# THE PHYTOSOCIOLOGY OF WEEDS IN AGROFORESTRY SYSTEMS IN DIFFERENT TYPES OF AMAZONIAN FOREST COVER

**ABSTRACT:**

Agroforestry systems are examples of soil exploration that are closest to the natural form of the forest, with consortia of several species within an area, thus being sustainable alternatives. Therefore, the objective of this work was to evaluate the weed community in agroforestry systems in two ecosystems: terra firme and várzea in the state of Pará. This was done in eight areas, with one hectare each, cultivated in agroforestry systems, four land areas, and four lowland areas, in the rural area of Cametá-PA. Four plots of one square meter per area were randomly sampled, where the species were identified, counted, and taken for weighing, to evaluate the weed community. Among the evaluated environments, the species that stood out the most in the mainland environment was the *Kyllinga brevifolia*, leading most of the indexes evaluated. In the lowland ecosystem, the species *Brachiaria purpuracens* was the most relevant.

**Keywords**: Weed community, agroecosystems, sustainable agriculture, *Brachiaria purpuracens*



## INTRODUCTION

The forest cover in the Pará Amazon is configured in floodplain forest, whose vegetation occurs along rivers and floodplains sheltering animals and plants adapted to seasonal hydrological conditions, and also by terra firme forest, with complexity in composition, distribution, and density of species [1]. However, the disorderly

exploitation of both floodplain and upland forests has caused significant damage to the vegetation of these environments [2].

The Agroforestry System emerges as a sustainable alternative for agriculture in degraded environments, because besides presenting great potential for reducing soil erosion, it has potential for soil recovery, increases productivity, and contributes to food security in a scenario of climate change [3].

In agroforestry systems, the production components are allocated to be efficient and sustainable, so that they use the production factors with the least competition between them. However, the appearance of weeds can compromise the balance of production factors by competing with them for growth [4].

The phytosociological analysis has stood out in obtaining knowledge about the populations and biology of weed species as an important tool in the technical basis of management recommendations and cultural treatments for deployment and conduct of crops [5]. Thus, the phytosociological survey results in a list of species distributed in hierarchical ways, according to their position relative to the others, allowing the quantitative interpretation and ecological relationships of the weed community [6].

In this context, this work aimed to evaluate the weed community in areas under agroforestry systems, in two Amazonian Forest covers: dryland forest and floodplain forest.



## MATERIAL AND METHODS

This work was in the period from October to November 2018, in rural areas of the municipality of Cametá, located in northeastern Pará, a microregion of lower Tocantins. Eight agricultural areas conducted in agroforestry systems with an

average size of one hectare each were evaluated, being four areas of terra firme forest and four of várzea forest.

In each evaluated area, four sample plots of one square meter were randomly admitted for weed community analysis [8]. Then, the weed species contained in the adopted plots were collected by pulling them from the soil and later taken to the laboratory to be quantified and weighed.

The identification of plants collected in the field was done by consulting specialized literature [9,10]. When identification was not possible, they were sent to the Emilio Goeldi Museum (Belém-PA) identification.

Based on the data collected from the species present in the analyzed areas, the following phytosociological indices were determined: density (Den), relative density (DenR), frequency (Fre), relative frequency (FreR), abundance (Abu), relative abundance (AbuR), relative fresh mass (MF) value of importance index (IVI) and the relative value of importance index (IR). The Microsoft, Office Excel® program was used to perform descriptive analysis and obtain tables and graphs of frequency analysis, relating to the floristic composition of the weed communities. The following formulas were used to calculate the variables according to [11]:

$$Den\ (plantas\ .m^{-2}) = \frac{N^{o}\ \text{total number of individuals per species}}{\text{Total area collected}}$$

$$DenR\ (\%) = \frac{\text{Species density x 100}}{\text{Total density of totas species}}$$

$$Fre = \frac{\text{Number of plots containing the species}}{\text{Total number of samples used}}$$

$$FreR\ (\%) = \frac{\text{Frequency of species x 100}}{\text{Total frequency of totas species}}$$

$$Abu = \frac{\text{Total number of individuals per species}}{\text{Total number of plots containing the species}}$$

$$AbuR\ (\%) = \frac{\text{Species abundance x 100}}{\text{Total abundance of totas species}}$$

$$MF\ (\%) = \frac{\text{Fresh pasta x 100}}{\text{Total fresh mass of totas species}}$$

## RESULTS AND DISCUSSION

In the evaluated sites, both on terra firme forest and floodplain areas, 881 plants were found, represented by 48 species and divided into 19 botanical families, as presented in (Table 1). The monocotyledons showed a higher percentage (52%) compared to the eudicotyledons, the Poaceae family (monocotyledonous) was the most representative, with about (23%) of the weed community found in both ecosystems, followed by the Cyperaceae family with 19%, besides Arecaceae with five and Melastomataceae with three species. Amaranthaceae, Euphorbiaceae, Lamiaceae, Malvaceae and Urticaceae had two species each. The remaining families were represented by only one individual.

