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Original article

Effect of woody plant removal in herb-subshrub communities in preserved and disturbed Brazilian Chaco areas

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ABSTRACT

The impacts caused on Chaco plant communities by the removal of woody species, together with the effects on the composition and functional structure of herbaceous plants, are still unknown. Therefore, this study aimed to assess the effects of anthropization on herb-subshrub communities in preserved and disturbed Chaco areas. Specifically, we examined differences and similarities in species diversity, composition and proportion of life forms in eight areas of Brazilian Chaco. Samples were taken from herb-subshrub communities using 800 1x1m² plots located in disturbed and preserved areas. Among 130 recorded species, 46 were exclusive to disturbed areas. The composition of species differed between preserved and disturbed areas (PERMANOVA; $p = 0.001$). PCoA ordination analysis showed greater aggregation of the plots in disturbed areas than in preserved areas. In preserved areas, an analysis of indicator species showed Hemicryptophytes species as the most representative life form. In disturbed areas, the proportion of life forms among indicator species was Hemicryptophytes, followed by Therophytes and Chamaephytes. Our study shows evidence that alterations in species composition, structure, and diversity, as well as sets of indicator species, occur in herb-subshrub communities. The removal of trees and bushes leads to a new configuration of this component in Chaco environments.

Keywords: anthropization, Chaco vegetation, functional structure, herbaceous plants, indicator species, life form, plant communities, richness, thorn forest

Introduction

The potential regeneration of vegetation in anthropogenic areas has been investigated in different ecosystems using richness, floristic composition, structure, functional traits and life forms (De Wasseige & Defourny 2004; Behera & Misra 2006; Felton *et al*. 2006; Santos *et al*. 2013). During the last few decades, anthropogenic activities, such as farming with the expansion of agricultural and cattle breeding areas and wood extraction for construction or fuel (Nyssen *et al*. 2004; Zak *et al*. 2004; Cinquini *et al*. 2011), have reduced the natural resources available and impaired the regenerative potential of natural systems and even

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their ecological features (De Wasseige & Defourny 2004). Anthropogenic disturbances are well known to impact the biodiversity and structural characteristics of a community (Mishra *et al*. 2004).

The general thought - according to global data - is that removing woody plants results in ecosystem improvement, which is a controversial issue because removal can have distinct ecosystem effects (Ding & Eldridge 2019). Analyses of the ecosystem structure on a global scale show an increase of herbaceous plant cover and density with the removal of woody plants (Ding & Eldridge 2019). However, in determined areas, values of richness (Blanco *et al*. 2005) and cover (Allegretti *et al*. 1997) of herbaceous species can remain unchanged or even decrease (Behera & Misra 2006) with the removal of woody plants.

The herb-subshrub component integrates important South American ecosystems, such as Cerrado, Caatinga, Pampa and Chaco domains, as well as Pantanal wetland (Batalha & Martins 2002; Overbeck *et al*. 2007; Pott *et al*. 2011; Santos *et al*. 2013; Sartori *et al*. 2017). The relevance of this in both biological and economic terms can be tested by the potential use of the herb-subshrub component as native pastures. More than 50 % of the richness of the herb-subshrub component is represented by fewer than ten botanical families in the five systems found in the Brazilian territory (Batalha & Martins 2002; Overbeck *et al*. 2007; Pott *et al*. 2011; Santos *et al*. 2013; Sartori *et al*. 2017). We have just begun to assess the herb-subshrub component in the context of anthropogenic activities in South American tropical and subtropical environments (Felton *et al*. 2006; Santos *et al*. 2013; Vieira *et al*. 2015; Santos *et al*. 2018).

In particular, Chaco vegetation types have been exposed to strong anthropization (Cinquini *et al*. 2011), especially from extensive livestock farming (Zak *et al*. 2004). Some tree species have been affected by the degree of tannin extraction, and others, such as thorny plants, have been removed as an economic nuisance. Such practices have endangered plant formations known as subtropical seasonal spinous forests (UNESCO 1973) where xerophytic plants, which characterize the Chaco region, are prevalent (Cabrera & Willink 1980).

The natural areas of Chaco have been altered by overgrazing of the herb-subshrub component. This use sharply decreases grass forage resulting in an increase of pressure from cattle browsing on shrubs and tree seedlings. A cascade effect ensues and is characterized by the decrease, or disappearance, of herbaceous cover, proliferation of a few woody species (*e.g.*, *Prosopis ruscifolia* and species of the genera *Celtis* and *Vachellia*, among others) and impoverishment of forage grasses (Fernández & Busso 1999).

