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Dynamic Change Characteristics of Litter and Nutrient Return in Subtropical Evergreen Broad-Leaved Forest in Different Extreme Weather Disturbance Years in Ailao Mountain, Yunnan Province

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Abstract: By studying the dynamic change characteristics of litter production, composition, nutrient content, and return amount of different components in different extreme weather interference years of Ailao Mountain evergreen broad-leaved forest, the paper provides theoretical support for the post-disaster nutrient cycle, ecological recovery, and sustainable development of the subtropical mid-mountain humid evergreen broad-leaved forest. Square litter collectors were randomly set up to collect litter. After drying to a constant mass, we calculated the seasonal and annual litter volume and the contents of organic carbon (C), total nitrogen (N), total phosphorus (P), total potassium (k), total sulfur (S), total calcium (Ca), and total magnesium (Mg). Finally, the nutrient return amount is comprehensively calculated according to the litter amount and element content. We tracked dynamic changes in litter quantity, nutrient composition, and nutrient components across different years. The results showed that the amount of litter from 2005 to 2015 was 7704–8818 kg·hm^{-2}, and the order of magnitude was: 2005 (normal year) > 2015 (extreme snow and ice weather interference) > 2010 (extreme drought weather interference); the composition mainly included branches, leaves, fruit (flowers), and other components (bark, moss, lichen, etc.), of which the proportion of leaves was the largest, accounting for 41.70%–61.52%; The monthly changes and total amounts in different years exhibited single or double peak changes, and the monthly litter components in different years showed significant seasonality. In this study, the nutrient content of litter was higher than that of litter branches each year. The total amount of litter and the nutrient concentration of each component are C, Ca, N, K, Mg, S, and P, from large to small. The order of nutrient return in different years was the same as that of litter, and the returns of nutrients in litter leaves were greater than that of litter branches. The ratio of nutrient returns of litter and litter branches from 2005 to 2010 was 2.03, 1.23, and 3.69, respectively. The research shows that the litter decreased correspondingly under the extreme weather disturbance, and the impact of the extreme dry weather disturbance was greater than that of the extreme ice and snow weather disturbance. However, the evergreen broad-leaved forest in the study area recovers well after being disturbed. The annual litter amount and nutrient return amount is similar to that of evergreen broad-leaved forests in the same latitude and normal years in other subtropical regions. The decomposition rate and seasonal dynamics of litter nutrients are not greatly affected by extreme weather.

Keywords: litter quantity; nutrient content; return of nutrients; subtropical evergreen broad-leaved forest; extreme weather disturbance

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1. Introduction

Forest litter refers to the general term for all organic matter in the forest ecosystem that is produced by aboveground plants and other biological components and returned to the forest surface as a source of material and energy for decomposers to maintain ecosystem functions, including litter leaves, litter branches, flower, and fruit reproductive organs and debris [1,2]. Leaf litter is considered to be an important survival strategy for plants to cope with adverse growth conditions, such as soil drying due to temperature reduction or drought [3,4]. Forest litter is an important structural and functional unit of material circulation and energy flow in the forest ecosystem. Its litter, accumulation, and decomposition are basic ecosystem processes. Important functions have irreplaceable ecological roles, and a large amount of organic matter and mineral elements are transported from the canopy of plants to the soil surface through the litter. Therefore, the collection and measurement of forest litter are important means of studying the structure and function of forest ecosystems [5–8]. To a certain extent, litter yield and nutrient return are suitable indicators of the overall function of forest ecosystems and play a key role in forest ecosystem dynamics, nutrient cycling, and forest productivity [9–12].

The forest types in subtropical regions are important forest ecosystems unique to the same latitude in the world. They have high primary productivity and are biodiversity hotspots, which play an important role in carbon storage in global terrestrial ecosystems [13]. The montane moist evergreen broad-leaved forest in the Ailao Mountain Nature Reserve in Yunnan is currently the largest and most well-preserved subtropical evergreen broad-leaved forest in my country. It is one of the valuable zonal vegetation. It is of great significance to study the dynamic change law of yield, nutrient cycle law and composition characteristics of the litter of the evergreen broad-leaved forest in Ailao Mountain to understand the nutrient availability and productivity of the forest system [14–17].

Forest litter has a distinct seasonal pattern, mainly in a unimodal, bimodal or irregular pattern [18–21]. The temporal variability of forest litter is an important source of uncertainty in the forest carbon cycle, and biological factors such as forest type, origin, forest age, tree species richness, phenological rhythm and genetic characteristics are important factors affecting the seasonal pattern of litter [22–25]. Different forest communities in different climatic zones around the world are not the same. According to research, the annual litter of the main forest types in each climatic zone can be specifically expressed as rainforest > evergreen broad-leaved forest > mixed coniferous and broad-leaved forest > deciduous broad-leaved forest > coniferous forest [26–28]. Although in the past few decades, litter yield, structure and composition, decomposition rate, and its influencing factors have been extensively studied around the world, the existing dynamic changes of litter are mostly related to litter yield, nutrient The results of a single study on the return of elements or nutrients for one year are mostly planted forests, and there are relatively few studies on primitive natural forests [29–31]. In addition, the research on the evergreen broad-leaved forest in this region mainly includes the vegetation type and diversity research, and the multi-year comparative comprehensive research combining the dynamic law of litter yield and nutrient return is rarely reported [7,10,32–36].

Forest litter is an important carbon pool for forest ecosystems. Its nutrient cycle and nutrient balance are strongly affected by climate, and play a complex source-sink effect in the process of global change. It is one of the basic parameters of carbon exchange with the atmosphere and is closely related to global change and the circulation of materials in the global ecosystem [37]. Climatic factors (including temperature, precipitation, long-term extreme weather, etc.) are important factors affecting forest productivity, in addition, trees take a long time to regenerate and increase biomass, so forest ecosystems are sensitive to extreme weather disturbances. In recent years, forest litter has begun to be studied in the context of the global environment, focusing on its important role in carbon and nutrient cycling [38,39]. Climate change will not only directly affect the community structure and vegetation composition of forest ecosystems by changing climatic factors such as temperature and precipitation, but also indirectly affect the primary productivity level of forest ecosystems and the nutrients of forest ecosystems by changing the area and intensity of natural disturbances. The distribution and material circulation process have an impact, which in turn affects the amount, composition and dynamic changes of litter in forest ecosystems [40–42]. Specifically, with global warming since the 20th century, the scope, frequency, and intensity of extreme weather events around the world have increased significantly. Compared with conventional weather change, extreme weather will have a greater impact on forest ecosystems, increasing the The survival pressure of forest communities and the potential risk of local extinction have caused a series of crises to the security of forest ecosystems [43]. In particular, extreme weather disasters such as drought, ice and snow have become one of the most important climate disasters due to their high frequency and large scope, and they have always been widely concerned [44,45].

