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Chapter 25

Shortage of Biodiversity in Grassland

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1. Introduction

In this chapter, we report existing distortions between the cultivation of native and exotic forage plants for breeding at pasture, a practice that reduces the biodiversity in grassland environments.

Raising animals on pasture with native forage species is cheaper than the cost of confinement and the use of exotic species. The introduction of exotic plants in pastures may increase production costs for farmers when introducing forage species that are not adapted to the system, in addition to causing environmental damage due to the reduction of biodiversity and the failure to consider the soil and climate of the region.

An approach will be made in relation to the climate-soil-plant-animal complex, emphasising the economic feasibility of using forage species with high genetic potential for native and exotic pastures and aiming to assist in the selection of the most appropriate forage species for grazing production systems and to avoid problems with biodiversity in grasslands.

2. Grass production

Ruminant grazing on native forage is the most economical way of producing meat for human consumption. Livestock grazing is generally a more profitable approach than raising confined livestock [1]. The use of concentrate feeds in the diet increases the cost of production, as does the use of exotic forage that is not adapted to the environment. In Ethiopia, pastures are not only used as an economical source of food for herbivores; most are also used for recreation, because in this country, there are many natural parks, reserves and sanctuaries [2]. The management of rangelands with native species goes beyond animal production, because there

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are many factors in this diverse ecosystem with different purposes. Reducing the biodiversity of natural pastures to cultivate only a single species can cause serious environmental problems.

Native forage species reduce problems with invasive species, improve the wildlife habitat, contribute to carbon sequestration and increase the stability of the ecosystem [3], because they maintain the biodiversity of the environment. According to [4], the effect of cattle on native pasture is important for management because it prevents excess dead biomass, which would increase the risk of fires.