Thus, in certain areas of the Chaco, mechanical manipulation, chains, or roller chopping have been used to prevent or control the proliferation of certain tree species in order to increase grazing areas (Fernández & Busso 1999; Rossi 2010). A study in the arid Chaco region (Blanco *et al*. 2005) has shown no change in species richness after removing woody plants. However, increases in the cover of herbaceous-shrub layer resulted from planted grasses and were not associated with the native grasses (Blanco *et al*. 2005).

The effect of different management regimes on species composition, community structure, and plant diversity of forests is difficult to quantitatively compare (Wen *et al*. 2016). Identifying the changes that plant communities undergo is a key step toward recovering woodland remnants and conserving biodiversity. In certain phytophysiognomies of Chaco, it is worth noting that herb-subshrub communities are responsible for high species richness (Freitas *et al*. 2013; Sartori *et al*. 2017; Aguillar *et al*. 2018).

Different life forms are recognized in plant communities throughout the world and account for different adaptations of plants to the environment (Box 1987; Tarhouni *et al*. 2015), each contributing with its own traits to balanced ecosystem function (Khan *et al*. 2018). For instance, in open physiognomies of South American systems, such as the Cerrado, the prevalent life form is the Hemicryptophytes, while in closed physiognomies, it is the Phanerophytes (Batalha & Martins 2002). In the Caatinga, the prevalent life form is Therophytes (Araújo *et al*. 2011; Costa *et al*. 2007; Santos *et al*. 2013). The few studies that have reported on life forms in areas such as the Chaco (Blanco *et al*. 2005; Freitas *et al*. 2013; Aguillar *et al*. 2018) directly address the growth habit or other morphological characteristics easily recognized in plants (Blanco *et al*. 2005; Aguillar *et al*. 2018), but that diverged from life forms recognized by the Raunkiaer system, which is a precise tool for comparing plants among different ecosystems.

The impact of anthropogenic activities on Chaco plant communities by the removal of woody species, as well as the effects on the composition and functional structure of herbaceous plants, remains to be elucidated. The removal of trees can result in a higher number of herbaceous species because the opening of the canopy may favor the colonization of these plants (Devi & Behera 2003). A positive effect on the development of herbaceous species has been found in areas of shade provided by more isolated trees or those that are spaced apart, whereas shade provided by a high density of woody plants that are close together negatively affects herbaceous populations (Riginos *et al*. 2009; Andrade *et al*. 2015).

Since anthropogenic activities continue to pose a threat to herb-subshrub communities in Chaco, we set out to determine differences and similarities in richness, diversity, composition and proportion of life forms of the anthropogenic communities compared to preserved areas. We expected that richness would be greater in disturbed areas since the removal of trees would allow for a greater penetration of light favoring herb-subshrub communities. This would also be true for diversity and differences in composition. We also expected to identify

Hemicryptophytes and Therophytes as the dominant life forms, as in other Chaco areas (Freitas *et al*. 2013), since such plants predominate in sites with open physiognomies.

Materials and methods

Study area

This study was carried out in Chaco areas located within the boundaries of the town of Porto Murtinho city (21°42'04" S, 57°53'06" W) in the southern Midwest region of Brazil, Mato Grosso do Sul state (Fig. 1). The vegetation in the area is classified as Chaco woodland (Fig. 2). The study areas are characterized by sparse, gnarled, spinescent, 5-meter-tall trees, on average (Cabrera & Willink 1980), and a continuous herbaceous layer, making this phytophysiognomy even more endangered since the land is easily deforested and converted into pastures (Silva *et al*. 2008). The climate is the Awa type (Köppen 1948) with rainfall concentrated between November and February and a dry period between March and October. Mean rainfall is 900 mm/year and temperatures range from 18 to 25 °C (CEMTEC - Monitoring Center for Weather, Climate and Water Resources of the State of Mato Grosso do Sul, Brazil). Soil is planosol, with high clay and salt content (Brasil 1982), and it is characterized by slow drainage (Santos *et al*. 2011).

We selected eight areas, four in preserved environments (Fig. 2A) and four in disturbed environments (Fig. 2B). The replicates for each situation are located on different properties or in distant areas on the same farm. We named as disturbed those areas where some Phanerophytes (woody) plants were removed 20 years ago to create grazing land. On the other hand, areas considered preserved had no vegetation removed. The removal of some woody species was reported by farmers as an intervention in the areas disturbed. Cattle can freely graze on disturbed areas where trees have been removed. Information on the vegetation extracted in the selected areas was obtained by consulting with owners and analyzing satellite images. Generally, the areas considered preserved in this study had lower use for cattle grazing than those areas considered disturbed, but all of these areas were used for cattle ranching.

