The potential role of *Loxodonta africana* in control of the invasive species *Acacia mearnsii* in South Africa

Potential interactions between a landscape transformer and a landscape engineer

Caroline Danielson

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Swedish University of Agricultural Sciences, SLU
Faculty of Forest Sciences
Department of Southern Swedish Forest research Centre
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Supervisor:	**Annika Felton, Department of Southern Swedish Forest Research Centre, SLU**
Examiner:	Carl Salk, Department of Southern Swedish Forest Research Centre, SLU

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Swedish University of Agricultural Sciences
Faculty of Forest Sciences
Southern Swedish Forest Research Centre

Abstract

Invasive plants are one of the global threats to biodiversity. *Acacia mearnsii* was brought to South Africa from Australia 150 years ago and is known as a landscape transformer due to its invasive capacities, creating homogenous dense vegetation outcompeting endemic fauna. Elephants (*Loxodonta africana*) are megaherbivores and can transform food webs, ecosystems and herbivore communities with their need for forage. As such, they have the potential of performing an ecosystem service by acting as an agent of biological control of *A. mearnsii or* perform ecosystem disservices by supporting the spread of the species. In this report, I review published literature on the interaction between elephants and *A. mearnsii* and identify a knowledge gap on their interactions. One scientific publication found in this review report that elephants consume *A. mearnsii*. A comparison of plant traits between *A. mearnsii* and native African *Acacias* species frequently consumed by elephants suggests that the species could be an important source of food for elephants. Based on the comparison, it remains unclear whether elephants function as seed dispersers of the invasive species. This may be investigated by further research on seed germination after ingestion of *A. mearnsii* by elephants.

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1 Introduction

Exotic plant species invasions are recognized as one of the most prevalent threats to biodiversity and has disrupted ecosystems globally (Mungi et al. 2023, Lusizi et al. 2024, Maxwell et al. 2016). Invasiveness of an introduced plant species refers to its propensity to invade an ecosystem (Medoc et al. 2017). Consumption of such plants by herbivores can in some cases act as a countermeasure against further spread in a region. Herbivory is recognized in its role of controlling plant biomass (Mungi et al. 2016, Bond 2024) and extant large mammal herbivores exert significant consumer control over plant vegetation (Bond 2005). With their significant metabolic requirements, megaherbivores (animals with a body mass >1000 kg) are suggested to have a particular influence in shaping vegetation structure (Bond 2005, Mungi et al. 2016). Intermediate herbivory in a habitat increases light at ground levels, generally promoting plant species richness and structural diversity (Moi et al. 2020). The local effect of herbivory on plant species is multifaceted and depends on a variety of factors, including the plants' defence mechanisms (War et al. 2012). While native plants may have developed defence mechanisms to local herbivores, such traits may be lacking among exotic plants if they have developed in regions without similar herbivory pressure (Mungi et al. 2023). Instead, most successful invasive plants are specialised on fast growth strategies. It has been theorized that disruption from herbivores may act as a threshold for invasive species to establish dominance in a new ecosystem (Mungi et al. 2023). On the contrary it has also been suggested that herbivores may act as propagule dispersers, increasing the rate of plant invasion, supporting the switch to alternative ecosystem states by feeding on and spreading seeds of invasive species (Holmgren 2002, Eschtruth et al. 2009).

A region that is struggling with the problem of invasive plant species is southern Africa. For example, in the country of South Africa, around 550 invasive plant species have been identified. South Africa is one of the world's top ten nations for plant species richness (Chapman Poulsen 2020, Copeland et al. 2016) and has one of the highest frequencies of endemic plants (69%; Copeland et al. 2016). This is a result of the country's varied climate, topography and geology offering a variety of ecosystems for endemic species to thrive in (Chapman Poulsen 2020). However, invasive plant species currently posing a large threat to these ecosystems, as the circa 550 known invasive plant species are estimated to cover approximately 100'-200' km^2 (10-20 Mha corresponding to 13% of the land) of mostly grassland and savannas (Lusizi et al. 2024).

Acacia mearnsii is one among 141 species of *Acacia* that was introduced to the country 150 years ago from Australia for the production of timber and tannin (Lusizi et al. 2024). 33 species of *Acacia* are still present, and *Acacia mearnsii* is among the top ten invading species in Africa (Neergaard et al. 2005, Lusizi et al. 2024). 21-24 species of *Acacia* are considered invasive globally (Lusizi et al.

2024, Griffin et al. 2011, Souza-Alonso et al. 2017). *A. mearnsii* has dramatic effects on the ecosystem it invades. It creates homogenous dense vegetation formations, hindering establishment of understory plants by drastically decreasing light availability leading to lower grass productivity, reduced species richness and diversity; it also modifies habitat suitability for birds and mammals, decreasing the species variety (Souza-Alonso et al. 2017). *A. mearnsii* is also known to alter soil chemicals that favour their own productivity, changes that remain after the species has been cleared (Lusizi et al. 2024). It occupies approximately 25 000 km^2 (2.5 Mha) in South Africa (Lusizi et al. 2024) corresponding to approximately 2% of the surface (1,2 Mkm^2; Boston University n.d.). It is largely found in the Eastern Cape, Kwa-Zulu Natal, Hauteng and Limporo provinces (Luisizi et al. 2024). Its easy germination, good survival, rapid growth rate (Souza-Alonso et al. 2017) and short generation time contribute to its success of invasiveness (Lusizi et al. 2024, Souza-Alonso et al. 2017). It is considered a "landscape transformer" for its capacity to substantially change the character and nature of the ecosystems (Souza-Alonso et al. 2017). *A. mearnsii* poses a significant threat to the endemic flora in South Africa and is simultaneously widely used in commercial timber production providing both income (from production of timber, tannin, fuel wood and resins) and employment (Jami et al. 2017). It is representative of the contradictory perception of exotic species as socially-economically valuable at the same time as ecologically threatening to biodiversity (Souza-Alonso et al. 2017).

Elephants (*Loxodonta africana*) are classified as megaherbivores (Bond 2005, Fritz 2017, Mungi et al. 2023, Owen-Smith 1988) and they can have dramatic impacts on the area they inhabit by the top-down consumption pressure they exert (Owen-Smith 1988, Bond 2005, Mungi et al. 2023, O'Connor et al. 2007). Elephants forage between 55-300 kg of vegetation during 17-19 hours of every day (Owen-Smith 1988, Rammala et al. 2022) and consume a large amount of food to sustain their metabolic requirements (Rammala et al. 2022). With their consumption and behaviour, they can transform food webs, ecosystems, herbivore communities and landscapes (Fritz 2017, Mungi et al. 2023) and affect their environment through habitat modifications, tree mortality, seed dispersal and water use (O'Conner et al. 2007). The role of elephants as top-down regulators of ecosystems and savanna woodland dynamics and their capacity to transform woodlands to open savanna or grassland is well known (O'Kane et al. 2011, O'Connor et al. 2007, Mungi et al. 2023) and has given rise to the notions of elephants as ecosystem engineers, keystone species, flagship species and the "elephant problem" (Fritz 2017, O'Connor et al. 2007, Swanepoel 2019, Gandiwa et al. 2011). Their impact on woody vegetation has led to concern about possible extirpation of woody plant species (O'Connor et al. 2007) as well as discussion of elephants as a potential nature-based solution to combat invasive species (Mungi et al. 2023).