**Table 1.** Weed communities are found in areas of terra firme and várzea agroforestry systems in the municipality of Cametá-PA.

| \ | scientific name | popular name | Group | occurrence |
|---|---|---|---|---|
| Amaranthaceae | *Cyathula prostrata* Blume | Foxtail tick | Eudicotyledonous | Terra Firme |
| | *Amaranthus deflexus* L. | Caruru-rasteiro | Eudicotyledonous | Terra Firme |
| Arecaceae | *Montrichardia linifera* (L.) Schott | Aninga-de-várzea | Monocot | Várzea |

| | | | | |
|---|---|---|---|---|
| | *Montrichardia arborescens* (L.) Schott | Aninga-de-várzea(2) | Monocot | Várzea |
| | *Mauritia flexuosa* L.f | Buriti | Monocot | Várzea |
| | *Galinsoga parviflora* Cav. | Gold Button | Eudicotyledonous | Terra Firme |
| | *Physalis angulata* L. | Camapú | Eudicotyledonous | Terra Firme |
| Brassicaceae | *Lepidium virginicum* L. | Mentruz | Eudicotyledonous | Terra Firme |
| Caryophyllaceae | *Spergula arvensis* L. | Asparagus | Eudicotyledonous | Terra Firme |
| Commelinaceae | *Commelina benghalensis* L. | Maria-mole | Monocot | Terra Firme |
| Cucurbitaceae | *Cucumis anguria* L. | Maxixe | Eudicotyledonous | Terra Firme |
| Cyperaceae | *Rhynchospora cephalotes* (L.) Vahl | Grass-assapê | Monocot | Terra Firme/Várzea |
| | *Cyperus odoratus* L. | Timothy | Monocot | Terra Firme |
| | *Kyllinga brevifolia* Rottb. | Juquinho | Monocot | Terra Firme |
| | *Cyperus rotundus* L. | Tiririca | Monocot | Terra Firme |
| | *Cyperus esculentus* L. | Yellowtail | Monocot | Terra Firme |
| | *Cyperus Bravifolius* Hassk | One-tailed grasses | Monocot | Várzea |
| | *Fimbristylis autumnalis* | False Sandpiper | Monocot | Várzea |

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|---|---|---|---|---|
| | (L.) Roem & Schult | | | |
| | *Cyperus verens* Michx | Junça | Monocot | Várzea |
| | *Cyperus difformis L.* | Grasshopper | Monocot | Várzea |
| Euphorbiaceae | *Chamaesyce hirta* L. | St. Lucia weed | Eudicotyledonous | Terra Firme |
| | *Acalypita Arvensis* Poepp. & Endl | Great Urtinga | Eudicotyledonous | Várzea |
| Lamiaceae | *Stachys arvensis* L. | Stinging Nettle | Eudicotyledonous | Terra Firme |
| | *Hyptis atrorubens* Poit | Spearmint | Eudicotyledonous | Várzea |
| Malvaceae | *Sida planicaulis* Cav. | Broom | Eudicotyledonous | Terra Firme |
| | *Sida spinosa* L. | Thornback Raccoon | Eudicotyledonous | Várzea |
| Melastomataceae | *Miconia guianensis* (Aubl.) Cogn. | Lacrera | Eudicotyledonous | Terra Firme |
| | *Carapa guianensis* Aubl. | Andiroba | Eudicotyledonous | Várzea |
| | *Miconia minutiflora* (Bonpl.) D.C | White seal | Eudicotyledonous | Várzea |
| Myristicaceae | *Virola surinamensis*(Rol.) Ward. | Ucuuba | Eudicotyledonous | Várzea |
| Onagraceae | *Ludwigia Elegans* | High Cross | Eudicotyledono | Várzea |