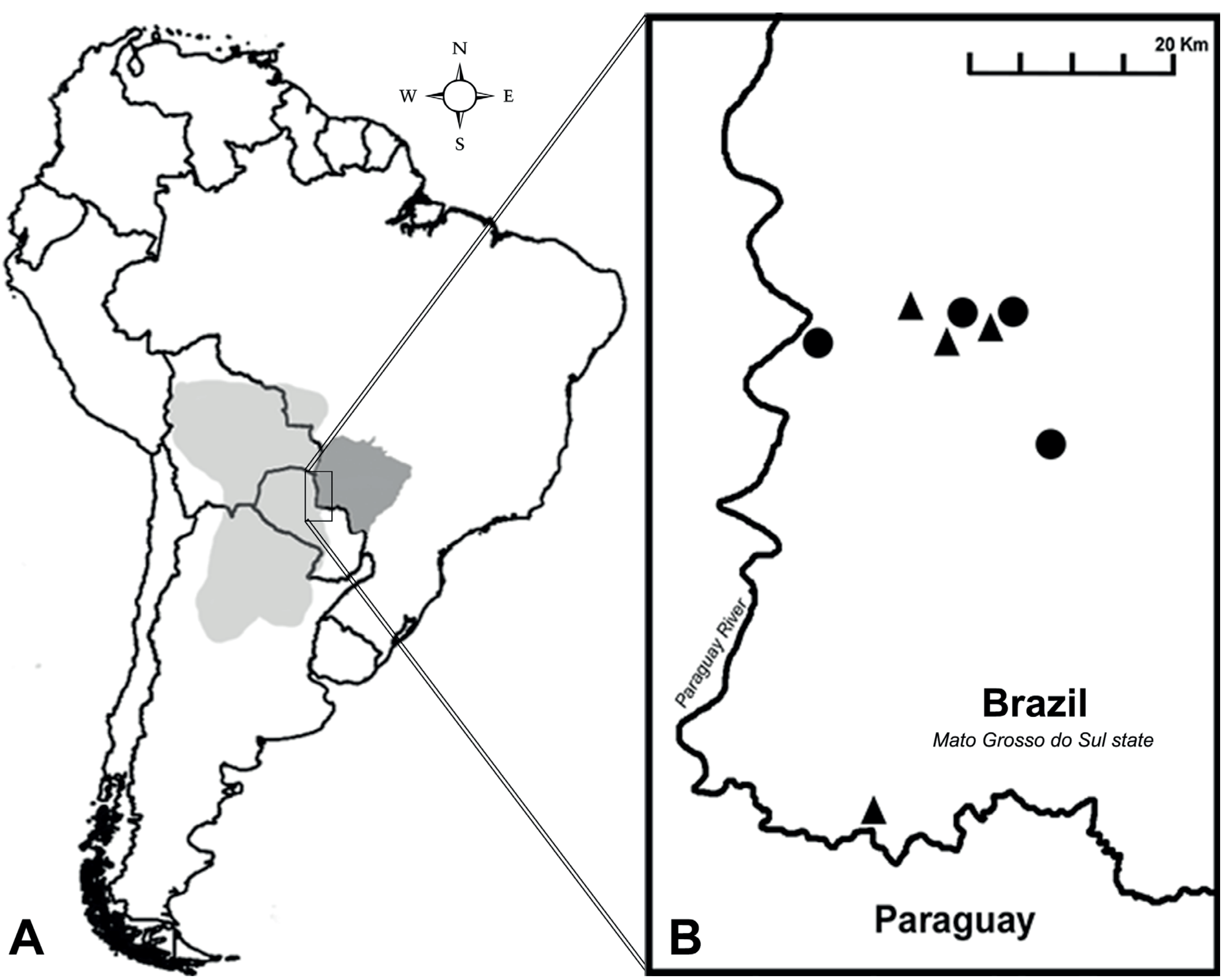

Figure 1. Location of Chaco in South America (**A**) and distribution of preserved (▲) and disturbed (●) areas (**B**) in Brazilian Chaco.

Figure 2. Images of study areas: preserved (**A**) and disturbed (**B**) areas.