From a geographical point of view, Yunnan, as one of the areas with the most frequent drought disasters in Southwest China, has attracted extensive attention of many scholars. However, most of the current related researches focus on the analysis of the spatial and temporal distribution characteristics and causes of drought and flood disasters in Yunnan. The research results on the combination of litter dynamics and drought in typical subtropical evergreen broad-leaved forests have not yet been reported [46,47]. In 2010, parts of Yunnan suffered continuous severe drought, which was the most severe drought event ever recorded in Southwest China, which caused serious damage to the forest ecosystem in the region [48,49]. Subtropical evergreen broad-leaved forests have become the main victims of ice and snow disasters due to their evergreen and relatively wide canopies [50], and mechanical damage is particularly serious. Therefore, the disturbance of extreme freezing rain and snow weather disturbances to subtropical forest ecosystems is also very serious [51,52]. As far as ice and snow disasters are concerned, because they mainly occur in Europe and eastern North America, the research on the impact of snow and ice disasters on forest vegetation is also mainly concentrated in this region, resulting in the response model of subtropical forests to snow and ice disasters is still not completely clear [53–55]. However, in January 2015, Ailao Mountain encountered a catastrophic ice and snow weather disturbance, resulting in a certain degree of fragmentation of the evergreen broad-leaved forest in the area, and overall changes in the woodland habitat and forest structure. The forest ecosystem and diversity have caused serious damage [56]. Once the dynamics of litter changes, the material cycle of the forest ecosystem will be affected, and the productivity and service functions of the forest will change [42,57]. Therefore, it is very important to study the dynamics of litter in the study area. In addition, human beings and forest ecosystems are closely related, and these changes will inevitably have a direct impact on human beings. How to promote the flow of material circulation and energy in post-disaster ecosystems, strengthen the protection of biodiversity in damaged forest ecosystems, and restore ecological functions is an urgent problem to be solved. However, the solution to these problems is inseparable from the research on the changes of litter and its nutrient cycle after disasters [37,58].

However, the current research on whether extreme drought will change, how it affects, and the degree of impact on the litter dynamics of subtropical forest ecosystems and the development process of forest ecosystems is relatively scarce, and the comparison of the degree of damage to the same forest ecosystem caused by different extreme weather disturbances not clear [37,42]. To this end, this study selects three special years with equal intervals of growth in the virgin forest of Ailao Mountain National Nature Reserve, including 2005 (a normal year not disturbed by extreme weather) and 2010 (a year disturbed by extreme arid weather), 2015 (the year disturbed by extreme ice and snow weather), the amount of litter in different parts and the nutrient element content and return amount of each component were measured to explore the components and total amount of litter in normal years and before and after being disturbed by different extreme weathers. The interannual variation, monthly dynamic variation, seasonal dynamic variation characteristics of litter volume and its significant differences with each component and nutrient element content and return amount. On the basis of a comprehensive analysis of the impact of extreme weather change on litter dynamics, this paper attempts to summarize the variation laws and nutrient cycling laws of litter under different extreme weather disturbances, in order to enrich the ecological structure, ecological structure, and nutrient cycle of the montane humid evergreen broad-leaved virgin forest. The research on the function provides a theoretical basis for the material cycle, nutrient balance, and ecological restoration of the disturbed forest ecosystem. This paper discusses how to better apply the ecological function of litter to forest ecosystem management, so as to improve the management level of forest ecosystem and give full play to the self-sustaining mechanism of forest ecosystem.

According to previous studies, we know that extreme weather interference can form a large number of abnormal litters, which refers to the fresh residues and litters of individual plants or plant organs caused by external forces under extreme weather, fire, or geological disasters, such as a large number of fallen trees, twigs and litter leaves on the forest land due to the impact of natural disasters such as low temperature, snow, freezing, or typhoon, to affect the amount of litter and its nutrient content [44–47,59]. Based on this, we propose the following main research questions: (1) Can extreme drought and ice and snow weather disturbance affect litter yield and nutrient return? (2) Will extreme arid weather disturbance hinder or destroy the normal succession process, seasonal dynamic changes, and decomposition rate of forest ecosystems? (3) If there is an impact, is the impact of different extreme weather disturbances on the components of litter consistent?

2. Materials and Methods

2.1. Overview of the Study Area

The study area (Figure 1) is located in the Xujiaba area (24°32′ N, 101°01′ E) in the core area of Ailao Mountain National Nature Reserve, with an altitude of 2400–2600 m, and the soil is fertile acid yellow-brown soil [14]. According to the long-term monitoring data of the Ailao Mountain Forest Ecosystem Research Station, the average annual temperature in this area is 11.3 °C, the average annual precipitation is 1931 mm, and the average annual evaporation is 1192 mm. The climate belongs to the southwest monsoon region, with distinct dry and rainy seasons. The precipitation in the rainy season (May to October) accounts for about 85% of the annual precipitation, and the average annual relative humidity is 85% [15,16]. The zonal vegetation is the mid-mountain humid evergreen broad-leaved forest, the canopy is highly closed, the community tree, shrub, and grass layers are clearly layered, the interlayer plants are common with woody vines, and epiphytes are abundant, mainly mosses and ferns. The dominant species are *Castanopsis rufescens* Hook. f. et Thoms., *Schima noronhae* Reinw. ex Bl. Bijdr., *Lithocarpus xylocarpus* (Kurz) Markgraf, *Camellia forrestii* (Diels) Coh. St., *Machilus bombycina* King ex J. D. Hooker and other large trees, as well as shrubs such as *Sinarundinaria nitida* Franch. widely distributed in the forest and Plagiogyria communis and other herbs.

2.2. Sample Plot Setting and Litter Collection

The evergreen broad-leaved forest community in this area was selected, and a square fixed plot with a plot area of 1 hm^2 (100 m × 100 m) was established, and the established fixed plot was divided into 100 small plots of 10 m × 10 m. A total of 25 of them were randomly selected for long-term litter observation. A box-type litter collector with an area of 1 m^2 was placed horizontally on the forest floor or at a certain distance from the ground. The bottom of the collector was 0.5 m from the ground, and nylon mesh screens were used, and the surrounding areas were fixed with PVC pipes. Then, all the fresh litter in the collector is collected at the end of every five years at equal intervals, that is, at the end of each month in 2005, 2010, and 2015. Stones and other sundries are numbered and placed in sterile plastic bags, and all litter is used to record the amount of litter recovered [2,60,61]. We separated the collected litter by branches, leaves, flowers, and fruits (reproductive organs), other components (bark, moss, lichen, debris), and cleaned up the attached impurities. Then the litter were dried to constant weight in the oven at 65 °C and weighed and recorded for calculating the litter amount of each component of the litter [62,63]. The litter amount of each litter component was converted from the average value of the corresponding components in 25 collection frames. The monthly litter amount was the sum of the litter components of the month, and the annual litter amount is the sum of the litter amount of 12 months [25,33,64–66].

