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Review

Consequences of Invasive *Prosopis* (Mesquite) on Vegetation, Soil Health, Biodiversity, and Compliance of Management Practices in South African Rangelands: A Review

Siviwe Odwa Malongweni [1,2,3,*], Kaya Mrubata [4], Johan van Tol [3], Mohamed A. M. Abd Elbasit [2] and Douglas M. Harebottle [1,2]

[1] Centre for Global Change (CGC), Sol Plaatje University, Private Bag X5008, Kimberley 8300, South Africa; doug.harebottle@spu.ac.za
[2] Department of Physical and Earth Sciences, School of Natural and Applied Sciences, Sol Plaatje University, Private Bag X5008, Kimberley 8300, South Africa; mohamed.ahmed@spu.ac.za
[3] Department of Soil, Crop and Climate Sciences, Faculty of Natural Sciences, University of the Free State, Bloemfontein 9301, South Africa; vantoljj@ufs.ac.za
[4] Agricultural Research Council, Natural Resources and Engineering, Private Bag X79, Arcadia, Pretoria 0001, South Africa; mrubatak@arc.agric.za
* Correspondence: siviwe.malongweni@spu.ac.za

Abstract: *Prosopis glandulosa* (Mesquite), an invasive alien tree species, poses major threats to soil health, native vegetation, and biodiversity in South African rangelands. The negative impacts of *Prosopis* on socio-economic, environmental, and ecological resources outweigh the benefits. Most South African researchers are afraid that if left uncontrolled or poorly managed, it can cause severe land degradation, reduced agricultural productivity, indigenous-species shift, and ultimately the loss of biodiversity. Consequently, this will undermine key sustainable development goals related to food security and environmental conservation. In this review we conducted a systematic review, identifying 309 peer-reviewed articles from Google Scholar and Web of Science, screening and analyzing 98 of these, and ultimately reviewing 34 publications in detail. Three key research gaps were identified: (1) insufficient research focused on *Prosopis* invasion in South Africa; (2) limited integration and collaboration between the agricultural sector, environmental conservation sector, and governmental bodies; and (3) challenges in policy implementation within invaded areas. The study seeks to address these gaps by highlighting the impact of this alien invasive *Prosopis* species on land, biodiversity, and overall ecosystem stability. It also investigates policy issues surrounding invasive species and their control. Effective management of *Prosopis* within the country will not only control the spread but also support the broader objectives of environmental conservation, agricultural sustainability, and socio-economic development.

Keywords: ecological impact; environment; invasive species; livestock; rangeland management; semi-arid; soil properties; sustainable development goals (SDGs); wildlife

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1. Introduction

Rangelands are extensive natural landscapes, often characterized by native vegetation such as grasses, shrubs, and herbaceous plants [1]. They are among the most important ecosystems in sub-Saharan Africa and play a crucial role in supporting biodiversity, climate regulation, and sustaining wildlife [2]. They support biodiversity through the provision of habitat to a wide range of plants and animal species, contributing to ecological balance [3,4].

Carbon sequestration through their vegetation and soil helps mitigate greenhouse gas emissions, which regulates climate [2,5]. Additionally, rangelands sustain wildlife by offering forage and shelter, facilitating ecosystem processes and nutrient cycling [3,6]. The United States Institute of Peace [7] claims that in Africa, native rangelands cover approximately 43% of the continent's land area. African rangelands are underdeveloped areas prone to degradation, erosion, desertification, and drought. Grazing is the most important type of disturbance that significantly affects ecosystem services in rangelands [4,8]. According to Teague and Kreuter [4], this is because grazing significantly influences biodiversity indicators. This influence is primarily reflected in indicators such as species richness, vegetation biomass, and soil health [1,3,4,9]. These are measurable variables used to assess and monitor the state and trends in biodiversity within an ecosystem. They help evaluate the health, composition, and function of biological communities [10]. Unmanaged rangeland grazing affects species richness and vegetation biomass by changing species composition and abundance, often reducing plant diversity and size, coupled with soil trampling which promotes compaction, erosion, and the loss of essential plant nutrients through runoff [4,6,9]. These changes greatly influence rangelands by shifting their composition and ecological processes, which affects nutrient cycling and soil health [3,10].

Advocates for grazing optimization counter the argument that rangeland grazing, in its entirety, has a negative impact on vegetation, soil health, and biodiversity because of repeated defoliation and soil tramping. For instance, Frank et al. [11] claim that grazing may improve soil health by increasing soil carbon (C), which then stimulates root growth and the production of above-ground biomass. The buildup of litter toward the soil surface where it is more susceptible to decomposition stimulates root development [12–15]. Grazing can also initiate changes to tissue chemistry that decrease palatability, potentially reducing the rates of decomposition [12]. At the same time, chronic grazing can decrease soil C by reducing root productivity as well as the size and quality of biomass, and thus litter inputs [13]. Grazing can enhance microbial growth and function by increasing root exudation in defoliated plants [16]. In addition to grazing, there have also been global concerns and varying opinions on the impact of invasive species on ecological sustainability. For instance, Pejchar and Mooney [17] claim that the impacts of invasive species span a broad range of effects on ecosystems. Shackleton et al. [18] assert that some invasive species are beneficial, and others have detrimental aspects that can create vulnerability in socio-ecological systems. A multitude of South African researchers, rangeland ecologists, resource managers, land use planners, and policy analysts unequivocally agree that invasive alien species degrade the land and cause socio-economic issues. These include the extinction of native plants and animals, reductions in agricultural productivity, increased resource competition, the spread of diseases, and hazards to human and animal health [19–22].

One invasive species that greatly threatens South African rangelands is *Prosopis glandulosa* (Fabaceae). It is commonly known as mesquite and was first introduced to the country in the late 1800s until the 1960s [22]. It is extensively planted across the Northern Cape, Western Cape, Free State, and North-West Provinces [19,22,23]. Initially, this plant was of great value because it provided forage, fodder, and shade for livestock in arid regions lacking indigenous trees, fuelwood, timber, food products, traditional medicine, cultural crafts, and aesthetic landscapes [24–26]. However, by the 1960s, the *Prosopis* species aggressively spread across arid and semi-arid regions of Southern Africa and became problematic as its negative invasive effects on ecosystems, biodiversity, and local livelihoods became apparent. Versfeld et al. [27] reported that, in South Africa, *Prosopis* can spread about 3.5 to 8% per year, which implies that every 5 to 8 years, the invaded areas can potentially double. According to Van Den Berg [28], *Prosopis* invasions within the Northern Cape Province increased by almost 1 million ha between 2002 and 2007, which amounts to

27.5% per year. *Prosopis* is ranked as the second-worst invasive alien plant taxon in South Africa after the Australian *Acacia* species [29]. The lack of natural seed-eating insects further exacerbates the spread and associated challenges. The core challenges caused by *Prosopis* are displacement of native vegetation, changes in soil chemistry, disruptions in soil microbial balance, alterations in soil quality, increased cost to manage and control, extreme water consumption, increased fire risk, and competition with crops [19,30,31].

Objectives

Since *Prosopis* presents challenges but also provides beneficial ecosystem services, it is crucial to review the existing literature to understand the detriments and contributions to ecosystem functions. This is to ensure that applied programs support life by promoting fundamental functions and stability in the semi-arid rangeland ecosystems of South Africa. To date, most of the literature exploring invasive alien species in South Africa has been centered around social issues, and there is a significant gap in the impact on bio-geosciences. Therefore, this review aims to understand how invasive alien *Prosopis* species (mesquite) influences soil health, native vegetation, biodiversity, and overall ecosystem stability in the semi-arid rangelands of South Africa. By evaluating the effects reported in various studies, this review aims to offer insights into optimal management for sustainable land use in invaded semi-arid regions throughout the African continent. The findings will aid in developing effective management strategies that will benefit both biodiversity conservationists and livestock specialists. The findings will also serve a critical role in informing policy development. Given that many scientific studies on South African rangeland ecosystems fail to influence policy directly, this review emphasizes the importance of translating scientific evidence into actionable policy recommendations. The ultimate goal is to bridge the gap between scientific research, and policy development, ensuring that evidence-based strategies are implemented. For that reason, this review will address the following:

1. Understand the reporting of dominant species, coverage, and spread of *Prosopis* in South Africa.
2. Examine both perceptions and facts regarding the positive and negative impacts of *Prosopis* on land and local livelihoods.
3. Analyze policies and regulations governing the management, control, and removal of *Prosopis* from rangelands.
4. Explore how effective management strategies can contribute to sustainability, with a focus on aligning with the UN Sustainable Development Goals (SDGs).

2. Methodology

2.1. Study Selection

This review focuses on South Africa's rangelands, owing to the region's highly diverse and ecologically significant rangeland ecosystems (Figure 1). Provinces with extensive areas of rangeland ecosystem in South Africa are the North-West and Northern Cape Province, where approximately 62% of the total area is rangeland [32]. Rangelands in these provinces are crucial for agricultural, pastoral, and eco-tourism economies [33,34]. However, degradation is a major issue and according to Kellner et al. [35], it is escalating at an alarming rate, primarily due to climate change, the mismanagement of land, and unsustainable land-tenure systems. The North-West and Northern Cape also happen to be the provinces with the biggest issue of alien species invasion, particularly *Prosopis* [25].

