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Utilitarian Perspective of the Invasion of Some South African Biomes by *Acacia mearnsii*

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Abstract: South Africa has one of the largest problems of invasive alien plants in the world. Invasive plant species are species that are able to survive, reproduce, spread unaided and sometimes at rapid rates across different landscapes. Invasive trees pose one of the most serious threats to nature conservation in the world. Invasive alien plants affect the capacity of ecosystems to deliver goods and services. *Acacia mearnsii,* an invasive plant in South Africa threatens native habitats by outcompeting indigenous vegetation for water, nitrogen and organic materials, replacing grass communities. *Acacia mearnsii* reduces native biodiversity and increases occurrence of water loss from riparian zones. Thus, a holistic approach is imperative for their management, that require good background information which may be insufficient and where available it might be scattered in bits and pieces. The aim of this review article is to aggregate the available scientific information on the invasion of *A. mearnsii* and its effects in South Africa. In order inform appropriate decision for control activities to achieve both ecological and economic effects.

Key words: *Acacia mearnsii* · Invasive plants · Woody species · Riparian ecology

INTRODUCTION

South Africa has the largest proportion of invasive alien plants in the world [1]. The forest plantations were identified as the most invaded under tree plantations [2]; with 38% of the area under commercial forestry consists of alien woody species, particularly the *Pinus* and *Acacia* species [3]. *Acacia mearnsii* is currently considered to be a major invasive tree species in South Africa; it has invaded more than 2.5 million hectares land space, mostly riparian areas, rangelands and forest [4]. *Acacia mearnsii* threatens native habitats by outcompeting indigenous vegetation for water, soil nutrients and organic matter. It decimates grass communities, reduce native biodiversity and increase water loss from the riparian areas [5]. Its high evapotranspiration rate compared with that of native flora has been reported to significantly alter the hydrological balance of the invaded areas, with noticeable lower water tables [6].

The displacement of native vegetation by *Acacia species* has been attributed to habitat modification by the *Acacia species* [7] through mineral enrichment associated with high leaf litter decomposition [8]. Invasion of grassland by woody species is a global phenomenon, but the effect of such on ground water and salt fluxes remain poorly understood [9]. A known effect of *A. mearnsii* invasion is the high desiccation of soil under its canopy compare to what obtains under convectional grass cover. This makes seed germination and vegetation succession difficult [4]. Mass of leaf litter in areas invaded by *A mearnsii* was reported to be greater than that of uninvaded area [10]; this suggests that the dense layer appears to inhibit the establishment of native seedlings [2]. Concerns have been raised on the potential impact of *A. mearnsii* as a threat to plant species diversity of the affected area and on the issue of water loss through high levels of consumption by the invasive tree [11].

Invasive plant species are species that are able to survive, reproduce, spread unaided and sometimes at rapid rates across different landscapes, they also have detrimental effects on commercial plant species with noticeable management problems [12]. They constituted

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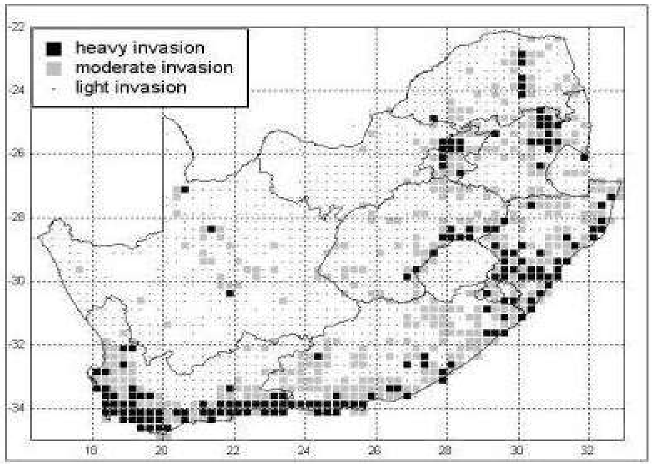

Fig. 1: Map showing the extent of invasions in South Africa (Source DWAF [15])

a threat to nature conservation [13], through substitution of species (an exotic) for one or more native species which has dare consequences for conservation, ecosystem structure and function [14], thus, invasive species are a sign of habitat degradation [5]. When splited into major biomes, the fynbos (a Mediterranean-type shrub land) is the most invaded biome by *Pinus*, *Acacia* and *Hakea* species in the mountains, lowlands and along all major river systems in South Africa [15].