Vegetation sampling

Fieldwork was carried out from June to September 2011 and from October 2011 to February 2012. We sampled a total of 800 m² of herbaceous and sub-shrub vegetation. In each area, we delimited 1 ha and randomly established 100 plots. The cover of each species was estimated inside the 1 x 1 m plots, and no scales were used. Only estimated percent of cover was noted in fieldwork. The cover of bare soil, litter and water were also recorded. Percent of cover was always estimated by the same person to avoid bias.

All specimens with branches without lignification were classified as herbaceous plants, in addition to those plants with partially lignified branches, growing between five centimeters and one meter, above soil level, and measuring less than one meter, and considered as subshrubs according to Whittaker (1975). At least one specimen per species was collected for taxonomic identification. The main life forms of the collected species were classified according to Raunkiaer, as adapted by Martins & Batalha (2011). Hemicryptophytes were defined as plants with buds at, or near, the soil surface, usually protected by scales, sheaths, or leaves. Therophytes were considered annual plants. Chamaephytes were characterized as plants with perennial buds above the soil surface, at a maximum height of 25 cm, while Geophytes were characterized as plants with underground buds. Only species at the adult stage, with flowers and/or fruits, were considered, and these plants were classified during botanical collections. Collected specimens were deposited in the CGMS herbarium of the Universidade Federal de Mato Grosso do Sul.

The definitions and classifications of plant origin, including native, exotic and invasive species, were obtained from Richardson *et al.* (2000). Plants occurring naturally in the region without any kind of human intervention were considered to be native. Plants in a given area determined to be intentional or accidental because of human activity were classified as exotic. Data on exotic and native plants were obtained from the Brazilian Flora Checklist (BFG 2015) and from the database of the herbaria.

Statistical analyses

The phytosociological parameters estimated in each plot were relative frequency (RF) and relative cover (RC), the sum of which yields the importance value (IV) (Damasceno-Junior & Pott 2011). The cover percentage of each species was estimated by the area they occupied. Shannon's index (H') was used to determine diversity based on relative cover values. Differences between Shannon index values for each area were verified by the *t*-test for diversity index (Hutcheson 1970), using the eight areas as sample units and mean values of cover for each area.

The chi-squared test (Zar 1999) was used to determine any variance of frequency distribution between environments using Raunkiaer's biological spectrum. A matrix was built with the percent cover of each species sampled per plot, in both preserved and disturbed areas. We used a PERMANOVA analysis to verify differences in species composition between the two states of conservation considered in the study. This analysis was run as a mixed model using the plots as sample units and the eight areas as a random factor. The PERMANOVA analysis was performed using the Adonis function in the vegan package (Oksanen *et al.* 2017). The differences were shown graphically using a Principal Coordinates Analysis (PCoA) analysis with Bray-Curtis distance, also performed in the vegan package (Oksanen *et al.* 2017).

An Indicator Species Analysis (ISA) was performed to determine which species were indicative of each sampled conservation status. This analysis was performed using the indicspecies package (De Cáceres & Legendre 2009). The indicator species resulting from analysis were grouped by life form to verify differences in life forms among the indicator species for both preserved and disturbed areas. All analyses were performed using R language (R Development Core Team 2017).

Results

Floristic and richness

A total of 130 species, classified into 88 genera and 33 families, were sampled in the present study (see Tab. S1 in supplementary material). Sixty-three species were common to both sampled areas. Differences in species richness were detected between categories. In the preserved areas, we found a total of 84 species, 21 of which were exclusive and thus classified into 69 genera and 20 families. The most representative families were Poaceae (14 species), Cyperaceae (7), Fabaceae (6), and Malvaceae (6). The richest genera were *Portulaca* (4 species) and *Paspalum* (3). The percent cover of bare soil was recorded as 20.7 %, the percentage of litter as 15 %, and the percentage of flooded land as 4.2 %. Four species were classified as aquatic. In the disturbed areas, we recorded 109 species, 46 of which were exclusive and thus classified into 80 genera and 27 families. Poaceae (18 species), Malvaceae (11 species), and Fabaceae (10 species) were the most representative families. *Sida* (6), *Cyperus*, *Paspalum* and *Portulaca* (4 each) were the most common genera. The percentage cover of bare soil was 23 %, the percentage of litter 16 %, and the percentage of flooded land 1 %. Twelve species were classified as aquatic.

