Ciência Agrícola, Rio Largo, v. 20, n. 1, p. 1-7, 2022

LITTER PRODUCTION IN AGROFORESTRY SYSTEM, CASTANHAL, PARÁ.

Lucas Lázaro Cirineu Santos[1], Lívia Gabrig Turbay Rangel Vasconcelos[2], Breno Pinto Rayol[3].

[1*]Mestre em Engenharia Florestal, Centro de Ciências Agroveterinárias, Universidade do Estado de Santa Catarina, Av. Luiz de Camões, 2090 - Conta Dinheiro, Lages – SC.
[2] Professora Doutora do Instituto de Ciências Agrárias, Universidade Federal Rural da Amazônia, Av. Tancredo Neves, nº 2501 – Terra Firme.
[3] Professor Doutor do Instituto de Ciências Agrárias, Universidade Federal Rural da Amazônia, Av. Tancredo Neves, nº 2501 – Terra Firme.
***Corresponding author**: Lucas Lázaro Cirineu Santos, ef.lucass@gmail.com

ABSTRACT: Litter is the layer above the soil, consisting of leaves, twigs, flowers, fruits, and miscellany. It is an important indicator of environmental recovery and is responsible for major processes in the forest ecosystem, such as soil protection, moisture retention, and nutrient cycling. Agroforestry systems are consorting models between forest, agricultural, and/or animal species. They are used as alternative for the recovery of degraded areas as well as for economic purposes. The aimed of this study was to quantify the litter produced in an agroforestry system located in the municipality of Castanhal, Pará. The experiment was conducted in the `Fazenda Escola` of the Federal Rural University of the Amazon, Castanhal, Pará. Twelve wooden collectors with dimensions of 1 m x 1 m were randomly installed within the agroforestry system under study. Collections were monthly conducted between the months of June and September 2019. Litter samples were sent to the laboratory for analyses such as fractionation, drying, and weighing. The average litter produced was equal to 6.30 $Mg.ha^{-1}$. There was no significant difference between litter production months, however, leaves were the fraction that most influenced the litter layer formation, with 66.7% of representativeness of all the material collected by collectors, differing significantly from the other fractions. Leaves are the fraction with the greatest impact on the litter layer formation in the agroforestry system under study.

KEYWORDS: Amazon. Agroecosystems. Leaf litter.

PRODUÇÃO DE SERAPILHEIRA EM SISTEMA AGROFLORESTAL, CASTANHAL, PARÁ.

RESUMO: A serapilheira é a camada que se localiza acima do solo, constituída de folhas, galhos, flores, frutos e miscelânea. Ela é um importante indicador de recuperação ambiental e é responsável por grandes processos no ecossistema florestal, como proteção do solo, retenção hídrica e ciclagem de nutrientes. Os sistemas agroflorestais são modelos de consórcio entre espécies florestais, agrícolas e/ou animais. São usados como alternativa para recuperação de áreas degradadas bem como para fins econômicos. O objetivo deste trabalho foi quantificar a serapilheira produzida em um sistema agroflorestal localizado no município de Castanhal, Pará. O experimento foi conduzido na Fazenda Escola da Universidade Federal Rural da Amazônia, em Castanhal, Pará. Foram instalados doze coletores de madeira com dimensões de 1 m x 1 m de maneira aleatória dentro do sistema agroflorestal em estudo. As coletas foram realizadas mensalmente entre os meses de junho e setembro de 2019. As amostras de serapilheira foram conduzidas para análises laboratoriais como fracionamento, secagem e pesagem. A média de serapilheira produzida foi igual a 6,30 $Mg.ha^{-1}$. Não houve diferença significativa entre os meses de produção da serapilheira, entretanto as folhas foram a fração que mais influenciaram na formação da camada de serrapilheira, tendo 66,7% de representatividade de todo o material aportado nos coletores, diferindo significativamente das demais frações. As folhas são a fração de maior impacto na formação da camada de serapilheira no sistema agroflorestal em estudo.

PALAVRAS CHAVE: Amazônia. Agroecossistemas. Serapilheira foliar.

INTRODUCTION

The mechanism for converting native forests into agricultural areas is one of the main problems currently faced in the Amazon region. Thousands of hectares of native vegetation have been transformed into areas for activities aimed at the Brazilian agricultural sector. These activities cause degradation of the environment and a decrease or total loss of biodiversity and generate irreversible consequences such as soil erosion, silting of rivers and death of wild animals.