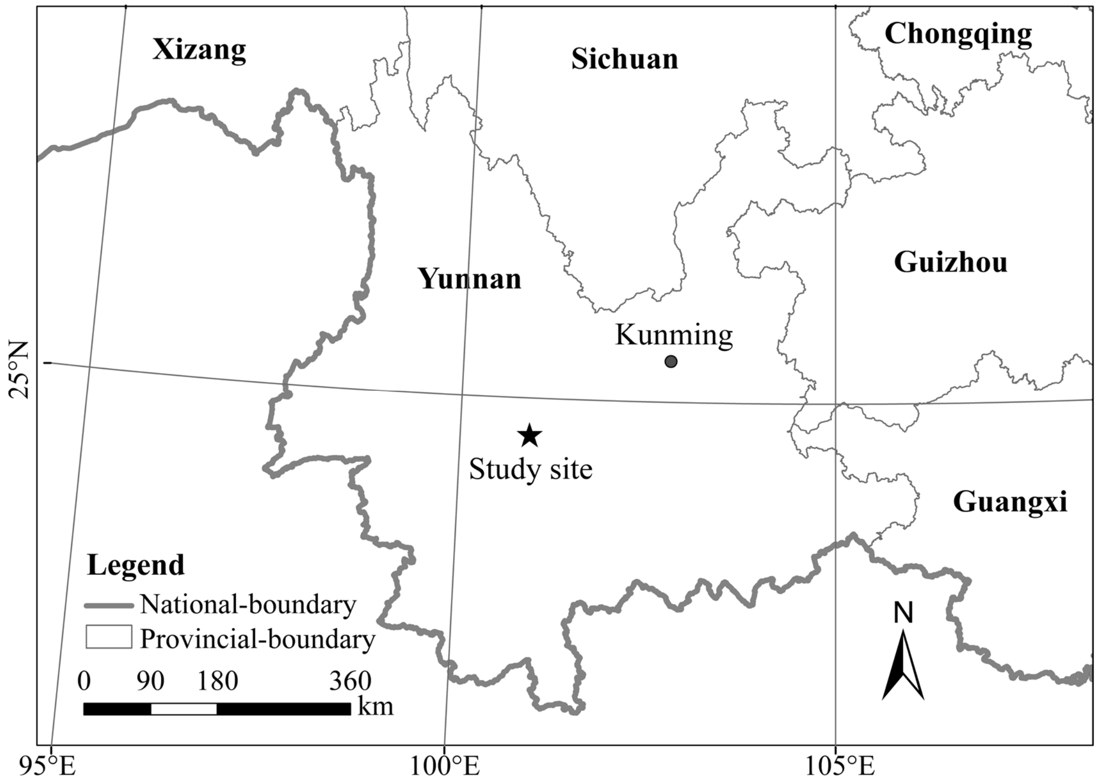


Figure 1. Study Area Map.

2.3. Determination of Litter Nutrients

The dried and weighed litter analysis samples were ground with a plant crusher and sieved through a 60 mesh to determine the nutrient contents. Carbon (C) and nitrogen (N) were measured with a carbon element analyzer (EA3000, EuroVector, Milan, Italy) [33–35]. For the determination of other elements, the sample was digested by the H_2O_2–H_2SO_4 digestion method and then prepared into the solution to be measured. The content of total phosphorus (P) is determined by the Mo-Sb colorimetry method, and the content of total potassium (K), total sulfur (S), total calcium (Ca), and total magnesium (Mg) were determined by the flame photometer and spectrophotometer [6,36]. The amount of nutrients returned by litter is closely related to the amount of litter and nutrient content in the litter.

2.4. Calculation of Nutrient Return of Litter

The amount of nutrient return of litter is closely related to the amount of litter and the nutrient content in the litter. The amount of nutrient return is equal to the product of the amount of litter and the nutrient content in the litter. The specific calculation is that the monthly nutrient return amount of each component of the litter is the product of the nutrient content of the component of the litter in the current month and the litter amount of the component in the current month. The total annual nutrient return amount of the litter is the total return amount of each component of the litter in 12 months [25,33,37,38].

2.5. Data Analysis

After using the Shapiro–Wilk test to test the normality of the data, one-way ANOVA and LSD were used to compare the difference in the amount of litter in different parts of different years and its components, the content of nutrient elements, and the amount of return. For seasonal dynamic changes, the coefficient of variation was used to characterize the annual variation of litter volume, which was obtained by dividing the standard error of litter volume in different years by its mean. The annual variation of litter was obtained by dividing the difference between the maximum monthly litter volume and the minimum monthly litter volume by the monthly average litter volume during the observation period. All data statistical analysis and chart production were completed on Excel 2010 and SPSS 25.

3. Results

3.1. Annual Changes in Litter and Composition in Different Years

3.1.1. Annual Variation in Litter Components and Total Amounts in Different Years

It can be seen from Table 1 that the total amount of litter from 2005 to 2015 was between 7704.15 and 8817.50 kg·hm^{-2}·a^{-1} and the order of magnitude was 2005 > 2015 > 2010. The litter amount fluctuated from year to year, and the coefficient of variation was 7.03%. The composition of litter mainly includes litter branches, litter leaves, litter fruits (flowers), and other litter components (bark, moss lichens, debris, etc.), among which litter branches and other components are significantly different from litter leaves and litter fruits (flowers) ($p < 0.05$), but the difference between litter branches and other components is not significant ($p > 0.05$). Each component of litter and its proportion to the total forest litter in different years are as follows: litter leaves > litter branches> other components> litter fruits (flowers), and the total average percentage is: 50.89% > 25.28% > 15.86% > 7.97%. Litter leaves are the absolute dominant component of the litter in the evergreen broad-leaved forest community in Ailao Mountain, accounting for 41.70%–61.52% of the total litter in different years, the highest in 2010 and the lowest in 2015. Litter branches, litter fruits (flowers), and other components accounted for 17.26%–32.05%, 6.29%–9.37%, and 14.57%–16.88% of the total forest litter from 2005 to 2015, respectively. It accounted for the highest percentage of total forest litter, followed by 2005 and 2010.

Table 1. Annual variation of litter components in different years (kg/hm^2).

Year	Litterfall				
	Litter Branch	Litter Leaf	Litter Fruit (Flower)	Other Litter	Litter Total
2005	2276.36 ± 260.55 ^{A} (25.82%)	4404.97 ± 170.26 ^{A} (49.96%)	719.90 ± 27.88 ^{A} (8.16%)	1416.27 ± 60.31 (16.06%)	8817.50 ± 319.67 ^{A} (100%)
2010	1357.74 ± 83.05 ^{B} (17.26%)	4739.35 ± 268.05 ^{A} (61.52%)	484.72 ± 27.16 ^{B} (6.29%)	1122.34 ± 67.98 ^{C} (14.57%)	7704.15 ± 400.3 ^{B} (100%)
2015	2567.25 ± 465.77 ^{A} (32.05%)	3340.59 ± 142.72 ^{B} (41.70%)	751.02 ± 37.73 ^{A} (9.37%)	1352.02 ± 88.71 ^{B} (16.88%)	8010.87 ± 643.65 ^{B} (100%)
Total average	2067.12 ± 631.32 ^{Ac} (25.28%)	4161.64 ± 730.44 ^{Ab} (50.89%)	651.88 ± 145.60 ^{Ae} (7.97%)	1296.88 ± 154.53 ^{Bd} (15.86%)	8177.51 ± 575.08 ^{Ba} (100%)

Note: the percentage of litter amount of each component in the total litter amount of the whole year is shown in brackets. Different capital letters in the same column indicate significant differences between different years, and different lowercase letters in the same row indicate significant differences between different litter components in the same year ($p < 0.05$).

3.1.2. Monthly Dynamics of Litter Components in Different Years

It can be seen from Figure 2 that in 2005, the total amount of litter and each component exhibited an irregular pattern, with multiple peaks, in which the total amount of litter showed a four-peak pattern with peaks in February, April, August, and November (727.71, 943.44, 1647.86, and 764.36 kg/hm^2, respectively). The total amount of litter in August was significantly higher than in the other months. Leaves showed a bimodal pattern, with the first peak in April at 693.59 kg/hm^2 and the second peak in November at 499.74 kg/hm^2. The number of litter branches also significantly increased in February (310.23 kg/hm^2) and August (982.01 kg/hm^2), whereas the monthly variations in fruits (flowers) and other components were relatively flat. In 2010, the total amount of litter and the amount of litter leaf showed a double peak curve, one in April and the other in November. The difference between the two peaks was obvious, but they both appeared in the dry season, among which the peak of the litter was in April. The span of the twigs was larger, and the amount of litter was higher, which was significantly higher than that in November, and the litter branches and other components also showed obvious unimodal monthly variation characteristics, which were all significantly increased in April. In 2015, the highest value of the total amount of litter and the amount of each component was concentrated in January, and then the number dropped sharply and then slightly rebounded in March and September. Overall, the litter in 2015 showed a single peak pattern throughout the year. The amount of litter in January was higher than the annual average, and the peaks were mainly concentrated in the dry season rather than the rainy season. In 2005, 2010, and 2015, the annual changes in the total amount of litter in the study area were 161.50%, 209.12%, and 359.37%, respectively, of which 2015 had the largest change, indicating that the intermonthly variation of the litter amount was more severe, while in 2005 The smallest variation range indicated that the monthly variation of litter in this year was relatively gentle.