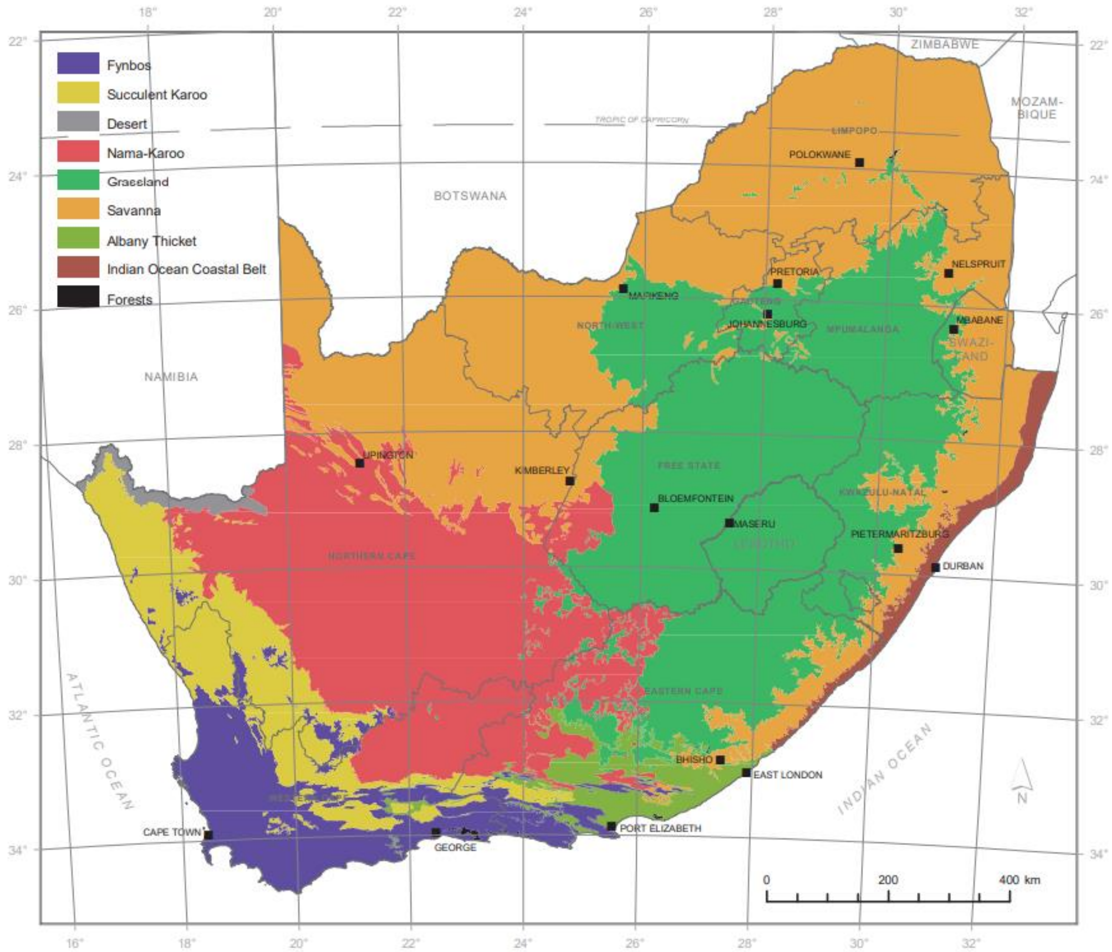

Figure 1. Rangeland types of Southern Africa and their distribution throughout the country [8].

Vegetation in these rangelands is dominated by succulent and woody trees in the Albany Thicket Biome and dwarf shrubs in the Succulent and Karoo Biomes. In addition, there is a prevalent mixture of woody perennials in conjunction with C4 and C3 grasses in the Savanna Biome and Grasslands, whereas a patterned landscape of grassland, wetland, forest, and savanna occurs in the Indian Ocean Coastal Belt Biome [36]. A detailed breakdown of each biome covering the areas they occupy is listed in Table 1.

Table 1. Biomes that function as rangelands in South Africa.

Biome	Total Area (km^2)	% of South Africa	Area Transformed (km^2)	Remaining Natural Area (km^2)	Area Under Conservation (km^2)	Mean Grazing Capacity (ha/LSU)
Indian Ocean Belt	11,529	0.9	7381	4148	825.88	4
Grassland	330,860	27.1	132,803	198,057	14,844.78	6
Savanna	394,158	32.3	75,065	319,093	52,863.43	12
Nama-karoo	249,353	20.4	4827	244,526	3901.66	25
Succulent Karoo	78,203	6.4	3595	74,607	6077.25	65
Albany Thicket	35,250	2.9	3124	32,125	4212.38	14

Ha/LSU is a measurement unit indicating the number of hectares required to sustain one large-stock unit (LSU) of grazing animals for one year (adapted from Mucina and Rutherford [8] and O’Connor and van Wilgen, [34]).

These rangelands are primarily utilized for grazing a diverse array of livestock and wildlife. They support a complex web of life and serve as a crucial natural ecosystem habitat for species such as large mammals, birds, reptiles, amphibians, aquatic life, invertebrates, and soil microorganisms. Additionally, rangelands in South Africa operate as a major source of tourist attractions and provide products such as game/bush meat, mutton, milk, wool, cashmere, crafts, ornaments, etc. [37,38]. In the country's rangeland ecosystems, there are three main types of animal production systems, namely communal and/or commercial livestock grazing land, wildlife game ranches, and nature reserves [32].

2.2. Search Strategy and Selection of Literature

A systematic review was conducted following the updated guideline for reporting Systematic Reviews and Meta-Analyses (PRISMA) of Escarcha [39] and Page et al. [40]. An advanced thorough literature search was carried out to capture relevant peer-reviewed articles appearing in the Google Scholar and Web of Science database. The articles had to be published in English and have no imposed limitations on the year of publication; as this ensured a thorough analysis and allowed us to analyze long-term trends and assess the impact of the various factors under investigation, namely vegetation, soil health properties, and biodiversity. To ensure a comprehensive understanding, we also considered specific non-scientific and government annual reports or response papers that were relevant to the topic. For instance, the National Biodiversity Assessment Synthesis Report that evaluated the threat status and protection level of invasive species across terrestrial ecosystems in South Africa. This allowed us to support or refute specific statements of the literature based on reliable external sources. We initially broadened our search to rangelands across the world. Afterward, we narrowed down our search to the literature on studies that focus on rangeland grazing in sub-Saharan Africa and its impact on vegetation community, and soil properties. The studies also had to look into policy issues and effective management strategies that contribute to sustainability, with a focus on aligning with the UN SDGs. Primary focus and emphasis were later placed on studies either conducted in South Africa or addressing South African contexts. Studies from various regions worldwide were occasionally utilized to provide supporting evidence and justification during the discussion. This was done to cater to the shortage in studies specifically focusing on the impact of *Prosopis* on soil properties within South Africa [31]. Consequently, we have referenced studies from other regions to support and strengthen our argument. The following Boolean search terms were used: *Prosopis glandulosa* OR Mesquite OR invasive plants OR alien species AND rangeland OR grazing land OR exclosure OR enclosure OR savanna OR grassland OR Nama-karoo OR succulent Karoo OR Albany thicket OR veld OR ranch OR game reserve AND Africa OR Sub-Sahara OR Sub Sahara Africa OR followed by South Africa AND native vegetation OR native plants OR native species OR indigenous plants OR indigenous specie AND soil health OR soil fertility OR soil properties OR soil nutrients OR soil chemistry OR soil biology OR soil physics AND biodiversity OR diversity. Furthermore, a supplemental further search was conducted on all the references appearing in the reference list of the retrieved papers. Overall, we had a total of 309 articles, excluding duplicates. We screened all the retrieved articles and filtered out 98 articles, which were fully reviewed and analyzed further. After completing our final screening, we had 34 publications (Figure 2).