Agroforestry Systems (AFS) are excellent models for the replacement of these predatory production methods, as in addition to offering economic benefits, they are also important agents in the recovery of degraded areas. Agroforestry systems are consorting models including tree, agricultural and/or animal species and are used to recover degraded areas due to their ecological potential, and are also used to supply food and raw materials.

Agroforestry systems seek to recreate conditions that are present in natural systems, promoting the supply of the main ecosystem services present in non-anthropic environments (Vasconcelos; Beltrão, 2017). The use of agroforestry systems is recommended for the recovery of degraded areas, as well as for the preservation of areas surrounding environmental reserves (Silva et al., 2012). The arrangement of species in these systems represents an alternative economic stimulus for forest restoration; however, there are still doubts about the potential of agroforestry systems (Martins et al., 2019).

The importance of litter within agroforestry systems is highlighted, as this component is responsible for offering ecosystem services of high importance to the environment. Examples are soil protection, seed bank shelter and moisture retention.

Litter is the organic layer originating from the shoot of the vegetation, consisting of leaves, twigs, branches, flowers, fruits and seeds which, together with roots, begin a stage of decomposition as part of the nutrient cycling process (Marques; Junior; Vourlitis, 2017). Expressive amounts of nutrients can return to the soil through the fall of senescent components of the shoot of plants and their decomposition (Toledo; Pereira; Menezes, 2002).

Part of the return of organic matter to the forest floor occurs through the production of litter, which is considered the most relevant means for the transfer of essential elements from the vegetation to the soil (Vital et al., 2004) and according to Toscan (2017), the litter layer is characterized as an organic matter inflow and outflow system.

In addition to being a source of nutrients for vegetation and microorganisms, litter allows greater moisture retention, prevents erosion and improves the soil physical attributes (Holanda et al., 2015), that is, litter is of great importance for ecosystems, since it is responsible for important environmental processes.

In addition to the nutritional importance of litter, litter provides the interception of light, shading seeds and seedlings and reducing the soil thermal amplitude and, in this way, creating a barrier to the diffusion of water vapor and minimizing soil evaporation (Longhi et al., 2011).

Studies carried out with the production and accumulation of this material provide information for a better understanding of the dynamics of nutrients (Godinho et al., 2014). It is of great importance to emphasize the fact that in this compartment, the decomposition of its fractions occurs and nutrients return to the soil to be used by the vegetation.

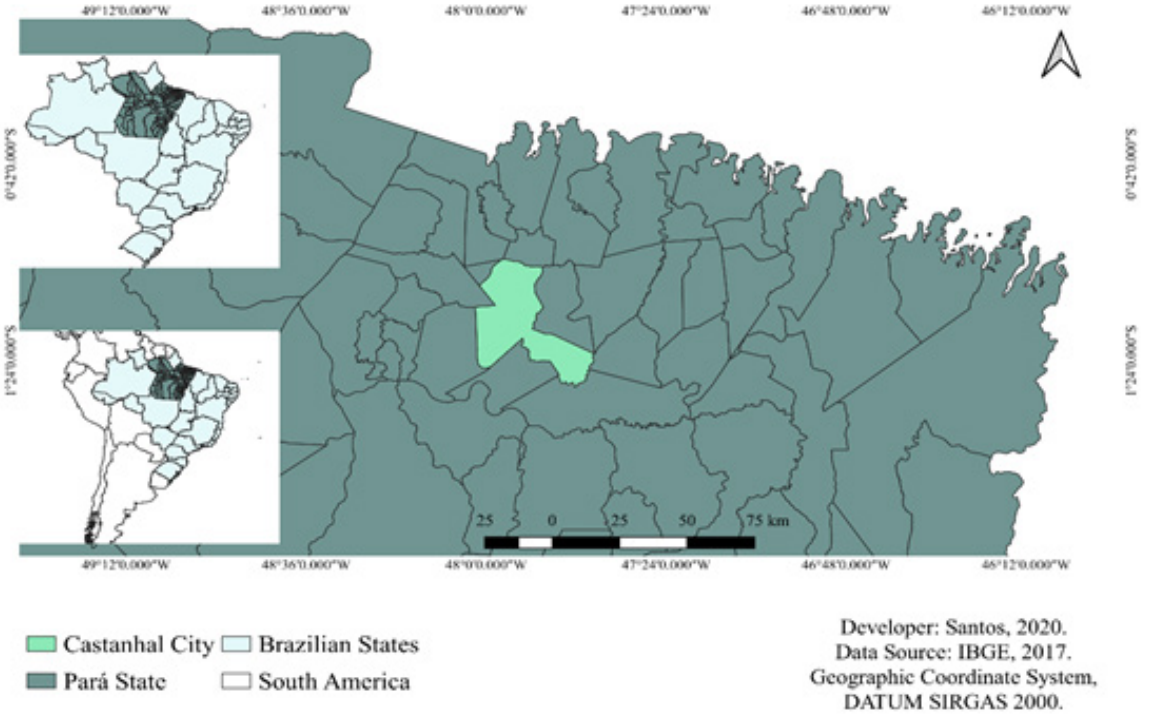
The importance of evaluating litter production and accumulation lies in the understanding of the inflow and outflow of this material in the ecosystem, contributing to the understanding of the dynamics of nutrient transfers, as well as the functioning of the forest, also serving as a basis for the supply of information for projects to recover degraded areas (Farias et al., 2019).

