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Rainfall Partitioning in Amazon Forest: Implications of Reduced Impact Logging on Litter Water Conservation

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Abstract: This study aimed to investigate how sustainable forest management can affect litter hydrological properties. We investigated the net precipitation, litter mass, water-holding capacity, effective water-holding and retention capacity, maximum water retention and water content in unlogged and logged forests over 13 months in the Amazon Forest, where reduced-impact logging is allowed. The mean litter mass was similar for unlogged and logged forests. The litter water-holding capacity was 220% for unlogged and 224% for logged forests, and for fractions followed: unstructured > leaves > seeds > branches for both forests. The effective water-holding capacity was 48.7% and 49.3% for unlogged and logged, respectively, and the effective water retention was 10.3 t·ha^{-1} for both forests. The effective water retention in the rainy and dry seasons accounted for 12.5 t ha^{-1} and 7.2 t ha^{-1} for unlogged and logged, respectively. The maximum water retention was slightly greater for logged forests (16.7 t ha^{-1}) than unlogged (16.3 t ha^{-1}). The litter water content had 40% less water in the dry season than in the rainy in both forests. In general, there were no significant differences in litter storage and hydrological properties between stands. This suggests that reduced-impact logging did not significantly affect the hydrological dynamics of the litter layer in the Amazonian forests studied.

Keywords: forest hydrology; logging concessions; reduced-impact logging; selective logging; stemflow; Jamari National Forest

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Citation: de Lima, J.A.; Tonello, K.C. Rainfall Partitioning in Amazon Forest: Implications of Reduced Impact Logging on Litter Water Conservation. *Hydrology* **2023**, *10*, 97. https://doi.org/10.3390/hydrology10040097

Academic Editors: Songhao Shang, Qianqian Zhang, Dongqin Yin, Hamza Gabriel and Magdy Mohssen

Received: 22 March 2023
Revised: 6 April 2023
Accepted: 10 April 2023
Published: 21 April 2023

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1. Introduction

Litter studies are mainly related to stocks, decomposition, and biogeochemical cycles [1–4]. However, it is important to highlight that litter also acts as an insulating layer that protects the water and soil loss [5,6], making it essential for regulating surface hydrological processes [7] as a stage in the forest hydrology dynamics. Although the role in mediating the impact of raindrops, reducing, delaying, or often eliminating surface runoff and soil erosion [8–10] is recognized, the relevance of litter is still often underestimated in forest hydrology [6,8,11], especially in tropical forests.

Rainfall interacting with the forest canopy can take multiple paths, with some being intercepted and evaporated, while others reach the soil through throughfall and stemflow, constituting the net precipitation. However, before the net precipitation can contribute to soil moisture, it must cross the intermediate layer of litter. The litter layer can either retain the net precipitation without allowing it to reach the soil, initiate surface runoff, or facilitate infiltration into the soil. For example, it can protect soil water from wind and radiation-induced evaporation, thereby minimizing soil evaporation by 26.1–53.8% and reducing the surface runoff by 71.1–90.5% in a *Pinus tabulaeformis* plantation [8]. The forest litter layer is thus a key factor for water conservation in forest ecosystems. The retention of water in the litter layer is essential for hydrological modeling, as it can alter the amounts of water available for infiltration and/or runoff [7,12,13]. However, it depends

on the physical-chemical composition of the material [14], which is influenced by the forest's age and type, as well as climatic conditions. Understanding the structure and composition of the litter in the forest ecosystem is therefore crucial for determining the best way to manage the system, contributing to soil and water conservation. This is especially important in areas where exploration activities are carried out—like in Amazon forest—although the litter hydrological properties have not yet been quantitatively reported to the authors' knowledge.

Given the escalating rates of deforestation in tropical forests, particularly in the Amazon, it is crucial to conduct more studies on the ecosystem services provided by these forest environments. The Amazon Forest is globally significant, acknowledged for its environmental services, biological diversity, carbon sinks, and as a regulator of climate through its contribution to biogeochemical cycles [15,16]. However, the current situation is concerning, as the environmental impacts generated by human exploitation of the Amazon are imperiling its vast biodiversity reserves and globally important ecosystem services [17]. Deforestation in the Amazon hit a 15-year high in 2022, with a record 10,573 km^2 of deforestation between January and December [18]. In 2020, Brazil, which occupies 60% of the Amazon Forest [19], produced an estimated 29.2 million m^3 of tropical industrial roundwood, excluding plantations [20]. Given that current Brazilian law allows a maximum of 30 m^3 ha^{-1}, timber-harvesting activities affect a substantial area every year. To control the predatory exploitation of forests, the conservation potential of managed production tropical forests has promoted the implementation of timber harvesting practices generally referred to as 'low-impact' or 'reduced-impact' logging (RIL) [21]. Managers and certifiers widely recognize RIL as a sustainable and environmentally friendly approach to harvesting primary tropical forests [22]. This practice is a rational model of forest exploitation that aims to reduce environmental impacts by aligning natural resource conservation with forestry and the intensity of the impacts is related to the number and volume of trees removed from the natural ecosystems [23]. However, the impacts of RIL activities on tropical-forest ecosystem services, such as hydrological processes, are still understudied. To establish ecologically and economically productive harvesting cycles, a more detailed understanding of the effects of RIL on ecohydrological processes is also necessary.