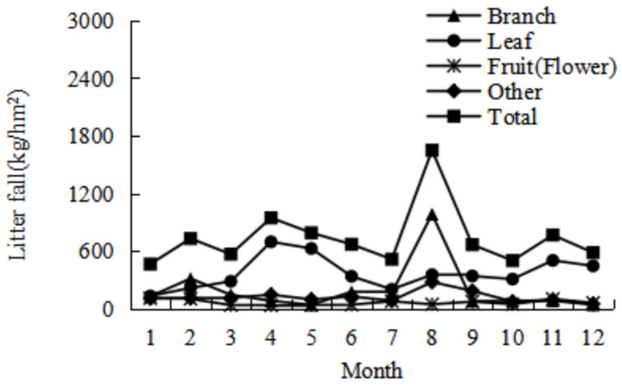
3.1.3. Seasonal Dynamics of Litter Fractions in Different Years

Seasons in this experiment were divided as follows: March–May for spring, June–August for summer, September–November for autumn, and December–February for winter. The monthly litter of different components in different years exhibited significantly different seasonal variation (Figure 3). The total amount of litter in different years was significantly higher than that of other components. In 2005, the components with the highest amount of litter in the other three seasons were leaves, except in summer, which was dominated by branches. The distribution of branch components across seasons peaked in summer. Leaves represented the highest proportion in spring, which then fluctuated and decreased with the passage of summer, autumn, and winter; fruit drop (flower) slowly rose from spring to winter. Other components rose from spring to summer, and then decreased gradually after reaching a high point in summer, with small fluctuations. In 2010, litter was composed mostly of leaves and least by fruit (flower). The seasonal variation in fruit (flower) was lowest in spring. After reaching a peak in summer, fruit (flower) remained stable until autumn, decreased from autumn to winter, and reached the lowest value in winter. The seasonal variation in other components was similar, showing a peak in spring, followed by a sharp decline. In 2015, the maximum value of litter component in winter was branches, and the component with the highest amount of litter in the other three seasons was leaves. The seasonal variation in each component was highest in spring, then decreased reaching the lowest values in summer, and rose thereafter.

3.2. Dynamic Characteristics of Litter Nutrient Contents in Different Years

3.2.1. Annual Average Nutrient Contents of Litter Components in Different Years

The nutrient content of all years was higher in litter than in branches, while the concentration of different nutrients was C > Ca > N > K > Mg > S > P (Table 2). The C content was not significantly different ($p > 0.05$) between branches and leaves in all years except for 2010. The overall distribution of C in the two organs was relatively average, and the distribution of C content in the leaves was only slightly higher than that in the branches. Branches and leaves showed significant differences ($p < 0.05$) between 2005, 2010, and 2015 in N and K contents, whereas P, S, Ca, and Mg contents were not significantly different ($p > 0.05$) between the years. C, Ca, and Mg contents in branches were the same in different years, with the highest in 2005 and the lowest in 2015. The trends in N and S content were also 2010 > 2005 > 2010, and the P and K contents showed the highest levels in 2015 (0.48 and 0.87 g/kg). The P content and K content were the lowest in 2005 and 2010, respectively. In leaves, the annual average contents of N, P, and S increased with the year, while the content of C, K, Ca, and Mg is 2005 > 2010 > 2015.



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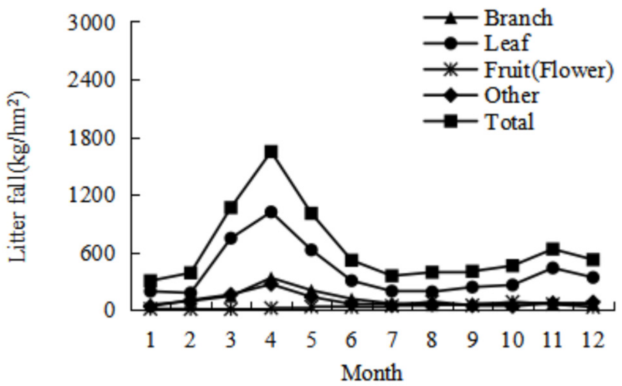

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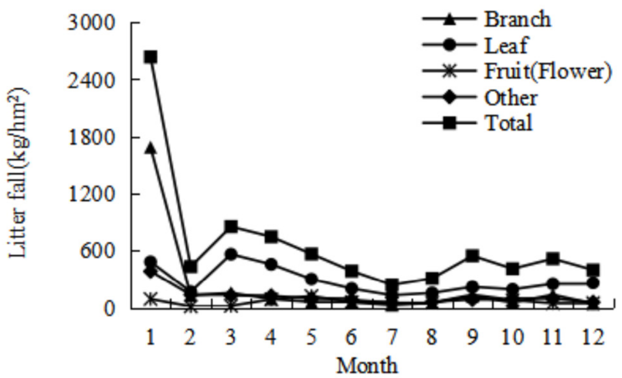
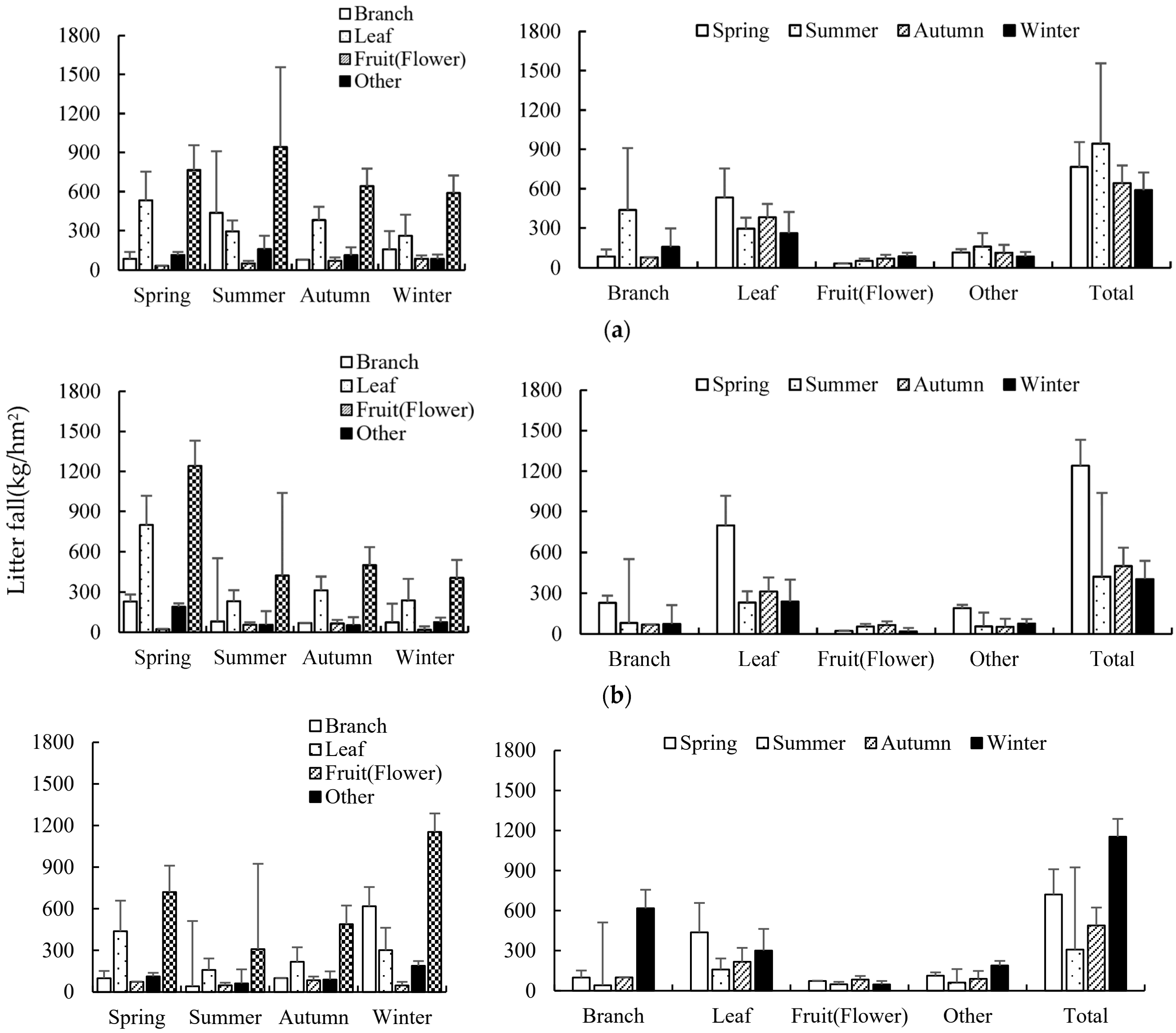