Understanding the litter production flow in agroforestry systems is of great relevance to better understand the dynamics of this process in these land use models, therefore, mentioning the importance of the theme and the AFS, the aim of this work was to quantify the litter production in an agroforestry system located in the municipality of Castanhal, Pará.

MATERIAL AND METHODS

The study was carried out in an agroforestry system located at `Fazenda Escola de Castanhal`, Federal Rural University of the Amazon, Castanhal, Pará, located at the following geographic coordinates 1º17'42" S and 45º55'00 W, 07º20'53" S latitude and 50º23'45" W longitude, 68 km away from the state capital, Belém (Figure 1).

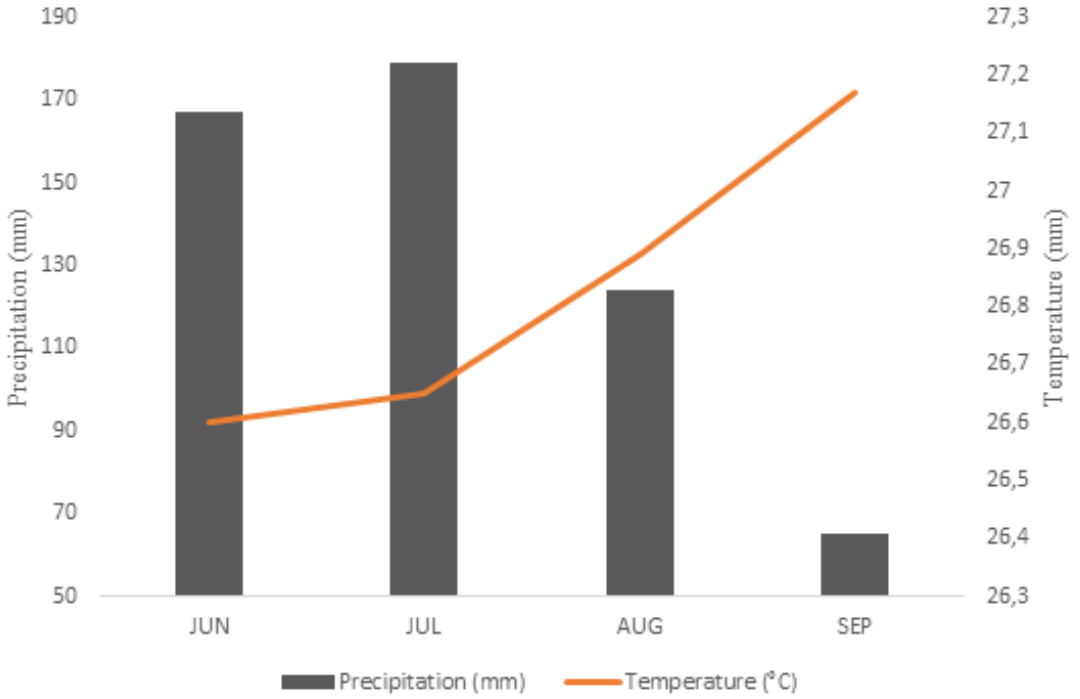
Figure 1: Location of the municipality of Castanhal, Pará, Brazil.