This study was conducted in Jamari National Forest, a conservation unit whose primary objective is the sustainable multiple use of natural resources and scientific research [24], where sustainable forest management is allowed through RIL. As RIL is one of the most important sustainable economic activities in tropical forests, understanding these impacts is essential to evaluate RIL as a sustainable solution. Thus, to investigate how sustainable forest management actions can affect the hydrological processes of the forest, this study aims to test the following hypothesis: changes in vegetation structure by sustainable forest management activities will alter the composition of litter fractions, which in turn affects the water retention capacity of litter. To test this hypothesis, the study aims to (1) understand the dynamics and seasonality of litter stocks, (2) the water retention capacity of litter, and (3) evaluate the effective water retention and water content of litter in unlogged and logged (RIL) Amazonian forests. The goal of this study is to provide a scientific basis for understanding sustainable forest management actions in the Amazon and their impact on the hydrological dynamics of litter and water conservation.

2. Materials and Methods

The study site is located southwest of the Jamari National Forest (JNF) at the Forest Management Unit III (FMU-III). The physiognomic-ecological classification shows the predominance of Dense Tropical Rain Forest, with Open Rain Forest, characterized by spaced trees forming a canopy of 40 m in height [25]. The JNF area has a rainy tropical climate (Aw according to the Koppen classification) (Brazilian Forest Service 2019), precipitation from 1800~2200 mm y^{-1}. The weather in Amazon is well defined [26] with two distinct periods: rainy (from October to April) and dry (from June to August); May and September

are transition months. The mean air temperature is 24~26 °C, and the relative humidity is 80~90%.

Open precipitation, net precipitation, and litter yield were studied for 13 months (from October 2019 to October 2020) on three plots of 20 × 20 m at unlogged and logged forest stands (total per stand: 1200 m^2) at FMU-III. The general characteristics of the stands are listed in Table 1, as also the methodology and the name of the tree species/family for each stand are in Tables S2 and S3, respectively. The unlogged forest (UF) (9°24′53.15″ S and 63°04′29.48″ W) represents vegetation that retains the characteristics of primary forest and logged forest (LF) (9°23′27.52″ S and 63°02′27.08″ W) in which the silvicultural system adopted is polycyclic with 25-year cutting cycles, a maximum cutting intensity of 25 m^3 ha^{-1} $year^{-1}$, and minimum cutting diameter equal to or greater than 50 cm, as determined by law no. 11.284/2006 [27,28]. The UF is located at UAP-18 and LF is located at UAP-11 which was exploited in 2018. UAP means the Units of Annual Production, i.e., subdivision of the Forest Management Area, designated for logging within one year [29].

Table 1. Forest structure in the studied stands (UF—unlogged and LF—logged forest), Jamari Na-tional Forest, Rondônia, Brazil.

Parameters	Forest Structure									
	D [cm]		Ht [m]		CA [m^2]		Vc [m^3]		Tree Density [trees ha^{-1}]	
	UF	LF	UF	LF	UF	LF	UF	LF	UF	LF
Min	12.7	12.7	12.0	9.0	7.2	0.4	8.0	1.3	1625 *	1450 *
Max	111.5	140.8	28.0	36.0	199.7	284.8	795.4	1512.8		
Means	21.8	29.0	17.4	17.3	41.4	49.9	133.7	161.6		
SD	18.0	24.5	3.5	4.9	37.5	58.8	154.5	284.0		

D = diameter at breast height; Ht = tree height; CA = crown area; Vc = crown volume. * Indicates differences between means ($p < 0.05$).

Rain gauges were installed outdoors, 50 m from each other in places free of treetops and other forest structures. Throughfall was monitored by 7 rain gauges randomly installed inside each plot, totaling 21 rain gauges per stand. To measure stemflow volume [L $tree^{-1}$], collectors were installed in 60 trees with a diameter of breast height [D] > 10 cm. Stemflow collars were constructed by wrapping individual tree stems with a polyurethane gutter, fixed at 1.3 m from the ground. Water running down the stem was captured by these gutters, then drained by a 16 mm hose (5/8 inch) connected to 20 L collection bins. Event stemflow volumes [L $tree^{-1}$] were calculated by each tree's projected canopy area [m^2 $tree^{-1}$]. Open precipitation, throughfall and stemflow samples were measured in the field in a measuring cylinder (1-L, at 0.5-L graduation) or in a graduated bucket (20-L, at 0.5-L graduation). Net precipitation [NP, mm] per plot was found by summing throughfall to stemflow and represents the portion of open precipitation that reaches the soil surface.