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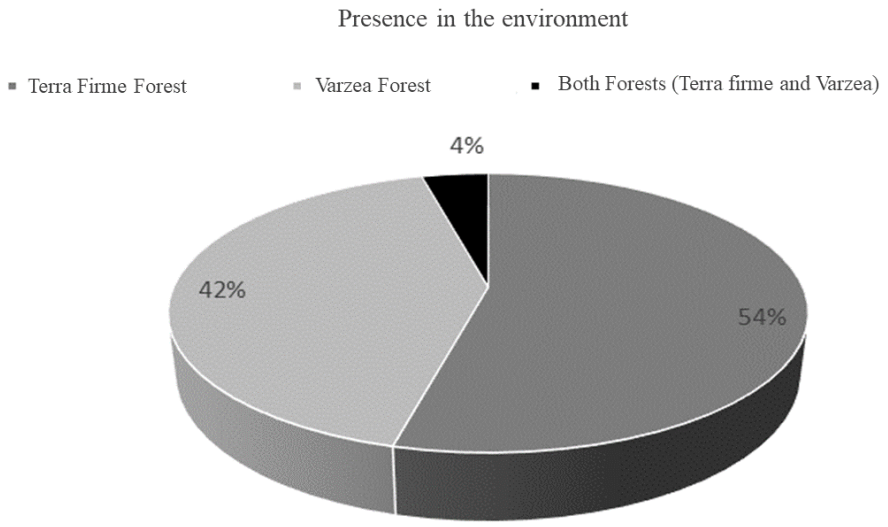
| Phyllantaceae | *Phyllanthus amarus* Schumach. | Stonebreaker | Eudicotyledonous | Terra Firme |
| Poaceae | *Digitaria horizontalis* Willd. | Weedgrass | Monocot | Várzea |
| | *Paspalum maritimum* Trin. | Ginger grass | Monocot | Terra Firme |
| | *Pennisetum clandestinum* Hochst. ex Chiov. | Kikuio-grass | Monocot | Terra Firme/Várzea |
| | *Urochloa plantaginea* (Link) R.D. Webster | Armelgrass | Monocot | Terra Firme |
| | *Imperata brasiliensis* Trin. | Grass | Monocot | Terra Firme |
| | *Digitaria insularis* (L.) Fedde | Raggrass | Monocot | Terra Firme |
| | *Digitaria sanguinalis* (L.) Scop. | Eelgrass | Monocot | Várzea |
| | *Brachiaria purpurascens* (Radd) Henrard | Rangoon grass | Monocot | Várzea |
| | *Cynodon dactylon* (L.) Pers | Bermuda grass | Monocot | Várzea |
| | *Eleusine Indica* (L.) Gaertn | Timothy | Monocot | Terra Firme |

| | | | | |
|---|---|---|---|---|
| | *Andropogon bicornis* L. | Foxtail grasses | Monocot | Várzea |
| Pontederiaceae | *Eichhornia crassipes* (C.R.P Mart) | Water Hyacinth | Monocot | Várzea |
| Portulacaceae | *Portulaca oleraceae* L. | Beldroega | Eudicotyledonous | Terra Firme |
| Solanaceae | *Solanum tabacifolium* Vell. | Tobacconist | Eudicotyledonous | Terra Firme |
| Urticaceae | *Boehmeria caudata* Sw. | Assa-fish | Eudicotyledonous | Terra Firme |
| | *Cecropia pachystachya* Trécul | Embaúba | Eudicotyledonous | Terra Firme |

When analyzing the species present in the environments, more than 54% of the species found were present in the upland forest areas, 42% in the floodplain environment, and only 4% were species present in both environments, consisting of the species *Rhynchospora cephalotes* and *Pennisetum clandestinum* (Figure 1). The terra firme is the ecosystem of greatest expressiveness and great complexity in the composition, distribution, and density of species. It is characterized by floristic heterogeneity with a predominance of aggregated species in some formations and random in others [12].

**Figure 1**: Percentage of the species that composed the weed community in the two types of environments evaluated. Cametá-PA, 2018.



