this tree, it is often the only source of dense shade. Leopards also hide their prey from other predators under or near to shepherd's trees (Bothma 1982). Any animal seeking shelter in this tree is almost invisible from the outside and thus it provides good cover for predators while hunting. Lionesses also use the tree for giving birth and as a hiding place while she is hunting (Bothma 1982, Eloff 1979). This tree is also important for smaller mammals, e.g. Tree rats (*Thallomys* spp.), that nest within this tree (W.R.J. Dean *pers. comm.*) and for birds. In areas where arboriciding has taken place, vultures and raptors now build their nests within *B. albitrunca*, when previously they would have tended to use thorn trees (A. Maritz, *pers. comm.*).

The shaded area under a shepherd's tree provides perfect for a suite of invertebrate fauna from a variety of guilds (Bothma 1982, Venter & Venter 1996). This microhabitat is thus vital to continued biodiversity patterns in the Kalahari.

Much of the environment in which *B. albitrunca* occurs is characterised by oligotrophic sands, yet its nutritious foliage suggests that this species obtains nutrients from ground water and perhaps also from the concentration of nutrients beneath its canopy because of animal activities. In this way *B. albitrunca* is important to nutrient cycling in the environments in which it occurs, as well as performing other ecological services such as diminishing nutrient leaching, mitigating soil degradation, preventing soil erosion, sequestering carbon and replenishing organic matter.

CULTURAL VALUE

The Shepherd's tree is of great cultural importance, forming an inseparable part of the cultural history of many groups (Bothma 1982). In some rural areas, many locals believe that the wood must not be burnt as it results in cows only producing bull calves (Coates Palgrave 1983). It is also believed that if the fruit withers before the millet crop is ripe then the harvest will fail and many believe that destruction of this tree is forbidden (Coates Palgrave 1983). It is a Tswana custom to praise the local paramount chief for his deeds from atop a shepherd's tree (van der Walt & le Riche 1999).

TOURISM/AESTHETICS

It is difficult to quantify the economic value of *B. albitrunca* aesthetically, but this tree is particularly important in arid areas where it provides shade and adds interest to the landscape, thus it is no doubt valued by local inhabitants and tourists, alike.

CONCLUSION AND RECOMMENDATIONS

B. albitrunca is a slow growing species (van Wyk 1984) with non-dormant, endozoochorous seeds with short life-expectancy (Briers 1988). It appears to require suitable germination and establishment sites (Milton and Dean 1995, Dean et al. 1999, Leistner 1967, 1996, van der Walt and le Riche 1999). *B. albitrunca* is also characterised by low germination rates, and high seed mortality after only one or two seasons in the soil (Briers 1988). Such life history characteristics suggest this species may be vulnerable to high frequency or intensity of exploitation such as harvesting of seed-bearing trees (Cunningham 2001). Studies indicate that *B. albitrunca* may be sensitive to browsing disturbance, generally resulting in reduced densities (Kalikawa 1990, Brundin and Karlsson 1999, Nott and Stander 1991). Apart from direct browsing by livestock, branch and crown removal to provide fodder supplement may have equally serious implications for *B. albitrunca* populations, reducing trees to flat, multi-stemmed shrubs (Van der Walt and Le Riche 1999). Frequent pruning, or pruning too low down the stem may also kill trees (Van der Walt and Le Riche 1999). Although trees are capable of resprouting, the elicited coppice growth is vulnerable to herbivory, and the level of subsequent herbivory that can be tolerated is unknown. High browsing pressure and trampling may also compromise sustainable levels of establishment and recruitment of this species.

Browsing and harvesting branches for livestock feed thus appear to exert the greatest pressure on its resources, and may be considered the most important threat to the species. Information is therefore needed on browsing pressure that may be sustained, under various factors such as tree density, stock type and stocking rates, fire, and rainfall.

Success of recruitment episodes and the influence of stocking rates and environmental factors on these are also needed. A rapid assessment of population health and stability subject to such factors can be achieved by ascertaining whether differences in these characteristics exist between populations subject to various levels of herbivory. This can be achieved by sampling transects from areas of high browsing pressure to low browsing pressure, and recording all size classes.

In order to gain insight into the effects of harvesting or browsing of *B. albitrunca*, comparison of the effects of these disturbances over a gradient of intensities is needed. The simplest approach is to compare size-class distributions, and hence population structure, at different sites of different intensities or frequencies of browse and/or harvesting (Cunningham 2001). Size-class distributions give an indication of size-specific mortality and therefore the status of a population (Cunningham 2001). Such an assessment also elucidates how browsing intensity affects tree size, shape, survival and regeneration potential. Population modelling, using a simple approach such as matrix population modelling, may also assist in determining which rates of browse and harvesting impact populations negatively.

SUMMARY OF RESEARCH GAPS

B. albitrunca has no commercial value, nor is it harvested for fuel wood. It is heavily used as domestic livestock fodder, however, particularly in drought years, constituting the primary threat to this species. Information on the extent, nature and impact of browsing and harvesting on this species is thus needed to allow evaluation of the status of this species. More specifically, research should address the following:

1. How do size-class distributions compare between populations subject to intense versus low (or zero) browsing? This can be established relatively quickly by conducting surveys of populations along browsing or harvesting gradients. Knowledge of size-class distributions gives an indication of size-specific mortality and therefore the status of a population.
2. What is the effect of browsing on regrowth, particularly where regrowth is a response to direct browsing by livestock or cutting to provide fodder?

3. How do amount and frequency of rainfall, drought and browsing and trampling by livestock affect seedling establishment?
4. Are trees that have been heavily browsed able to regenerate normally, and which particular size classes (or growth heights) are most susceptible to browsing?
5. What is the threshold of maximum branch removal and browse, and at what frequencies can such disturbances be tolerated?
6. Does harvesting of food for human consumption, such as root bark and fruit, affect survival and regeneration potential of individual trees?
7. To what extent does dependence on other tree species (for suitable germination sites) affect regeneration potential of *B. albitrunca*? This may be a crucial point to consider in areas where there are few 'foster' trees in the system, particularly in light of removal of large *Acacia erioloba* in the Kalahari.
8. Further research needs to be conducted on the effects of fire, herbicide and lowered ground water on the survival of *B. albitrunca*.

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