Litter samples were collected from a 100 × 100 cm litter square [30], which was partitioned into 4 quadrants. Collection was random and only materials in one quadrant (50 × 50 cm) were collected. A total of 390 litter bags per stand (3 plots × 10 random quadrants × 13 months) were collected. In the laboratory, soil was sieved and removed from the litter samples, which were classified into four fractions: branches, leaves, seeds and unstructured material. Monthly and annual litter yields were estimated by summing the fractions. The fresh mass [FM, g] for each fraction was determined on a suitably accurate scale [0.01 g] and rehydrated through immersion in water for 90 min. After this, the litter fractions were deposited on sieves and drained for 30 min for further humid litter mass [HM, g] determination. Subsequently, the amount of litter dried mass [DM, g] was determined by oven-drying samples at a forced circulation oven at 70 °C, until reaching constant mass. Finally, the equations applied to calculate the hydrological properties of litter can be found in Table 2.

Table 2. Hydrological properties of litter applied to unlogged and logged litter from Amazon Forest, Rondônia, Brazil.

Hydrological Properties	Equation	Notes
Water-holding capacity [WHC, %] [30–32]	$WHC = \frac{(HM-DM)}{DM} \times 100$	HM = humid litter mass, g; DM = dry mass, g
Effective water-holding capacity of the litter under ambient conditions [EWC, %]	$EWC = \left[\frac{FM-DM}{FM}\right] \times 100$	FM = fresh mass, g; DM = dry mass, g
Litter effective water-retention capacity [W_{eff}, t ha^{-1}]	$W_{eff} = \frac{(0.85*WHC-EWC)\times M}{100}$	WHC = water-holding capacity, %; EWC = effective water-holding capacity; %M = is the unit litter mass (t·ha^{-1})
Maximum water-retention capacity [W_{max}, t ha^{-1}]	$W_{max} = \frac{WHC\times M}{100}$	WHC = water-holding capacity, %; M = is the unit litter mass (t·ha^{-1})
Litter water content [WC, g_{water} $kg_{litter}{}^{-1}$]	$WC = \left[\frac{FM[g]-DM[g]}{FM[kg]}\right]$	FM = fresh mass, g; DM = dry mass, g

The differences in the litter stocks and hydrological properties were tested for homoscedasticity of variance using the Bartlett test and for normality using Lilliefors (Kolmogorov–Smirnov) test for statistical analysis. Analysis of variance was applied to normal data using the Student's *t*-test at a 5% probability level. Data that did not meet ANOVA assumptions were subjected to a non-parametric Mann-Whitney test. The analyses were performed at BioEstat 5.3 [33] and @Minitab 17. For further examination of seasonal changes, monthly groups were created from the data.

3. Results

3.1. Hydrometeorological Observations and Litter Accumulation

There was no significant difference in the mean open precipitation between UF (1868 mm) and LF (1771 mm) ($p = 0.316$). Similarly, there was no significant difference in the mean net precipitation between UF (2106 mm) and LF (1680 mm) ($p = 0.082$). The net precipitation in UF was 13% higher than the open precipitation, and 25% higher than LF (Figure 1). It is worth noting that there was no rainfall in July (see Supplementary Materials Table S3). Seasonally, the lowest accumulations were observed in the dry period (May to September), representing approximately 9.6% and 8.6% of the open precipitation recorded in UF and LF, respectively.

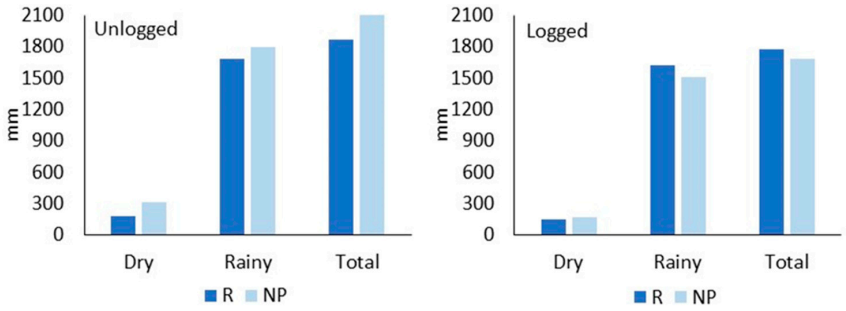

Figure 1. Open precipitation [R, mm] and net precipitation [NP, mm] partitioning in the dry and rainy season at unlogged and logged forests, Flona of Jamari, Rondônia—Brazil.