With the non-negligible threat of *Acacia mearnsii* invasion to the South African landscape and biodiversity, and with the presence of elephants as megaherbivores, this report aims to investigate available literature on the interaction between the landscape transformer *Acacia mearnsii* and the landscape engineer *Loxodonta africana*. What is documented with regards to their interaction? Is there evidence in scientific literature of elephants consuming *A. mearnsii* and is it likely that elephants provide an ecosystem service by their consumption, or do they perform an ecosystem disservice by spreading its seeds? Would it be likely to think that elephants with their capacity to transform landscapes could act as an agent for biological control of the species? Could elephants' metabolic needs lead to a possible extirpation of *A. mearnsii* and act as an agent of biological control of the species? This thesis paper aims to clarify the available literature on the topic and hypotheses around the likely consequence of the interaction between the two species.

2 Method and results of literature review

A systematic review of available literature on the topic of *Loxodonta africana* and *A. mearnsii* was done to find relevant information on the topic of the interaction between the two organisms. Five independent searches were done on the three topics 1) black wattle and elephant diet, 2) black wattle, Africa, invasive species, and 3) elephant diet, Africa.

2.1 Method of literature. review

I initially conducted the search for the focus area of “Black wattle *and* Elephant diet” in Web of Science with the limitation of countries in the African region (search 1, Table 1). When it generated limited results, I expanded the search by eliminating words related to “diet, diet preference and forage” (search 2, Table 1). As the results remained limited and of low relevance, I continued an additional search on Google Scholar (GS; search 3, table 1) without limitation of region, publication date or words related to “diet” applied to the search filter. GS searches entire publications for the indicated keywords and is not limited to titles or abstracts of articles published in scientific publications enabling a wider search result (Google n.d.). The results were then methodically reviewed as described below. When the generated results on the combined topic of “Black wattle and elephant” still remained limited, separate searches for literature concerning the areas “Elephant diet” and “Black wattle” were done in Web of Science (WoS) limited to Africa and for publications from 2001 onward (searches 4 and 5, Table 1). I conducted a total of 5 searches for the three different search approaches on two different platforms (Table 1).

Table 1: Search strings and focus areas for the literature search fundament for this report. I used Boolean terms such as “AND” and “OR” to combine keywords to refine the searches. WoS=Web of Science, GS= Google Scholar.

Search	***Platform***	***Focus***	***Search string***	***Search field***
1.	WoS	Black wattle and elephant diet in Africa	TS=(("Acacia mearnsii” OR “black wattle” OR swartwattel) AND ("diet preferences" OR Diet* OR forage) AND (elephant* OR loxodont*) AND (africa OR guinea-bissau OR Guinea OR Sierra Leone OR Liberia OR Burkina faso OR cote d'ivoire OR Togo OR Benin OR Nigeria OR cameroon OR Central african republic OR South sudan OR Ethiopia OR Uganda OR Kenya Or Tanzania OR Rwanda OR burundi OR malawi OR mozambique OR zimbawe OR botswana OR Lesotho OR Angola OR namibia OR South Africa OR Eswantini OR sambia OR kenya OR namibia OR botswana OR zimbabwe OR mozambique OR zambia OR angola OR tanzania OR congo OR uganda OR rwanda OR ethiopia OR somalia OR sudan OR gabon OR cameroon OR Nigeria OR Senegal OR Gambia OR sierra leone OR Liberia OR Burkina Faso OR Cote divoire OR Ghana OR Togo OR Be-nin OR Burundi OR Lesotho OR Eswatini) AND (Invasive* OR biodiversity OR ecosystem))	TS

2.	WoS	Black wattle and elephant in Africa	TS=(("Acacia mearnsii" OR "black wattle" OR swartwattel) AND (elephant* OR loxodont*) AND (africa OR guinea-bissau OR Guinea OR Sierra Leone OR Liberia OR Burkina faso OR cote d'ivoire OR Togo OR Benin OR Nigeria OR cameroon OR Cen-tral african republic OR South sudan OR Ethiopia OR Uganda OR Kenya Or Tanzania OR Rwanda OR burundi OR malawi OR mozambique OR zimbawe OR botswana OR Lesotho OR Angola OR namibia OR South Africa OR Eswantini OR sambia OR kenya OR namibia OR botswana OR zimbabwe OR mozambique OR zambia OR angola OR tanzania OR congo OR uganda OR rwanda OR ethiopia OR somalia OR sudan OR gabon OR cameroon OR Nige-ria OR Senegal OR Gambia OR sierra leone OR Liberia OR Burkina Faso OR Cote divoire OR Ghana OR Togo OR Be-nin OR Burundi OR Lesotho OR Eswatini))	TS
3.	GS	Black Wattle and elephant diet	("acacia mearnsii") AND (elephant OR loxodonta) AND (diet OR fodder OR forage OR consumption)	All
4.	WoS	Black Wattle, botany Africa, invasive	TS=(("Acacia mearnsii" OR "black wattle" OR swartwattel) AND (africa OR guinea-bissau OR Guinea OR Sierra Leone OR Liberia OR Burkina faso OR cote d'ivoire OR Togo OR Benin OR Nigeria OR cameroon OR Cen-tral african republic OR South sudan OR Ethiopia OR Uganda OR Kenya Or Tanzania OR Rwanda OR burundi OR malawi OR mozambique OR zimbawe OR botswana OR Lesotho OR Angola OR namibia OR South Africa OR Eswantini OR sambia OR kenya OR namibia OR botswana OR zimbabwe OR mozambique OR zambia OR angola OR tanzania OR congo OR uganda OR rwanda OR ethiopia OR somalia OR sudan OR gabon OR cameroon OR Nige-ria OR Senegal OR Gambia OR sierra leone OR Liberia OR Burkina Faso OR Cote divoire OR Ghana OR Togo OR Be-nin OR Burundi OR Lesotho OR Eswatini) AND (botany OR ecosystem OR vegetation OR Invasive))	TS
5.	WoS	Elephant diet	TS=((elephant OR loxodonta) AND (africa OR guinea-bissau OR Guinea OR Sierra Leone OR Liberia OR Burkina faso OR cote d'ivoire OR Togo OR Benin OR Nigeria OR cameroon OR Cen-tral african republic OR South sudan OR Ethiopia OR Uganda OR Kenya Or Tanzania OR Rwanda OR burundi OR malawi OR mozambique OR zimbawe OR botswana OR Lesotho OR Angola OR namibia OR South Africa OR Eswantini OR sambia OR kenya OR namibia OR botswana OR zimbabwe OR mozambique OR zambia OR angola OR tanzania OR congo OR uganda OR rwanda OR ethiopia OR somalia OR sudan OR gabon OR cameroon OR Nige-ria OR Senegal OR Gambia OR sierra leone OR Liberia OR Burkina Faso OR Cote divoire OR Ghana OR Togo OR Be-nin OR Burundi OR Lesotho OR Eswatini) AND (diet OR fodder OR consumption OR forage))	TS

Evaluations of the search hits were done systematically in three steps, based on assessing1) the title 2) the abstract, and 3) the entire publication.