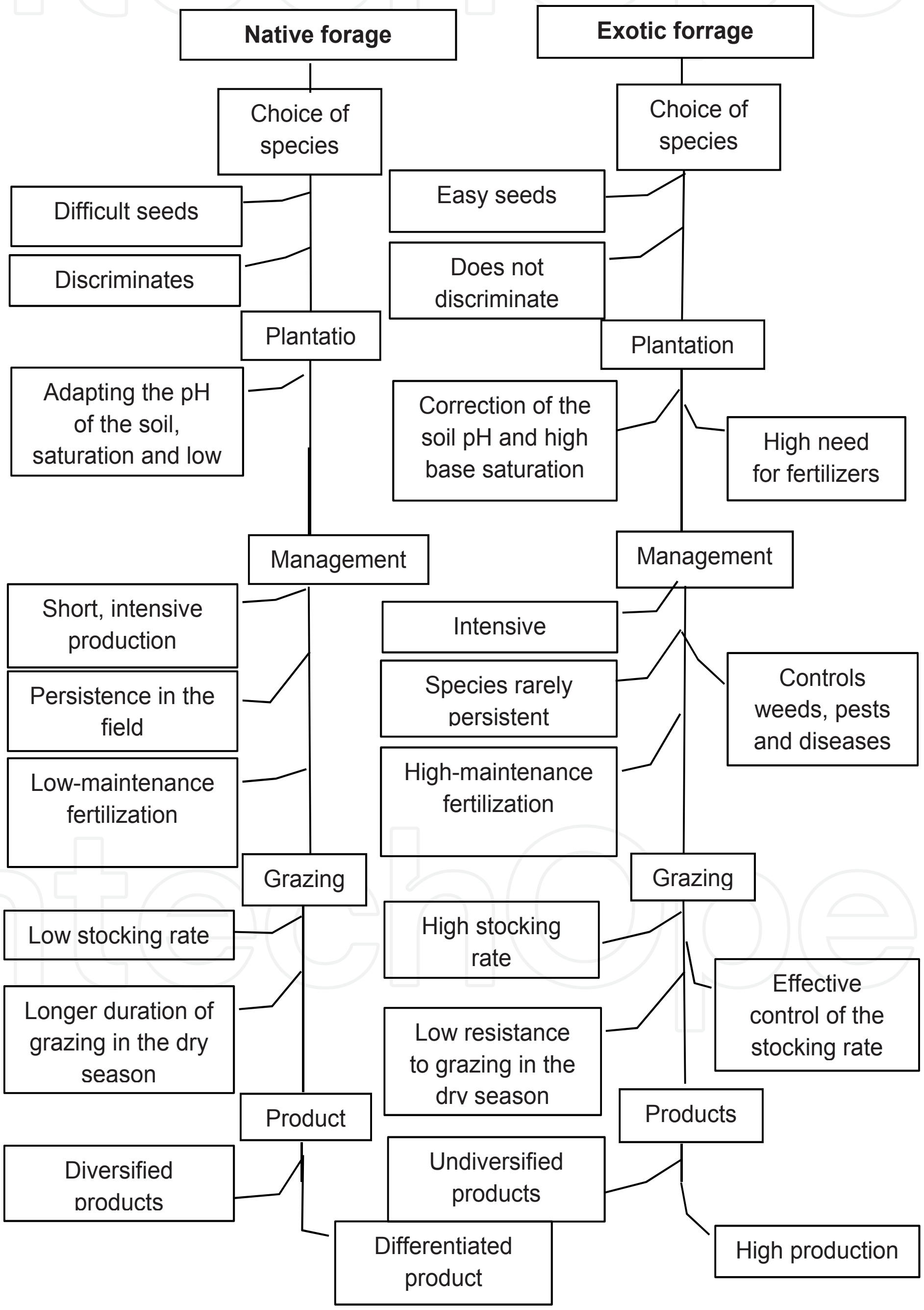

Figure 1. Livestock system with native and exotic (introduced) fodder plants

Note that when working with agriculture, all of the investment is returned quickly because the product is generated by the plant, while livestock products come from the animal that consumes the plant forage in pastures, which represents an additional cost to the production system compared to agriculture. Therefore, systems that integrate agriculture with livestock represent a viable option for the present and future of both agriculture and livestock, mainly due to increased environmental biodiversity and to the reduced production costs associated with this type of system.

The farmer must carefully analyse every investment that will be made in the cultivation of forage species, because the introduction of species into unnatural environments can require expensive treatments to render the soil suitable for their cultivation; livestock production also renders this task more expensive because of the cost of the animals (Figure 1).

In India, only 4% of the land requires pasture to increase the area under cultivation with forage species; however, there are fewer seeds of forage quality that are available in the local market. The authors note that the percentage of germination of available tropical grass seeds averages 20-30% [5]. The acquisition of forage seeds for planting pasture is expensive, and farmers in this country prefer to work with agricultural crops, which is concerning because the shortage of quality in the seed market is the decisive point in the selection of forage species.

The native species have little or no available seed in trade, as multinational companies acting in tropical climate countries restrict the distribution and sale of seeds of forage species to a few cultivars, which are often of the same species. In the selection of forage species, several criteria are considered rather than only assessing certain aspects, such as productivity and nutritional value. Table 1 presents the main criteria for the selection of forage species, comparing between the native and exotic species.

	Native forage	Exotic forage
Adaptation to soil	+	-
Seed quality	-	+
Seek marketing	-	+
Fertiliser requirement	-	+
Growth	+/-	+
Productivity	+/-	+
Persistence in pasture	+	-
Technicalisation level	-	+
Resistance to pest and diseases	+	-
Acceptance of producer	-	+
Nutritional value	+	+/-
Production cost	-	+

Table 1. Comparison between native and exotic (introduced) species of grasses

3. Forage species

Forage species are of fundamental importance for livestock everywhere on the planet because these species are responsible for feeding the herds of herbivores that in turn feed a large part of the world's population and some carnivorous animals. The use of native species is important because these plants are already adapted to inhabit regions that, due to a long process of natural selection carried out over time by nature, maintain the natural biodiversity of the grassland ecosystem. The variation in the wealth of native forage species is a valuable source for selecting the best kind [6].

The adaptation of forage plants to their natural environment occurs in the same way as for any other plant species in which the most suitable species for situations of soil and climate prevail in the region, along with different animals, such as insects, birds and herbivores. Long-term research must be conducted in native environments because there are several factors that affect the biodiversity and productivity of native pastures, and potential carbon sequestration is more complex and unpredictable than previously believed [7].

Native grasses have the potential to revegetate degraded land; however, due to little knowledge about their biology, preference is given to the use of exotic species that can be invasive, thus affecting local biodiversity [8]. The establishment and spread of plant species from other regions in natural ecosystems can reduce, disrupt or terminate the original flora populations and thus alter the balanced ecosystem, which today is one of the most significant environmental problems [9]. The planting and management of native grasses are difficult because information about these plants is scarce [10]. According to these authors, the native grasses of Brazil *Andropogon bicornis*, *Andropogon leucostachyus*, *Echinolaena inflexa* and *Setaria parviflora,* among others, show morphological and physiological characteristics that allow them to survive in environments with different stages of degradation, making these species good options for pasture recovery.