About 750 tree species and around 8 000 shrubby, succulent and herbaceous species are recorded to have been introduced into South Africa in the 19th century [16]. Of the 8 750 species, 161 are now regarded as invasive and 68 percent of these invasive species are woody [12].

The total area invaded by alien trees in South Africa is over 100 000 km^2, which is over 8 percent of the country's total area [12] (Fig. 1). These invasions are mostly concentrated in wetter regions of the country or sometimes along river and other water bodies (perennial, seasonal or ephemeral) [12]. The negative effect of invasive species is noticed mainly in the agricultural sector viz., crop production, range management and forestry [17]. Nonetheless, some segment of the society is already converting these woody species into products with commercial relevance such as the tannin extracted from bark of *A. mearnsii*. Thus a holistic approach is imperative for their management, such require good background information which may be insufficient and where available they are scattered in bits and pieces. The aim of this review article is to aggregate the available scientific information on the invasion of *A. mearnsii* and its effects in South Africa.

Botanical Description of *Acacia mearnsii*: *Acacia mearnsii* belongs to the genus *Acacia* and division Botrycephalae, a group of 44 mostly arborescent species characterized by bipinnate adult foliage and flower heads normally arranged in elongated racemes [15]. *Acacia mearnsii* is native to Australia [12]. It is a fast-growing pioneer species which reaches its maximum growth rate at 3-5 years after planting [8]. In South Africa, it is an important invader of forest and plantation margins, riparian zones, savannas, woodlands and roadsides [7]. It is a fast growing leguminous (nitrogen fixing) tree and often used as a commercial source of tannins in Australia and fire wood in local communities of South Africa [15].

Unlike other *Acacia species* that pioneer the succession of grasslands to woody savannah or from savanna to drier-forests, *A. mearnsii* occupies a higher position in that it is present as a normal component of the climax forest in its native habitat [12]. *Acacia mearnsii* is an evergreen tree, six to twenty meters high and 0.1 to 0.6 m in diameter [15]. The stems of *A. mearnsii* do not have spines or prickles, the leaves are bipinnate on petioles that are 1.5-2.5 cm long. The leaves have gland above and rachis which is 4-12 cm long with numerous raised glands all along its upper side [18]. The pinnae occur in 8-30 pairs, pinnules in 16-70 pairs [19]. The tree has dark brown pods that are finely hairy [20]. Apart from producing copious numbers of seeds the plant generate numerous suckers resulting in monotypic thickets [12]. The plant grows in disturbed mesic habitats [21]. Soils with lateritic pan close to the surface are most unsuitable for the growth and production of *Acacia mearnsii* [19]. This *Acacia species* is fast growing but short lived, moderately frost tolerant and vigorous at high elevations [15]. It thrives on poor dry soils but favors deeper, moister and more fertile soils [22].

The invasiveness of this species is partly due to its ability to produce large numbers of seeds (which lie dormant and may be triggered to germinate following bush fires) and the development of a large crown that shades other vegetation [19]. *Acacia mearnsii* is a light-demanding species, which is sensitive to fire when young (< 3 years) [23]. Its lower altitudinal range is decided by the fact that trees cannot stand high summer temperatures and the upper altitudinal limit is based on the fact that the tree does not tolerate temperatures below 0°C [24].

Winter frosts and cold winds during the early part of the rainy season affect growth and survival rate of *A. mearnsii*, but older trees can withstand mild frost [25]. Localities experiencing severe hailstorms and snowfall are unsuitable for the growth of the invasive tree [8]. Adequate soil moisture is a prerequisite for satisfactory growth [26]. *Acacia mearnsii* trees cannot withstand drought because of their superficial root system and high rate of transpiration [27]. *Acacia mearnsii* is a hermaphrodite and flowers profusely in winter [8].