(**c**)

Figure 2. Monthly dynamics of litter components and totals in 2005, 2010, and 2015. (**a**) Monthly dynamics of litter components and totals in 2005; (**b**) monthly dynamics of litter components and totals in 2010; (**c**) monthly dynamics of litter components and totals in 2015.



(c)

Figure 3. Seasonal dynamics of litter in 2005, 2010, and 2015. (**a**) Seasonal dynamics of litter in 2005; (**b**) seasonal dynamics of litter in 2005; (**c**) seasonal dynamics of litter in 2005.

The values of C/N, C/P and N/P of litter in 2005, 2010, and 2015 were 57.66, 658.05, 19.02; 47.88, 998.59, 20.86; 55.65, 869.55, 15.63, respectively. The ratios of C/P and N/P were 42.27, 772.86, 18.29; 36.73, 685.47, 18.66; 33.78, 573.80, 16.99, respectively. The mean ratios of C/N, C/P and N/P of litter were 48.65, 904.69, 18.59; 41.45, 803.68, 18.66; 41.89, 684.83, 16.35, respectively.

Table 2. Annual average nutrient content of litter components in different years (g/kg).

Nutrient	2005 Litterfall			2010 Litterfall			2015 Litterfall		
	Litter Branches	Litter Leaves	Average	Litter Branches	Litter Leaves	Average	Litter Branches	Litter Leaves	Average
C	526.44 ± 22.42 ^{aA}	541.10 ± 21.06 ^{aA}	533.77 ± 10.37 ^{aA}	489.31 ± 10.80 ^{aB}	507.25 ± 10.92 ^{aA}	498.28 ± 12.69 ^{aB}	486.95 ± 9.62 ^{aB}	499.21 ± 11.80 ^{aB}	493.08 ± 8.67 ^{aB}
N	9.13 ± 1.06 ^{bB}	12.80 ± 2.39 ^{bA}	10.97 ± 2.60 ^{bA}	10.22 ± 0.87 ^{bB}	13.81 ± 2.55 ^{bA}	12.02 ± 2.54 ^{bA}	8.75 ± 1.92 ^{bB}	14.78 ± 2.07 ^{bA}	11.77 ± 4.26 ^{bA}
P	0.48 ± 0.06 ^{dA}	0.70 ± 0.17 ^{dA}	0.59 ± 0.16 ^{dA}	0.49 ± 0.02 ^{dA}	0.74 ± 0.15 ^{dA}	0.62 ± 0.18 ^{dA}	0.56 ± 0.19 ^{dA}	0.87 ± 0.17 ^{dA}	0.72 ± 0.22 ^{dA}
K	1.99 ± 0.60 ^{cB}	4.79 ± 1.70 ^{cA}	3.39 ± 1.98 ^{cA}	1.80 ± 0.05 ^{cB}	4.55 ± 0.73 ^{cA}	3.18 ± 1.94 ^{cA}	2.82 ± 1.79 ^{cB}	5.46 ± 0.59 ^{cA}	4.14 ± 1.87 ^{cA}
S	0.87 ± 0.13 ^{dA}	1.20 ± 0.19 ^{dA}	1.04 ± 0.23 ^{dA}	0.92 ± 0.05 ^{dA}	1.25 ± 0.09 ^{dA}	1.09 ± 0.23 ^{dA}	0.76 ± 0.16 ^{dA}	1.26 ± 0.15 ^{dA}	1.01 ± 0.35 ^{dA}
Ca	15.19 ± 1.87 ^{bA}	13.25 ± 0.99 ^{bA}	14.22 ± 1.37 ^{bA}	14.38 ± 0.95 ^{bA}	12.18 ± 0.61 ^{bA}	13.28 ± 1.56 ^{bA}	10.77 ± 2.78 ^{bA}	10.30 ± 2.33 ^{bA}	10.54 ± 0.33 ^{bB}
Mg	1.55 ± 0.20 ^{cA}	2.48 ± 0.43 ^{cA}	2.02 ± 0.66 ^{cA}	1.54 ± 0.06 ^{cA}	2.47 ± 0.25 ^{cA}	2.01 ± 0.66 ^{cA}	1.37 ± 0.24 ^{cA}	2.41 ± 0.25 ^{cA}	1.89 ± 0.74 ^{cA}

Note: the percentage of litter amount of each component in the total litter amount of the whole year is shown in brackets. Different capital letters in the same column indicate significant differences between different years, and different lowercase letters in the same row indicate significant differences between different litter components in the same year ($p < 0.05$).

3.2.2. Seasonal Dynamics of the Nutrient Contents of Each Component of Litter in Different Years

It can be seen from Table 3 that the order of nutrient content of each component in each season is C > Ca > N > K > Mg > S > P. Therefore, C, Ca, N, K and Mg are the major elements of the evergreen broad-leaved forest, and S and P are the trace elements. The seasonal dynamic change characteristics of nutrient content of each component of litter in different years are quite different, and the seasonal change regularity of the content of each element is uncertain. In 2005, the seasonal variation of C nutrient content was spring > winter > summer > autumn, while the seasonal sequence of N content was completely opposite; P. The contents of K, Mg, S, and Ca are higher in winter and lower in summer. In 2010, the seasonal variation of C and Mg nutrient content was the same, which was summer > spring > autumn > winter; N. The nutrient contents of P, K, and S were the highest in summer and the lowest in spring. In 2015, C and Mg nutrient contents were the highest in spring and the lowest in summer; N. On the contrary, the contents of P, Ca, and other macroelements were the highest in summer and the lowest in spring; K content sequence is consistent with that in 2005; S content is similar to 2010.

Table 3. Seasonal dynamics of nutrient content of branches and leaves in different years (g/kg).