The municipality where the study was carried out has humid climate, low water deficit in the dry period, which occurs between June and November and average temperature during all months equal to 18 °C (Megathermic) and Af subtype, according to the Koppen classification, which corresponds to rainy tropical climate, with average annual precipitation ranging from 2,500 mm to 3,000 mm and relative humidity ranging from 80% to 85 % (Valente et al., 2001; Iderflor-Bio, 2017).

The study was conducted between the months of June and September, a period known as the Amazonian summer, characterized by decrease in rainfall and increase in temperature. Climatic data (rainfall and temperature) were observed and rainfall decreased during the months of the experiment, with the highest value being recorded in July. There were no significant changes in the average temperature, between 26° and 27°C, as shown in Figure 2.

Figure 2. Rainfall (mm) and temperature data obtained from the National Institute of Meteorology (INMET).



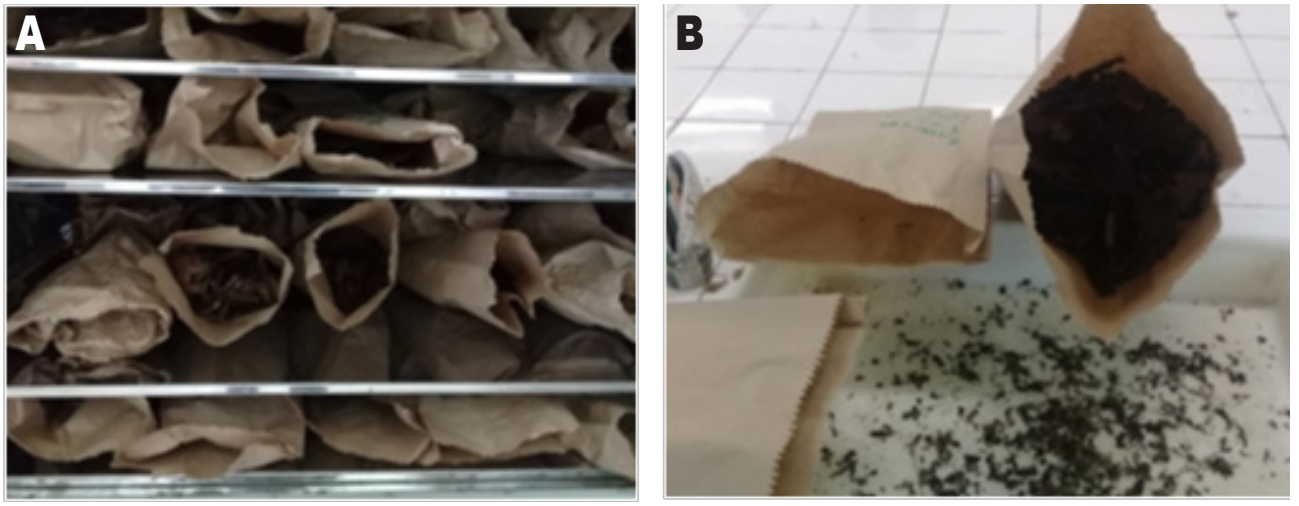
The agroforestry system is nine years old and presents the following species: *Euterpe oleraceae* Mart., *Tectona grandis* L.f, and *Theobroma grandiflorum* Schum, being popularly known as açaí, teca and cupuaçu, respectively. Teca constitutes the arboreal component of the AFS and açaí and cupuaçu constitute the agricultural component. The agroforestry system has approximately 1 ha.

Twelve wooden collectors measuring 1 m2 and thirty centimeters in height were installed. Collectors were covered with a 1 mm nylon mesh so that the material could be maintained inside each collector. Collectors were randomly distributed within the agroforestry system (Figure 3).

Figure 3. A: Installation of collectors in the Agroforestry System. **B:** Litter being collected by collectors.

All the material inside the collectors was collected and taken to the Laboratory of Management of Ecosystems and Hydrographic Basins, on the main campus of the Federal Rural University of the Amazon, for the litter to be sorted. For litter fractionation, steel clamps and plastic trays were used. Sorting was performed in the following fractions: leaves, twigs, reproductive material (flowers, fruits and seeds) and miscellany (Figure 4).

Figure 4. **A:** Greenhouse litter samples; **B:** Litter fractionation.