The minute, fragrant flowers are self-fertile, but cross-pollination occurs; with bees being the main pollinators [28]. Trees begin to yield fertile seed from the age of 5 years, yielding to good annual crops [29]. Pods mature in 2.5 years and gravity or propulsion from drying of dehiscent pods initiates seed dispersal [19]. In the Southern Africa region, *A. mearnsii* flowers from late July to October [12]. Plants commence flowering when about two years old [21]. A pod normally contains 1 to 14 seeds, but the average is 7 seeds [28]. Seed yield is between 48, 600 to 70,200 seeds per kilogram [24] from the fifth or the sixth year onwards; annual seed yields are normally copious [21]. By contrast, in its native range, good seed years are relatively infrequent and often no seed at all may be produced in some years, mainly because of insect pests [28]. The species does not seem to produce viable seed at lower altitudes, which explains why most of the other plantings in South Africa, which were not in mist belts, never became invasive e.g. Zimbabwe [12].

The species has all the three attributes of a successful invader: short juvenile phase; good annual seed crop; and small seed size [30]. *Acacia mearnsii* is regarded as an out crossing species with partial self-compatibility [31]. It can be crossed with *Acacia decurrens*, hybrids show more sterility than parents [12].

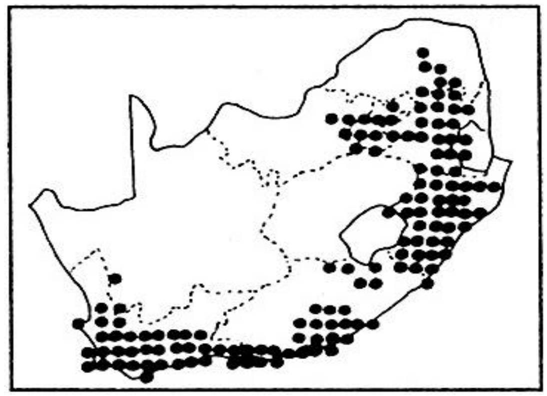

Fig. 2: Distribution of Acacia mearnsii within South Africa. Each black circle indicates the prescences of *Acacia mearnsii* [15]

Meiosis is regular for *A. mearnsii* with no gross cytological abnormalities and sterility may be due to gene differentiation between species [20]. Estimates of out crossing rates are variable, ranging from 48 to 100% [12]. The natural range of distribution of *A. mearnsii* is bound by latitudes 34° S and 44° S and altitudes from sea level to 885 m asl [18] The tree coppices poorly, it is a noxious weed and in South Africa, it has been called "green cancer" because it spreads vigorously [2]. The seed is spread by running water and heat from fire improves seed germination [28]. The species was declared an invader species in South Africa in 1984, after years of protracted debate on proposals for the species to be declared a weed [15].

The species is rated as number eleven in the invaders list in the fynbos biome, fifth in the KwaZulu Natal Province and sixth in Gauteng Province [12]. The species is also considered to be the major invader in the mist belt of the eastern highlands of Zimbabwe [12]. *Acacias* like *A. saligna* trees can use the greater nutrient availability to be more successful and native plants cannot do like the invasive trees [32]. *Acacias* essentially give themselves a competitive advantage [29] more than the native tree species. *Acacia saligna* also out competes local plants by overtopping them, growing to a height of 3 to 10 meters [32]. Since native plants are shade-intolerant, they typically do not fare well in *Acacia*-infested habitats [8]. With their large canopy and high transpiration rates, *Acacias* also reduce soil water availability [33]. *Acacia mearnsii* is susceptible to various pathogens, some of which are responsible for economic losses in plantations physiological disorder known as 'gummosis', in which gum is exuded in the absence of any obvious injury [34].

***Acacia mearnsii* in South Africa:** *Acacia mearnsii* was introduced into South Africa in the year 1864 [12]. The purpose of its introduction was for shade, windbreaks, fuel wood and later for the tannin content of its barks [54]. One hundred years after its introduction, there were close to 324 000 ha of *A. mearnsii* in South Africa [31]. The area has then progressively declined reaching the current official level of about 107,000 ha [27].