The genus *Paspalum* is promising for this country, but there are few studies of this genus. According to Barreto [11], 75% of the described *Paspalum* species occur in Brazil under a wide range of ecological conditions and as part of several plant communities. The importance of the genus *Paspalum* for Brazil is not only due to the production potential and quality of the species but also because it has a high potential for use in the recovery and conservation of degraded soils [12]. *Paspalum nicorae* is usually found in sandy soils, indicating a potential to tolerate drought and low soil fertility, and has a high response to fertilisation [13]. *Paspalum nicorae* has a wealth of natural morphological variation, which is a valuable source for the selection of new varieties for the native forage for Brazil [6].

In Congo, it is necessary to conduct studies with native and adapted species; the use of species that are not adapted to their conditions promotes food shortages at certain times of the year due to a lack of food during the dry season, which was a major cause of the reduced herd of the Sud-Kivu region in this country [14]. The identification of native forage species is essential for the establishment of small traditional farmers as agro-pastoralists [14]. In Nepal, species that are regarded as weeds in agricultural crops are native forage species; according to the authors, these species demonstrate an adaptability that could be used with greater frequency in animal feed [15].

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The climate-soil-animal-plant complex must be considered when seeking to utilize grassland; it is not a simple task to introduce a system of livestock production using species from other regions for the purpose of feed because the native or exotic livestock will therefore have the same soil and climatic conditions of the place of origin in the new habitat. The use of exotic forage species is disturbing when introduced irrationally without considering the large climate-soil-plant-animal complex, and the introduction of these species can influence the biodiversity of the environment.

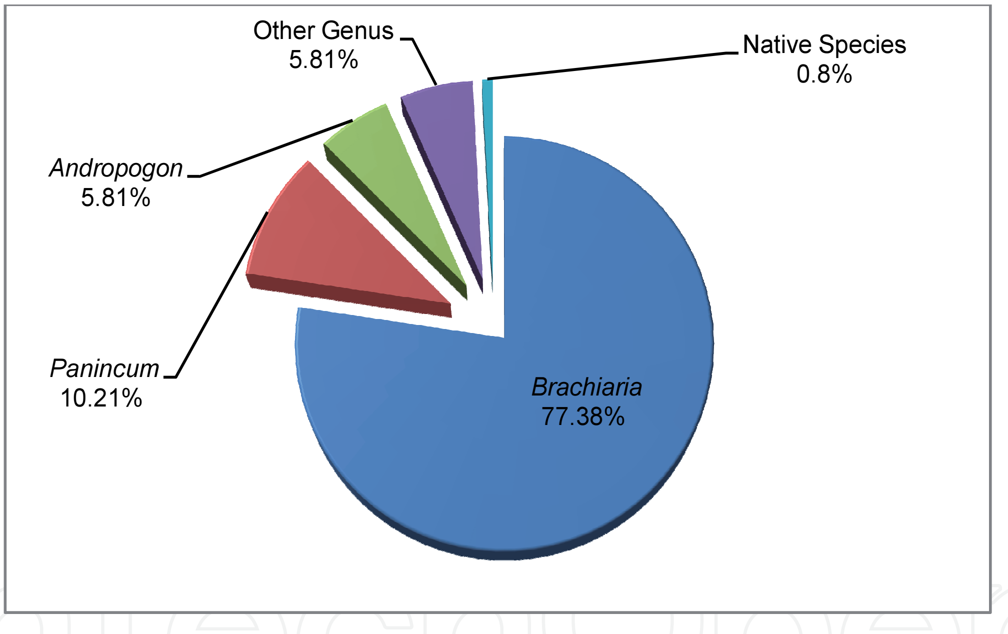
The control of native species to introduce exotic species is generally done with fire or herbicide use, causing environmental damage [16]. Santos et al. [17] argue that the reasons for using fire in rangelands are diverse. Fire is one of the practices that causes environmental damage to the soil and is rarely carried out in pastures with exotic cultures, showing that not even the crop treatment applies. Another important aspect is the production cost of these exotic forage species when accounting for a system of livestock production. The production and introduction of new forage species are frequent; every year private sector and public companies launch new varieties of these species which, in most cases, are exotic species that originated in another region. The improvement being realised is that the Kikuyu (*Pennisetum clandestinum*) originates from material coming from local farms, as a previous bid improved the tropical grass *Digitaria milanjiana* by giving it more leaves and a higher grass digestibility, but this species did not persist in the same pasture under proper management.