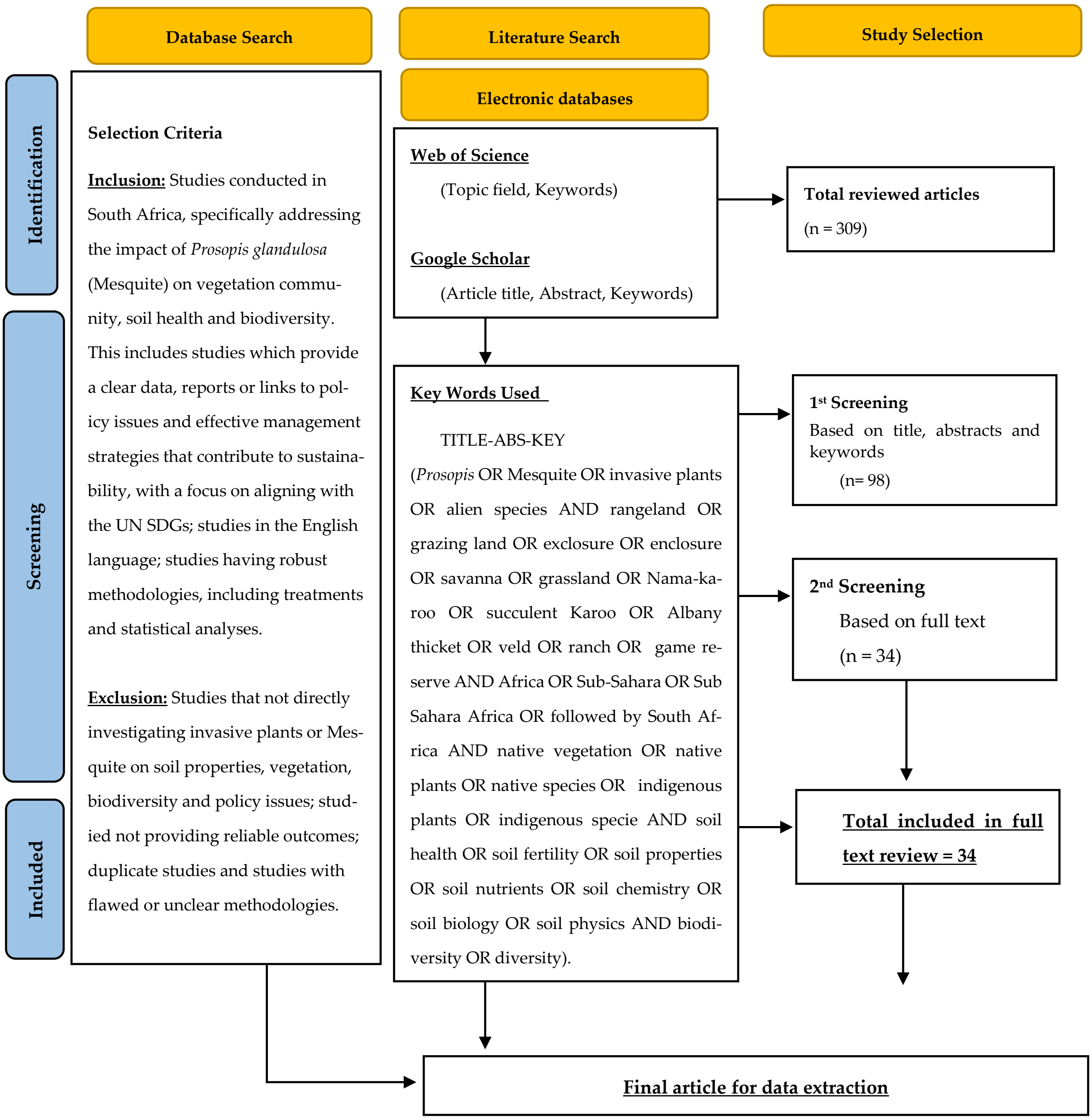

Figure 2. PRISMA 2020 flow diagram for updated systematic reviews to address the database search and literature selection process of the documents for review.

3. *Prosopis* in Rangelands of Southern Africa

3.1. Plant Description and Distribution in South Africa

Prosopis, in South Africa, commonly known as mesquite, is one of the most harmful invasive species of deciduous, leguminous thorn trees and hybrids belonging to the genus *Prosopis* L. (Fabaceae) [23,29]. It originates from Central and South America and has invaded tens of millions of hectares worldwide and continues spreading rapidly throughout the African continent [41]. Zachariades et al. [25] claim that *Prosopis* covers 1.8 million ha of land in South Africa. According to Kruger [42], plants of this species are multi-stemmed shrub or small trees that closely resembles *Acacia*, and they can be up to 10 m in height with dense thickets, straight paired thorns, and reddish-brown young branches with small yellow flowers that occur in spikes (Figure 3). Trees develop surface lateral roots and deep tap roots [43]. These root systems may play a crucial role in hydraulic redistribution and contribute to the trees' survival in drier conditions, despite the lack of obvious xeromorphic adaptations [44]. The trees have feathery, dark green compound leaves, with individual leaflets 10–20 mm in length. The tree carries yellow/purple pods which are palatable to game and livestock due to a high sugar content [19,22].

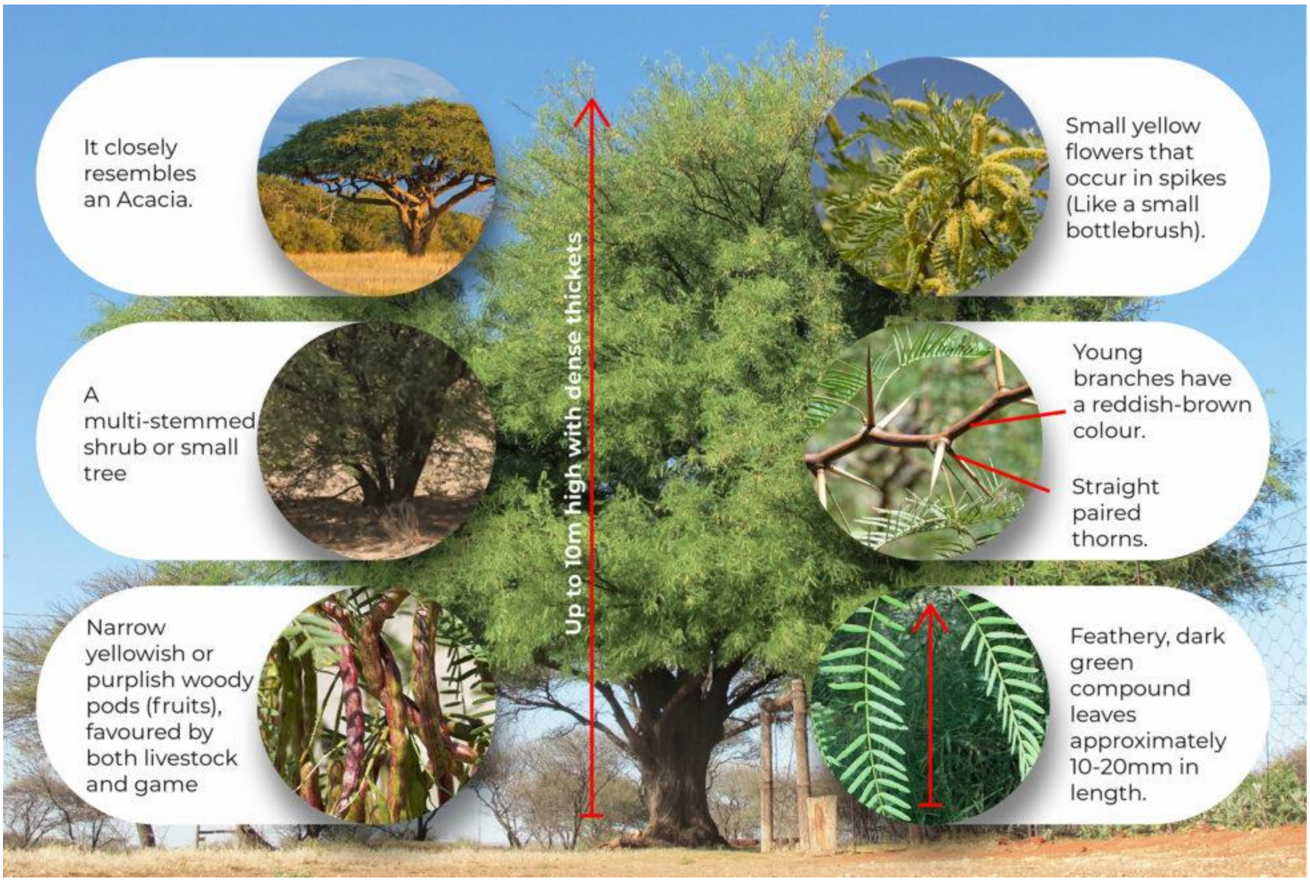

Figure 3. Visual representation of *Prosopis*, providing a clear illustration of its distinctive features (adopted from Kruger [42]).

According to a report by the Agricultural research Council (ARC), in South Africa, the most abundant forms of this highly undesirable invasive alien weed are *P. glandulosa* var. *torreyana* (honey mesquite), and *P. velutina* (velvet mesquite), as well as their hybrids. As a result, they are registered as invasive species in terms of the Alien and Invasive Species Regulations (AIS), National Environmental Management: Biodiversity Act (Act No 10 of 2004). They were recorded as category 1b species in the Eastern and Western Cape, Free State, and North-West Provinces, which implies that they need to be controlled, removed, and/or destroyed if possible (Figure 4). In the Northern Cape Province, they are listed under category 3 status, which suggests that they can stay in areas where they are already established, except for riparian areas, where they will be regarded as category 1b species [45,46]. The main regulation in all the above-mentioned provinces is the prohibition of propagation and trade of *Prosopis* [22]. This regulation does not apply to the other provinces within South Africa.