After the fractionation step, the material was placed in an oven and dried at 65 °C for 48 hours. After the end of this time, each fraction was weighed on a precision scale and its respective weight was recorded. The result was reported in $mg.ha^{-1}$.

Statistical analyses were performed using the RStudio software (version 4.0.5), with data being submitted to the Shapiro-Wilk normality test, after which, analysis of variance (ANOVA) was performed to verify whether or not there was significant difference between

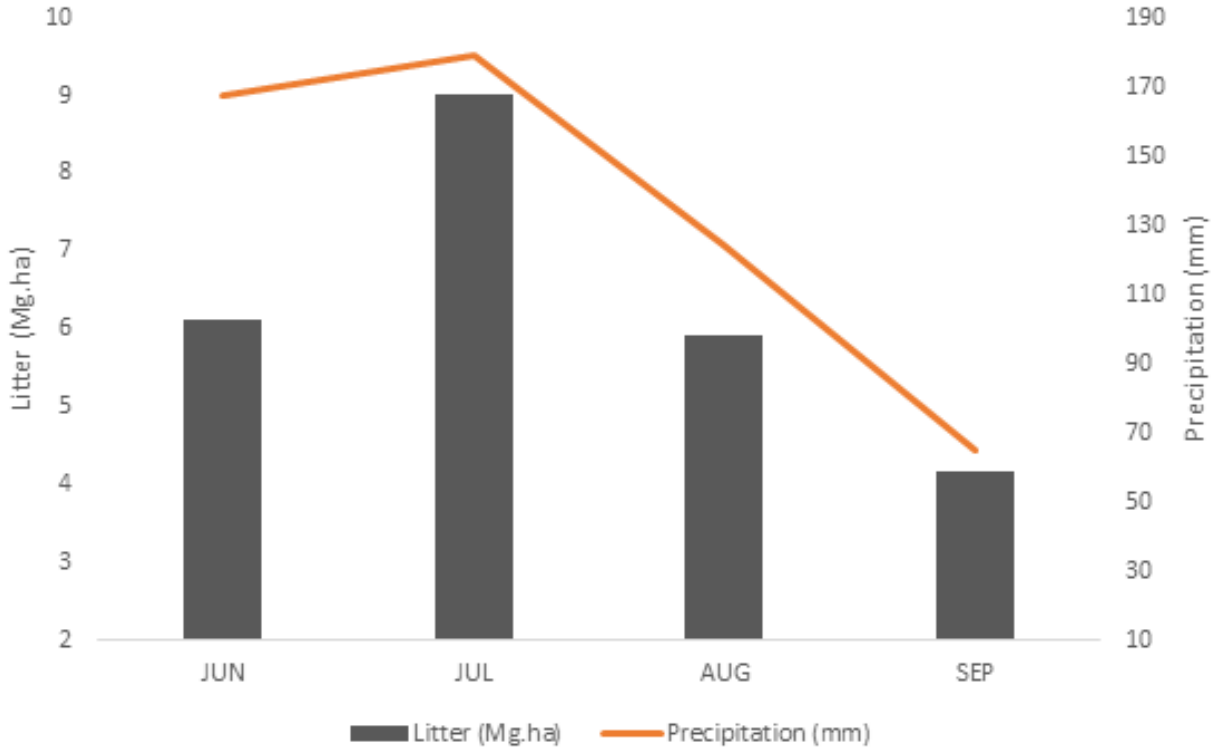
months of production and between litter fractions and later to the Tukey test (5%).

RESULTS AND DISCUSSION

The average litter production in the agroforestry system during the four months of study was 6.30 Mg.ha^{-1}. The month with the highest production was July, with average production equal to 2.25 Mg.ha^{-1} and the month of September was characterized as the month with the lowest production, with average of 1.04 Mg.ha^{-1}.

It is important to emphasize that the production of this component is influenced by the local topography, by the species present in the area and by climatic factors, such as temperature and rainfall. During the experiment, it was observed that litter production followed rainfall (Figure 5).

Figure 5. Litter production in mg.ha^{-1} in Agroforestry System.



The results found in ANOVA showed that there was no significant difference in litter production during the months of study conduction (p-value > 5%). However, among litter fractions, significant difference was found between the average values (p-value < 5%).