Due to the constraint of time of this thesis, only the review articles were included for evaluation in searches 4 and 5 (Table 2).

2.2 Results: literature review

2.2.1 Search results

The five search strings I applied generated a total of 1449 results whereof 57 were review articles (Table 2). The combined search of "Black wattle" AND "elephant diet in" AND "Africa" (search 1) generated 0 results in Web of Science (WoS). When search 1 was broadened by excluding the word "diet" (search 2) two results with low relevance to the topic were generated. To additionally widen the search, I used Google Scholar (GS) for the topic of "Black wattle and elephant diet in Africa". This generated a much larger search output of 350 results.

When I applied the search string for search 4 with the focus area "black wattle", 209 results including 10 reviews were generated. When the search string for search 5 was applied for the topic "Elephant diet" 907 results and 24 reviews was generated (see Table 2 for summary of search results). The search results were generated the 30th of April 2025.

Table 2: Result of the searches per focus area. For details regarding the search strings, see Table 1. (A login to Web of Science may be needed to see the results on the provided links.)

Search	***Platform***	***Focus***	***Search field***	***No. Results***	***No. Reviews***	***Link to results***	***Relevance***
1.	WoS	Elephant diet and Black Wattle, Africa	TS	0	0	Search 1	-
2.	WoS	Elephants and Black Wattle, Africa	TS	2	0	Search 2	Low
3.	GS	Elephant diet and Black Wattle	All	350	24	Search 3	Medium
4.	WoS	Black Wattle, botany, Africa	TS	209	10	Search 4	High
5.	WoS	Elephant diet	TS	907	24	Search 5	High

2.2.2 Systematic review of search results

The results from searches 1 and 2 generated in Web of science were discarded due to low quantity (0 results for search 1) and low relevance (2 results on unrelated topics for search 2). The 350 publications generated from GS (search 3) included scientific articles, reviews, e-published books, marketing material and reports were systematically reviewed as indicated in section 2.2.1.
Out of the 350 publications, 80 articles were evaluated as relevant based on the title (see evaluation process in Figure 1). Reading the abstract reduced the number of relevant articles to 36 based on reasons for exclusion that can be seen in Table 3. Reading the entire publication further reduced the number of relevant articles to 22. One publication concerned the feeding behaviour of Elephants (*Loxodonta Africana*) and included the species black wattle (*A. mearnsii*) in Africa. The evaluation of the arti-

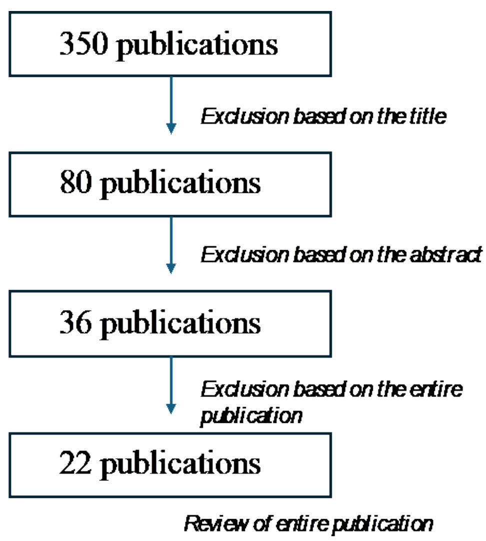

Figure 1: Evaluation process of the search result generated on Google Scholar on the search topic "Elephant diet and Black Wattle, Africa"

cles resulted from the searches 1, 2 and 3 on GS and WoS, revealed 21 semi-relevant and 1 relevant article on the combined topic Elephant diet and Black wattle. The remaining 21 were relevant either for the topic of "Elephant diet" or "black wattle".

The article that was found to be relevant presented information from three anecdotal interviews with two game guards that had been observing elephants during 1990-2000 in Knyasa (in the Cape Floristic Region, South Africa). It supports that elephants frequently consume invasive exotic *Acacias* and *A. mearnsii*, both fruit and trees. It also reports frequent destruction of juvenile-form trees of *A. mearnsii* up to 8 m tall by elephants breaking the bole and leaving most of the plant to decay, even though some of the bark, foliage and pods were eaten (Milewski 2002).

Exclusion reason
Irrelevant title
Superficial information
Elephant was reference to another species than loxodonta or a name
Only rreference to *Acacia mearnsii* in unrelated topics
Only reference to acacia
Only reference to elephant
Reference to other animal and discussion around diet (goats, giraffes, livestock)
Only concerning elephant outside the relevant territory
Reference to other animals than elephant and no mentionning of elephant

Table 3: Reasons for excluding results from the evaluation.

Relevant information from the review articles generated in searches 4 and 5, together with information that may give clues about the interaction between elephants and *A. mearnsii* from sources outside the literature search results is presented in chapter 3.

2.2.3 Conclusion from the literature review

One relevant study was found in searches 1-3 by Milewski (2002) that supported that there is an interaction between *Loxodonta africana* and *Acacia mearnsii* and that elephants both consume its foliage as well as frequently fell juvenile individuals to reach forage in the crown. The information rendered from searches 4 and 5 demonstrated that there is a wealth of literature available on the separate topics "Elephant diet" and "Black wattle". However, my search revealed a knowledge gap and lack of available information on the combined subject.

3 Background information on *Loxodonta africana* and *Acacia* mearnsii

In Chapter 3, I present more information about the black wattle, elephant diet and behaviour based on the review articles from searches 4 and 5 together with appropriate information from additional sources that may shed light on possible interactions between elephants and *A. mearnsii*. I present information on elephant interactions with native *Acacia* trees and compare their characteristics with the exotic *A. mearnsii.* Traits of bark, fruits, seeds and foliage influence elephants' tendency to consume the species and information about these traits may therefore provide clues on the interaction.