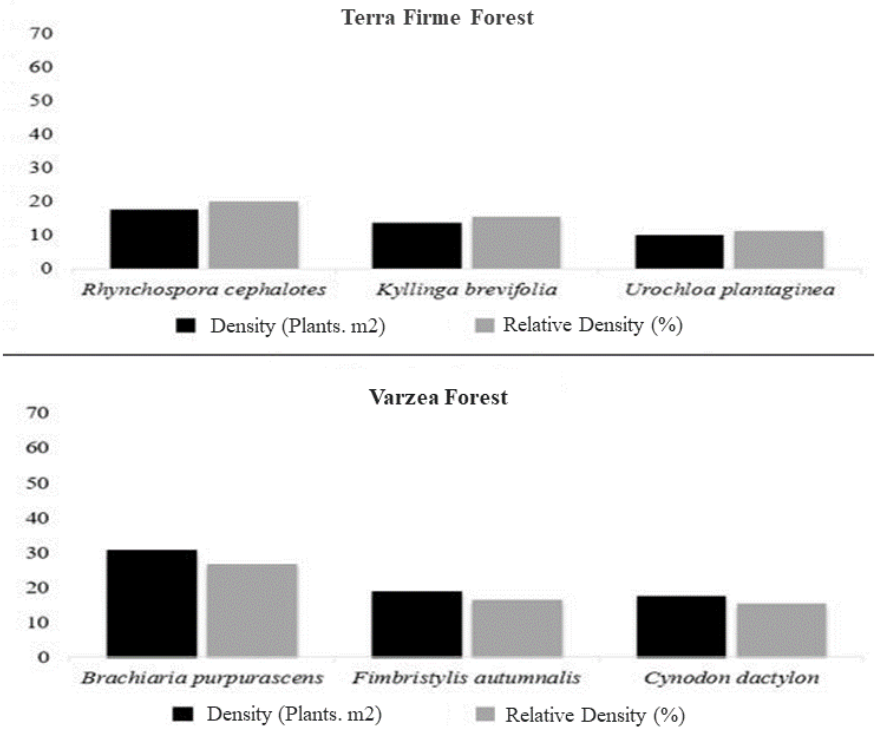

According to [12] et al. (2005), among the main weeds found in Brazil, the most prominent are grasses (Poaceae) and thyrrhizae (Cyperaceae). Which, most of them, were voluntarily introduced by man in Brazil, for economic purposes, mainly for forage purposes, and have become major hindrances in agricultural production [13].

Regarding the density index (Den) and relative density (DenR), in the dryland forest areas, the species that obtained the highest number of individuals was *Rhychospora cephalotes,* with 17 plants.m$^{-2}$, obtaining a DenR index of 19.4 followed by the species, *Kyllynga brevifolia* with 13 plants.m$^{-2}$ and relative density of 14.4 and *Urochloa plantaginea,* with density above 9 plants.m$^{-2}$ and relative density of 10.5, respectively (Figure 2).

In the same Amazon region of this research, [14] found that the grass assapê (*R. cephalotes)* led all phytosociological indices evaluated, and the density of plants found was also similar around 19 plants per square meter. Of the Cyperaceae genera occurring in Brazil, *Rhynchospora* Vahl is the most representative, with 157

species, 40 of which are endemic and 23 occur in all Brazilian geographic regions [15].

**Figure 2.** Density (Den) and Relative Density (DenR) of the most representative species found in terra firme and várzea forests. Cametá-PA, 2018.

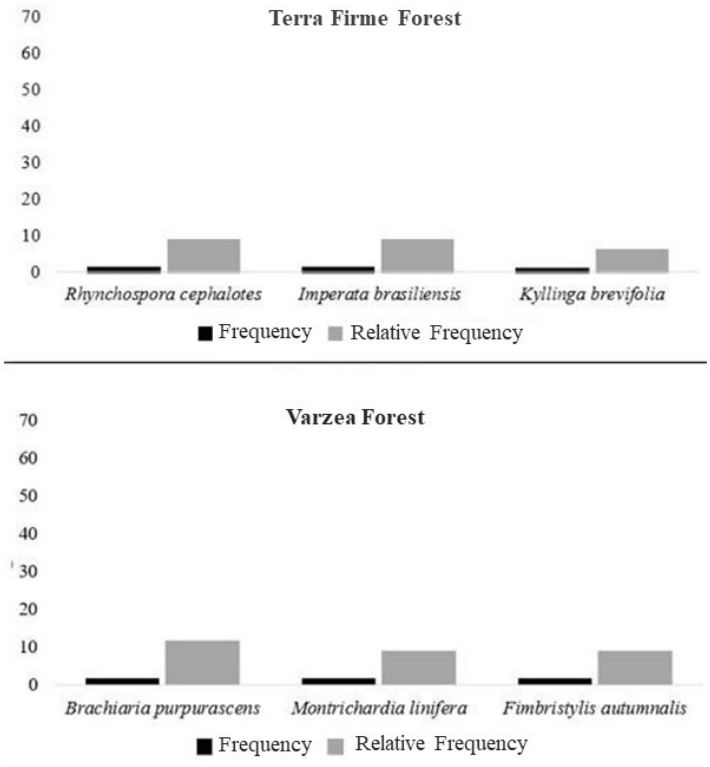



In areas of agroforestry systems present in floodplain forests, the species *Brachiaria purpurarascens* stands out among the others, with a density of 30 plants.m$^{-2}$ and relative density index above 25, followed by the species *Fimbristylis autumnalis and Cynodon dactylon* with densities of 18 and 15.7 plants.m$^{-2}$ and relative densities of 16.7 plants.m$^{-2}$ and 14.4 respectively (Figure 2).