Susceptibility of Riparian Ecosystem to Plant Invasion: Plants invade new environments in response to movement of animal vectors, evolution of new biotypes and the activities of humans [35]. Changes in stream flows, the frequency of wildfires and firefighting could promote the invasion by non-native species whilst suppressing the growth and development of native vegetation [36]. The most critical factor responsible for encroachment of rangelands by woody plant is overgrazing which leads to the reduction in overall grass biomass, production and soil cover [37]. In some coastal grassland in south-eastern Australia, removal of soil cover by excessive grazing and burning appears to trigger invasion by indigenous shrubs, especially *Acacia sophorae* [33].

Characteristics of invaded environments often include: geographical and historical isolation; low vegetative diversity and production of native species [38]. High levels of natural disturbance or human activities; absence of co-adapted enemies, including competitors, predators, herbivores, parasites and diseases also characterize invaded areas [38]. Areas where the vegetation and soil have been disturbed by humans or domestic animals are more susceptible to invasion [39, 40]. Riparian ecosystems are highly prone to invasion by alien plants, largely because of their dynamic hydrology, high nutrient levels and ability to disperse propagules [4]. The impact of weed infestations in riparian vegetation increases as the stream or river flows downstream, particularly as it flows through the highly developed alluvial soil flats [41].

A community is prone to invasion when the composition and diversity of the resident vegetation is low because the higher the composition or diversity, the more the resources are utilized fully and the less prone the environment is to invasion [42]. People from some cultures are more likely to introduce plants from their homelands when they migrate to new regions [25]. Seeds are transported by flowing water [5]. Riparian zones are unique and dynamic ecosystems with complex disturbance regimes and such communities are generally considered to be prone to plant invasions [43].

Perceived Negative Effects of Invasive Trees Specie: When discussing the ecological impact of invasive plants, there are several known parameters quantifying the impacts of invasive tress, these include: range, abundance and effect per individual tree species [17]. The effect of an invasive species on ecosystem processes is expected to depend on whether it differs functionally from native species or its requirements are lower than the native species [44]. When a new species is introduced, its effects on nutrient cycling will depend on how different it is from the constellation of traits present within the existing plant community [14]. Invasive alien tree species had known negative environmental and economic impacts in South Africa [23]. Invasive alien plants affect the capacity of ecosystems to deliver goods and services [45], such as water purification; soil generation; decomposition; and nutrient cycling [46].

The extent of invasive species impact may depend on their abilities to compete for resources and exploit disturbances compared to the abilities of native species [47]. Invaded ecosystems often have altered species composition and community structure [44]. The alien trees can reduce groundwater recharge and affect sediment dynamics in stream and river courses, contributing to siltation of dams and converting perennial streams to seasonal ones [48]. If introduced or spread into habitats with closely related species, invasive species could interbreed with native species resulting in changes to the genetic makeup of either species through hybridization with local related genera (e.g. *Rubus* sp.), thus exchanging genes [4]. Exotic plant invasions affect the levels of a variety of elements, including Phosphorus, cations and metal pollutants [14].

The Tamarisk, a non native invader plant in California, has a very high salt content that affects the soil and native plants around it [49], showing the potential negative effects of invasive trees around native trees. Thickets of alien plants species can increase the fire hazard, therefore increasing the costs of fire protection and the degree of damage caused by fires [50]. Invasive plants have negative effects on all components of biological diversity, from genes to whole ecosystems [51]. In South Africa, invasive alien tree species and shrubs have negative effects such as reduction in stream flow and available water; loss of potentially productive land for cropping and loss of grazing potential in rangelands [52]. Some invasive species are also poisonous to humans and livestock (e.g. *Melia azedarach* and *Lantana camara*); they increase soil erosion following fires in heavily invaded areas; cause siltation of dams; change habitat suitability for native animal species [53]. For instance in the Mitchell grasslands of northwest Queensland (Australia) *Acacia nilotica* suppresses pasture production by 50% at 25-30% tree canopy cover or 2m^2 basal area per hectare [7].