3.1 Loxodonta africana morphology and diet

Loxodonta africana is one of eight terrestrial mammals that are classified as megaherbivores together with four rhinoceros, one hippopotamus and one additional elephant species native to Asia. It is the largest living mammalian herbivore whose weight is estimated to 5500-6000 kg in males and averages 3200 kg in females (Smith-Owen 1988). The shoulder height averages 3.2 m for males and 2.7 m for females. Elephants are hindgut fermenters which, in contrast to foregut fermenters (cervids and bovines), enables absorption of protein and soluble carbohydrates before ingested foods undergo fermentation (Owen-Smith 1988). The high rate of food passage and a short pass-through time of 12-14 hours (O'Connor et al. 2007, Owen-Smith 1974) compared to other ruminants (O'Connor et al. 2007) allows for the capacity to process coarser forage at a more rapid rate (O'Kane et al. 2011). Elephants' nutrient requirement is larger than for any other terrestrial animal (O'Connor et al. 2007). Protein, sugars, starch and lipids are, from an herbivore perspective, soluble materials that can be easily incorporated into the cell cytoplasm after ingestion (hereafter referred to as cell solubles), and can be easily released by chewing (O'Connor et al. 2007). For elephants, the potential intake rate of cell solubles is the highest in green grasses and the lowest in woody roots. They prefer soft broad-leafed (short and tall) grasses, soft-bodied herbs (O'Connor et al. 2007, Owen-Smith 1988) with a high proportion of cell solubles relative to structural material (O'Connor et al. 2007). Handling times by elephants when grazing (consumption of grasses) and browsing (consumption of trees and bushes) are usually similar, but greater mass intake rate is achieved when grazing since larger trunkloads can be achieved from grass grazing than from browsed material (O'Connor et al. 2007). Browse usually provides a high protein intake during the growing season (O'Connor et al. 2007). It has been predicted and demonstrated that African elephants forage on the most nutritious food source available (O'Kane et al. 2011).

L. africana exhibits large variation in graze-browse proportion with seasonal change and environmental conditions (Owen-Smith 1988). During the wet season, intake of grasses and herbs is high and continues if availability permits during the dry season to ensure maximum intake of extractable cell content relative to availability (O'Connor et al. 2007, Owen-Smith 1988). Under open grassland conditions grass account for around 40-70% of the feeding time during wet season but decreases to 2-40% during the dry season months. This also varies with environment. Studies have observed that the grazing browsing ratio switched from 57:43 to 28:72 and from 66:34 to 6:94 from wet to dry season in Kidepo (Uganda) and Sengwa (Zimbabwe), respectively (Owen-Smith 1988). When browsing during the wet season, elephants strip leaves and break branchlets to consume terminal twigs. Bark is stripped by drawing small branches through the mouth (Smith-Owen 1988). The sugar-rich phloem tissue is consumed mainly for its sugars (O'Connor et al. 2007). Fruits and seed pods are also actively sought out by savanna elephants when available and are considered high-quality items (O'Connor et al. 2007, Owen-Smith 1988).

During the dry season, elephants feed more on foliage, woody stems (O'Connor et al. 2007, Owen-Smith 1988), roots and bark when leaves start to fall (O'Connor et al. 2007). Elephants tend to strip bark just before trees flower or leaf out, when bark is rich in sap (O'Connor et al. 2007, Owen-Smith 1988) and secondary chemicals are the lowest (O'Connor et al. 2007). During the dry season, elephants select the leaf bases and roots of grass species by kicking tussocks free from the ground with their feet, with leaves and stems being discarded and uneaten. Among the favoured tree species are the *Acacias* (Owen-Smith 1988) from which woody material ingested outweighs the foliage. During years of drought when less green grass is available, elephants' impacts on woody plants' leaves, bark and roots increase (O'Connor et al. 2007).

Elephants' maximum browsing height with their trunk extended is about 6 m, and taller trees may be pushed over, bringing higher branches within reach. Rate of trees being pushed over by elephants varies with the environment. Bulls pushing over 5 trees per day and cows 2.6 pushing over trees per day have been reported from Zimbabwe. From Tanzania the corresponding rate was 0.7 trees per day where only 30% of pushing attempts were successful (Owen-Smith 1988). Pushed over trees generally coppice from the base. The selective damage could lead to increased availability of food at an accessible feeding level (Owen-Smith 1988). Elephants feeding close to timber production stands are attracted to regeneration in the patches opened by timber management; they favour stems under 250 mm in diameter and commonly break off leader shoots (Owen-Smith 1988).

Elefants drink one to three times daily when water is readily available. During dry season they may go for periods of one to three days between waterhole visits but remain dependant on regular access to surface water (Owen-Smith 1988).

3.2 Key determinants of plant species vulnerability to extirpation by elephant utilisation

Elephants can dramatically affect the landscape they inhabit and turn a forest into a savanna or grassland by affecting the living trees (O'Connor et al. 2007). They are selective in their choice of how different species are handled (O'Connor et al. 2007) and native *Acacias* are often amongst the trees that are damaged by elephants (Vesey-Fitzgerald 1974).

Elephants commonly damage trees through complete stem breakage (pollarding), ringbarking, uprooting or repeated severe defoliation, with pollarding and ringbarking being the most frequent (O'Connor et al. 2007).

Pollarding and uprooting of woody plants are usually a result of elephants wanting to harvest crown foliage, fruits and exposed roots of a woody plant, and is done by pushing against the stem (O' Connor 2008; Figure 2). The choice of species for pollarding and uprooting depends on availability and the nutritional and toxic content of the foliage (O' Connor et al. 2008) and is mostly done during dry season (O'Connor et al. 2008, Owen-Smith 1988). The soil and the wood characteristics (hardwood or softwood) of the tree will determine if the tree is uprooted or pollarded when the elephant is reaching for harvesting the crown by pushing the tree (O'Connor et al. 2007).

The degree to which trees are debarking dependents on their bark characteristics, such as nutritional and toxic content and the degree of ease of which bark is separated from the stem. The degree to which complete ringbarking is done depends on if the tree has several stems or not (O'Connor et al. 2007).

Figure 2a and b: An example of an elephant pollarding large Acacia tree for browsing. Figure a showing the technique, figure b showing the browsing. Picture from Latest sightings video on Youtube. Full video can be seen on here.

A plant's capacity to further grow after elephant damage determines the rate of survival. High capacity to activate buds and shoots increases the survival rate after elephant utilisation and decreases the risk of extirpation of the population. Risk of extirpation is higher for species whose regeneration occur on rare occasions with a low number of seedlings compared to species that has specialized in regeneration with many seedlings (O'Connor et al. 2007).