The monthly accumulated litter ranged from 3.8 to 12.2 Mg ha^{-1} in UF and from 4.9 to 13.3 Mg ha^{-1} in LF (Figure 2, Supplementary Materials Table S4), and no significant differences were observed between stands (p-value = 0.974). The number of fractions varied for both forests, with branches being the most abundant fraction (40% for UF and 38% for LF), followed by leaves (33% for UF and 37% for LF), unstructured (20% for UF and 19% for

LF) and seeds (3% and 2% for UF and LF, respectively). Despite no significant differences between fractions and seasons, it was observed that the highest litter mean accumulation was in the rainy season, with 69.1% (8.3 ± 2.3 t ha^{-1}) for UF and 67.3% (8.1 ± 2.9 t ha^{-1}) for LF. During the dry season, the accumulated litter decreased by 28% (6.0 ± 1.4 t ha^{-1}) and 22% (6.3 ± 1.3 t ha^{-1}) for UF and LF, respectively. The accumulation of all fractions was lower during the dry season.

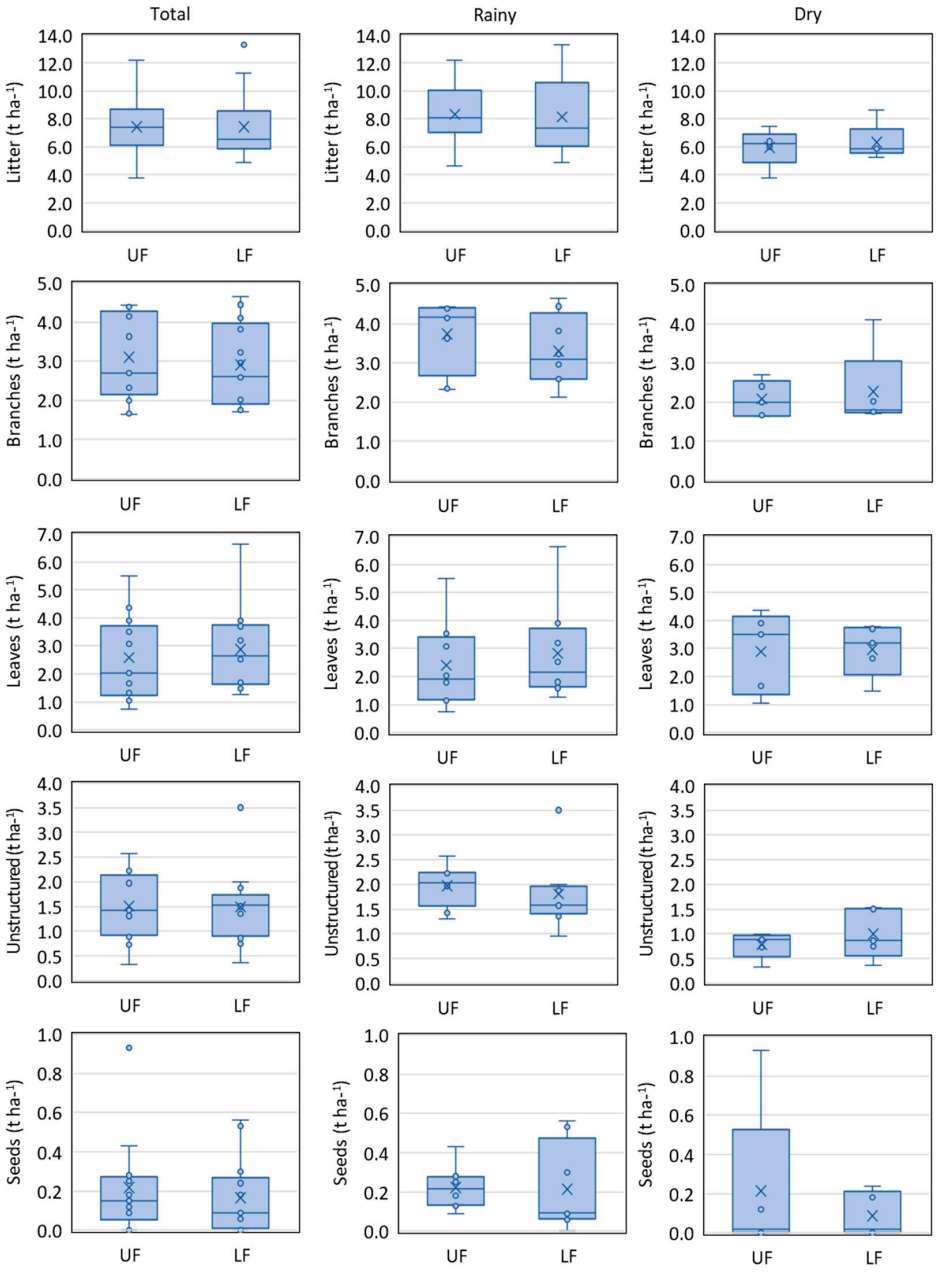

Figure 2. Monthly litter and fractions accumulation (dry mass) for total period, rainy and dry seasons at unlogged (UF) and logged forest (LF), Jamari National Forest, Rondônia—Brazil.