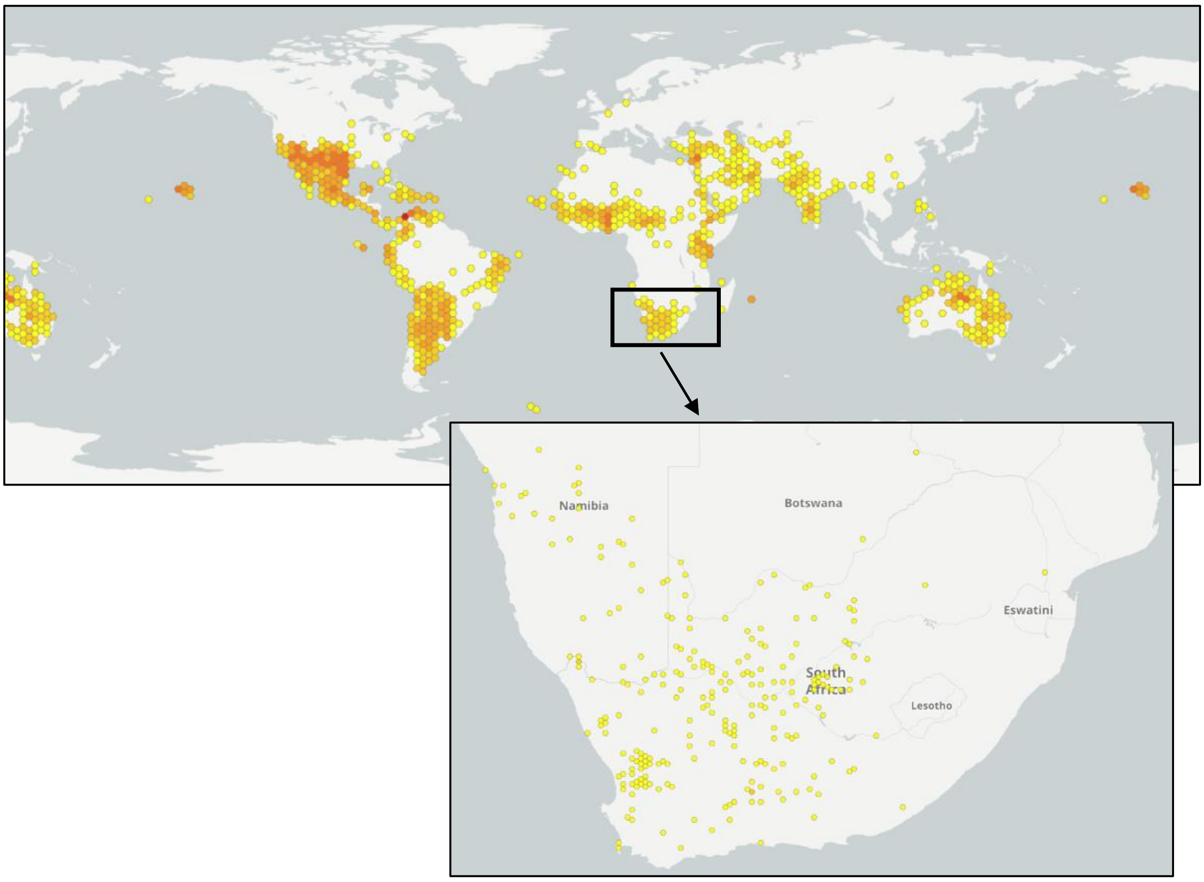

Figure 4. Global and local distribution of *Prosopis* in South Africa (Generated using OpenStreetMap contributors, OpenMapTiles, GBIF).

3.2. Benefits and Problems Associated with Prosopis

In the beginning, whenever *Prosopis* was introduced in a new area, it was promoted as a useful tree with multiple benefits (Figure 5). For instance, Ravhuhali et al. [22], Shackleton et al. [47], and Poynton [48] state that, when it was first established throughout several areas in South Africa in the late 1800s, particularly in the Northern Cape, Western Cape, Free state and North-West Provinces, it was introduced as a beneficial fodder, fuel and protective cover against soil degradation, amongst many other benefits. However, it has since become apparent that when it spreads, its invasive nature leads to ecological challenges that overshadow the initial benefits.

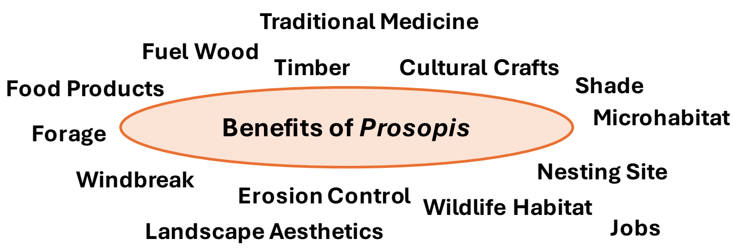

Figure 5. Advantageous uses and valuable benefits of *Prosopis*.

Prosopis species exert a broad spectrum of socio-economic, and ecological impacts on both the environment and soil health, as illustrated in Figure 5. These impacts range from providing valuable resources like fuelwood and fodder to influencing soil properties and biodiversity. A study by Shackleton et al. [19] in the Northern Cape province found that the most common benefits within the province include being used as fodder, fuelwood, and shade amongst four different stakeholder groups. In the urban affluent areas, *Prosopis* is regarded as having medicinal benefits, particularly for stabilizing blood-sugar levels through a South African product known as "Manna". People in rural areas and/or informal settlements pointed out that they use *Prosopis* pods as a source of food, primarily as snacks for children as consumption by adults carries a negative connotation of poverty and poor living conditions [36,47]. In urban informal and affluent suburbs, *Prosopis* has promoted local job creation where locals are able to make money by collecting pods in the Prieska area for the company that produces "Manna". They also clear *Prosopis* as part of the Working for Water program [41,47]. However, most South African farmers complain that this invasive species has far more negative economic impacts than benefits on their businesses, including high costs for control, loss of profits, and decreases in the value of farms. One farmer mentioned that the costs of clearing can sometimes exceed the purchase price of the land. The farmer further stated that it cost them ZAR 5000 per ha to clear *Prosopis* on land that they purchased for ZAR 1500 per ha [19].

Prosopis also negatively affects the environment, animals, and peoples' lives [49]. This is because it severely demolished a variety of natural resources utilized by local communities, such as water, soil health, habitat, fisheries, and biodiversity [50,51]. For that reason, people in areas where *Prosopis* is abundant want it managed or removed [46]. The National Environmental Management: Biodiversity Act (NEMBA), No. 10 of 2004, permits the eradication and control of invasive species in the country; however, there are certain administrative requirements, which can create delays. Enforcing this act throughout rangelands can be challenging due to resource constraints, and the fact that the process for compliance monitoring can be bureaucratic, limiting timely action [45]. Moreover, regulations in the Conservation of Agricultural Resources Act (CARA), No. 43 of 1983 permit the control of invasive plants that threaten agricultural land. In contrast, these regulations require that the landowners manage invasive species. Most persons who utilize rangelands do not have land ownership and, therefore, cannot independently address or meet such regulations without consulting and collaborating with a range of stakeholders [52,53]. Stakeholders can include local community leaders and elders, local government authorities, and NGOs, as well as agricultural and environmental agencies. Therefore, Palmer and Bennett [54] argue that implementation can be complicated by the need for coordination across different land uses (e.g., agricultural vs. conservation priorities). Such challenges are some of the main reasons why *Prosopis* invasion is still an issue, and South African rangelands remain degraded. This is where regulatory authorities can step in and highlight which policies are relevant and which regulatory bodies are responsible for implementation and oversight. Perhaps, the Proactive Land Acquisition Strategy (PLAS) could serve as an initial step in helping restore these rangelands in some provinces [55]. Since the Department of Rural Development and Land Reform (DRDLR) aims to allocate approximately 2,500,000 ha of land for title deeds under both the land redistribution and land restitution programs; leveraging the release of these title deeds has the potential to stimulate growth in the agricultural sector [56]. Upon the release of title deeds, livestock farmers in degraded rangelands dominated by invasive plants could potentially have a chance to manage and restore their land to health without extended delays. For that reason, obtaining title deeds would potentially represent an opportunity for land control and renewed hope for rangeland biodiversity conservation [53,56]. We need biodiversity, not only for survival, as we rely on essential ecosystem services, but also for recreation, stress reduction, general health and well-being, employment, income-generating opportunities, and education. At the same time, it is worth noting that, despite obtaining title deeds, landowners might face limitations in resources needed to comply with CARA, as the responsibility to manage invasive plants on both private and public lands can be extensive. We need to acknowledge such challenges exist in order to appreciate the full challenge of trying to conserve the wealth of biodiversity in rangelands [46,53].