Work on *Acacia melanoxylon* indicated that residues from the *Acacia* tree produce a strong inhibitory effect that is toxic and affects germination at the initial phases and the greatest effects are on the growth of a plant [29]. The tree releases phenolic compounds into the soil that inhibit growth and development of vegetation. The soils sampled from the *Acacia* tree showed strong toxic effects on radicle growth and germination of indigenous vegetation [29]. Most vascular plants form mycorrhizal associations with arbuscular mycorrhizal fungi (AMF) and many plants are highly dependent on this association for their growth and survival, particularly native woody perennials and others found in late-successional communities [54]. As such the invasive Garlic mustard targets arbuscular mycorrhizal fungi (AMF) in the soil, forming mutually beneficial relationships with many forest trees [55]. Exotic plants have been found to be poorer hosts and depend less on native AMF than native plants [56]. The invasive trees release phytochemicals into soils as root exudates, as a result of damaged root tissue, or in the form of leaf litter [57].

Effects of Invasive Trees on Soil Moisture Properties: Invasive species may alter water balance whenever they are established in areas with available water that are not utilized by the indigenous vegetation [58]. Alien invaders are estimated to use approximately 6.7% of the estimated annual water runoff in South Africa, translating to about 3,300 million cubic meter [26]. Stands of *Acacia spp* were shown to affect streams flow linearly; an increase in *Acacia spp* population led to a decrease in the volume of water at the downstream [10]. The invasion of *A. mearnsii* has also been reported to increase rainfall interception and transpiration resulting in decreased stream flow [6]. This was attributed to the high evaporative potential of trees due to their deep rooting system and effective use of sub soil water [9]. Jobbagy and Jackson [9] showed that despite the extreme rainy conditions that prevailed during their study, Castelli plantation was able to reverse the vertical groundwater fluxes and maintain low levels of soil moisture. In turn, harvesting of forest trees was observed to lead to a significant rise in water table due to reduced transpiration rate as a result of reduced leaf area and less utilization of ground water [59, 59].

Table 1: Water Consumption of Different Invasive Trees in South Africa (Adapted from Le Maitre *et al*., 2000) [6]

Estimated mean annual water use	
Acacia mearnsii	576.58
Acacia cyclops	487.63
Acacia dealbata	248.32
Acacia mixed spp.	242.63
Pinus spp.	231.53
Eucalyptus spp.	213.98
Prosopis spp.	191.94
Acacia saligna	171.13

Acacia mearnsii has been reported to use up to seven millimeters of water per day with an additional loss of 185 mm of water from rainfall annually [26]. The major South African invading species have been found to reduce surface runoff in the Keurbooms catchment by about 20%, four times more than the planted plantation [6]. Invading pines account for 46% of the total volume of water, Hakea species 32% and *Acacia* species, specifically *A. mearnsii*, for 21% [6]. Commercial plantations with invasive stands of *A. mearnsii* in South Africa have been estimated to decrease water ability, causing an estimated annual economic loss of USD 2.8 million [23]. *Acacia mearnsii* is highest in terms of water consumption per year, followed by *Acacia cyclops* in South Africa as shown in Table 1. The species were ranked according to their water consumption levels in South Africa. The least water consumer per year was *Acacia saligna*.

Effects of Alien Trees on Soil Properties: Recent research has shown that individual plant species, many of which are nonnative and invasive, are capable of altering; soil organic matter quality and quantity; nitrogen status through biological nitrogen fixation; nutrient stocks; nutrient cycling rates; soil moisture content; the pH and cation distribution of soils in invaded ecosystems [60]. Nutrient dynamics may also become altered as a result of changes in the physical properties of the soil caused by the introduction of new species [61]. Other introduced species release compounds that can inhibit the growth of their competitors [62]. Plants impact the diversity of soil microbial communities by their rooting characteristics, exudates production and the chemical quality of the aboveground litter [63]. The changes in the soil microbial community can be related to differences in the quantities and qualities of inputs to the soil by different plant species [64].