3.3 Acacia

The genus *Acacia* is part of the family fabaceae, commonly known as legumes (Britannica 2025). The genus is estimated to contain 1350 species of the range from herbs to large trees. Most of the species in *Acacia* are shrubs or small trees. The natural habitat ranges from arid to moist areas including riverbanks and they are found on most soil types. Approximately 1000 *Acacia* species are native to Australia and 144 to Africa but they are rare in Europe (Brockwell et al. 2005). The Australian native species have historically been transported extensively between 35 degrees north and 40 degrees south. Most *Acacias* have numerous small creamy or golden balls or cylinders of flowers and leguminous pods and many of the species have bipinnate feathery leaves. In contrast to Australian *Acacias*, African species of the genus *Acacia* have spines. The evolution of spines on plant species is a result from co-evolving with large herbivores (Coverdale 2020). In general, *Acacias* form symbiotic relationships with root-nodule bacteria that fixate nitrogen (Kull et al. 2008). All Australian species have durable soil-stored seeds which have been shown to be critical to their invasiveness, resilience to disturbances such as fire, and support their spread (Richardsson 2008). Some *Acacia* species are known to form mutualistic relationships with local ants species that appear to protect them from herbivory both in Australia and Africa (Goheen et al. 2010, Tamashiro et al. 2019, Eichhorn et al. 2011). Presence of ants on *Acacia drepanolobium* in Africa hinders elephants from feeding on them (Goheen et al. 2010). However, exotic *Acacias* in Portugal that form mutualistic relationships with ants in Australia do not seem to have been able to form the same sort of mutualistic relationship with local ants in Portugal (Eichhorn et al. 2011). The invasive success of Acacia trees in South Africa is ascribed to rapid growth rates, copious seed production with seed banks left in the soil (Richardson 2008), their capacity to alter soil chemical properties that gives them an advantage over native species (Lusizi et al. 2024) and absence of natural enemies (Richardson 2008). A range of biological control agents has been applied to the woody *Acacia* species worldwide. 24 seed-attacking biological control agents has been implemented on 22 different species (Richardson et al. 2008). Browsing in grasslands is described as a potentially useful practical method of control (Richardson et al. 2008).

3.3.1 Acacia mearnsii

The black wattle (*Acacia mearnsii*) is native to large parts of southeastern Australia and Tasmania and is known to be invasive in eastern Africa (Kenya, Tanzania, Uganda, South Africa; Richardson et al. 2008, Lusizi et al. 2024). The species is water demanding and exacerbates water scarcity difficulties (Lusizi 2024) and prefers cool climate (Kull et al. 2008).

The tree has bipinnately compound leaves, grows 2-30 m high (Kull 2008), is evergreen with shallowly rigged branchlets all covered with fine hair (Figure 3). It has smooth, tannin-rich grey bark becoming black and fissured with time and the plant gives a resinous gum (Kull et al. 2008, Bio-Eafrinet 2011). The leaflets are olive green, and each leaflet on the compound leaf is only 4 mm long. The leaflets are densely packed together. Cream-coloured or pale yellow and fragrant flowers occur in small spherical heads. *A. mearnsii* develops pods which are straight or twisted, dark brown when ripe and up to 10 cm long with 2-13 joints between seeds (Bionet-Eafrinet 2011). In contrast to many African *Acacias*, but like many Australian *Acacias*, *Acacia mearnsii* has no spines (Kull et al. 2008).

Figure 3:Acacia mearnsii. A.) A mearnsii stand(Forest & Kim Starr- CC BY 4.0) b): juvenile stand (FOREST & KIM STARR - CC BY 4.0) c.) Flowers (FOREST & KIM STARR (2010), CC BY 4.0.) d.) Stem and bark.(Jeremy R. Rolfe, Date taken: 20/04/2016, Licence: CC) e.) Foliage (John Smith-Dodsworth, Licence: CC BY-NC (n.d.) f.) Pods (Jeremy R. Rolfe, Date taken: 20/04/2016, Licence: CC-BY.).

Seeds and their dispersal

Acacia mearnsii exhibit sexual and asexual reproduction depending on environment, showing a preference to sprouting in disturbed areas and seed-based reproduction in undisturbed areas (Souza-Alonso et al. 2017). It sprouts profusely from root suckers, especially when roots are damaged, as when mechanical control is exerted or when affected by fire (Richardson et al. 2008). They seeds germinate easily, and seedlings have rapid growth rate and good survival (Souza-Alonso et al. 2017). They have short generation period and reach reproductive maturity within 2-3 years (Lusizi et al. 2024). Despite their capacity of self-fertilisation, *Acacias* are pollinated by generalist insects and usually require presence of pollinators to

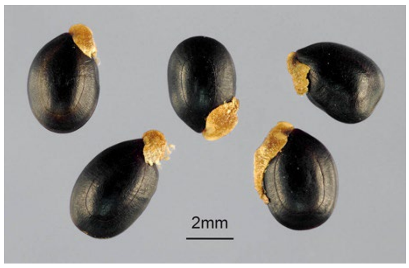

Figure 4: Seeds of Acacia mearnsii (Photo by Steve Hurst, rights to use in Public Domain)

achieve significant seed production. Seeds can be dispersed both by wind and water and remain viable up to 150-200 years (Souza-Alonso et al. 2017; see Figure 4).
A. mearnsii spreads into terrestrial habitats following dispersal along rivers or by human-created soil movements such as by mud, cars, or horticultural stock (Richardson et al. 2008). Germination is stimulated by fire which may support future invasive success of *Acacia mearnsii* with an expected increase in wildfires because of climate change (Souza Alonso et al. 2017).

Control
Management of the spread of invasive *A. mearnsii* is resource demanding due to their sprouting capabilities and long-lasting seed banks (Souza-Alonso et al. 2017). Herbicides, prescribed burns, manual clearing and cultural grazing management have been used as control methods (Souza Alonso et al. 2017, Richardsson et al. 2008). Biological control of *A. mearnsii* has been applied by the flower galling midge (*Dasineura rubiformis*) which has greatly reduced its reproductive capacity (Souza-Alonso et al. 2017). *A. mearnsii* relies on microbes to fixate nitrogen. The plant has a low specificity to rhizobia and is compatible with a large range of rhizobia species (Souza-Alonso et al. 2017). It changes the chemical and physical properties of soil in a way accommodating to its own growth. The changes remain after the trees have been cleared (Lusizi et al. 2017).

3.3.2 Herbivory in Australia

Historically, Australia has been home to a variety of large herbivores of which a fraction is currently present (Reid 2020). Native herbivores include Eastern grey kangaroos (*Macropus giganteus*), red kangaroos (*Osphranter rufus*), wallabies (*Wallabia bicolor*), wombats (*Vombatus ursinus*; Davies 2008) and koalas (*Phascolarctos cinereus*; Wildark n.d.). Historically, giant wombats, (*Diprotodon*), a marsupial that went extinct 40,000 years ago*,* the *Nimbado*n (a koala-like animal that went extinct 13 million years ago (Australian museum, 2021) and a range of other large marsupial herbivores used to inhabit the continent but became extinct, mostly coincident with human colonisation. Unlike the African savanna, no megaherbivores are present today in Australia (Davies et al. 2008).