Another challenge is that the seeds of this tree are primarily dispersed by animals that browse on the pods. Pods can also be washed away by water during heavy rainfall events and later deposited en masse in floodplains [57]. This results in the formation of expansive, impenetrable thickets of this weed (Fessehaie and Tessema 2014). In semi-arid rangelands of Southern Africa, *Prosopis* engenders significant ecological and socio-economic problems. According to Shackleton et al. [19] and Ravhuhali et al. [22], this non-native species can outcompete existing indigenous vegetation for space and resources, leading to poor soil health in conjunction with reductions in native biodiversity. Shackleton et al. [19] further expand on the notion that *Prosopis* ultimately causes land degradation by disrupting the natural balance of rangeland ecosystems through alterations in soil fertility, moisture availability, and the cycling of nutrients. This subsequently leads to reduced agricultural productivity, health concerns, and threatens food security. For instance, Agha [58] points out that the dense thickets of *Prosopis* create habitats for pathogen carriers such as fleas, mosquitoes, and ticks. This makes these areas breeding grounds for disease-carrying vectors, which spread diseases such as malaria, tick-borne encephalitis, and dengue fever. Also, animals sometimes consume the seeds and pods of *Prosopis*, which can lead to digestive problems and dental issues [51,59]. When an animal ingests vast quantities of *Prosopis* pods, it can suffer from *Prosopis* toxicity and develop conditions like jaw and tooth deformities, which affect its ability to graze and maintain proper nutrition [59,60]. Shackleton et al. [50] and Bekele et al. [61] reported that the thorns of this invasive plant are long and sharp and can injure both humans and animals by easily piercing through the skin, causing infections if not properly treated.

According to Shiferaw et al. [62], deep pricks from *Prosopis* thorns are known to cause intense itching, and the resulting wounds can lead to lameness and sometimes even amputation due to severe infection. Seid et al. [63] describe how villages in Ethiopia are harmfully impacted by *Prosopis* tree thorns and that the thorns can inflict pain comparable to a snake bite. Moreover, Shackleton et al. [47] reported that *Prosopis* thorns not only injure livestock and people but also puncture car tires. Furthermore, they claim that dense thickets cause a loss of access to recreational areas in urban areas and a loss of access to rivers and grazing areas in rangelands. The National Water Act, act No. 36, of 1998 mandates the acquisition of water use licenses to remove invasive plants near water bodies [64]. The process of obtaining such licenses can be lengthy and administratively burdensome, creating delays in invasive species management. This is another point that shows the need for a holistic approach to rangeland management to ensure that implementation is not hindered by policy makers and regulatory bodies. According to a report by the Department of Water and Sanitation [65], South Africa is a water-scarce country and rated the 30th driest in the world with an average rainfall of about 40% less than the annual world average. The report by the South African Government further argues that the country cannot continue to not conserve water and needs to act quickly because our current state of water storage across the country is estimated at 64.3%. According to a report by Skowno et al. [45], the Garden Route National Park has successfully cleared invasive plants near the Knysna River over the course of three years. The Knysna river has seen improvements in the amount of water it receives because of the clearing of invasive plants within that 3-year period. Such cases are a testament to the rewards to be gained. Removal of *Prosopis* could potentially lead to surface flow in water channels that have dried up over the years. The large amounts of water consumed by *Prosopis* species not only deplete water resources and create water scarcity issues but also increase the risk of waterborne diseases due to reduced water availability and quality [19,51,52,66].

The species is both a problem weed and a useful tree in South Africa. However, many conservationists, natural resource managers, and environmental policymakers support the notion that its costs are greater than the benefits [19]. Despite this realization, the country still fails to implement effective, unified strategies for invasive species control due to inconsistent policies, varying priorities amongst departments, insufficient communication, and a lack of coordination between different government agencies and stakeholders [53,54,67]. Therefore, there is a great need for a coordinated approach and enhanced collaborations to ensure consistent policies and practices because the best option for future sustainability and quality of life in *Prosopis*-invaded rangelands is to make sure that the conservation of built, cultural, and natural environments are integrated. Moreover, increasing funding and resources for research, management, and education could also help support more effective conservation efforts [45].

4. Escalating Threats and Growing Ecological Crisis of *Prosopis* in South African Rangelands

Recent studies, such as those by Shackleton et al. [19], demonstrate that most South African stakeholders consider *Prosopis* harmful, with more than 90% of farmers and people in rural communal areas viewing it as harmful, more so than people in urban areas. About 27.6% of the farmers had disclosed that *Prosopis* had spread naturally onto their land, with roughly 52% of them located in rural villages, 46.6% in informal settlements, and 6.2% of them in affluent suburbs. This is most likely because there are lower invasion densities near and within towns than in rangelands. Complaints from rural residents stem from the tangible, adverse effect of this invasive plant on their agricultural land, soil health, and biodiversity, combined with potential governance challenges that exacerbate control issues [47,66]. The challenge is that addressing these issues requires targeted policies and support tailored to the needs of rural communities. Rural communities are aware of the fact that without human intervention, much of our valuable rangelands will forever be transformed into useless, environmentally damaged *Prosopis* monocultures [47]. Land degradation and biodiversity loss have been a critical issue in South African arid and semi-arid rangelands for more than a century [35]. Many researchers blame the spread of alien invasive species and land use practices, more especially communal land use practices, as drivers of invasion [34,68,69]. *Prosopis* is known to cause land degradation, leading to a subsequent loss of biodiversity through a wide range of mechanisms:

1. **Alteration of Soil Properties**: Bhatta et al. [70] claim that the leaves and pods of *Prosopis* have high tannin content, which can significantly alter soil properties by inhibiting organic matter decomposition, thus leading to reduced soil fertility. Additionally, the species can further degrade soil quality by raising soil pH and increasing soil salinity [71]. For instance, Shiferaw et al. [72] found that *Prosopis* invasion can considerably elevate soil pH levels by at least 1.5%. In their study, they also reported that this alien species also decreases exchangeable sodium (Na^+) by 24.2%, exchangeable Na^+ percentage by 21.6%, and water-soluble calcium (Ca^{2+}) and magnesium (Mg^{2+}) by at least 39.9%, compared to non-invaded lands.
2. **Competition with Native Vegetation**: According to Shiferaw et al. [62], *Prosopis* species have a deep and extensive tap root system that often forms dense stands that can reach up to 60 m deep into the soil. This gives *Prosopis* a competitive advantage over native plants for resources such as water, nutrients, light, and space [30,41,66,73]. Ravhuhali et al. [22] observed that their ability to access water from deeper soil layers can lower the water table and reduce the availability of water for other plants and ecosystems. This competitive exclusion can diminish local biodiversity and disrupt the surrounding ecosystems.

3. **Displacement of Native Flora and Fauna**: *Prosopis* species can form dense thickets that make rangelands less accessible and usable for agricultural land use activities such as livestock grazing and crop cultivation [22,62]. This is because they often lead to reductions in the diversity of native plant species, habitat quality, and food sources for native fauna. As a result, one major threat is that they cause extinction of the native plants and animals if they are unable to adapt to *Prosopis* invasion [20,73]. For instance, Shackleton et al. [19] found that *Prosopis* reduced the abundance of native tree species such as *Acacia erioloba* and *A. karroo*, which are important fuelwood species in South Africa. However, they also reported that farmers observed that *Prosopis* invasions caused an increase in native *kudu Tragelaphus strepsiceros* populations, which is often considered a benefit. *Prosopis* thickets also benefited problematic animal species, such as jackals, which prey on lambs, African porcupines and aardvarks, which break water pipes, and baboons and feral pigs, which cause extensive destruction.
4. **Fire Regime Alteration**: Recent research has shown that since *Prosopis* consumes large quantities of water, this causes the land more susceptible to wildfires [34,35,46]. Their dense stands can increase the risk of frequent high-energy and intense fires, which can further impact native vegetation and soil stability [34]. Water is already a scarce resource in South Africa, which means *Prosopis*-invaded areas experience elevated fire risk and incite an increasing concern for the sustainability of natural resources and public safety [22].
5. **Reduction in Biodiversity**: By outcompeting native species and altering habitat conditions, *Prosopis* invasions can lead to a loss of plant and animal biodiversity [21,33]. This reduction in biodiversity can weaken ecosystem resilience and stability [18,41,47,73,74].

Overall, the invasive nature of *Prosopis* species can significantly disrupt and degrade ecosystems, leading to a range of negative environmental impacts that make rangelands more vulnerable to climate change [71]. Elevated temperatures and increased CO_2 levels can weaken native species and enhance the growth of some invasive species, making them more competitive against native flora [73,74]. According to Huang et al. [75], rising mean temperatures have increased the number of invertebrate pests, while Medlock and Leach [76] observed that high temperatures have resulted in the emergence of mosquito species and related vector-borne diseases. Climate change also worsens the problem by opening new pathways for the introduction and range expansion of already-introduced species [33]. For that reason, we also need to remove invasive species in invaded provinces as a means of coping with climate change whilst also meeting biodiversity targets, much like the approach that the Western Cape government is taking [45]. This action will involve the process of developing a spatial biodiversity plan that identifies one or more categories of biodiversity priority areas, using a systematic biodiversity planning approach [77,78]. The approach can be developed closely following the Technical Guidelines for Critical Biodiversity Areas (CBA) and Ecological Support Area (ESA) Maps.

5. Soil Health Characteristics and Biodiversity as Affected by the Spread of *Prosopis* Species

5.1. Soil Nutrients

Nitrogen (N) is a major critical nutrient needed by plants for their growth and development [79]. The *Prosopis* genus belongs to the leguminous (Fabaceae) family and is known for its N-fixing capabilities [26]. Additionally, *Prosopis* trees shed leaves and, in most cases, eventually die. When that happens, the elevated N levels in their biomass cause chemical changes in the soil, potentially leading to nutrient imbalances [23,49,62].