Year	Components	Season	C	N	P	K	S	Ca	Mg
2005	Litter branches	Spring	547.44	9.30	0.49	2.53	0.87	15.34	1.58
		Summer	517.44	8.48	0.42	1.46	0.75	13.31	1.25
		Autumn	506.06	10.28	0.55	2.03	1.04	16.80	1.69
		Winter	534.83	8.48	0.46	1.93	0.82	15.32	1.67
	Litter leaves	Spring	557.11	11.29	0.60	5.98	1.14	13.74	2.75
		Summer	521.50	13.96	0.74	3.50	1.20	13.29	2.04
		Autumn	531.17	12.74	0.65	4.35	1.17	13.24	2.49
		Winter	554.06	12.79	0.78	5.58	1.25	12.82	2.65
	Average	Spring	552.28	10.30	0.54	4.26	1.01	14.54	2.16
		Summer	519.47	11.22	0.58	2.48	0.98	13.30	1.64
		Autumn	518.61	11.51	0.60	3.19	1.11	15.02	2.09
		Winter	544.44	10.64	0.62	3.76	1.03	14.07	2.16
2010	Litter branches	Spring	488.75	6.63	0.36	1.68	0.60	10.20	1.38
		Summer	502.50	11.60	0.69	4.36	0.97	12.00	1.84
		Autumn	484.25	7.95	0.46	3.40	0.71	9.70	1.19
		Winter	484.48	9.23	0.68	3.19	0.82	9.68	1.27
	Litter leaves	Spring	506.00	12.51	0.62	5.05	1.06	9.60	2.46
		Summer	520.00	17.92	0.97	4.86	1.42	9.19	2.57
		Autumn	496.50	15.46	0.89	5.62	1.38	11.69	2.62
		Winter	490.50	13.80	0.85	5.55	1.21	11.43	2.36
	Average	Spring	497.38	9.57	0.49	3.36	0.83	9.90	1.92
		Summer	511.25	14.76	0.83	4.61	1.20	10.60	2.20
		Autumn	490.38	11.71	0.68	4.51	1.05	10.70	1.91
		Winter	487.49	11.51	0.77	4.37	1.01	10.55	1.82
2015	Litter branches	Spring	488.75	9.05	0.51	1.81	0.91	13.17	1.55
		Summer	474.25	10.33	0.50	1.73	0.86	14.32	1.48
		Autumn	497.75	11.16	0.50	1.85	0.97	14.58	1.63
		Winter	496.50	10.34	0.47	1.82	0.96	15.47	1.51
	Litter leaves	Spring	520.75	11.42	0.60	5.36	1.27	12.02	2.58
		Summer	494.00	17.22	0.95	4.51	1.37	12.81	2.23
		Autumn	507.25	14.24	0.72	3.59	1.15	12.51	2.30
		Winter	507.00	12.38	0.70	4.73	1.22	11.41	2.78
	Average	Spring	504.75	10.24	0.56	3.58	1.09	12.59	2.06
		Summer	484.13	13.77	0.72	3.12	1.12	13.57	1.85
		Autumn	502.50	12.70	0.61	2.72	1.06	13.54	1.96
		Winter	501.75	11.36	0.59	3.28	1.09	13.44	2.14

3.3. Characteristics of Nutrient Return of Litter in Different Years

3.3.1. Annual Nutrient Return from Litter

The nutrient return in other years generally showed C > Ca > N > K > Mg > S > P (Table 4), and litter was higher than branches, which is consistent with the order of annual average nutrient concentrations of each component. Among branches, the returns of C and Ca were highest in 2005 (1191 kg/hm^2), and then decreased year by year. The return of N, P, K, S, and Mg was highest in 2010, followed by 2005, and lowest in 2015. Among leaves, C, N, P, K, S, and Mg restitution was highest in 2015, and only Ca restitution was different in order of size, with the highest in 2005 and the lowest in 2010.

3.3.2. Seasonal Dynamics of Nutrient Return from Litter in Different Years

As shown in Table 5, In 2005, the maximum value of the nutrient return of each element in the litter branches was concentrated in summer and winter, the minimum value was concentrated in spring and autumn, and the seasonal change order of nutrient return of each element in the litter was opposite, the maximum value was in spring and autumn, and the minimum value was concentrated in summer and winter. In 2010, the maximum value of the nutrient return of each element in the litter branches was spring, followed by summer, and the minimum value fluctuated in winter and autumn. The order of nutrient return of most elements in the litter leaves was consistent with that in 2005. The nutrient return amount of most elements in the litter branches and leaves in 2015 was basically consistent with the seasonal fluctuation law of the litter leaves in 2010.

Table 4. Dynamic characteristics of litter nutrient return in different years (kg/hm^2).

Nutrient	2005 Litterfall Branches	2005 Litterfall Leaves	2005 Litterfall Total	2010 Litterfall Branches	2010 Litterfall Leaves	2010 Litterfall Total	2015 Litterfall Branches	2015 Litterfall Leaves	2015 Litterfall Total
C	1191.09 ± 261.69 ^{aB}	2390.65 ± 209.59 ^{aA}	3581.74 ± 848.22	1127.58 ± 257.77 ^{aA}	1385.35 ± 615.05 ^{aA}	2512.93 ± 182.27	663.66 ± 113.75 ^{aB}	2426.98 ± 430.36 ^{aA}	3090.64 ± 1246.86
N	19.93 ± 4.18 ^{cB}	54.92 ± 3.42 ^{bA}	74.85 ± 24.74	23.17 ± 6.42 ^{bA}	29.59 ± 11.84 ^{bA}	52.76 ± 4.54	13.31 ± 1.93 ^{bB}	61.48 ± 8.20 ^{bA}	74.79 ± 34.06
P	1.03 ± 0.20 ^{dA}	2.96 ± 0.16 ^{dA}	3.99 ± 1.37	1.43 ± 0.38 ^{dA}	1.81 ± 0.74 ^{dA}	3.24 ± 0.27	0.68 ± 0.12 ^{dB}	3.27 ± 0.42 ^{dA}	3.95 ± 1.83
K	3.95 ± 0.65 ^{dB}	21.98 ± 2.82 ^{cA}	25.93 ± 12.75	8.46 ± 2.45 ^{cA}	10.91 ± 4.25 ^{cA}	19.37 ± 1.73	2.45 ± 0.42 ^{cB}	22.70 ± 4.77 ^{cA}	25.15 ± 14.32
S	1.84 ± 0.36 ^{dA}	5.19 ± 0.38 ^{dA}	7.04 ± 2.37	1.98 ± 0.53 ^{dA}	2.51 ± 1.03 ^{dA}	4.49 ± 0.38	1.24 ± 0.21 ^{dA}	5.92 ± 1.03 ^{dA}	7.17 ± 3.31
Ca	32.59 ± 6.43 ^{bB}	58.83 ± 5.28 ^{bA}	91.42 ± 18.56	25.23 ± 6.40 ^{bA}	31.62 ± 13.32 ^{bA}	56.85 ± 4.52	18.96 ± 2.89 ^{bB}	57.54 ± 9.71 ^{bA}	76.50 ± 27.28
Mg	3.22 ± 0.58 ^{dB}	11.12 ± 1.16 ^{cA}	14.34 ± 5.58	3.65 ± 1.01 ^{cA}	4.66 ± 1.86 ^{dA}	8.31 ± 0.72	2.09 ± 0.36 ^{cB}	11.85 ± 2.15 ^{cA}	13.94 ± 6.90
Total	1253.66 ± 446.40	2545.66 ± 894.11	3799.32	1191.49 ± 422.27	1466.45 ± 518.65	2657.94	702.39 ± 248.50	2589.75 ± 907.37	3292.13

Note: the percentage of litter amount of each component in the total litter amount of the whole year is shown in brackets. Different capital letters in the same column indicate significant differences between different years, and different lowercase letters in the same row indicate significant differences between different litter components in the same year ($p < 0.05$).

Table 5. Seasonal dynamics of litter nutrient return in different years (kg/hm^2).