The frequency and relative frequency indices were led by the species *R. cephalotes* and *B. purpurascens* in the areas conducted in agroforestry systems in terra firme forest and várzea forest respectively (Figure 3). In the upland environment, *Imperata brasiliensis had* the second highest frequency index (0.75) and relative frequency (8.33), followed by *K, brevifolia* with indexes of 0.5 (Fre) and 5.5 (FreR) (Figure 3).

Sapê grass (*I. brasiliensis*) is a very common invasive plant, especially in acidic and dry soils. It infests roadsides, vacant lots, and annual and perennial crops. Correcting soil acidity and fertility usually leads to its eradication [16].

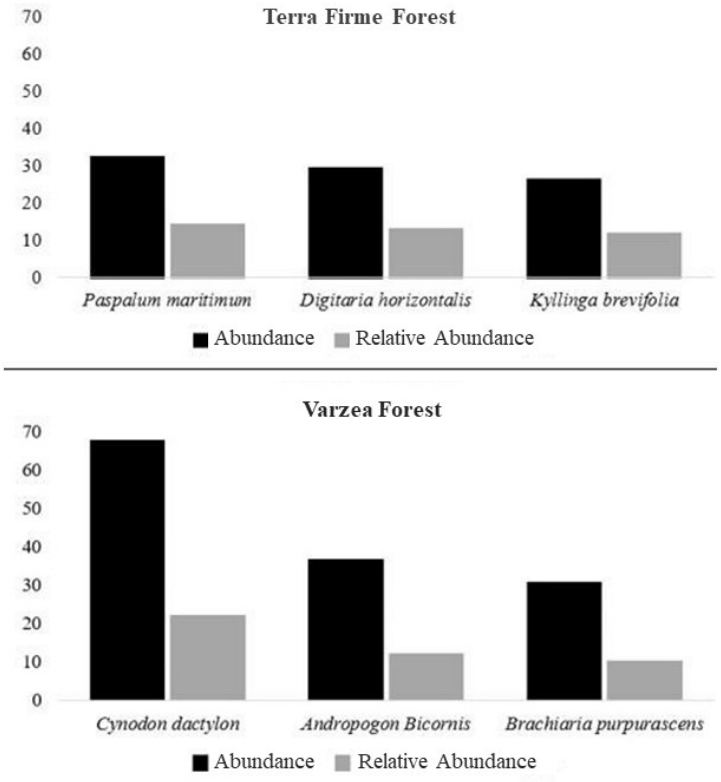
**Figure 3.** Frequency (Fre) and relative frequency (FreR) of the most representative species found in terra firme and várzea forests. Cametá-PA, 2018.



In the floodplain forest environment, the species *M. arborescens* and *F. autumnalis*, showed the same value of frequency (0.75) and relative frequency (8.11), thus composing the most relevant species, along with *K. brevifolia.* in the frequency indices in this environment (Figure 3). The genus *Kyllinga* Rottb. has about 50 species distributed in tropical America and Africa, the region where it has the greatest richness. Six species have testimonial material confirming its occurrence in Brazil [17].

The indices of abundance and relative abundance showed distinct species of the previous items, with the species *C. dactylon* being very representative in the floodplain forest environment with high values of abundance being Abu equal to 67 and AbuR around 21% (Figure 4). The weed *C. dactylon* has vegetative propagation, producing large numbers of rhizomes and stolons, which makes it a difficult plant to control [18].

**Figure 4.** Abundance and relative abundance (%) of the most representative species found in terra firme and várzea forests. Cametá-PA, 2018.




The other most relevant species in the abundance indices were *Andropon bicornis* with Abu of 36 and AbuR of 11.54% and *B. purpurascens with Abu* 30 and AbuR 9.62% (Figure 4).