3.2. Litter-Water Interactions

Despite the lowest variation in water-holding capacity for UF (153–271%) than LF (140–332%), both stands showed similar properties (*p*-value = *0.856*), even when considering different fractions and seasons (Figure 3; Supplementary Materials Table S3). The mean water-holding capacity was 220 ± 43.7% for UF, distributed in unstructured material (320 ± 65.9%) > leaves (271 ± 79.6%) > seeds (222 ± 99.7%) > branches (136 ± 34.7%). Mean-

while, the mean WHC was slightly higher for LF at 224 ± 58.7%, and its fractions were ranked as follows: unstructured material (309 ± 67.8%) > leaves (283 ± 88.1%) > seeds (213 ± 99.5%) > branches (145 ± 43.3%). Regarding seasons, both stands showed the highest WHC during the rainy season, in which the litter from LF had the capacity to hold more water than UF, although only branches in the rainy season showed the highest WHC for LF.

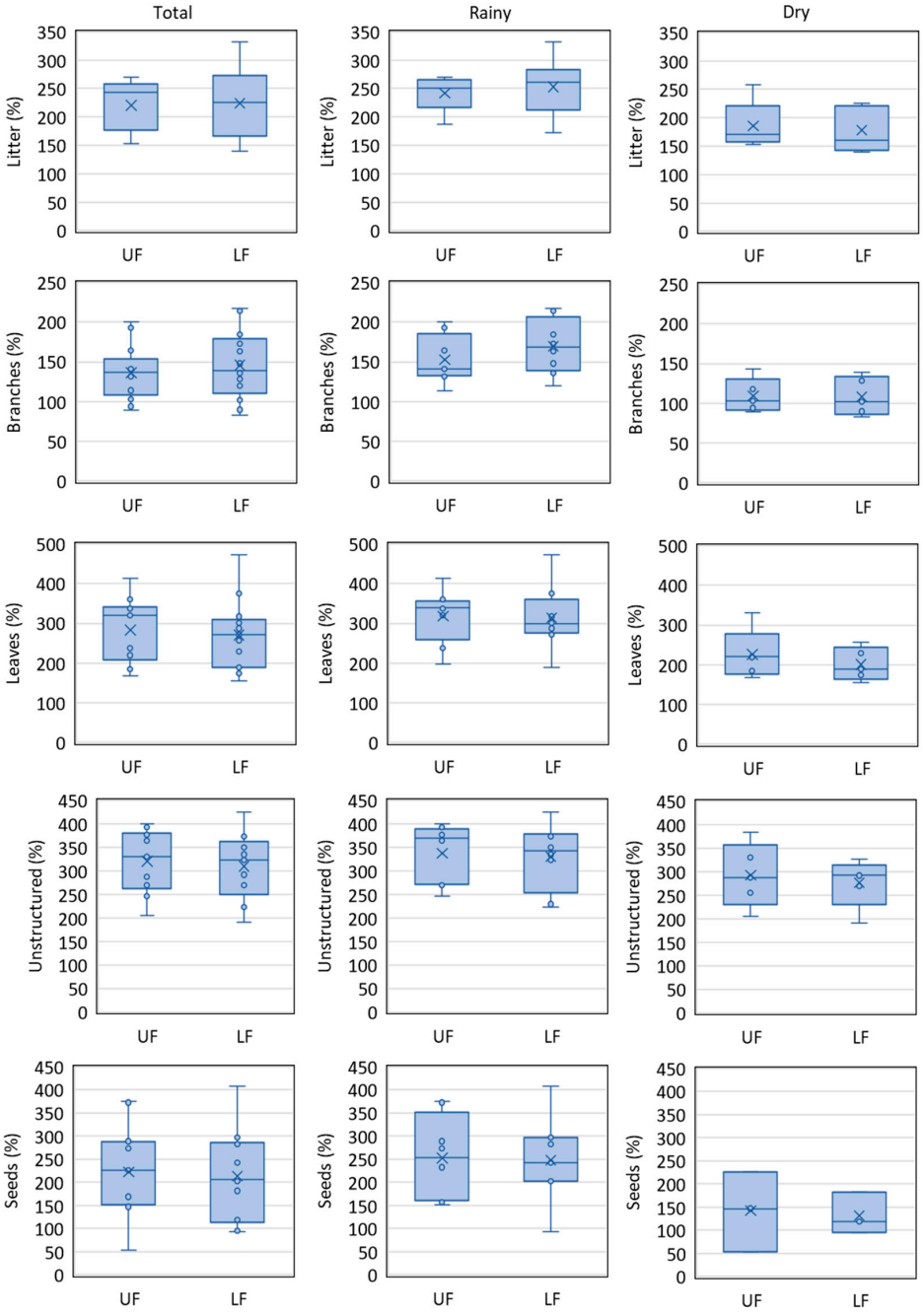

Figure 3. Monthly litter and fractions water-holding capacity for total period, rainy and dry seasons at unlogged (UF) and logged forest (LF), Jamari National Forest, Rondônia—Brazil.