Community structure

Species with the highest IV were *Selaginella sellowii* (IV=31.070), *Tripogonella spicata* (IV=13.779), and *Urochloa adspersa* (IV=7.891) in the preserved areas and *Selaginella sellowii* (IV=20.586), *Urochloa adspersa* (IV=12.973), and *Chromolaena lilacina* (IV=6.391) in the disturbed areas. Four species were classified as non-native: *Boerhavia erecta* and *Megathyrsus maximus* in the disturbed areas, and *Urochloa adspersa* and *Portulaca gilliesii* in both areas. Among these, only *Urochloa adspersa* was recorded with high values of RF, RC and IV in both areas.

Shannon's diversity was relatively high in disturbed (H'=3.07 nats.individual^{-1}) compared to preserved (H'=2.70 nats.individual^{-1}) environments (Hutcheson *t*-test, p < 0.0001). Equitability of Pielou was J'=0.60 and J'=0.65 in the disturbed and preserved areas, respectively. A more than 50 % decrease in relative cover was recorded for *Tripogonella spicata* and *Steinchisma laxum* in the disturbed areas, and a 22 % to 16 % decrease was recorded in the relative cover of *Selaginella sellowii* from preserved and disturbed areas, respectively.

The two sampled areas were different in composition and percent cover of species (PERMANOVA p = 0.001). In PCoA analysis (Fig. 3), disturbed areas were more similar, and in preserved areas, they were more dispersed in the first axis.

Life Forms

In both sampled areas, the most representative life forms were Hemicryptophytes, followed by Therophytes, Chamaephytes and Geophytes (Fig. 4A). However, no significant differences were observed between the two sampled areas (x^2=98.74; p>0.05). Nevertheless, when we consider only the cover of indicator species (Fig. 4B), these proportions were not the same for the two researched situations (x^2 = 8.16, p = 0.04).

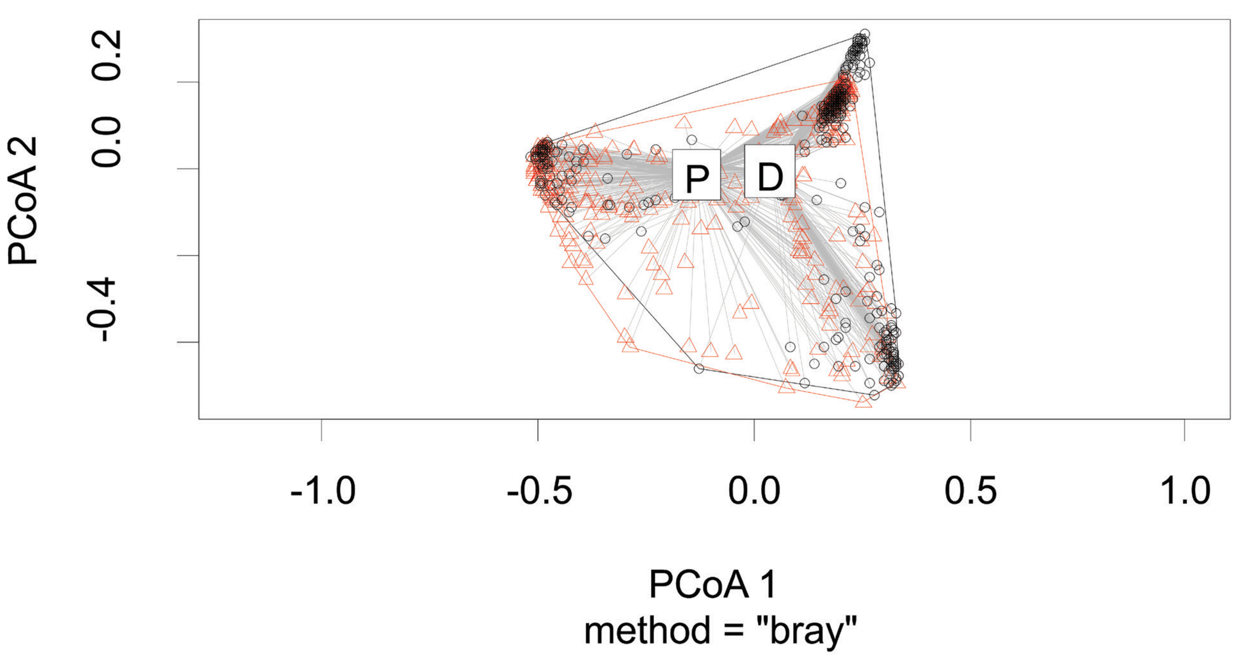

Figure 3. Principal coordinates analysis using Bray-Curtis distance applied to the percent cover of species matrix per plot in Brazilian Chaco. The black circles are the disturbed plots (D), and red triangles are the preserved (P) plots.