Year	Components	Season	C	N	P	K	S	Ca	Mg
2005	Litter branches	Spring	139.79	2.37	0.12	0.65	0.22	3.92	0.40
		Summer	680.30	11.14	0.56	1.92	0.99	17.50	1.64
		Autumn	118.58	2.41	0.13	0.48	0.24	3.94	0.40
		Winter	252.42	4.00	0.22	0.91	0.39	7.23	0.79
	Litter leaves	Spring	890.75	18.05	0.96	9.56	1.82	21.96	4.39
		Summer	459.91	12.31	0.65	3.08	1.06	11.72	1.80
		Autumn	606.15	14.54	0.74	4.96	1.34	15.11	2.85
		Winter	433.84	10.01	0.61	4.37	0.98	10.04	2.08
2010	Litter branches	Spring	336.38	6.23	0.35	1.24	0.62	9.06	1.06
		Summer	114.76	2.50	0.12	0.42	0.21	3.47	0.36
		Autumn	102.50	2.30	0.10	0.38	0.20	3.00	0.34
		Winter	110.02	2.29	0.10	0.40	0.21	3.43	0.34
	Litter leaves	Spring	1246.19	27.33	1.44	12.83	3.03	28.77	6.16
		Summer	342.38	11.93	0.66	3.13	0.95	8.88	1.55
		Autumn	476.20	13.37	0.67	3.37	1.08	11.74	2.16
		Winter	362.20	8.84	0.50	3.38	0.87	8.15	1.98
2015	Litter branches	Spring	124.81	1.69	0.09	0.43	0.15	2.61	0.35
		Summer	660.65	15.25	0.91	5.73	1.28	15.78	2.42
		Autumn	113.47	1.86	0.11	0.80	0.17	2.27	0.28
		Winter	228.65	4.36	0.32	1.51	0.39	4.57	0.60
	Litter leaves	Spring	809.03	20.01	0.99	8.07	1.69	15.35	3.93
		Summer	458.59	15.81	0.86	4.29	1.25	8.11	2.26
		Autumn	566.59	17.64	1.02	6.41	1.58	13.34	2.99
		Winter	384.07	10.80	0.67	4.34	0.94	8.95	1.85

4. Discussion

4.1. Litter Dynamics in Different Years

Litter volume is a component of the forest ecosystem biomass, which reflects the primary productivity level of the forest ecosystem and reflects the functions of the forest ecosystem [26,67–70]. The global annual change range of forest litter is 0.13 (Alaska's Picea crassifolia forest in the United States)—15.3 (Congo's tropical rain forest) t·hm^{-2} [28,42], and it can be divided into tropical, subtropical, temperate, and cold temperate zones according to climatic conditions. The forest litter yield in different climatic zones shows a downward trend with the increase in latitude. On average, Eurasian forests are tropical (8.40 t·hm^{-2}) > subtropical (5.25 t·hm^{-2}) > temperate (3.81 t·hm^{-2}) > cold temperate (t·hm^{-2}) [21,37,43,71]. The annual litter amount of different forest types in different climate zones in the world also varies greatly. The annual litter amount of main forest types in different climate zones can be shown as the maximum average annual litter amount of tropical rain forest and seasonal rain forest, which is 9.98 t·hm^{-2}. It is followed by evergreen broad-leaved forest, with an average annual litter of 6.96t·hm^{-2}. Then, 5.79 t·hm^{-2} in coniferous and broad-leaved mixed forest; deciduous broad-leaved mixed forest 5.1 t·hm^{-2}; The coniferous forest with the smallest litter is 4.77 t·hm^{-2} [72]. The subtropical evergreen broad-leaved forest in the study area is located in the north-south transition zone between the middle subtropical climate and the south subtropical climate. In this study, the average annual total litter in 2005, 2010, and 2015 is 8.18 t·hm^{-2}, which is within the range of subtropical forest changes (1.01–13.00 t·hm^{-2}). Compared with the evergreen broad-leaved forest in different regions of the subtropical zone, its annual litter is less than that of the Dinghushan monsoon evergreen broad-leaved forest in the south subtropical zone (8.45 t·hm^{-2}) [17], greater than that of the Tiantong evergreen broad-leaved forest in the north subtropical zone (5.55 t·hm^{-2}) [73–75], but similar to that of the Xiaokeng subtropical evergreen broad-leaved forest in the middle subtropical zone (7.99–8.450 t·hm^{-2}), It shows that the litter of wet evergreen broad-leaved forest in Ailao Mountain is similar to the geographical location and stand composition structure of the middle subtropical forest [70].

In different years, each component of litter and its proportion in the total forest litter are the largest, and the sum of the two reaches 76.17% of the total, which is consistent with the general situation of plant growth and litter, and basically consistent with the proportion sequence of each component of litter in other research results [71,76–79]. The total amount of litter in the study area in 2005 (normal year without extreme weather interference), 2010 (affected by extreme arid weather), and 2015 (affected by extreme ice and snow weather) are 8.82, 7.70, and 8.01 $t{\cdot}hm^{-2}$, respectively, of which the proportion of litter is 49.96%, 61.52%, and 41.30%, respectively, and the proportion of litter branches is 25.82%, 17.26%, and 32.05%. Compared with other subtropical forests of the same type, the annual average percentage of leaves (50.89%) is lower, while the three-year average percentage of branches (25.28%) is higher. In 2005, the proportion of litter branches in the study area was less than 30%, which was still in the middle and early stages of succession. The proportion of litter branches was small. With the succession, the proportion of litter branches should have gradually increased, but the proportion of litter branches in the region from 2005 to 2010 was gradually decreasing, reached the valley in 2010, and then gradually increased from 2010 to 2015. This is because of the rare serious drought in Yunnan in 2010. After the forest was disturbed by the extreme arid weather for a long time, the characteristics of the plant community degenerated toward the type of low-grade community, and secondary succession occurred within the community. At the same time, because the soil was lack of water for plant growth in this dry season, some leaves fell, so the proportion of branches and litter was less than that when the forest was not disturbed, The proportion of leaf litter also increased correspondingly [42,43], indicating that extreme drought weather interference seriously hindered the normal succession process of forests. In 2015, the proportion of litter leaves was less than that of undisturbed years, but the proportion of litter branches increased accordingly, which is consistent with the short duration of this extreme ice and snow weather disturbance. The wood litter in the forest, such as branches, is quite random. The litter collected every month is the litter branches that died on the trees before. Therefore, the litter of branches is usually not directly related to phenology but is greatly affected by climate factors. It also shows that although the evergreen broad-leaved forest in Ailao Mountain is affected by extreme ice and snow weather, However, due to the rich species and complex community structure in Ailao Mountain, the forest ecosystem has the ability of self-regulation and high early post-disaster recovery, which makes the evergreen broad-leaved forest vegetation in Ailao Mountain recover slowly. Thus, the litter amount of evergreen broad-leaved forest in Ailao Mountain after being disturbed by extreme weather is close to that of evergreen broad-leaved forest in the same latitude in normal years [37,71]. To sum up, the impact of extreme drought weather on litter yield and nutrients in the study area is greater than that of extreme ice and snow weather interference, and it mainly has a greater impact on litter branches, litter leaves, and the total amount of litter, while the impact on other litter components is relatively small [56].

Due to the influence of external environmental factors, the dynamic changes of litter in different years show some regularity but also show some differences [70–72]. The cause of the occurrence of the litter rhythm is mainly determined by the climate change factors and the biological characteristics factors of the tree species that make up the community [1,3,23,47]. The monthly dynamic performance patterns of litter in 2005, 2010, and 2015 are different, including single peak, two peaks, and four peaks, with different peak sizes, and all of them play a leading role in litter amount. In the normal year 2005, the maximum peak value of withering occurred in the rainy season, while in the two special years, 2010 and 2015, the peak value of withering mainly occurred in the dry season.