It was found that litter production was higher in July, and this month also showed higher rainfall levels. As rainfall in the study area decreased, litter production also decreased. Litter production is directly linked to factors such as type of vegetation present in the area, soil and climate conditions and history of the area. It is noteworthy that litter production values may vary from location to location, precisely due to these influences on the production and accumulation of this material.

Lima et al. (2015) reported that latitude and altitude, as well as the relief and stage of development of the vegetation are also factors that influence litter deposition. Some of these factors mentioned may have been associated to litter production in the present study.

The present research was carried out during the Amazonian summer period, therefore, it is recommended that litter production should be evaluated during the rainy season in the region in order to verify the influence of the climatic variables temperature and rainfall on litter production, as well as to find out if there is difference in litter production between the dry and rainy seasons.

In relation to litter fractions, leaves were more prominent, with average production equal to 4.20 Mg.ha^{-1} of the total production. Twigs were the components with the lowest representation in litter production, with average production equal to 0.35 Mg.ha^{-1} of the total material produced. Table 1 shows the Tukey test for the comparison of means of each litter fraction, with emphasis on the leaf fraction, which was higher in relation to the others.

Table 1. Tukey test (5%) to compare the means of litter fractions.

Fraction	Average	Result
Leaves	4.20	a
Reproductive Material	1.03	ab
Miscellany	0.72	b
Twigs	0.35	b

Leaves accounted for 66.7% of all material collected by collectors, followed by reproductive material, with 16.5% of the total material, and the miscellany fraction and twigs with 11.3% and 5.5%, respectively. This can be explained by the fact that teca presents leaves with much larger dimensions than the leaves of the other species present in AFS.

Similar values were obtained by Arato (2003) with the leaf fraction representing 67.46% of the litter. Pimentel et al., (2018) in a study carried out in two AFS in the Lower Amazon region found 62.77 and 47.30% representation of the leaf fraction in litter deposition in both agroforestry systems.

Rayol & Alvino-Rayol (2018) also in a study carried out in an agroforestry system in the Lower Amazon region, western state of Pará, observed that the leaf fraction was the most significant in the deposit of material for the formation of the litter layer, representing 81% of all material.

It is important to emphasize the contribution of leaves in the formation of the litter layer, since this fraction is the most representative in studies of this nature in different plant typologies. The litter layer is characterized as an important agent in forest ecosystems and studies that seek to understand its formation are relevant for the good understanding of the vegetation dynamics, as well as the dynamics of the formation of this layer.

Leaves were the main responsible for the formation of the litter layer in the agroforestry system under study. It is recommended that litter production should be evaluated during the rainy season in the region in order to verify if there is influence on the monthly litter production. The agroforestry system has the potential to offer ecosystem services, such as soil protection through the litter layer.

ACKNOWLEDGMENTS

To the Federal Rural University of the Amazon (UFRA, Belém) and to the Fazenda Escola de Castanhal (FEC UFRA).

REFERENCES

Arato, H.D.; Martins, S.V.; Ferrari, S.H.S.; Produção e decomposição de serapilheira em um sistema agroflorestal implantado para recuperação de área degradada em Viçosa – MG. *Sociedade de Investigações Florestais*, **2003,** 27, 715-721, DOI: http://dx.doi.org/10.1590/S0100-67622003000500014.

Farias, D.T.; Barreto, F.R.S.; Souza, M.R.; Silva, C.J.; Serapilheira em fragmento florestal de caatinga arbustivo-arbórea fechada. *Revista Verde*, **2019,** 14, 331-337, DOI: 10.18378/rvads.v14i2.6378.

Godinho, T.O.; Caldeira, M.V.W.; Caliman, J.P.; Prezotti, L.C.; Watzlawick, L.F.; Azevedo, H.C.A.; Rocha, J.H.T.; Biomassa, macronutrientes e carbono Orgânico na serapilheira depositada em trecho de floresta Estacional Semidecidual Submontana, ES. *Scientia Forestalis*, **2014,** 41, 131-144.

Holanda, A.C.; Feliciano, A.L.P.; Marangon, L.C.; Freire, F.J.; Holanda, E.M.; Decomposição da serapilheira foliar e respiração edáfica em um remanescente de caatinga na Paraíba. *Revista Árvore*, **2015,** 39, 245-254. DOI: http://dx.doi.org/10.1590/0100-67622015000200004

Lima, N.L.; Silva-Neto, C.M.; Calil, F.N., Souza, K.R., Moraes, D.C.; Acúmulo de serapilheira em quatro tipos de vegetação no estado de Goiás. *Enciclopédia Biosfera*, **2015,** 11, 39 – 46.