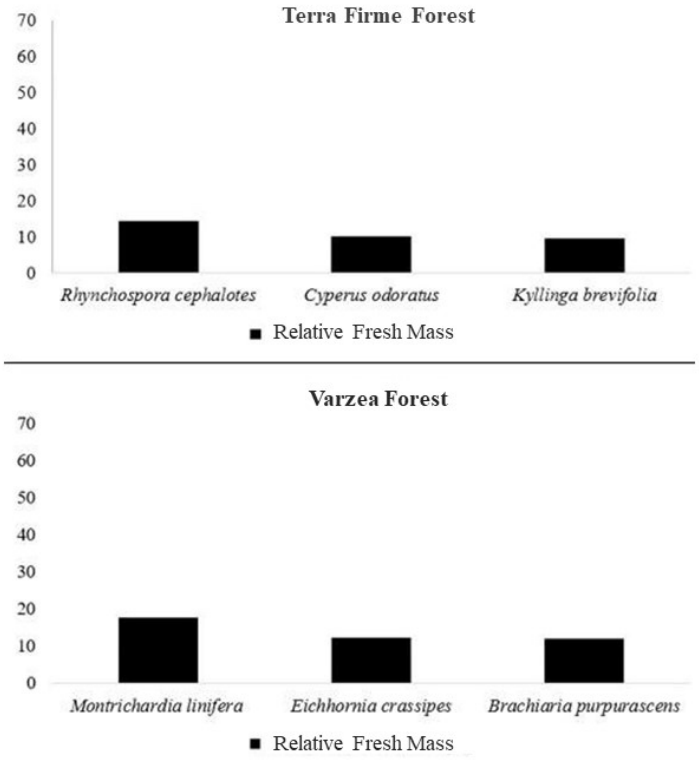
The plants of *Paspalum maritimun* were the most relevant in abundance in the dryland forest areas, having 32 abundance and 13.83% relative abundance, followed by the species *Digitaria horizontalis* with Abu of 29 and AbuR 12.54% and *K. brevifolia* with Abu 26 and AbuR 11.24% (Figure 4).

Again, *K. brevifolia was* among the three most relevant species in the dryland agroforestry system. The grass (*K. brevifolia*) generally occurs associated with moist and shaded environments, being easily found in rice crops [19].

The species *R. cephalotes* and *Montrichardia arborescens* showed higher mass found in both environments, consequently, they reached the highest relative

fresh mass indices in the terra firme forest (17.4%) and várzea forest (14.4%), respectively (Figure 5). In the Tocantine Amazon region, researchers Gonçalves [14], and Souza [4] also validated that the species *R. cephalotes* was the one that obtained the highest value in this phytosociological index.

**Figure 5.** Relative fresh mass (%) of the most representative species found in terra firme and várzea forests. Cametá-PA, 2018.



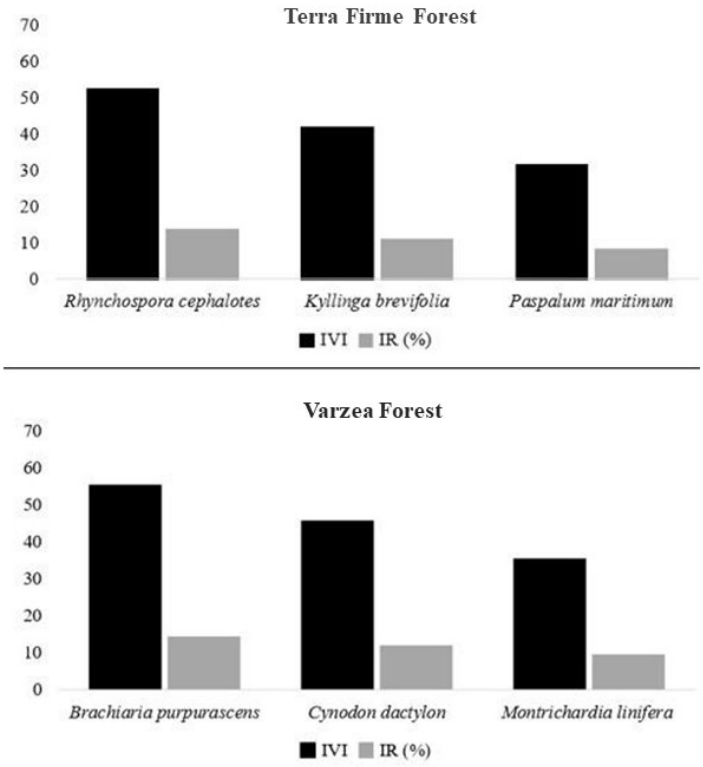

Belonging to the Araceae family, the species *Montrichardia linifera,* popularly known as aninga, is an amphibious aquatic macrophile widely distributed in the Amazon floodplains and equally found in various floodable ecosystems such as igapós, riverbanks, furious, and igarapés [20].