Changes may result from alterations in the patterns of species dominance within the plant community, since the effects of a given species on ecosystem processes are modulated by its relative abundance within the community [65]. Potential impacts on microbial communities from invasive species often occur because non-native species differ in plant morphology, phenology, and leaf litter chemical composition compared to co-occurring native plants [14]. Phytotoxic chemicals that leach from the leaves and litter of the eucalypts during rainfall and fog drip events can directly inhibit germination and retard seedling growth of grasses, as well as of the eucalypts themselves [66]. Montgomery [67] reported that soils under *Acacia mearnsii* have lower pH values (4.4) than adjacent soils under grassland (5.3). Brown [68] investigated the effects of the invasive *Syzygium jambos* on soil properties and found that areas under a high density were higher in minerals phosphorous, calcium and potassium compared to areas under low *Syzygium jambos*.

Heneghan [69] compared the effects of the invasive buckthorn (*Rhamnus cathartica* L.) on the soil chemistry and showed that areas that are invaded by the buckthorn had twice the soil percentage total nitrogen (mean, 0.54%) compared to that of uninvaded areas (mean, 0.27%). Soils in buckthorn dominated areas had 80% more organic carbon (mean, 6.83%) than open areas (mean, 3.81%). Potassium chloride extractable nitrogen did not differ between buckthorn areas and open areas across the three sites. Soil pH was significantly higher in buckthorn areas than open areas, indicating the low acid effects of the invasive tree. Neal [70] showed that soil under *Hieraciurn* invasion had total organic Carbon and total Nitrogen concentrations that were significantly higher under *Hieraciurn* than under areas without *Hieraciurn*. Areas under *Hieraciurn* had higher soil C:N ratio than uninvaded areas (26 and 11% higher, respectively) due to higher dry-matter production and C inputs. *Hieraciurn* presence also influenced soil pH, base saturation and mineral-N concentrations [70]. These data support the idea that *Hieraciurn* depletes available soil N pools, potentially increasing *Hieraciurn's* competitive advantage over other grassland species [70].

Soils under *Acacia saligna* stands had higher concentrations of N, Calcium, Magnesium, Potassium, Manganese and Boron compared to soils not under the stands when soil samples were collected and analyzed for mineral content [7]. The soils under the *Acacia saligna* stands were lower in iron concentration compared to the soils outside the stands. Comparing the soil properties of the soils under greenhouse conditions, soils from under the invasive *Microstegium vimineum* shrub and *Berberis thunbergii* grass were compared to the native *Vaccinium pallidum* shrub by Ehrenfeld [61]. Soils under the invasive vegetation were shown to have higher pH values compared to the native shrub [61]. Extractable ammonium concentrations were higher under the exotics than under the native *Vaccinium*, while the nitrate concentrations were similar. Ehrenfeld [61] also showed that net ammonification rates were similar for both the exotics and the native species [61]. Higher overall soil respiration for the exotics was partly due to larger root biomass compared to the native. Nitrification rates were higher in soils beneath both exotic species, compared to soils beneath the native *Vaccinium* [61].

Effects of Invasive Alien Trees on Grass Seed Bank: Plants can propagate themselves by vegetative or sexual reproduction, with many species using a combination of these two strategies [71]. The soil seed bank serves as propagule storage system and is very important to species establishment [72]. The soil seed bank consists of viable, ungerminated seeds that are stored in the soil [10]. These seeds enter the soil seed bank as they are produced by local plants and fall to the ground or disperse into an area [71]. The composition of soil seed bank is influenced by the existing above ground vegetation [73]. The soil seed bank is an important component of the forest, which may affect several aspects of ecological function, including genetic, population and community level dynamics [74]. The soil seed bank can influence the genetic variation of a plant population by acting as a buffer to changes in a population's genetic composition that might arise from major fluctuations in population size [75]. Seed banks play an important role in population dynamics [66]. The survival of species' under the changing environmental conditions is partially dependent on the persistence of its soil seed bank [84].