The mean effective water-holding [EWC, %] was similar for both stands (p = 0.775) (UF = 48.7 ± 61.8% and LF = 49.3 ± 54.2%) (Figure 4). In general, both the annual and seasonal water content of litter did not differ significantly between stands but showed that litter contains more water during the rainy season. In the dry season, EWC was 41% and 35% lower than rainy for UF and LF, respectively. The W_{eff} ranged from 6.4

to 16.5 and 5.6 to 19.1 t·ha^{-1} for UF and LF, respectively (Supplementary Materials Table S5). The mean did not differ between the stands (p = 0.935) and represented 10.3 t·ha^{-1} month^{-1} for both. In the same way, for both stands, the rainy and dry seasons accounted 12.5 t ha^{-1} month^{-1} and 7.2 t ha^{-1} month^{-1}, respectively. The W_{max} varied from 9.7 to 25.7 t·ha^{-1} and from 8.2 to 28.7 t·ha^{-1} for UF and LF, respectively, and did not differ significantly between stands (p = 0.916). The mean W_{max} was slightly greater for LF (16.7 ± 1.5 t ha^{-1}) than UF (16.3 ± 1.0 t ha^{-1}). The rainy season was 45% (20.1 ± 4.5 t ha^{-1} month^{-1} and 20.6 ± 5.2 t ha^{-1} month^{-1} for UF and LF, respectively) higher than dry season (11.1 ± 1.1 t ha^{-1} month^{-1} and 11.2 ± 1.2 t ha^{-1} month^{-1} for UF and LF, respectively). During the study period, the litter WC ranged from 162 to 634 g_{water} kg_{litter}^{-1} for UF and from 176 to 696 g_{water} kg_{litter}^{-1} for LF and did not show significant differences (p = 0.809) between forests. The dry season had 40% less water than the rainy in both forests.

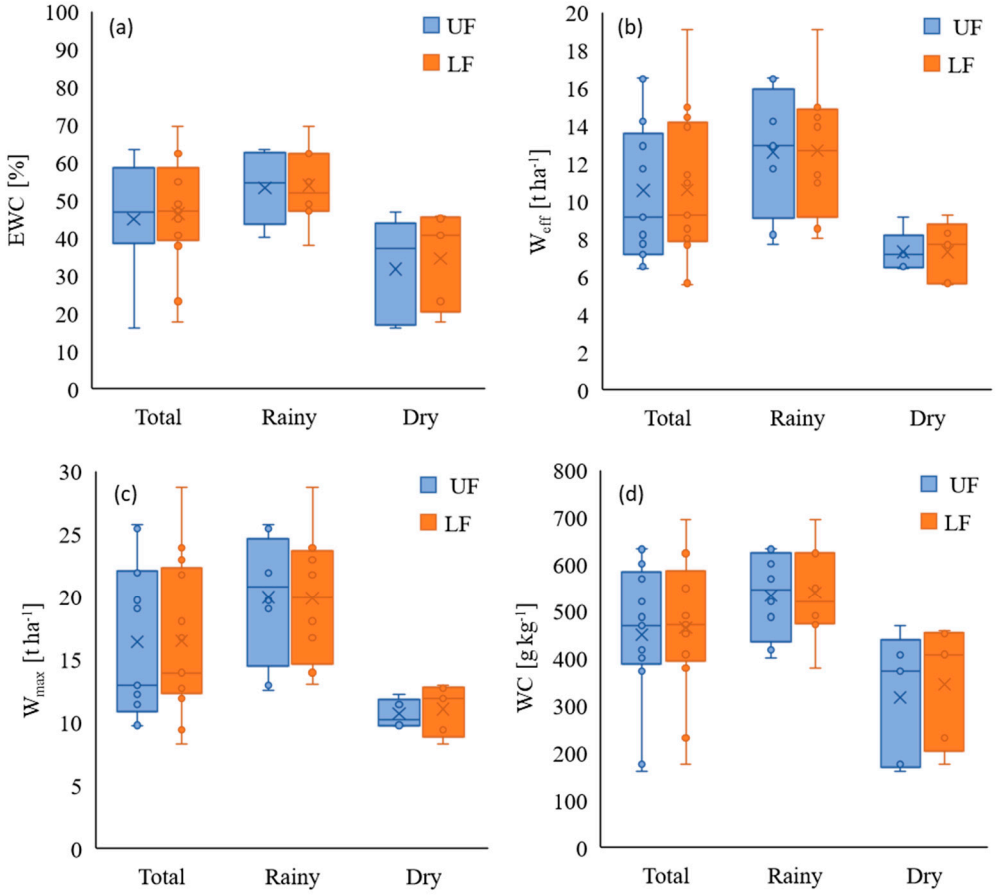

Figure 4. Monthly (**a**) effective water-holding capacity (EWC, %), (**b**) effective water-retention capacity (W_{eff}, t ha^{-1}), (**c**) maximum water-retention capacity (W_{max}, t ha^{-1}), (**d**) and litter water content (WC, g_{water} kg_{litter}^{-1}) in unlogged and logged forest. Jamari National Forest, Rondônia, Brazil.