3.3.3 Other *Acacia* species affected by elephants

Acacia woodlands have been reported as heavily effected by elephants (O'Connor et al. 2007, Owen-Smith 1988, Pringle 2008). *Acacia* species that are mentioned as components of elephant diet are *A. tortilis*, *A. xanthophloea*, *A. seyal* (Vese-Fitzgerald 1974 Owen-Smith 1988, Calenge et al. 2002), *A. elatior* (Browning, n.d., Ihwagi 2007), *A. mellifera* and *A. nilotica* (Pringle 2008). In the lack of more information regarding interactions between *A. mearnsii* and elephants, in this chapter I present more information on *Acacia* species commonly consumed by elephants to give clues upon interactions between *A. mearnsii* and elephants. Further, I speculate whether elephants with their enormous food requirements could act as agents controlling the plants' invasiveness.

Plant structure of Acacias commonly fed on by elephants
Of the six above-mentioned trees that elephant eat, two are large (*A. xanthophloea* and *A. elatior,* up to 30-40 meters tall), two are middle sized (*A. tortilis* and *A. seyal,* 15-17 m) and two are shrub-like small trees (*A. mellifera* and *A. nilotica;* Figure 5a-f) (Random harvest 2025abcd, Mariod et al. 2017, Flora of Zimbabwe 2025, REDD+, Pakistan n.d.). They are known to tolerate drought, high temperatures, and sandy and stony soils (*A. tortilis*), and grow on open grasslands or the wooded savanna (*A. mellifera, A. seyal, A. nilotica;* Abdalbasit 2017, Random harvest 2025ab, Feedopedia 2015ab,).

Figure 4a-f) Photos illustrating Acacia trees. growth form A. tortilis *- a medium sized (up to 17 m) slow-growing tree with an umbrella-shaped canopy. The plant is known to tolerate drought, high temperatures, sandy and stony soils and heavy browsing (Abdalbasit 2017) b*) A. xanthophloea *- a fast-growing deciduous tree up to 30 m, native to southeast Africa; its natural biomes are grasslands along rivers and streams (Random harvest 2025d). c)* A. elatior *- evergreen tree up to 7-40 m with a round or flattish crown (Botanika, 2025) and growing in the arid and semi-arid areas (Wildflowers n.d.)). d)* A. seyal- *is a typical savanna Acacia, a medium-sized shrub tree that grows up to 17 meters, with thin and with layered branches (Feedopedia 2015b; e)* A. mellifera-*–a deciduous dense shrub or small tree growing to a height of 3-9 m, has an extensive root system allowing for survival in dry areas (Feedopedia 2015a) and is widespread in wooded grasslands, and an aggressive colonizers (Cabi Library 2020) f)* A. nilotica *- a small to medium-sized tree growing to 3-10 meters in a mushroom-shaped form, slow growing, drought resistant and grows well in well drained a clayey soils in sun or semi-shade wooded grasslands (Random Harvest 2025b). (Photos by: a) John Ratzlaff (2012) CC BY-NC-ND. b) Steve Pastor Ngorongoro (2006) (public domain), c) Bryanadkins (2016) CC BY-NC. d) Marco Grandis (2017) (CC BY-NC) e) Alex Dreyer (2008) (Available for use). f) Janet Taylor (2022) (CC BY-NC)).*

Foliage and spines
All *Acacias* commonly fed on by elephants have pinnately or bipinnately compound leaves, up to 20 pairs of leaflets such as in the *A. seyal.* In contrast to the

other species mentioned in this comparison, *A. mellifera* has round leaflets compared to narrow leaflets among the other species. All species included in this comparison of trees eaten by elephants have spines (Figure 6 a-f) (Abdalbasit 2017, Random Harvest 2025abcd, REDD+ n.d., Feedopedia 2015ab, Cabi Digital Library 2020, World Agroforestry 2009). *A. tortilis* and *A. elatior* both exhibit two types of thorns on the same plant, one longer and straight, and the other smaller and hooked (Random Harvest 2025c, Agroforestry database, *Acacia* elatior 2009). When elephants feed on *A. xanthophloea*, they flatten the thorns between a tusk and the base of their trunk and discard the pricklier distal parts (Owen-smith 1988).

Figure 5a-f: Photos of Acacia *foliage and thorns. a.)* A. tortilis *- the leaves have about 15 pairs of leaflets each composed of 4-10 pairs of 2.5 cm long pinnae (Abdalbasit 2017). The tree has both long straight white spines and small, brown hooked spines to help protect its nutritious leaves (Random Harvest 2025c). b.)* Acacia xanthophloea *– clustered leaves appear on short lateral shoots in 4-6 pairs of pinnae and leaflets in 10-17 pairs of pinnae. Spines appear in pairs, are white and grow up to 7 cm (Flora of Zimbabwe 2025). c.)* Acacia elatior*- leaves appear in 5-13 pairs of pinnae, leaflets in 13-25 pairs up to 4 mm long. Spines appear in two forms. Shorter, brown sometimes curved up to 7 mm long and longer, up to 9 cm straight and white (Agroforestry database, Acacia elatior 2009) d.)* A. seyal *- leaves appear in compounds of 3-7 pinnae in 11-20 pairs of leaflets of the size of 2-8 mm long. The leaves, pods and flowers are major source of early dry-season fodder that can be browsed. Sharp straight spines occur on the branches and smaller curved thorns are presented near the tips of the branches (Feedopedia2015b). d.) A. mellifera* - *Leaflets appear in blue-green colour, round with 2-4 pairs of pinnae, round at the base and sparsely fringed with hairs. It has vicious hooked spines appearing every 5-14 mm (Feedopedia,2020a). The leaves are protein rich and useful browse. Initially green and fringed with white hairs (Cabi Digital Library, 2020. f.)* A. nilotica *– the leaves are alternate, bipinnately compound, 5-15 cm long and fairly hairy. The leaflets are 1-4 cm long and grey green (World agroforestry, Acacia nilotica, 2009). The tree has spines that can develop up to 9 cm long (Tree SA, Vachellia nilotica, 2025).(Photos by: a.) Franco Colnago (2020)(CC-BY-NC), b.) Ekuyler (2021) (CC-BY-NC) c.) Mr Kamau 2022 (CC-BY), d.) Stefan Dressler, iNaturalist (N.d.)(CC BY-NC-SA 4.0), e.) Feedopedia, Acacia mellifera (2015) (permission to use granted), f.) Wynand Uys (n.d.) (CC BY).*

Fruits and seeds
All *Aacias* in this review have flowers that range from white- yellow to greenish, described as aromatic with sweet scent. They all have pods bearing green, brown, or beige seeds and appear in distinctively curled (*A. tortilis*) to long oblong pods (*A. seyal*) Figure 7a-f). The pods are browsed by animals and if the pods open, the seeds may be dispersed by wind or water (Abdalbasit et al. 2017, Random Harvest 2025c, Flora of Zimbabwe 2025, Global Plants Acacia elatior 1959, Feedopedia 2015b, Random harvest 2025a, Tree SA 2025).