The soil seed bank can impact community composition by serving as a reservoir for species not currently present in the above ground layer [72]. In a study by Bossuyt [76] soils from under a calcareous grassland seed bank were compared to that from the scrub vegetation. There was no decline in seed density or species richness under the scrub vegetation and the species composition of the seed bank was rather similar to that of the calcareous grassland [76]. This means that calcareous grassland species or their seeds remain persistent under the developing scrub vegetation for at least 15 years whilst less light-demanding or competitive species only gradually establish and replenish the soil seed bank [76]. Seed dynamics play an important role in structuring and maintaining plant communities [77]. Seeds sustain populations during temporarily unfavorable conditions, allow establishment in new areas and can introduce novel genotypes to populations [74]. Seed banks, in particular, are important in maintaining species and genetic diversity in communities and in allowing species to persist through disturbance or adverse conditions [77].

Positive Effects of Invasion: While the invasive plants have detrimental effects on the environment, economy and the ecosystem, the presence of the plants brings benefits as well [16]. The South African government has used the opportunities offered by the need to control and prevent the spread of *A. mearnsii* for labor-intensive clearing programs to generate a range of benefits [15]. This involves engaging unemployed people in labor-intensive clearing, follow ups and rehabilitation projects aimed at bringing invasions of alien plants under control [15]. The Working for Water Programme was started in October 1995, with the aim of protecting water resources and creating employment opportunities [78]. The program employs the poorest members of the communities settled closest to the alien infested areas, targeting women especially single mothers [16]. In 2001, South Africa exported 1.2 million tones of *A. mearnsii* wood product worth around R360 million (US$31.5 million indicate the exchange rate) from 130,000 ha of managed plantations centered in the provinces of Mpumalanga and KwaZulu-Natal in northeast South Africa and from black wattle control programme [78].

Uses of *Acacia mearnsii*: The timber from *A. mearnsii* is used for building materials and the pulp and wood chips are used to produce paper [78]. In rural communities in South Africa the trees are important as a source of building material and fuel [8]. *Acacia mearnsii* has some known medical applications, such as its use as a styptic or astringent [3]. The planting of *A. mearnsii* has also been used as a soil stabilizer to reduce the rate of erosion [15]. The agro forestry industry promotes the use of *A. mearnsii* (among other similar species) as a potential plant in improving the soil [30]. The leaves have high protein content (about 15%) [25]. In Hawaii, *A. mearnsii* has been fed to cattle during drought periods [8]. The extra floral nectar of *A. mearnsii* (containing about 20% pollen protein and 40% sugar) and its late flowering makes the tree suitable bee forage [15]. Originally distributed as a source of tannin, *A. mearnsii* is now recognized as a valuable fuel wood [30]. Wood is moderately dense with specific gravity about 0.75, splits easily and burns well with a calorific value of 3500-4600 kcal/kg [34].

The charcoal from *A. mearnsii* is extensively used in Brazil and Kenya and in Indonesia the tree is extensively used as a domestic fuel and for curing tobacco [28]. The pulp productivity of *A. mearnsii* is about 320 kg/cm ^{3} [15]. *Acacia mearnsii* is also used for rayon [8]. The wood from *A. mearnsii* is used for house poles, mine props, tool handles, cabinet work, joinery, flooring, construction timber and matchwood [15]. *Acacia mearnsii* bark is the most widely used tannin material in the world [34]. The species has been planted as a shelterbelt, a fire belt and as a shade tree in plantations [15]. *Acacia mearnsii* is an effective nitrogen fixer and has an annual yield of wet leaves of 21-25 t/ha, containing 240-285 kg of nitrogen [50], it thus can restore and regenerate soils [79]. *Acacia mearnsii* is an attractive tree [34]. In central Java and in Kenya, foliage is used as a green manure to improve agricultural yield [28]. Sawdust of *A. mearnsii* has been found to be an excellent medium for growing edible mushrooms in China. Poles with bark intact are used to support oyster racks in New South Wales [25]. Extracted tannins from *Acacia mearnsii* have been used in mitigating methane emission without major losses in feeding value of the diet [25].