Indicator Species Analysis revealed 27 species indicative of the disturbed areas and 19 indicative of the preserved areas (Tab. 1). Hemicryptophytes (68 %) were the most representative life form among indicative species in preserved areas, and Chamaephytes (5.2 %) were the lowest (Fig. 4). In disturbed areas, the proportion of cover of life forms among indicative species was similar for Hemicryptophytes (40 %), Therophytes (33 %) and Chamaephytes (22 %) (Fig. 4).

Table 1. Group of Indicator species of preserved and disturbed areas in the communities of Brazilian Chaco with respective indicator values and life forms of each species.

Preserved areas	Species	Status	p.value	sign	Life form
	Arachis lignosa	0.348	0.001	***	Hemicryptophytes
	Steinchisma laxum	0.311	0.001	***	Hemicryptophytes
	Tripogandra glandulosa	0.297	0.001	***	Therophytes
	Froelichia procera	0.261	0.001	***	Hemicryptophytes
	Stachytarpheta indica	0.259	0.001	***	Hemicryptophytes
	Dianthera laevilinguis	0.246	0.001	***	Hemicryptophytes
	Paspalum plicatulum	0.23	0.001	***	Therophytes
	Kyllinga odorata	0.208	0.016	*	Geophytes
	Cleistocactus baumannii	0.205	0.008	**	Hemicryptophytes
	Leptochloa neesii	0.2	0.002	**	Hemicryptophytes
	Scoparia montevidensis	0.197	0.012	*	Therophytes
	Cyperus luzulae	0.195	0.001	***	Hemicryptophytes
	Chromolaena odorata	0.188	0.002	**	Therophytes
	Paspalum coryphaeum	0.167	0.002	**	Hemicryptophytes
	Alternanthera ficoidea	0.159	0.004	**	Hemicryptohytes
	Alternanthera sp	0.142	0.007	**	Hemicryptohytes
	Chloris canterae	0.123	0.029	*	Hemicryptohytes
	Croton trinitatis	0.123	0.033	*	Chamaephytes
	Sacciolepis vilvoides	0.123	0.028	*	Hemicryptohytes
Disturbed areas					
	Chromolaena lilacina	0.427	0.001	***	Chamaephytes
	Selaginella convoluta	0.361	0.001	***	Hemicryptophytes
	Evolvulus sericeus	0.333	0.001	***	Terophytes
	Galactia latisiliqua	0.333	0.001	***	Hemicryptophytes
	Sida acuta	0.318	0.001	***	Chamaephytes
	Sida ciliaris	0.311	0.001	***	Hemicryptophytes
	Commelina benghalensis	0.31	0.001	***	Therophytes
	Alternanthera cf. *paronichyoides*	0.298	0.001	***	Hemicryptophytes
	Hyptis brevipes	0.267	0.001	***	Therophytes
	Croton longicolumellus	0.257	0.001	***	Chamaephytes
	Portulaca pilosa	0.242	0.001	***	Therophytes
	Waltheria indica	0.219	0.001	***	Chamaephytes
	Croton lundianus	0.207	0.001	***	Chamaephytes
	Croton bonplandianus	0.201	0.001	***	Chamaephytes
	Portulaca grandiflora	0.189	0.001	***	Therophytes
	Euphorbia thymifolia	0.188	0.02	*	Therophytes
	Commelina diffusa	0.188	0.001	***	Therophytes
	Cyperus surinamensis	0.159	0.004	**	Hemicryptophytes
	Mollugo verticillata	0.157	0.002	**	Therophytes
	Gomphrena celosioides	0.14	0.012	*	Therophytes
	Eleocharis cf *nudipes*	0.133	0.011	*	Hemicryptophytes
	Fimbristylis dichotoma	0.133	0.007	**	Hemicryptophytes
	Megathyrsus maximus	0.113	0.031	*	Hemicryptophytes
	Paspalum cf *chacoense*	0.113	0.035	*	Hemicryptophytes
	Petalostelma robertii	0.113	0.036	*	Chamaephytes
	Stylosanthes hamata	0.113	0.037	*	Hemicryptophytes
	Paspalum virgatum	0.101	0.05	*	Hemicryptophytes

*** = probability of the species not being an indicator is null, ** = probability of the species not being an indicator is less than 0.001, * = probability of the species not being an indicator is less than 0.05.