Figure 6: Pods of Acacia consumed by elephants. a.) A. tortilis - *pods are distinctively curled (Random Harvest 2025c). b.)* A. xanthophloea - *Pods appear as straight, papery with wavy margin. c.)* A. elatior -*Pods are straight, narrow and oblong 3-12 cm and 1,2-1,8 cm wide. Seeds in pods 6-7 mm in diameter with oblique form (Global Plants, Acacia elatior, 1959). d.)* A. seyal – *Long curved pods (7-20 cm) containing 6-10 elliptic seeds (Feedopedia 201a5). e.)* A. mellifera –*Pods develop rapidly after flowering, in small, straw-coloured or pale brown in 4.5-6.5 cm long in thin, oblong, small and nutritious pods (Random harvest 2025a). f.)* A. nilotica *Dark brown pods develop up to 17 cm long carrying up to 15 warty well rounded seeds and is commonly browsed (Tree SA, 2025) (Photos by: a.) Botswanabugs (2023). (CC-EY-NC). B.) Mike Plagens (2022) (CC-EY-NC)c.) Bryan adkins (2016)(CC BY-NC-SA) d.) Claude Boucher Chisale 2015 (permission to use granted) e.) Jeff Morris (2020)(CC BY-NC),f.) Ricky Taylor (2023) (CC BY-NC).)*

Bark
The bark of the different *Acacia* species included in this review range from distinctive green-yellow smooth bark on *A. xantophloea* to deeply fissured on *A. tortilis* and *A. nilotica*, and rusty orange on A. seyal Figure 8a-f). A. tortilis bark is tannin rich (Random Harvest 2025c, Flora of Zimbawbe 2025, Wildflowers, Acacia elatior, n.d., Feedopedia2025b, Cabi Library 2020, Random Harvest 2025b).

Figure 7a-f: Photos of Acacia bark. a.) A. tortilis *– The bark is deeply fissured and has a rough feel and is rich in tannin (Random Harvest 2025c). b.)* A. xanthophloea *– a distinctive green-yellow powdery bark (Flora of Zimbabwe 2025) c.)* A. elatior **-** *Bark of a young A. elatior branch. Older bark of trunk is dark brown, almost black, and deeply fissured, similar to* A. nilotica*. (Wildflowers, Acacia elatior, n.d). d.)* A. seyal *-The bark is distractive, powdery, rusty or orange red, often peeling to reveal under bark (Feedopedia2025b). e.)* A. Mellifera - *Bark is light to dark grey and longitudinally fissured (Cabi Library2020). f.)* A. nilotica *-The bark is dark brown and distinctly fissured. The fissured bark is an attractive habitat for invertebrates which attract woodpeckers and insectivorous birds (Random Harvest 2025b). (Photos by): a.) Maia_guerra (2023) (CC BY-NC), b.) Errol Douwes (2023)* (*CC BY-NC), c.) Greenway PJ (1956)(Permission to use under CC). d.) Schmidt (2010) (Permission to use granted), e.) Ale Dreyer (2015)(CC BY-NC), f.) Grant Reed (2021)(CC BY-NC.))*

Reproduction and seed dispersal

The seeds contained in the pods of *Acacias* described in this chapter are as nutritious and suitable to browse and are dispersed by animals. If the pods open, the seeds are dispersed by wind and water (Cabi Library2020, Siyabona Africa, Umbrella Thorn 2025, Feedopedia 2015b, Cabi Library 2020, Cabi Digital Library, 2023). The seeds are similar in size to the seeds of *Acacia tortilis* (Figure 9) Unlike *A. mearnsii*, *Acacia tortilis* has a weak coppicing ability (O'Connor et al. 2007).

Figure 8: Seeds from Acacia tortilis (Photo by Tracey Slotta- Permission to use by CC).

Mineral content of Acacia species
Table 4 presents the micro-nutritional (mineral) content of some of the above-mentioned *Acacia* species compared to *A. mearnsii.*

Table 4: Mineral concentrations of foliage of A. nilotica, A. mellifera, A. tortilis, A. elatior, and A. mearnsii. Ca=calcium, P= phosphorus, Mg= magnesium, Na= sodium, S=sulphur Fe=iron, Cu= copper, Zn=zinc, Co=cobalt, Se=selenium, Mo=molybdenum and Mn= Manganese (Data from Ondiek et al.2010 and Pedro et al. 2024).

	Major elements, gkg^{-1} DM					Trace elements, mg/kg^{-1}DM						
Species	**Ca**	**P**	**Mg**	**Na**	**S**	**Fe**	**Mn**	**Cu**	**Mo**	**Co**	**Zn**	**Se**
Acacia nilotica (data from Ondiek et al. 2010)	12.1	1.49	1.81	0.458	2.03	200	32.3	74.9	41.9	4.61	22.8	87.9
Acacia mellifera (data from Ondiek et al. 2010)	18.6	1.32	8.67	0.627	1.54	224	22.1	31.4	30.9	3.63	15.9	47.8
Acacia tortilis (data from Ondiek et al. 2010)	28.1	1.45	3.89	0.581	1.72	229	29.9	38.7	13.9	3.65	12.2	124
Acacia elatior (data from Ondiek et al. 2010)	13.3	2.52	1.67	0.711	1.12	88.9	27.9	28.3	19.3	2.01	93.2	63.7
Acacia mearnsii (data from Pedo et al. 2024)	11.5	0.78	2.3	2.8		127.3	11.4	10.2			19.2	

A. tortilis is rich in calcium and iron. *A. mellifera* is rich in magnesium, *A. nilotica* is rich in copper, and *A. elatior* is rich in zinc. The foliage mineral content of *A. mearnsii* lies outside the range of mineral contents in regards to Ca, P, Na, Mn and Cu than for native *Acacia* species reported in Table 4.

Absent in this report is further information regarding plant secondary metabolites in *Acacia* species that may hinder browsers to consume large doses of the plant.

Mutualistic relationships between Acacias and ants
Some African native *Acacias* (*A. drepanolobium*) are known to form symbiotic relationships with ants where elephants are present (Goheen 2010, Tamashiro et al. 2019). Browsers such as elephants have been shown to avoid trees inhabited by ants (Goheen 2010) and increased browsing has been observed among goats when ants are absent from *Acacia* trees (Tamashiro et al. 2019).

3.4 Hypothesis about long term consequence of the interaction between elephant diet and black wattle on the South African landscape

Megaherbivores such as elephants can have a fundamental effect on the landscape they inhabit. They are known to both eat a wide array of plants consuming large quantities of them. This suggests that megaherbivores have the capacity to reduce the abundance of invasive species, both by including them in their diet but also consuming large volumes of them (Mungi et al. 2022). However, a common strategy for long term survival of plant species is by being eaten by herbivores and the seeds spread by the animal defecation, which may pave way for invasive species which has been reported from *Acacia* woodlands in Chile (Eschtruth et al. 2009). This literature study revealed publications that indicate that African elephants consume and utilizes the exotic *Acacia mearnsii* (Milewski 2002). However, deeper knowledge on the interaction between the two organisms seems to be missing in the published literature. In lack of such published information, I will here discuss differences and similarities between native *Acacias* included in elephants' diet and the invasive *Acacia* mearnsii, that may shed light on possible interactions between the two organisms.