This could cause nutrient competition among plants by reducing the availability of other essential nutrients [80].

Phosphorus (P) is another essential nutrient affected by *Prosopis*, as their seeds are rich in P [81]. A study by Sadeq et al. [71] reported higher available P, SOC, total N, and total soluble salts levels under the canopy of *Prosopis* trees than outside in a soil depth of 0–45 cm. P is mainly stored in *Prosopis* trees in the form of phytic acid, and the roots can percolate deep into the soil layers and deplete sub-soil P due to their extensive network [62,71,82]. Even though this may make P available to the tree, it can reduce the rate of P uptake by neighboring plant species. This reduction in the amount of accessible P can detrimentally affect ecosystem productivity [19,83].

5.2. Soil pH

Soil pH is significantly impacted by the introduction of *Prosopis* species. This is because, during the decomposition of their biomass, the plant tends to release alkaline substances through their leaves and root exudates, which can raise the pH of the soil over time [62]. This process often leads to soil alkalinity. The shift towards more alkaline conditions causes a decrease in plant diversity by disrupting the growth of native grasses, flowering plants, and trees that are adapted to neutral or acidic soil conditions [71]. In Kenya, Muturi et al. [84] show that soil chemical properties such as pH and calcium were higher under the canopy of *P. juliflora* species than in other zones. For that reason, *Prosopis* species can contribute to increased soil salinity under certain conditions. Conversely, Shiferaw et al. [62] reported significant increases in soil pH and decreases in exchangeable Na^+ in *Prosopis*-invaded areas than in non-invaded open grazing lands. Some species of *Prosopis*, like *P. cineraria*, also known as the 'Ghaf tree', have adaptations that allow them to tolerate saline environments and remain green even in harsh desert environments. When these trees are present in large numbers, they can cause soil salinity. The Ghaf tree is well-adapted to arid and saline conditions in the Middle East regions of Africa. However, it quickly dries out soil environments with extremely excessive concentrations of salt [85]. Elevated soil salinity can also be detrimental to other plants and reduce the overall productivity of the land, affecting both vegetation and soil health [22,44,79]. For instance, excess salts can cause soil particles to disperse and create water stress in plants by making it difficult for them to absorb water, even when moisture is present in the soil [79]. Also, the accumulation of salts such as sodium chloride can reach toxic levels in plants, causing leaf burn, necrosis, and ultimately death [86].

5.3. Soil Structure

The impact of *Prosopis* on soil structure can be quite complex [31,72]. In some instances, researchers reported that the dense canopy cover of *Prosopis* trees can protect the soil against surface runoff and provide some protection against erosion [54,87,88]. Tewari et al. [88] argue that in many semi-arid regions, a shelter belt of *Prosopis* planted around fields minimizes wind speed and lessens wind-induced soil erosion, decreases desiccation by reducing transpiration, and thereby increases plant and animal production. Nevertheless, if the trees die or are removed, their extensive root systems that previously stabilized the soil can leave the soil more vulnerable to structural deterioration [89]. For instance, Goel and Behl [90] claim that the extensive root systems of *Prosopis* trees can create dense, compacted layers, or hardpans, which in conjunction with the presence of salt concretions as granules, reduce soil porosity. This leads to poor soil aeration, decreased water infiltration rates, reduced air exchange, and restricted root growth for other plant species. This then promotes erosion, the runoff of water and essential nutrients, and gives rise to poorly aggregated soils, thus resulting in poor soil health [79].

5.4. Soil Moisture

Prosopis is well-adapted to arid and semi-arid environments and has high water demands throughout the year because it is evergreen and has extensive root systems [22]. According to Shiferaw et al. [72], this species can take up to 36 liters of water per stem per day. This strongly reduces soil moisture-available water and lowers the groundwater table [30]. It also results in drier soil conditions, reduced groundwater recharge, and decreased overall water availability in the ecosystem [19,46]. Such changes can have a detrimental impact on plant growth and local biodiversity, as other plant species may struggle to survive in the altered moisture regime [51,80].

5.5. Soil Organic Matter

The decomposition of *Prosopis* plant material, including leaves, branches, and bark, tends to occur at a slower rate compared to many native plants [91]. Slow decomposition reduces organic matter accumulation in the soil, thus leading to decreased nutrient availability, reduced microbial activity, and lower soil fertility [79]. Since organic matter is crucial for maintaining soil structure, water-holding capacity, and overall soil health, limited accumulation can have considerable adverse impacts on soil quality [22,62].

6. Justification for Invasive Species Control in South Africa

Shiferaw et al. [62] suggest that the benefits of *Prosopis* on soil properties surpass the drawbacks. It is also worth noting that the impact of *Prosopis* on the above-mentioned soil properties highlights the need for the careful management and monitoring of invasive species to mitigate their effects on ecosystems and ensure the health and productivity of rangelands (Figure 6). Hence, South Africa has put in place numerous legislative acts to ensure that this happens.

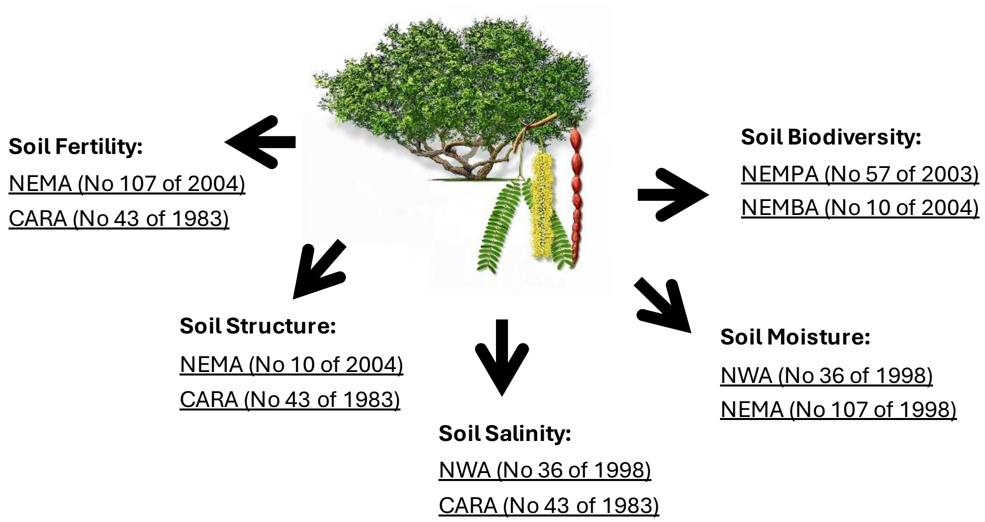

Figure 6. Soil factors influenced by *Prosopis* and associated legislative acts for ecosystem safeguarding and biodiversity conservation. The text in bold describes the soil factors affected by *Prosopis*, and the underlined text represents the acts associated with soil factors. (Tree image by Robert O'Brien).

There are however ongoing debates about the ability of these acts to contribute to the promotion of land protection and biodiversity conservation, particularly in areas with dense strands of *Prosopis* trees. This issue will continue to hamper progress with the planned escalation of management and control measures if the issues regarding different aspects of soil health are not prioritized. For instance, O'Connor and van Wilgen [34] infer that the general perception in South Africa is that rangelands are degraded and may be unable to continue supplying requisite ecosystem services. They claim that it is estimated that invasive alien plants have reduced the value of livestock production in the country by approximately ZAR 340,000,000 on an annual basis. At the same time, Gwate et al. [67] argue that these alien species transformed some rangelands into novel systems, where communities embracing these invasive species can exploit the opportunities they provide.

7. Effective *Prosopis* Control and Management Options on a Landscape Scale in South Africa

Since this invasive species' density increases over time and is estimated to spread by up to 10.5% in informal settlements and 23.6% in affluent suburbs per annum in South Africa, it is crucial to implement proactive control and management measures [47] (Figure 7). It should also be ensured that the implemented measures account for the current distribution and the potential spread of *Prosopis* to new areas and provinces.