Longhi, R.V.; Longhi, S.J.; Chami, L.B.; Watzlawick, L.F.; Ebling, A.A.; Marques, A.C.A.; Junior, O.B.P.; Vourlitisg.L.; Avaliação de Produção de Serapilheira em Planície Inundável no Pantanal Mato-Grossense. Ensaios e Ciência: *Ciências Biológicas, Agrárias e da Saúde,* **2017, 21, 148-151.**

Marques, A.C.A.; Junior, O.B.P.; Vourlitis, L.; Avaliação de Produção de Serapilheira em Planície Inundável no Pantanal Mato-Grossense. Ensaios Ciências: *Ciências Biológicas, Agrárias e da Saúde*, **2017,** 21, 148-151,

2017. Disponível em: http://www.redalyc.org/articulo.oa?id=26054727003

Martins, E.L.; Silva, E.R.; Campelo, E.F.C.; Lima, S.S.; Nobre, C.P.; Correia, M.E.F.; Resende, A.S.; O uso de sistemas agroflorestais diversificados na restauração florestal na Mata Atlântica. *Ciência Florestal*, **2019,** 29, 632–648. DOI: https://doi.org/10.5902/1980509829050

Pimentel, C.R.; Rebelo, A.G.M.; Capucho, H.L.V.; Pauletto, D.; Deposição de serapilheira em dois sistemas agroflorestais no Baixo Amazonas, oeste do Pará. *Cadernos de Agroecologia,* **2018, 13.**

Rayol, B.P.; Alvino-Rayol, F.O.; Aporte de biomassa em agroecossistemas do Baixo Amazonas, oeste do Pará. *Cadernos de Agroecologia,* **2015, 10.**

Silva, E.F.; Estudo técnico - criação da UC municipal bosque florestal diagnóstico do meio físico. Instituto de Desenvolvimento Florestal e da Biodiversidade do Estado do Pará. **2017,** 32p. Disponível em https://ideflorbio.pa.gov.br/wp-content/uploads/2018/02/7.Diagn%C3%B3stico_Meio_F%C3%ADsico.pdf

Silva, M.S.C.; Silva, E.M.R.; Pereira, M.G.; Silva, C.F.; Estoque de Serapilheira e Atividade Microbiana em Solo sob Sistemas Agroflorestais. *Floresta e Ambiente*, **2012,** 19, 431 – 441. Doi: http://dx.doi.org/10.4322/floram.2012.058

Toledo, L.O.; Pereira, M.G.; Menezes, C.E.G.; Produção de serapilheira e transferência de nutrientes em florestas secundárias localizadas na região de Pinheiral, RJ. Ciência Florestal. **2002,** 12, 9-16. DOI: DOI: https://doi.org/10.5902/198050981676

Toscan, M.A.G.; Guimarães, A.T.B.; Temponi, L.G.; Caracterização da produção de serapilheira e da chuva de sementes em uma reserva de floresta estacional semidecidual, Paraná. *Ciência Florestal*, **2017,** 27, 415–427**.** DOI: https://doi.org/10.5902/1980509827725

Valente, M.A.; Silva, J.M.L.; Rodrigues, T.E.; Carvalho, E.J.M.; Rolim, P.A.M.; Silva, E.S.; Pereira, I.C.B.; Solos e Avaliação da Aptidão Agrícola das Terras do Município de Castanhal, Estado do Pará. Belém, Embrapa Amazônia Oriental, Documento N° 119, **2001**. Disponível em https://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/403564

Vasconcellos, R.C.; Beltrão, N.E.S.; Avaliação de prestação de serviços ecossistêmicos em sistemas agroflorestais através de Indicadores ambientais. *Interações*, **2018**, 19, 209-220. DOI: h□ p://dx.doi.org/10.20435/inter.v19i1.1494.

Vital, A.R.T.; Guerrini, I.A.; Franken, W.K.; Fonseca, R.C.B.; Produção de serapilheira e ciclagem de nutrientes de uma floresta estacional semidecidual em zona ripária. *Revista Árvore*, **2004,** 28, 793-800**.** DOI: https://doi.org/10.1590/S0100-67622004000600004