African *Acacias* are a preferred choice of food for elephants over other woody plants during the dry season (Gondiwa et al. 2011). African *Acacias* usually exhibit large thorns which the Australian *Acacia mearnsii* is lacking (Kull et al. 2008). This would likely make *A. mearnsii* more attractive as food than thorny native *Acacias*. Many *Acacias* have become invasive globally (Lusizi et al. 2024, Griffin et al. 2011, Souza-Alonso et al. 2017) and exotic *Acacias* are as such free from their natural enemies but also from mutualistic relationships available in their natural habitat (Eichhorn 2011). Some African native *Acacias* form mutualistic relationships with ants, protecting them from elephant herbivory (Goheen et al. 2010, Tamashiro et al. 2019). In the limited literature review that was performed on *A. mearnsii*, the arthropod community was mentioned on one occasion. The authors suggests that ants use *A. mearnsii* stands as a pathway to reach isolated habitats (Souza-Alonso et al. 2017), indicating that there is some interaction between local ants and exotic *Acacias* however, it is not clear whether the ants protect *A. mearnsii* against elephant herbivory. The presence of ants may effect elephant interaction *A. mearnsii* similarly as reported by Goheen et al. (2010) where elephants avoid woody plants that are inhabited by ants.

Vesey-Fitzgerald (1973) reports that *Acacia* seeds are viable from elephant droppings (Vesey-Fitzgerald 1973) which is likely in relation native *Acacias*. Even though *Acacia mearnsii* carries pods containing seeds, the plant has not co-evolved with such large megaherbivores available on the African savanna but nevertheless with smaller animals like the kangaroo and wallabies. This does not exclude *A. mearnsii* seeds possibly being dispersed by smaller animals, however its strong resprouting capacity may indicate that the species has emphasised their capacities elsewhere. However, the seeds of *A. tortilis* and *A. mearnsii* look similar, are of the same size and of the same genus, which may argue that seeds from the latter may survive in faeces as well as the former. *A. mearnsii* has intense sprouting capabilities which is lacking among some of the native African *Acacias* such as the *A. tortilis*. In comparison to the native *Acacia* species such as *A. tortilis, A. nilotica, and A. mellifera, A. mearnsii* grows into thick stands covering large patches of soil which hinders large animals such as elephants enter the stand and potentially causing pollarding and uprooting as may be done single trees isolated on an open savannah.

Native *Acacia* species have been reported to be heavily impacted by elephants by pollarding, ringbarking and uprooting, but due to their regeneration ability, they have persisted (Vesey-Fitzgerald 1973). The mineral content of the foliage of *A. mearnsii* is within the range of native *Acacias* commonly consumed by elephants which support consumption of the species when available and particularly during dry season when the grass is senescent. Nutritional information with regards to the bark is lacking in this report. *A. mearnsii* has smooth bark and when compared to *A. tortilis,* it seems like a more difficult tree for an elephant to debark. This may indicate that *A. mearnsii* would not be the preferred choice for debarking when other *Acacia* species are available. Like *A. tortilis*, *A. mearnsii* has tannin-rich bark. Tannin modulates ruminal fermentation by binding to protein hindering protein absorption and degradation in the rumen. It has an anti-nutritional property on protein intake, especially when present in high concentrations in the diet. In moderate doses, it may improve ruminant performance (Yanza et al. 2021). This may indicate that that elephants consume *A. mearnsii* in limited quantities.

The persistence and survival of a woody plant after elephant attack depends on whether the rates of recruitment and regeneration can match mortality over time (O'Connor et al. 2007). An evolved mechanism may be its capacity to produce seeds that are viable after consumption by herbivores, a trait that exotic *Acacia* species may lack, but which remains to be confirmed. In the case of *A. mearnsii,* elephants' capacity to consume it may be outweighed by the species' high capacity to resprout and thereby avoiding extirpation. The dense stand structure may favour *A. mearnsii* as it hinders the entrance of large animals into the stand. However, considering the copious need of fodder elephants need, the lack of thorns on exotic Australian *Acacias*, these exotic *Acacias* may be a possible agent for control of the invasion of *A. mearnsii,* especially during the dry season. The mineral content of the leaves of *A. mearnsii* seems to lie outside the range of mineral content of native *Acacia* species, which may indicate that the foliage may be different (such as in composition and taste) to native *Acacias*, and as such may not be consumed as much by elephants as native species. Further research is needed to carefully investigate to what degree elephants consume *Acacia mearnsii* and when they do, if they spread viable seeds in droppings and in that case pave the way for further distribution.

3.5 Suggestions for further research on the interaction between A. mearnsii and elephants

To bridge the knowledge gaps that became evident in this literature review, I recommend further study of the patterns of *A. mearnsii* seed germination after ingestion by elephants. Some seeds may be destroyed during consumption by animals while other seeds are favoured by the dispersal and association with available nutrients in the gastrointestinal tract. This research may be preferred to be executed in a controlled environment like a zoo followed by germination in a greenhouse. Additional suggestions are to compare the preference *A. mearnsii* to known preferred food sources in a closed environment. For example, two stacks of food alternatives where the mass from each stack of food is measured after a certain time, also this may be preferred to do in a controlled environment. Another interesting topic would be to investigate how much *A. mearnsii* is eaten in the presence of alternative food sources. This could be done by careful observations of elephants where *A. mearnsii* is present as well as alternative food sources. It would additionally be interesting to observe when during the day and during the year (wet/dry season) elephants consume *A. mearnsii*. In case animals are collared, this may be done by data extraction on elephant position and compared to where *A. mearnsii* are present. Another relevant question is how elephants interact with the trees; are they torn down or do elephants feed from the hanging branches. It would also be interesting to observe ants relationships to *A. mearnsii* and like

Goheen et al. (2010) did, investigate how elephants react on the presence of ants on the trees.

4 Summary and conclusion

Loxodonta africana is considered a landscape engineer and *Acacia mearnsii* is an invasive species considered a landscape transformer threatening the ecosystem and biosphere in South Africa. This systematic literature search found only one study presenting information on the interaction between elephants and the tree species (Milewski 2002), highlighting a knowledge gap on the subject. There is a wealth of literature on "Elephant diet" and "*A. mearnsii*" but very few publications combining the two topics. Hypothetically, *A. mearnsii* could be an important and large component in the elephant diet in terms of volume since they lack thorns and likely the mutualistic relationships with ants. This would suggest that elephants may help humans to control this invasive species. However, the high re-sprouting capability of *A. mearnsii* and its formation of dense impenetrable stands could counteract the role of elephants as controlling agents. More research is needed to further investigate to what degree *Loxodonta Africana* consume *Acacia mearnsii* and when they do, if they spread viable seeds with consumption. These studies may best be performed in controlled environments.

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