On dryland, *Cyperus odoratus* was the second most relevant species with an index of 10.1, preceded by *K. brevifolia* with a fresh mass index of 9.6, which again appeared in the weed community with high values. Very important in East Africa and Madagascar, the genus *Kyllinga* has many species, being part of the vegetation cover of these regions [21].

In the floodplain forest environment, the second relevant species was *Eichhornia crassipes* (11.7%), followed by *B. purpurascens (*11.9%) in the fresh mass index (Figure 5).

When verifying the importance value index and the relative importance of the species that composed the weed community, in which this index relates to all the previous indexes analyzed, it was verified that the species *R. Cephalotus* (IVI of 52.01 and IR of 13.01%) and *B. purpurascens (*IVI of 54.72 and IR of 13.69%) were the most important in the upland and floodplain forest environments respectively (Figure 6).

**Figure 6.** importance value index (IVI) and relative importance index (IR) of the most representative species found in terra firme and várzea forests. Cametá-PA, 2018.




In the upland forest environment, the other two most important species were *K. brevifolia* (IVI of 41.23 and IR of 10.31%) followed by P*. maritimum* (IVI of 30.97 and IR of 7.74%). In the floodplain forest environment, the other two most important species were *C. dactylon*, (IVI of 45.01 and IR of 11.25% and *M. linifera* (IVI of 34.68 and IR of 8.67%) (Figure 6).

## CONCLUSION

In areas managed under agroforestry systems, *K. brevifolia* and *R. cepholotes* in terra firme forest and *B. purpuracens* and *M. linifera* in várzea forest, were the most expressive species in the weed community, being present with high values in

most phytosociological indices, being the species K. *brevifolia* and *B. purpuracens* present in all indices in the terra firme and várzea forest environments respectively.

## REFERENCES


[1]. DIAS, S. F., ALBUQUERQUE, C. R. A., LOBATO, C. R. S., SILVA, F. C., SILVA, G. G., RIBEIRO, I. S., BRANCO, J. L. M., COSTA, M. F. & LOBO, M. A. A. Ecological-economic zoning of the State of Pará. Belém, PA: IDESP, 1991. v. 1. (IDESP. Estudos Paraenses, 58).

[2]. GAMA, J. C. M. *Floristics, and Phytosociology of Spontaneous Plants in Anthropized Communities of the Cerrado in Minas Gerais*, 2009. Available at: <http://bibliotecadigital. ufmg.br/dspace/bitstream/handle/1843/NCAP>. Accessed on: 02 Nov. 2018.

[3]. MBOW, C., SMITH, P., SKOLE, D., DUGUMA, L. & BUSTAMANTE, M. Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability*, v. 6, p. 8-14, 2014.

[4]. SOUZA, L.S.A., SILVA, J.F., & SOUZA, M.D.B. *Composição florística de plantas danes em agrossistemas de cupuaçueiro (Theobroma Grandiflorum) e pupunheira (Bactris gasipaes).* Planta daninhas, Viçosa-MG, V.21, W.2, p. 249-255, 2003.

[5]. LIMA, A. K. O., ARAUJO, M.S., SANTOS, N.F.A., MELO, M.R.S., SOUSA. V. Q. PEDROSO, A. J. S., BORGES L.S. & FREITAS, L.S. Floristic composition and phytosociology of spontaneous plants in pastures of the genus brachiaria (syn. Urochloa) in northeastern Pará. *Agroecosystems Journal,* v. 9, p. 339-349, Apr. 2018. Available at: <https://periodicos.ufpa.br/index.php/agroecossistemas/article/view/4993/4658>. Accessed on: 01 Dec. 2018.

[6]. PITELLI, R. A. The term weed plant, 2015. Available at : < http://www.scielo.br/ scielo.php?pid=S010083582015000300622&script=sci_arttext&tlng=en >.Accessed: 15 Nov. 2018.

[7]. PITELLI, R. A. Estudos fitossociológicos em comunidades infestantes de agroecossistemas. *Jornal Conserb*, v. 01, n. 02, p. 1-7, 2000.