In 2005, the total amount and each component of litter reached the maximum in August, which was affected by the external temperature and accelerated the rate of metabolism, prompting a large number of plants to litter. The temperature in August is suitable for the vigorous growth of plants. The rising temperature of evergreen trees during the germination period will promote the sprouting of new leaves and accelerate the aging and apoptosis of old leaves. When the nutrients required for the growth of new leaves exceed the nutrients absorbed from the soil, the plants will preferentially transfer the nutrients stored in the old leaves for the growth of new branches and leaves, and the transfer and reabsorption of nutrients will accelerate the apoptosis of old leaves [17,39,71]. The other peak months in 2005 are basically the same as those in 2010. Although the plants in the evergreen broad-leaved forest gradually change leaves throughout the year, the temperature rises at the beginning of the rainy season (April and May), and a large number of new leaves germinate and grow vigorously. In these growing seasons, new leaves compete with old leaves for limited mineral elements. Because the strong vitality of new leaves makes the elements that can be transported from old leaves to new leaves, and finally causes the senescent leaves to fall off one after another, During this period, the rainfall increased, so the first short and concentrated peak of leaf litter appeared in April, basically in line with the physiological characteristics of evergreen broad-leaved forest. Another secondary peak of litter in the study area is at the end of the rainy season in November. The occurrence of the second peak of litter is related to the defoliation period of the dominant tree species of the evergreen broad-leaved forest in this area, Kaempferous, and because of the sudden drop in humidity and temperature in autumn and winter, the leaves of some evergreen broad-leaved forests lose their vitality in dry air and wither [17,70,71].

In January 2015, the study area had an extremely strong ice and snow weather. Because a large number of leaves on the crown of evergreen tree species condensed with ice and snow when the ice and snow disaster occurred, and some tree species were easy to break, strong wind, heavy rain and heavy snow can blow and break the litter branches of the previous period to the ground [5,14,37,42,70], After the interference of extreme ice and snow weather, the leaves were violently shaken by strong external forces, resulting in non physiological shedding, which led to a sharp increase in the amount of litter in January 2015 and a peak. This randomness can cause great changes in the number of litter branches at different times, which also indicates that the weather conditions in 2015 were worse than those in 2005 and 2010. In addition, after the interference of extreme ice and snow weather, a large number of trees fell down, branches were crushed and dropped by heavy snow, forest canopy was seriously damaged, forest canopy density was reduced, and insect food in habitats with severely damaged vegetation was reduced, so the amount of litter brought by insects was reduced successively, thus significantly reducing the amount of litter after the peak in January. However, the rose fluctuation amplitude of the litter after the forest was disturbed by the extreme ice and snow weather decreased significantly and tended to be stable, indicating that the extreme ice and snow weather caused great damage to the physiological structure of the tree species, leading to changes in the subsequent litter patterns. In a word, the litters in the three years have their own distinct littering rhythms, which may be because the species composition of evergreen broad-leaved forests in the study area, the climatic conditions and the degree of interference vary greatly in different years, and the litters are very vulnerable to the biological characteristics of forest species, climatic conditions, and other environmental factors, making the seasonal dynamics of each year different [20].

4.2. Nutrient Concentration Dynamics and Nutrient Return of Litter

The return of nutrients from the litter to the soil maintains soil fertility and promotes nutrient cycling in forest ecosystems, which is important for improving the habitat conditions of forest trees [2,26–30]. Analyzing the dynamics of nutrient concentrations and return in the litter is necessary for understanding the function of forest ecosystems [5,8,9,31,43,74,80].

The nutrient content of litter can reflect the nutrient utilization efficiency of plants. In this study, the total amount of litter and the different nutrient concentrations of each component have the same order, with the highest content of C, followed by the content of Ca and N, and the content of K, Mg, S, P, and other elements is relatively low [14,39,48]. The formation of this sequence is because the fresh litters in the study area are in the early stage of decomposition, and the initial content of N element is high, while the elements with low content of P and K in the litters are reusable elements, which can be transferred in large quantities before the leaves fall, and then the nutrient reuse is realized through the plant transfer mechanism, which indicates that the evergreen broad-leaved forest plants in this area have high nutrient utilization efficiency. However, the strong seasonal dynamics of nutrient concentration of each component also show that the transfer amount of different elements is different in different seasons, and the decomposition rate of litter is faster due to the rapid leaching and degradation of P and K [70,71,81]. The content of nutrient elements is greatly affected by their physiological functions. The subtropical climate is hot and rainy, so the leaching effect of litter is very strong. The rainy season in this region is long, mainly concentrated in summer and autumn, and the physiological functions of each element are different [66]. Among them, K and P are easy to be lost due to rainfall, but P is a limiting factor for plant growth and development in tropical and subtropical regions. For this reason, most organisms in the subtropical ecosystem have a mechanism to maintain that P is not leached out under high temperature and humidity conditions, which makes the K and P contents in the litter lower in spring and summer as a whole, but P content is far lower than K content [3,4,26]. Ca, N, and other elements are relatively stable and not easy to be washed away by rain, which makes the seasonal variation of various nutrient elements in different years and different components inconsistent, and there is no obvious correlation. These nutrient elements will eventually return to the soil, which is of great significance for maintaining the long-term productivity of the forest land [82].

The chemical properties of litter are the internal factors affecting litter decomposition. C/N and C/P in the litter are common indicators of litter decomposition. N/P also has a certain characterization ability for litter decomposition. Since N can affect the growth and turnover of soil microbial communities, the C/N ratio can best reflect the rate of litter decomposition [42]. N and P control the important process of litter decomposition through coupling with C. The C/N ratio of the litter in the study area in 2005 (the normal year without extreme weather interference) is 48.65, which is greater than 25, indicating that N is the main element limiting litter decomposition in the region [51]. From 2005 to 2015, the average C/N ratio was the highest in 2005, and the content of N was the lowest, indicating that the decomposition rate of litter was the slowest in that year, and the extreme weather interference did not weaken the decomposition rate of litter. The C/N ratio of litter branches and litter leaves is not the same each year, so it can be concluded that the response of nutrient content among various organs of forest litter to extreme weather disturbance is also different [82].

The annual total amount of litter in each year is in the order of 2005 (normal year not affected by extreme weather) > 2015 (affected by extreme ice and snow weather) > 2010 (affected by extreme drought weather). From the perspective of the annual amount of nutrient return of litter, the annual amount of nutrient return is roughly proportional to the amount of litter. In addition, leaf litter is the main component of the litter, accounting for more than 50% of the total litter. Compared with other components, the nutrient concentration is generally high and easy to decompose, so leaf litter is the main body of nutrient return of the litter.

5. Conclusions

Due to the longer duration and wider coverage of the extreme arid weather disturbance, the degree of damage to the forest ecosystem is greater than that of the extreme ice and snow weather disturbance. Due to the extreme arid weather disturbance, the number of litter branches of the subtropical evergreen broad-leaved forest in Ailao Mountain decreases, regresses to the lower community succession, and then slowly recovers. However, in general, the forest ecosystem of Ailao Mountain has the ability of self-regulation and high early recovery after disasters, which makes the amount of litter of the evergreen broad-leaved forest in Ailao Mountain after being disturbed by extreme weather close to the amount of litter of the evergreen broad-leaved forest in the same latitude in normal years. The nutrient element content, decomposition rate, and seasonal dynamics of the litter are not affected by extreme weather interference and have a high resistance to extreme weather interference events in the short term. It can strongly maintain soil fertility in the region. Therefore, studying the mechanism of litter change of evergreen broad-leaved forests in the same region in different extreme weather interference years can fully compare the damage caused by different extreme weather interference to the normal forest growth process, and provide a reference for the research of evergreen broad-leaved forests in other subtropical regions, At the same time, it has far-reaching significance for the recovery and evolution of subtropical forest ecosystem disturbed by extreme weather, sustainable management and improvement in ecological function to study the change of litter volume before and after extreme drought and ice and snow weather disturbance.

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