4. Discussion

Net precipitation is an important variable to analyze the hydrological processes in forest ecosystems. This parameter corresponds to the total amount of open precipitation that reaches the ground after crossing various barriers. The results of this study showed that a larger volume of water—in addition to rainfall—reached the forest floor in the unlogged forest. This behavior has already been observed in the Amazon rainforest by other studies [34,35] and may correspond to the input of water from fog—which, being a horizontal movement, is not quantified by rain gauges. On the other hand, when fog condenses as it interacts with the surface of leaves, branches, and trunks, it contributes to the throughfall and stemflow, thus justifying the higher amount of water within the

forest when compared to open precipitation. The study of net precipitation is important in hydrological research because it allows for the analysis of the amount of precipitation that reaches the soil surface and interacts with the ecosystem. This is especially critical in forest ecosystems, where various barriers, such as vegetation, topography, and fog, can alter the amount and distribution of water that reaches the soil. Understanding the dynamics of net precipitation can help us better comprehend hydrological processes in forest ecosystems and, consequently, promote their conservation and management more effectively. In this case, the reduced logging practices did not affect the distribution of net precipitation.

The mean annual litter deposition in the studied forest was similar to that reported for primary and successional stages of forests in the Brazilian Amazon [23,36,37]. The highest rates of litter deposition were observed during the rainy season and disagree with other studies [1,23,38] indicating that litterfall is not solely controlled by rainfall seasonality (rainy or dry season). Seasonal variation in litterfall production resulted in large variations in the amount of litter on the soil, with litter peaks occurring in several months of the year [39]. Factors such as forest structure, including age, species, soil nutrients, air temperature, luminosity, wind, and soil water, also play a role in litter deposition [3]. While leaves are typically reported as the predominant fraction in Amazon forests [1,40,41], the accumulation of branches was found to be more prevalent than leaves in the studied forest, which is consistent with observations in a Semideciduous Seasonal Forest [42,43]. The high amount of branches during the rainy season (October to April) may be attributed to the mechanical energy imposed by the wind during the rains, as well as the weight gain of the branches due to waterlogging, making them more susceptible to fall and consequently increasing their production at the onset of the rainy season.

The minor impacts of reduced-impact logging may minimize the effects on vegetation cover and, consequently, on litter deposition [23]. This is particularly important to maintain water conservation in sites under sustainable forest management and the results showed that reduced-impact logging did not affect the effectiveness per unit of mass litter in retaining water. Both stands showed higher water-holding capacity during the rainy season than the dry season, which is expected given the higher rainfall and humidity during the wet season. This similarity in hydrological properties between the stands could be explained by the similarity in the litter composition, such as the leaves, branches, seeds and unstructured materials. Despite the greater accumulation of branches in both sites, the highest rates of litter water-holding capacity were observed in the unstructured fraction. In fact, the water-holding capacity does not only depend on the amount of organic material, but also on the degree of decomposition of its fractions. The high-water retention rates observed in the amorphous fraction are due to the lower surface adhesion of this material [44,45]. This means that the greater the degree of litter decomposition, the greater the specific surface area, and consequently, the greater the potential for water retention compared to other more superficial and less decomposed fractions. The fact that the leaf fraction has a lower rate of water-holding capacity compared to the unstructured fraction can be understood as a function of the lower surface adhesion or leaf adsorption, which depends on aspects related to the leaf fraction itself, such as leaf area, structure, relief, shape, surface/weight ratio, and organic composition [45,46]. In relation to the branch fraction, which presented the lowest water retention rates, this is due to the nature of the woody material, which is more hydrophobic and presents less water absorption. These branches are mostly made of xylem with thick fibers and a relatively stable structure between cells, which is difficult for water absorption although the internal tubular structure is rich [47].