The *Brachiaria* genus originated in Africa and has resistance to acid soils and low fertility [19], allowing it to easily spread by seed and to be highly competitive with weeds [20], which explains the expansion of this type of grass to tropical and subtropical regions of the world [21]. However, cultivated species currently belonging to these genera demand large amounts of fertiliser to persist in the field and to compete with the native species of each region. Exotic species represent the high cost of deployment and maintenance. In Brazil, cultivated forage species originate from Africa (Table 2). Research of these species at the intuited has improved the forage potential of these species. The most cultivated species and that which is of greatest importance to Brazilian livestock are, respectively, *Brachiaria decumbens* and *Brachiaria brizantha* [22]. In Brazil, there is a lack of diversity in the cultivation of fodder plants in 45% of the areas, and 60% of the produced seeds are of cv. Marandu (*Brachiaria brizantha*) [23].

Species	Origin
Brachiaria decumbens	Africa
Brachiaria humidicula	Africa
Brachiaria brizantha	Africa
Panicum maximum	Africa
Penissetum purpureum	Africa
Cynodon sp.	Africa
Andropogon gayanus	Africa

Table 2. Origin of the forage species that are grown in Brazil

A lack of diversity can lead to future problems with pests and diseases, as these species are not natural in that particular region. Due to the large amount of area that is currently planted with these species in Brazil, future losses may occur in the livestock sector due to the lack of diversity of forage species. Brazil has 190 million hectares of grasslands that sustain 209 million cattle, the largest export of meat and the largest commercial cattle herd in the world [24]. According to these authors, the *Brachiaria brizantha*, *B. decumbens*, *B. humidicola* and *Panicum maximum* are the primarily used pastures (Figure 2); therefore, of the few cultivars that occupy a large amount of grazing area, only *Brachiaria brizantha* cv. Marandu occupies 50 million hectares of area in this country. Marandu is apomictic and resistant to leafhoppers-of-pastures [25], which has made this species the most produced in this country. The same mistakes were made as before, with areas being planted with cv. Marandu and with *Brachiaria decumbens,* which is susceptible to this pest. With the leafhopper attack that reduced pasture productivity in Brazil came the need to replace this forage species; the same may happen again with the Marandu. In this country only 0.8% of the grassland areas are planted with native species that are resistant to these natural pest attacks (Figure 2).



Adapted from www.rallydapecuária.com.br

Figure 2. Genus of the forage crops that were grown on farms in Brazil in 2012

In Brazil, there are five species of *Brachiaria* genus that are native and, according to these authors, do not possess forage potential [26]. Conclusions such as this undermine the achievement new research and the use of native species, as studies presenting such species do not evaluate all of the criteria to determine the actual potential forage and thus cannot conclude that these species do not have forage potential.

Studies with native forage species must be conducted to improve the production and nutritional characteristics of these plants so as not to harm their hardiness in relation to soil fertility.

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This fact is identified mainly in tropical and subtropical regions of the world, in which several authors have reported the need for studies with native species in each region. In this context, Hacker et al. [27] report that Australia is required to conduct studies that are related to the improvement of tropical and subtropical grasslands, mainly related to forage species.

There are efforts by multinational companies and researchers to assess fodder plant species in different regions of the world. Care must be taken in this type of approach, as it creates a need the evaluation of a region, which is more profitable for multinational companies that hold the production of these seeds in its area of operation and sale of seeds. In their study, Hare [28] report that the same efforts for distributing forage seeds are being addressed in more than 20 countries in tropical regions of Asia, Africa, the Pacific and Central and South America with the species *Brachiaria ruziziensis*, *B. Decumbens*, *B. Brizantha*, *Panicum maximum*, *Stylosanthes guianensis* and *Paspalum atratum*. The lack of diversity of cultivated forage species in extensive grazing area represents a risk to livestock production in any country that adopts this practice [24].

There is not a single grass species or group of fodder species that is cultivated in any region as a standard species in grazing production systems. Although these species are tolerant of different climate regions, the soil is the determining factor in modifying their fertility to adapt, which is costly. Temperate countries do not seek alternatives elsewhere, but rather study the development of technology with their own native species. In Canada, since 2001, efforts for the reestablishment of native forage species have successfully developed sustainably systems that use native pasture [29]. This example should be followed by countries in tropical and subtropical climates.