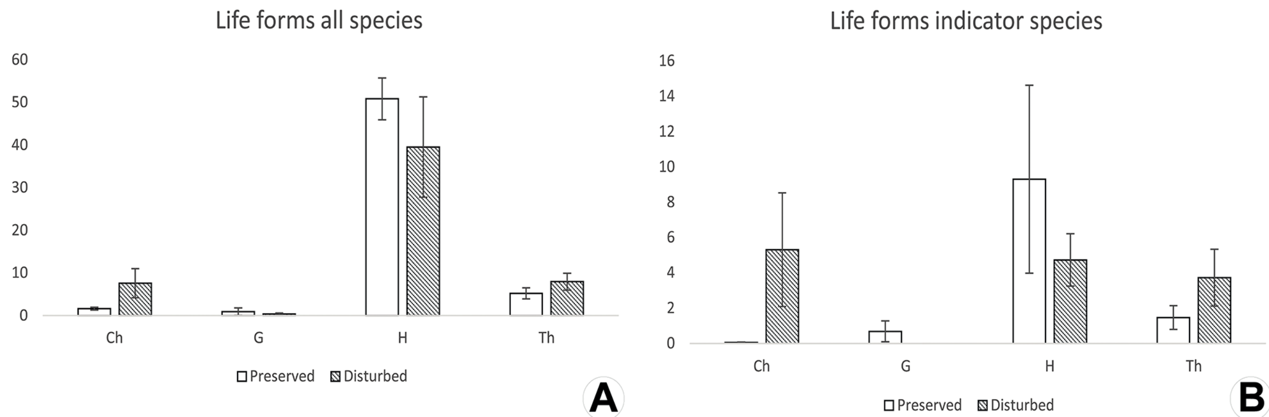

Figure 4. Participation of life forms of herbs and subshrubs in the preserved and disturbed areas in Chaco, Brazil. Life forms of all species in the preserved and disturbed areas (**A**) and life forms of the Indicator species in the preserved and disturbed areas (**B**). Chamaephytes (Ch), Hemicryptophytes (H), Geophytes (G), Therophytes (Th). Preserved areas (white bars). Disturbed areas (cracked bars). Values in Y axes refer to the cover percentage of the species.

Discussion

Floristic and richness

Species richness was higher in disturbed environments with data revealing 42 % of species to be exclusive to these areas. Besides, changes in floristic composition are clear at different taxonomic levels as families and genera when comparing preserved to disturbed areas. Four families accounted for 39 % of species richness in preserved areas, and three families accounted for 35 % of species richness in disturbed areas. Families, such as Fabaceae, Poaceae and Malvaceae, are among the most representative as determined by research conducted in the Brazilian Chaco (Sartori *et al*. 2017). The family with the second highest richness in preserved areas, Cyperaceae, is not particularly present in disturbed areas where Malvaceae and Fabaceae hold the second position in richness after Poaceae. Cyperaceae species usually produce many seeds with high viability, and many species have a rather ruderal character, accounting for their prominent presence in disturbed areas. However, several species in this family also have a preference for environments with a higher humidity (Pott *et al*. 2011), according to observations in some of the studied areas in Chaco. Morphophysiological adaptations in representatives of these families should favor the colonization of areas in the Chaco because of their specific morphological characteristics, types of reproduction and dispersion (Fryxell 1997; Sprent 2007; Baptista *et al*. 2020).

Disturbed areas can show greater species richness in all plant communities (Ding & Eldridge 2019) or in herbaceous communities (Ansley *et al*. 2006; Santos *et al*. 2013). Differences found in this study regarding the higher cover and richness of herbaceous plants in disturbed areas showed that the availability of light owing to the removal of trees is an important factor for the increase of these plants. Our results agree with other researchers who have recorded higher richness and cover of herbaceous plants in open physiognomies with higher incident sunlight and lesser canopy cover (Whittaker 1972; Riginos *et al*. 2009; Andrade *et al*. 2015).

Trees with narrow leaves, frequent and sparse in disturbed areas, such as *Mimosa hexandra* and *Parkinsonia praecox* (Lima 2012), favor higher incident light and could have contributed to the diversification of herbaceous components. Conversely, trees with large leaves, such as *Castela coccinea* and *Cynophalla retusa* (Lima 2012), in preserved areas probably favored the greater richness of ombrophilous species, such as *Tripogandra glandulosa* and *Dianthera laevilinguis*, which were present in the shaded plots.