Acacia mearnsii trees provide bark 5-10 years after seeding and one tone of *A. mearnsii* bark is sufficient to tan 2.530 hides, best adapted for sole leather and other heavy goods; the leather is fully as durable as that tanned with oak bark [15]. The species attributes of a successful invader, such as a short juvenile period and a short interval between large seed crops, imply early and consistent reproduction [30]. The ability to attain positive population growth rates under strenuous conditions allows the invading species to increase in abundance while in the presence of numerically superior, well established residents [47]. A typical early successful invader like *A. mearnsii* is able to monopolize recently disturbed ground due to its rapid dispersal to the site [16]. The invader should be able to have rapid growth and reproduction in the absence of significant competition for space and nutrients [81]. For a successful invader to alter community and ecosystem properties it must have an impact on energy, nutrient, or water flow, on the disturbance regime, or on the community response to the disturbance regime [3].

To be successful, an invasive species must both survive and attain a positive rate of increase while living on the resources left unconsumed by the resident species [47]. *Acacias* have been known to nodulate promiscuously with local bacteria and have mostly benefited from the resident biota [50]. Invasive trees produce small seeds and have a short period between large seed crops and all these are important factors for successful invasion [82].

The Control and Management of *Acacia mearnsii* Invasion: South Africa has one of the largest problems with invasive alien plants in the world [1]. In order to be successful, a control program against an invasive plant must take into account a wide range of extensive life history information about that plant [8]. An integrated approach involving the combined use of different control methods is necessary to manage invasive alien plants effectively [83]. Successful management of communities and ecosystems containing invasive species involves assessing whether the invaders have significantly altered the ecosystem from its pre-invasion condition [8]. It also involves recognizing and measuring specific community and ecosystem properties potentially being altered by the invader and developing strategies that return communities and the associated ecosystem processes to the pre-invasion state [22]. The most common means for removing invasive *Acacias* from the fynbos is through mechanical clearing [83]. This is typically done by individuals pulling up *A. mearnsii* seedlings by the roots and by chopping down the larger trees. Mechanical clearing is the primary method of restoration used by the Working for Water project [15]. If alien plants are cut and left at the site, the large amount of dead biomass may result in more intense fires killing indigenous plant seed banks [32].

Fire can be used in the control of invasive trees [84]. This technique, however, is problematic because fire plays a vital role in the natural regeneration of both *A. mearnsii* and native fynbos species [15]. Fire is also the main disturbance factor that creates an "invasion window" that allows alien invasive trees to establish in the fynbos [84]. This is because fires may break the dormancy of the seeds and hence cause germination [16]. When using chemicals to control *A. mearnsii*, it is important that selective herbicides are used where grasses are present and that diesel-based herbicides are not used along watercourses, so as to avoid contaminating the water [85]. Integrated control measures can be used in the control of invasive trees. Some examples of integrated control used on invasive alien species in South Africa include the control of *Hakea* species and *Opuntia stricta* [45]. Trees can be felled and the cut stumps treated with a chemical herbicide or a mycoherbicide (a formulation of fungal spores that can be sprayed onto a plant and will cause a fungal disease in the plant) [8]. Biocontrol agents could be released on the regrowth, or on an adjacent biocontrol refuge area, from where they can colonize the cleared area when the invaders regrow or when the seeds germinate [15]. Black wattle is a difficult target for biological control [8]. The biological control of wattle species was initiated in 1973 [8]. The programme targeted seed eating organisms that do not damage the vegetative parts of the Acacia mearnsii tree. Control programmes incorporate mechanical methods (felling and fire) and biological control [45]. The plants are felled using chainsaws and left for 12 to 18 months, then burnt [15]. Integrated control can be used through herbicide use on scattered populations and biological control agents are released on larger infestations [45].

CONCLUSION

The invasion of the rangelands by *Acacia mearnsii* is threatening agricultural production systems. The problem of *A. mearnsii* has the potential of persisting even though measures are currently being taken by the Working for Water to sustain the spread at provincial level. The *A. mearnsii* problem should be monitored and addressed at national scale as its spread will become even more detrimental. In as much as benefits are being obtained from *Acacia mearnsii*, further research has to be done to administer the level of invasion tolerable in rangelands so as to contain the spread of the tree. More biologically friendly control methods need to be tried so as to widen the methods of control where options are limited for its control. Utilization techniques can be developed so as to use *A. mearnsii* where heavy infestations have occurred; suggestions such as the use of goats and sheep for browsing can be tried.

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