In Australia, efforts are being made to encourage the planting of the native species *Themeda australis*, which is considered valuable forage that country, as it is food source for wild and domestic animals, conserves soil and water, decreases the use of exotic species and contributes to the rehabilitation of degraded and polluted [habitats 30]. Studies are underway in Africa and India to spread *Themeda triandra* species, which has physiological and morphological characteristics that are similar to those of Australia.

4. Importance of soil in the pasture production system

The soils in tropical regions are easily eroded and degraded by inappropriate land use, especially when trying to deploy a production system with fodder plants that are not suitable for the region without correcting the soil acidity and without adequate levels of fertiliser use, resulting in the depletion of pasture over time and thereby causing degradation in these areas. The loss of pasture productivity is mainly due to inadequate livestock management and the lack of nutrient replenishment [31]. Pastures in tropical regions are characterised by extensive grazing systems with the application of low levels of nitrogen fertilisers mainly due to unfavourable economic returns and the limited availability of fertilisers [32]. For planting forage species, farmers usually choose soils with severe limitations with regard to features such as natural chemical fertility, acidity and topography [33], because the best soils in terms of fertility and topography are intended for agricultural crops.

The costs of the cultivation of natural species of the region are always lower, although these plants often fail to achieve the production of commercialised exotic species that have high genetic potential. Planted under the same soil and fertility conditions, native and exotic forage plants have differential potentials. Fertile soils with high levels of chemical fertiliser for exotic forage with high genetic potential present greater production compared to that for native forage but with high costs to acquire seeds to achieve the high genetic potential of these plants. Comparisons between native and exotic species are often performed incorrectly; for example, genetically crafted plant species will produce more forage mass per plant than is produced by native plants, and many studies do not assess the cost of production, neglecting the costs of fertiliser. Despite the African continent having a similar climate as that of Brazil, the soil characteristics are different. The nutritional requirements in terms of exotic forage crops that are currently grown are high, excessively increasing the cost of production. Many farmers do not use the recommended fertiliser for forage plants, damaging the permanence of these species in the pasture. The cost fertilising is high because the grassland species that are selected for implantation are discerning. Studies that are performed with these species use high fertilisation, and the species that are evaluated have excellent results in this type of evaluation; however, economic feasibility studies are not performed considering that grazing areas are generally of large tracts.

The degree of adaptation to soil fertility of *Brachiaria brizantha* cv. Marandu leads to the recommendation of a medium nitrogen level of 200-250 kg ha^{-1} (10,000.00 m^2) per year for the Brazilian Cerrado soils [34]. An extensive grazing system with a carrying capacity from 0.5 to 0.8 AU (animal unit=450 kg animal live weight) ha^{-1} according to these authors for the same species would require only 50 kg of nitrogen per hectare (ha) and may reach 350 to 400 kg N ha^{-1} per year for irrigated grazing systems with a carrying capacity of 6-7 AU ha^{-1}.

The cost of fertiliser must be evaluated because every region of the world will have different recommendations for the correction of soil acidity using nitrogen, phosphorus, potassium and micronutrients. It can be seen in Table 3 that the cost of nitrogen fertiliser is different in Brazil and Thailand using the same species of forage crop. In 1980, Seifert reported that in Brazil, the species that were at their peak at the time were *Brachiaria decumbens* and *Brachiaria humidicula* and that these species reached high production on fertile soils. Costa et al. [34] reported that these species are considered to have low soil fertility requirements, with a recommendation of 100 kg ha^{-1} of nitrogen for both of these species. The recommendation of fertilisers has increased over time for the same species; this fact is related mainly to the impoverishment of the soil due to consecutive cultivation using species with high fertility requirements and to the non-replenishment of soil fertility.

In Brazil, due to the use of forages that are exacting with regard to soil fertility and to the inadequate handling of these plants, the degraded areas are increasing, and every year, approximately 8 million hectares are renewed or recovered in this country [24]. Low nitrogen availability in the soil is among the major limitations to the production of forage in tropical and subtropical areas and is one the greatest causes of pasture degradation [32]. Nitrogen is the nutrient that limits productivity, being rapidly depleted by the cultivation mainly of forage species with a C4 metabolic cycle that are characterised by rapid growth and high yields.