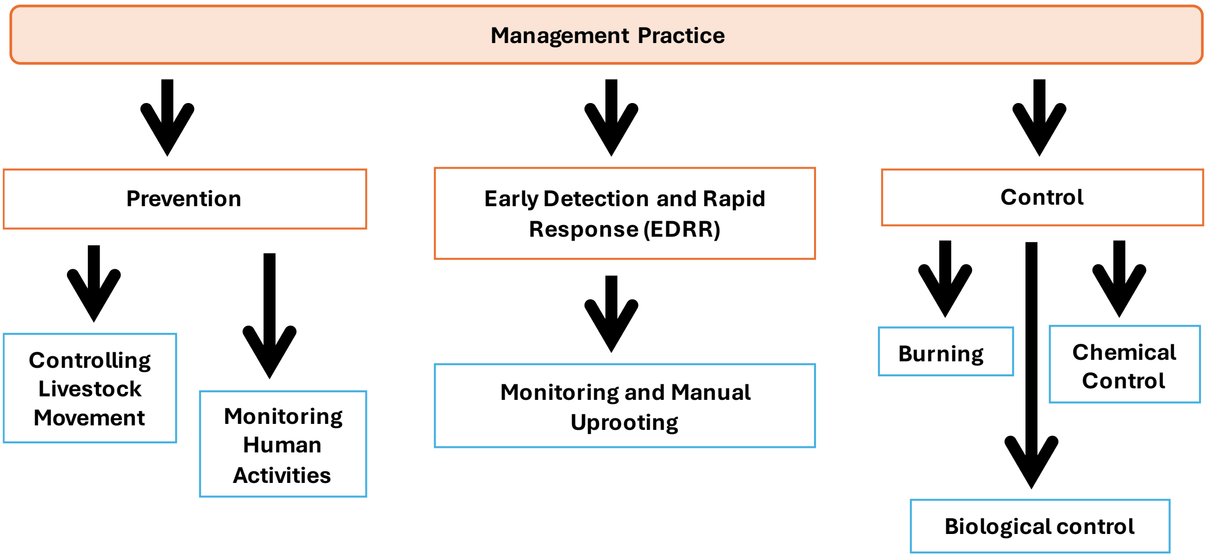

Figure 7. *Prosopis* management methods (indicated with the orange rectangles) and their examples (indicated with blue rectangles).

7.1. Prevention

In South Africa, it is advisable to protect regions where *Prosopis* has not yet established itself, as this is not just the most cost-effective approach but also the most strategic intervention [19]. This is because it substantially minimizes the potential spread of this invasive species to unaffected areas. Using this approach will allow us to circumvent the far greater economic impacts and issues associated with *Prosopis* management or later removal. The preventive measures include controlling livestock movement, monitoring human activities that could inadvertently spread *Prosopis* seeds, and managing water sources that might carry seeds to unaffected sites [19,92]. These can be achieved by regularly and systematically checking the area for new *Prosopis* seedlings or trees as swiftly as possible and removing them if it is still easy to do so. Different regions can train rangers, pastoralists livestock farmers, herdsmen, and/or community members in finding and recording new occurrences of *Prosopis*. Ideally, this practice is conducted by people who are living in or regularly traveling within the area. To ensure that livestock that has been in an invaded area does not spread seeds into uninvaded areas, livestock holding areas are normally used. The seeds usually take up to at least 7–10 days to transit the animals' digestive system before being defecated. Once seedlings have emerged, they should be continuously eradicated from the holding area [93]. Herders can be incentivized to do this by providing supplemental fodder for their animals during the containment period.

Effective prevention of the spread of *Prosopis* can lead to better soil health by reducing the competition for resources and preventing soil degradation caused by this invasive species [62,94]. This can lead to greater vegetation diversity and ecological resilience, mitigate soil erosion, improve fertility, and enhance structure through the preservation of native vegetation that stabilizes the soil. Additionally, it helps in maintaining a more balanced soil nutrient profile, as *Prosopis* can alter nutrient dynamics [94]. This ensures that natural habitats for various wildlife species are stable, and ecosystems remain functional and diverse. A healthy, diverse ecosystem provides better ecosystem services, such as C sequestration, water purification, and pollination, which are essential for overall biodiversity [94,95]. Therefore, taking this action can protect the countries' diverse ecosystems and agricultural lands from the damaging impacts of *Prosopis* invasion [96].

7.2. Early Detection and Rapid Response (EDRR)

In areas where *Prosopis* has already established itself, but only at low densities, it is advisable to use the early detection and rapid response (EDRR) management method [97,98]. This method involves the monitoring and early removal of all trees so that the area is cleared of *Prosopis* (Figure 7). It also involves the manual uprooting of new seedlings as seeds may survive in the soil for a couple of years. EDRR is cost-effective, but manual uprooting can be quite labor-intensive; hence, this method is mostly applicable in areas with relatively small invasions. To uproot *Prosopis* seedlings or young plants, up to 1 m in height, a "tree popper" or tree puller may be used. The ideal time to remove seedlings is after the rains when the soil is still moist. Trees taller than 1 m may be removed using a machete. To kill the plant, at least 30 cm of the rootstock needs to be removed. New seedlings may emerge after the removal of the trees and *Prosopis* stump or root sprouts vigorously, which is why areas where *Prosopis* has been uprooted should be subsequently revisited to check for new growth [78]. According to Kariyawasam et al. [97], this method restores native vegetation cover by effectively preventing the overgrowth of invasive plants that can outcompete and suppress native vegetation. In this way, native plant communities continue to contribute to soil fertility and structure, preserving the soil's natural balance [19]. By quickly addressing invasion, EDRR reduces the risk of soil disturbance, erosion, and compaction, which can occur when invasive species replace deep-rooted native vegetation.

7.3. Burning

Prosopis is extremely resistant to heat and if there is not enough grass underneath the tree to fuel a fire, the plant can survive [23,99]. A study by Starns et al. [99] reveals that this is because the epicormic buds in branches and stems of this invasive species are heat-protected by the outer bark. However, this protection is substantially inadequate to protect against intense fires. In many South African rangelands, fire is not intense or severe enough to lead to the mortality of *Prosopis* trees. For those reasons, some communities have developed a stem-cutting method that involves cutting stems at ground level and exposing the rootstocks by excavating the soil down to approximately 50 cm. Afterward, the hole around the rootstock is filled with and covered using flammable material such as dry branches or wood and then set on fire. This management method can have both positive and negative effects on soil and biodiversity in South Africa. For instance, the removal of *Prosopis* through burning can temporarily increase soil nutrients, especially N, due to ash production [23,100]. However, continuous burning can lead to organic matter depletion and soil structure disturbance, thereby resulting in long-term soil degradation [101]. The ash produced can also alter soil pH, typically making it more alkaline, thus affecting the growth of native species and the overall soil ecosystem. Also, burning kills beneficial soil organisms and exposes the soil to the risk of erosion, particularly in areas where the tree canopy provides significant ground cover [100,101].

While in some cases burning helps restore native plant communities, it can also temporarily displace wildlife, particularly species that rely on *Prosopis* for shelter or food [102]. In some instances, controlled burning of *Prosopis* can even support biodiversity by maintaining the natural fire regime. However, in areas that are not adapted to regular fires, this practice may harm biodiversity by altering the natural disturbance patterns. Furthermore, it may even create conditions that favor the spread of other invasive species, which can further threaten local biodiversity [103]. Furthermore, this management option carries certain restrictions in South Africa. For instance, the National Veld and Forest Fire Act No. 101 of 1998, which governs the management of veld fires, has strict regulations on fire management. Under this act, one requires a fire permit before burning for invasive species removal, especially in sensitive or protected areas [104,105]. It is essential for this act to continue being implemented because it helps reduce the incidence and severity of fires, protect biodiversity, prevent soil degradation, and safeguard the livelihoods of communities dependent on natural resources [104]. Also, effective enforcement can minimize economic losses, reduce greenhouse gas emissions, and enhance overall environmental resilience. However, these benefits are sometimes not of great benefit when dealing with invasive species because the longer the invasive species remains, the longer it spreads and outcompetes native biota [45].

7.4. Chemical Control

In addition to burning, there are two other main management methods used as control measures, namely chemical control and biological control [103] (Figure 7). Chemical control typically involving the use of herbicides, is often used for larger invasions, and is a faster and simpler technique than biological control [106]. It involves either the basal bark treatment or the cut-stump treatment. During the basal bark treatment, the herbicide is applied on the base of each stem around the entire circumference and at a distance of at least 0–75 cm above the ground using a knapsack sprayer or a brush. Conversely, the cut-stump treatment involves the cutting of the stems and immediately painting the stumps with herbicide thereafter. According to Eschen [107], herbicides that are typically used for *Prosopis* control include a Bromoxynil/MCPA mixture, which reduces shoot dry weight by 59%, and Oxyfluorfen, which achieves a 69% reduction. Mecoprop also significantly limits the growth of *Prosopis*, but the tree’s thick bark, woody stems, and small leaves hinder chemical absorption. Before being banned in the 1980s, 2,4,5-T was commonly used for *Prosopis control*, though it primarily suppressed top growth rather than killing trees outright [108].

Chemical control can lead to soil contamination and deteriorate soil quality [109,110]. Chemical residues from herbicide use may run into rivers or remain in the soil for a prolonged period, negatively affecting marine life, humans, soil microorganisms, and nutrient cycles [111]. The use of chemicals can also affect non-target native vegetation, leading to unintended damage and a decline in plant biodiversity [112]. Furthermore, it could potentially have an indirect effect on animal species, particularly those that rely on a diverse plant community. For instance, herbicides may scale back food sources or nesting materials for wildlife [110,112]. One also needs a permit to operate this method [113]. Obtaining the necessary permits for herbicide use or large-scale removal operations can be a lengthy and bureaucratic process. Furthermore, large-scale removal operations involving chemical use may sometimes trigger the need for an Environmental Impact Assessment (EIA) under South Africa’s environmental regulations. This process can be time-consuming and costly, potentially delaying or limiting invasive species management activities. This is because EIAs may impose specific conditions or mitigation measures that could complicate the removal process, such as restrictions on the use of herbicides or requirements to avoid damage to non-invasive vegetation. EIAs involve public participations, which is a positive thing in the sense that it allows communities and stakeholders to voice concerns, contribute local knowledge, and ensure that their needs are met. Above all, it helps prevent unintended ecological damage and protects biodiversity. However, the question needs to be asked, what happens when preventing the use of chemicals to protect against invasive species can lead to far greater treats to the ecosystem? Also, conducting EIA is costly and might present financial burdens to affected rural communities. Balancing environmental protection with the need for timely and effective alien invasive species management requires careful planning and consideration of both the benefits and limitations of the EIA process [47].