Community structure

In disturbed areas, IV showed a substantial increase of some species and reduction or non-occurrence of others. The cover area of determined species such as *Tripogonella spicata*, *Steinchisma laxum* and *Selaginella sellowii*, which occur naturally in Chaco preserved areas, has been drastically reduced in disturbed areas. The decrease in cover of these species may be related to the establishment of non-native species or groups of emerging plants that have the same biological attributes as their competitors (Woodward & Cramer 1996). *Urochloa adspersa* has been cultivated as pastures in determined Brazilian Chaco areas. This species of African origin is well suited to the grassland of the New World. The dispersal mode and reproduction of this species particularly favor its quick colonization. Our data show an increase in coverage of this species in the disturbed area (OR = 8.54) compared to the preserved area (OR = 3.648), indicating that the disturbed areas may be susceptible to competitions with non-native plants. Besides, *Urochloa adspersa* has a high adaptive capacity and can even modify the environment where it settles (D'Antonio & Vitousek 1992).

Life Forms

Hemicryptophytes and Terophytes were prevalent in an area of the humid Chaco (Freitas *et al*. 2013), totaling more than half of the studied species in the community. In this study, 74 % of species were identified in two categories of life forms with prevalence of the Hemicryptophytes. Longer-lived species, with the presence of buds at, or near, the soil surface, usually protected by scales, sheaths, or leaves (Hemicryptophytes), should represent an efficient strategy for maintaining a significant percentage of herb and shrub Chaco communities. Furthermore, Hemicryptophytes species mainly correspond to plants that form continuous cover on the ground in the Chaco open physiognomies. The life forms were classified as annual grass and forb, shrub, and tree, among others, in areas of the Arid Chaco (Blanco *et al*. 2005). The authors reported Raunkiaer's life forms, but it was not clear whether the plants were classified according to the relationships between the position and degree of protection of the buds and the growth surface. Other authors (Aguillar *et al*. 2018) determined life forms by categorizing species as woody or non-woody in fragments of the subtropical Chaco. In their classification, it is likely that these authors used the types of growth forms according to Whitakker (1975), such as trees, shrubs, herbs, lianas, epiphytes and thallophytes. The use of other classification systems makes it difficult to compare the data. The more acceptable mode for classifying life forms should follow Raunkiaer´s system.

Studies carried out in the Cerrado and Caatinga indicated the Hemicryptophytes (Batalha & Martins 2002) and Therophytes (Costa *et al*. 2007; Araújo *et al*. 2011; Santos *et al*. 2013), respectively, as the most representative life forms of open physiognomies in both systems (Cerrado and Caatinga). Hemicryptophytes, Therophytes and Chamaephytes were also increased in protected areas of a Tunisian park (Tarhouni *et al*. 2015) characterized by the authors as having harsh climatic conditions, such as high temperature and low rainfall. The data of our study may also reflect the adverse weather conditions of the Chaco characterized by a climate with marked seasonality where winter can cause low temperatures and where frost episodes are estimated to occur up to 5 times per year. Therophytes and Chamaephytes are plants more adapted to drought that usually lasts about 6 to 8 months in the Chaco. Chamaephytes are more resistant to drought by reducing their transpiration and assimilation organs and conserving their vegetative organs (Box 1987). Geophytes did not show variation between the two sampled areas studied. This life form has underground buds protected by bulbs, corms, rhizomes, tuberous roots and swollen taproots, structures that store water and nutrients. In the Chaco, water and nutrients are available in soil; therefore, a low occurrence of this life form is expected.

The occurrence of determined life forms, such as Therophytes, Chamaephytes and Geophytes, shows no changes between the anthropogenic and conserved areas in the Caatinga (Santos *et al*. 2013), indicating that these life forms are independent of the conservation level of the habitat. Despite no significant differences observed between the life forms, it is important to highlight the sets of indicator species of the two sampled situations. Even though some species do not show high values of RF, RC and IV in preserved environments, it is worth stressing that they are all indicator species of disturbed areas. Among the indicator species, several have a greater IV in each sample area studied (IV=1.6 - > 3.0). We observed that life forms of the indicator species in preserved areas had changed with a high reduction of Chamaephytes and Therophytes. In addition, in disturbed areas, the Chamaephytes were the most representative among the indicator species.

The removal of trees and shrubs contributed to the differences in species composition, structure and diversity. The prevalent life form was Hemicryptophytes between the two studied areas. However, the sets of indicator species were different in life forms between preserved and disturbed areas. We expected that the proportions of life forms would be the same as those found for the entire vegetation in the two studied situations. However, it is apparent that the particular use of an area can create a tendency for determined life forms to be favored, but that can only be confirmed by studying the different species in such an area.

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