Species	Kind	Nitrogen (kg ha^{-1} $year^{-1}$)	U$ ha^{-1} $year^{-1}$	Author
		BRAZIL		
Panicum maximum	Mombaça	307	367.70	Mello et al., 2008
Panicum maximum	Tanzânia	360	431.18	Corrêa et al., 2003
		THAILAND		
Panicum maximum	Mombaça	30	35.93	Hare et al., 2013
Panicum maximum	Tanzânia	30	35.93	Hare et al., 2013

ha: (10,000.00 m^2)

Value of U$: day 30/07/2014 in Brazil

Table 3. Recommendation and cost of fertilisation with nitrogen for *Panicum maximum* in Brazil and Thailand

Soil is an element that must be considered with great caution, because its management is expensive when seeking to make changes in fertility traits. The deployment of species elsewhere may represent higher production costs, as soil suitable must become suitable for the development of exotic species. The production of natural species for grazing is inexpensive because these species are already adapted to the soil and climate of the region, making it unnecessary to correct the soil acidity frequently to raise the base saturation of the soil to high levels, which is a common practice when planting exotic species and represents high costs to the livestock production system. This fact does not indicate that native species do not respond to the use of fertilisers.

In Brazil, many find that exotic forage plants have better forage potential than native or natural species. It is noteworthy that the forage potential encompasses several aspects and not only productivity and chemical composition. In reality, plants with forage potential should submit economic returns to farmers without compromising the integrity of the soil or the environment. How much more productive the most demanding fertility forage plant will be generally occurs with exotic forage species, in addition to the fact that these species are not adapted to the local soil, making it necessary to correct the soil pH to achieve the full potential of these species. Pastures with exotic species that are fertilised with nitrogen have a higher stocking rate than do native pasture species without nitrogen fertiliser [35]. This type of comparison is incipient because the native pasture was not fertilised and cannot be compared to a species under the influence of fertilisation. The native forage species tolerate low soil fertility and have a high response to fertilisation [36].

Intensive soil tillage may represent high costs for a production system that still has expenses for animal production. Rating adaptations to acidity and soil fertility were performed with the plant species that have been classified according to the degree of need for adaptation and fertiliser. This criterion is valid for identifying classes of soils in relation to base saturation and levels of phosphorus and potassium in the soil for many forage species [37]. Exotic species with high genetic potential are generally classified as the most demanding.

5. Nutritional differences

The interrelationship among the elements existing in an ecosystem for a forage species in a given region is more complex than for human consumption species because the animals of each region depend on this interrelationship to survive and influence the natural selection of species through grazing. The nutritional value of exotic species that are grown is undoubtedly superior to native species because these species have been enhanced to provide greater production and nutritional value for animals, while the native have been neglected by research. The nutritional value of exotic forage species does not justify the replacement of native species, although this value is used by many researchers and technicians to justify the introduction of exotic species in systems of grazing production [38]. More than one variable should be considered in the choice of forage; even if that species has a superior nutritive value than that of the native species, the nutritional parameter of an individual plant cannot define which exotic species is a better choice than the native species.

The existence of anti-nutritional factors in native pastures has been questioned by many researchers who report that these factors may be obstacles to animal nutrition at pasture [39], but research should be performed to improve these species to decrease the levels of these compounds, as is done with the exotic species with a high genetic potential. In a study evaluating the quality of native forages in Canada, native species during the dry season of the year were enough to maintain livestock [40]. Native species provide a differential characteristic in the products that are generated by grazing. Native species in a region provides characteristics and peculiar flavours to the products that are generated by the animals, valuing the product in the marketing. An appreciation of animal products exists in which animals graze native forages and are internationally known and marketed for a higher price. Thus, the low productivity of cattle is the main problem when trying to produce animals on pasture with native species, but this can be overcome by asking the highest price when marketing the generated products.

6. Conclusion

The cost of production is the decisive factor in choosing a forage species, especially in relation to the requirement of the plant in relation to soil fertility. The choice of forage species must be made with caution, especially when using exotic species with a high genetic potential. Native forage species are viable options for use in a production system with grazing animals. These species are already adapted to the characteristics of the soil and do not require changes to soil fertility, unlike exotic species. It is necessary to conduct further studies with native forage

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species in each region, especially in regions with a tropical climate. The use of native species in grasslands maintains an ecologically balanced environment because it preserves local biodiversity.

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