7.5. Biological Control

This management practice was initiated against *Prosopis* in South Africa in the mid-1980s, and it involves the release of natural enemies such as insects or pathogens that only attack and weaken the trees, leading to decreased density and spread [92,114]. Biological control resulted in the introduction and release of beetles that feed on the seeds and reduce their ability to spread [114]. This is an effective option to manage very large invasions. However, according to Zachariades et al. [25], biological control efforts in South Africa have largely failed to alleviate *Prosopis* problems. Kleinjan at al. [115] state that one notable control agent that has been used in South Africa is *Coelocephalapion gandolfoi* (a weevil). It was prioritized for development due to its specific attack on immature pods and effective seed suppression, as demonstrated in McKay et al. [116]. Despite being conditionally approved for release in 2014, logistical issues delayed further progress. Similarly, *Asphondylia prosopidis* (the gall midge), originating from North America, was initially considered for release but deprioritized due to its complex species structure, which posed challenges for host specificity testing. Nonetheless, certain cryptic species within the *A. prosopidis* complex, particularly those producing "large teardrop" and "barrel" galls, remain promising due to their multivoltine nature and potential for rapid population growth [115,116]. Finally, *Oncideres rhodosticta*, a beetle from the United States, has shown promise due to its ability to girdle stems, thereby damaging the plant. Quarantine testing revealed that it preferentially targets *Prosopis* over other legume species, supporting its potential as a specific biocontrol agent. These agents represent ongoing efforts in South Africa to control *Prosopis* spread, although further data on field outcomes and logistical challenges are needed to assess long-term effectiveness [115].

Van Klinken et al. [117] provide a more recent global perspective on *Prosopis* invasives and their control. If carried out successfully, the control method can enhance plant diversity and support ecosystem health by helping restore soil health, as the invasive species often disrupts soil nutrient cycles and physical structure. However, if poorly carried out, it can lead to unintended consequences for non-target species or disrupt existing ecological relationships [25,114]. Therefore, careful selection and monitoring of control agents is crucial to mitigate these risks.

8. Compliance of Existing Management Practices with SDGs

It is evident that effective control and management of invasive *Prosopis* in South African is necessary to help combat some of the urgent environmental and socio-economic challenges facing our rangelands [33,34]. To accomplish this, the United Nations (UN) has put in place a set of sustainable development goals (SDGs) that serve as a blueprint for achieving sustainable land management and biodiversity conservation [118,119]. Some of these SDGs are relevant in monitoring and analyzing changes in ecosystem health against the extent of sustainable land management implementation in ensuring adaptive management [120]. If *Prosopis* is not properly managed in South African rangelands, it could significantly undermine these UN global priorities by 2050. For that reason, it is important for us to identify SDGs relevant to alien invasive species clearing so that we can monitor soil health and ensure food security. Table 2 provides a detailed overview of SDGs relevant to the proactive management of *Prosopis* invaded rangelands, and their effect on soil health, vegetation, and biodiversity.

Table 2. Relevant SDGs affected by invasive *Prosopis* removal in South African rangelands and their impact on ecosystem health.

SDG	Indicator	Factor	Significance in Enhancing Ecosystem Health
1 NO POVERTY	Indicator 1.1.1 Proportion of population living below the national poverty line. Indicator 1.2.1 Proportion of population living below 50% of median income.	Indirect impact	Effective management of *Prosopis* can improve soil health and restore land, therefore enhancing agricultural productivity and economic opportunities for local communities, indirectly contributing to poverty alleviation. Communities could potentially create jobs by establishing small-scale industries around *Prosopis*-based products. For instance, they can explore selling the leaves as animal fodder or using them in composting to create organic fertilizers. The wood can be processed into high-quality charcoal, which is in demand both locally and internationally. They could also use the wood for making handcrafted goods, furniture, and biofuels.
2 ZERO HUNGER	Indicator 2.1.1 Prevalence of undernourishment. Indicator 2.4.1 Proportion of agricultural land under productive and sustainable agriculture.	Improved land use	Reducing *Prosopis* invasions can improve land availability and productivity, supporting more sustainable agriculture and food security by allowing native plants and crops to thrive. Moreover, the pods can be harvested and processed into flour, which is used in a wide range of food products.
3 GOOD HEALTH AND WELL-BEING	Indicator 3.9.2 Mortality rate attributed to unsafe water, sanitation, and hygiene services. Indicator 3.9.3 Mortality rate attributed to environmental pollution and contamination.	Healthier ecosystems	Controlling and managing invasive species contributes to healthier ecosystems that support better air and water quality, which are essential for public health. It also helps restore native vegetation.
6 CLEAN WATER AND SANITATION	Indicator 6.6.1 Change in the extent of water-related ecosystems over time.	Water quality	By reducing soil erosion and improving water infiltration, effective management and control of *Prosopis* can enhance watershed health, thus supporting cleaner water sources. Since *Prosopis* invasion often leads to the depletion of groundwater resources, its removal not only promotes biodiversity but also fosters a more balanced hydrological cycle. As a result, waterways such as streams and rivers are more likely to be replenished, enhancing overall water security in the region.

Table 2. *Cont.*

SDG	Indicator	Factor	Significance in Enhancing Ecosystem Health
13 CLIMATE ACTION	Indicator 13.2.2 Number of countries that have integrated climate change measures into national policies, strategies, and planning.	Mitigation and adaptation	Managing *Prosopis* invasion can lead to the re-establishment of carbon-sequestering native plant species that can help mitigate climate change by improving soil health, and contributing to climate adaptation efforts.
14 LIFE BELOW WATER	Indicator 14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches.	Protecting aquatic ecosystems	Improved land management and reduced erosion from controlling this water-thirsty invasive plant can benefit aquatic ecosystems by decreasing sediment and nutrient runoff into water bodies.
15 LIFE ON LAND	Indicator 15.3.1 Proportion of land that is degraded over total land area. Indicator 15.5.1 Reducing the degradation of natural habitats and halting biodiversity loss.	Combatting desertification and biodiversity conservation	Biological control and other management practices that prevent the spread of this invasive species that soaks up large quantities of water and triggers biodiversity loss can help combat land degradation and desertification, supporting more sustainable land management. Control and management align directly with efforts to restore native habitats, and protect terrestrial ecosystems and biodiversity.
17 PARTNERSHIPS FOR THE GOALS	Indicator 17.16.1 Number of countries reporting progress in multi-stakeholder partnerships. Indicator 17.17.1 Amount of global, regional, and national resources allocated to support the SDGs.	Collaborative Efforts	Effective management often involves collaboration between government agencies, NGOs, local communities, and research institutions, aligning with the goal of strengthening partnerships and achieving shared goals. For instance, the Centre for Global Change from the Sol Plaatje University has collaborated with the Global Environment Facility and the International Union for Conservation of Nature (IUCN) in a project aimed at restoring *Prosopis*-invaded rangelands situated in Rietfontein within the Northern Cape province of South Africa.

9. Current Recommendations and Conclusions

Uncontrolled or poor management of *Prosopis* populations constitutes a threat to soil health, indigenous vegetation, and biodiversity in South African rangelands. Effective management of invasive alien species is important in combating land degradation and improving ecosystem functioning. To address these challenges, it is important to implement comprehensive management strategies that include early detection and rapid response, biological control, as well as preventing the spread to areas where *Prosopis* has not yet established itself. This, in turn, addresses key sustainable development goals (SDGs) related to food security, poverty alleviation, and the promotion of agricultural sustainability. Protecting and restoring native habitats by removing *Prosopis* will help preserve local biodiversity, improve ecosystem health, and enhance habitat availability for native wildlife. Engaging and educating local communities about the impacts of *Prosopis* and training them on management techniques are crucial for the success of control programs and for promoting sustainable land use practices. Streamlining policies and regulations to support the control and prevention of invasive species, along with investing in research and innovation, will further enhance management efforts and adapt strategies as needed. This study highlights the fact that changes in governance systems and rangelands are complex and nonlinear. Therefore, transformative and adaptive collaboration among experts from stakeholder disciplines can provide concrete insights for policymakers in working to improve institutional and structural processes of natural resource governance in post-colonial areas. Furthermore, collaboration is crucial for developing holistic solutions to effectively conserve natural resources. We recommend that the government puts more effort into preventing further degradation and mediate the rehabilitation of existing degraded land. Furthermore, the policies should prevent further degradation of new 'communal' lands that are part of the land redistribution program, and provide support for governance structures that underpin decision-making.

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