It is important to highlight that litter water-holding capacity reflects the water-holding condition in the laboratory, i.e., in the ideal state and the maximum capacity of water retention [30,48]. The effective water retention was also similar between the unlogged and logged stands, indicating that both stands were able to retain a significant amount of water and that the water retention capacity of litter was not significantly affected by RIL. As reported by [49,50], W_{eff} defines the effective interception of precipitation by litter, which is an important hydrological property that can be used to consistently evaluate the

potential to absorb rainfall and reduce surface runoff [31,37]. The W_{eff} is also affected by the water content of litter, litter storage, and the nature of rainfall [27,40,45]. Our study shows that, regardless of the RIL management, the mean annual capacity of litter in the Amazon Forest to retain water was lower than that observed in *Eucalyptus mangium* and *Eucalyptus robusta* but greater than *Hevea brasiliensis* [32]. On the other hand, W_{max}, a measure of rainfall absorption, was higher than *Eucalyptus robusta* [32], and, especially in the rainy season, higher than *Hevea brasiliensis* [32]. If we consider that 1 mm of rainfall is equivalent to 1 t·ha^{-1} [32,49], the litter from unlogged or logged forests has the potential to intercept up to a mean of 12.5 mm and 7.2 mm of rainfall at the rainy and dry season, respectively, and a mean of 10.5 mm per year. In fact, the studied forest can retain in the litter the 3335 kg ha^{-1} and 3433 kg ha^{-1}—of water per month in unlogged and logged forests, respectively. Considering no statistical differences between unlogged and logged forests, the water content in the litter represented 3752 kg ha^{-1} and 2317 kg ha^{-1} per month during the rainy and dry seasons, respectively.

Studies investigating the patterns of litter and its fractions under field conditions to determine their effective capacity in retaining water are necessary, especially in complex and important environments undergoing accelerated changes, such as the Amazon biome. Although there are studies on litter production in different environments, there is a lack of knowledge on the water retention capacity of litter in field conditions. Research on the ecohydrological functions of litter in the water balance of forest ecosystems is essential [51]. The findings of this study have important implications for sustainable forest management in the Amazon. The results suggest that RIL can maintain the water retention capacity of litter, which is an important component of the hydrological cycle in tropical forests. This information can be used to develop more effective and sustainable forest management practices that maintain the ecological and economic values of tropical forests. It is important to note that while this study provides valuable insights into the impacts of RIL on the litter hydrological processes of tropical forests, further research is needed to fully understand the effects of RIL on other ecosystem services, such as carbon sequestration, biodiversity conservation, and soil erosion control. Additionally, more studies are needed to evaluate the long-term sustainability of RIL and its ability to maintain the ecological integrity of tropical forests.

5. Conclusions

The minor impacts of reduced-impact logging may minimize the effects on litter deposition, which is particularly important to maintain hydrological processes in sites under sustainable forest management. The litter water-holding capacity between unlogged and logged forests was similar, and the litter water dynamics kept the same properties. The results of the study indicate that both unlogged and logged forests have similar water-holding capacities, effective water holding and retention, maximum water retention and water content. Although there were some slight differences in the mean water-holding capacities of fractions, the overall differences between the two stands were not significant. The effective water retention was similar in both stands, and the W_{eff} and W_{max} did not differ significantly between the two stands. These findings suggest that sustainable forest management activities through reduced-impact logging did not significantly affect the hydrological dynamics of the litter layer in the Amazonian forests studied. More studies are needed to investigate the patterns of litter and its fractions under field conditions to determine its effective capacity to retain water, especially in complex and important environments such as the Amazonian biome. Understanding the ecohydrological functions of litter in the water balance of forest ecosystems is crucial for the management and conservation of these ecosystems.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/hydrology10040097/s1, Table S1. Dendrometry attributes applied for the characterization of the forest structure. Table S2. Families and forest species observed at unlogged (UL) and logged (L) plots at Jamari National Forest, Rondônia, Brazil. P1/P2/P3—plots at unlogged forest; P4/P5/P6—plots at logged forest. Table S3: Statistical analyses for open rainfall and net precipitation in the Unlogged (UL) and Logged (L) at Jamari National Forest, Rondônia, Brazil. Table S4: Litter fractions descriptive analyses for unlogged (UL) and logged (L) at Jamari National Forest, Rondônia, Brazil. Table S5: Effective litter water-holding capacity [EWC, %], water-holding capacity [WHC, %], litter effective water-retention capacity [W_{eff}, t ha^{-1}], maximum retention capacity [W_{max}, t ha^{-1}] and water content [WC, g_{water} $kg_{litter}{}^{-1}$] for unlogged (UL) and logged (L) at Jamari National Forest, Rondônia, Brazil.

Author Contributions: Conceptualization, K.C.T.; Data curation, J.A.d.L.; Formal analysis, J.A.d.L. and K.C.T.; Funding acquisition, J.A.d.L.; Investigation, J.A.d.L.; Methodology, K.C.T.; Supervision, K.C.T.; Writing—original draft, J.A.d.L.; Writing—review & editing, K.C.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Foundation to Support the Development of Scientific and Technological Actions and Research from the state of Rondônia (FAPERO).

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: The forestry company AMATA S/A for providing the field databases and the Brazilian National Council for Scientific and Technological Development (CNPq).

Conflicts of Interest: The authors declare no conflict of interest.

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