[8]. MUELLER-DOMBOIS, D. & ELLEMBERG, H. *Aims and methods of vegetation ecology.* New York: John Willey & Sons, p. 1974. 547.

[9]. LORENZI, H. *Manual de identificação e controle de plantas no weeds*, 2006. Available at :< http://hdl.handle.net11449/27936>. Accessed on: 29 Oct. 2018.

[10]. MOREIRA, H.J.C. & BRAGANÇA, H.B.N. *Manual de identificação de plantas infestantes: Hortifrúti.* 2011. Available at:<https://fmcagricola.com.br/portal/manuais/infestantes_hf/files/assets/downloads/publication.pdf>.Accessed Oct. 24, 2018.

[11]. CUNHA, J. L. X. L., FREITAS, F. C. L., COELHO, M. E. H., SILVA, M. G. O., SILVA, K. S. & NASCIMENTO, P. G. M. L. Phytosociology of weeds in bell pepper culture in no-till and conventional tillage systems. *REVISTA AGRO@MBIENTE ON-LINE,* [S.l.], v. 8, n. 1, p. 119-126, 2014.

[12]. ARAÚJO, A. P.; JORDY FILHO, S.; FONSECA, W. N. A vegetação da Amazônia brasileira. In: SIMPÓSIO DO TRÓPICO ÚMIDO, 1., 1984, Belém. Anais. Belém: EMBRAPA-CPATU, 1986. 493p. p.135-152. (EMBRAPA-CPATU. Documentos, 36).

[13]. SILVA, C. L. B. da. Cyperaceae Juss. nos campos de natureza de Cametá, Pará, Amazônia, Brasil. 125 f. 2018. Dissertação (Mestrado em Ciências Biológicas/Botânica Tropical) - Universidade Federal Rural da Amazônia/Museu Paraense Emílio Goeldi, Belém, 2018.

[14]. GONÇALVES, C.J.B. *Phytosociological survey of weeds in Amazonian agroforestry system.* Federal University of Pará - UFPA, 2017. Available at: <http://www.pibic.ufpa.br/resumos/7716.pdf>. Accessed on: 26 Oct. 2018.

[15]. ALVES, M., ARAÚJO, A.C., PRATA, A. P., VITTA, F., HEFLER, S., TREVISAN, R., GIL, A. S. B., MARTINS, S. & THOMAS, W. Diversity of Cyperaceae in Brazil. *Rodriguesia, 60*(4):771-782. 2009.

[16]. CÉSAR, R. G.,VIANI, R. A. G., SILVA, R,T., CANDIDO DA, M. & BRANCALION, P. H. S. Does a native grass (Imperata brasiliensis Trin.) limit tropical forest restoration like an alien grass (Melinis minutiflora P. Beauv.)? *Tropical Conservation Science,* v.7, n.4, p.639-656, 2014. Disponível em: <https://doi.org/10.1177%2F194008291400700405>. Accessed on: 30 Nov. 2018.

[17]. COSTA, S. M., PRATA, A. P. & ALVES, M. (2012). Kyllinga (Cyperaceae) from the state of Sergipe, Brazil. *Rodriguesia*, *63*(4),795-802.Available at:< https://dx.doi.org/10.1590/S 2175 -78602012000400005>. Accessed on: 30 Nov. 2018.

[18]. MARTINI, G., JUNIOR, A. F. F. P., FELICI, G. V., PIVA, F. M. & DURIGAN, J. C. (2002). Efficacy of a new glyphosate formulation for the control of silkgrass (Cynodon dactylon), in a citrus orchard. *Revista Brasileira de Fruticultura, 24*(3), 683-686. Available at: <https://dx.doi.org/10.1590/S0100-29452002000300028>.Accessed on: 28 Nov. 2018.

[19]. FERREIRA, P. M. A.; EGGERS, L. Espécies de Cyperaceae do Centro de Pesquisa e Conservação da Natureza Pró-Mata, município de São Francisco de Paula, RS, Brasil*. Acta bot. bras. 22*(1): 173-185. 2008.

[20]. MAYO, S.J., BOGNER, J. & BOYCE, P.C. *The Genera of Araceae. Royal Botanic Gardens, Kew*, United Kingdom. p. 370, 1997.

[21]. TREVISAN, R., LÜDTKE, R. & BOLDRINI, I. The genus Kyllinga Rottb. (Cyperaceae) in Rio Grande do Sul, Brazil. *Revista Brasileira de Biociências,* Porto Alegre, v. 5, n. 2-3, p. 27-36, abr./set. 2007.