Seasonal and interannual litter dynamics of a tropical semideciduous forest of the southern Amazon Basin, Brazil

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[1] This study analyzed how seasonal and interannual variations in climate alter litter dynamics, including production, decomposition, and accumulation. Monthly measurements of leaf, stem, and reproductive (flower plus fruit) litter and the forest floor litter mass were combined with a mass balance model to determine rates of litter decomposition for a semideciduous tropical forest located in the rain forest-savanna ecotone of the southern Amazon Basin for 2001–2007. Annual rates of litter production varied between 8 and 10.5 Mg ha\(^{-1}\) a\(^{-1}\), and leaf litter production accounted for the majority (70%) of the total litter production. Leaf litter production peaked at the end of the May–August dry season while stem litter production peaked during the wet season and reproductive litter production peaked during the dry-wet season transition. Forest floor litter mass ranged between 5 and 8 Mg ha\(^{-1}\) over the study period and generally declined as litter inputs declined. Litter decomposition rates were remarkably stable from year-to-year and varied between 10.8 and 12.4 Mg ha\(^{-1}\) a\(^{-1}\). On average, rates of litter decomposition were highest during the dry-wet season transition. Overall, our results suggest that rainfall variability directly altered litter production dynamics and indirectly altered forest floor litter mass and decomposition kinetics through its effect on litter production. Future changes in seasonal and/or interannual rainfall patterns, whether in response to El Niño or to anthropogenic climate change, will likely have important consequences for the litter dynamics of Amazonian semideciduous forest.


1. Introduction

[2] Tropical ecosystems, including rain forest, seasonally dry forest, and savanna, are thought to play a key role in global carbon storage and cycling [Grace et al., 2001; Keller et al., 2004]. On a global basis, soil carbon stocks are 2–3 times larger than aboveground C stocks [Schlesinger, 1991] and approximately 70% of the total annual carbon flux is derived from litter decomposition (above plus belowground) [Aerts, 1997]. Litter dynamics, including production, decomposition, and accumulation are vital links between plant and soil C and nutrient storage and cycling [Schlesinger, 1991; Xu and Hirata, 2002], especially in humid tropical forests where nutrient availability is intimately tied to litter inputs and decomposition [Morellato, 1992; Alvarez-Sanchez and Enriquez, 1996; Sundarapandian and Swamy, 1999; Read and Lawrence, 2003; Alhamd et al., 2004; Dias, 2005].

[3] Litter production and decomposition are controlled by biological and physical processes such as the activity and composition of soil and litter macro- and micro-fauna and climate variations, in particular rainfall and temperature [Meentemeyer, 1978; Cornejo et al., 1994; Wieder and Wright, 1995; Aerts, 1997; Barajas-Guzmán and Alvarez-Sánchez, 2003; Cleveland et al., 2004]. Tropical forests that experience larger annual variations in rainfall, such as tropical dry or semideciduous forests, are thought to exhibit larger seasonal fluctuations in litter production, with peak litter production occurring during the dry season [Gaur and Pandey, 1978; Wieder and Wright, 1995; Sundarapandian and Swamy, 1999; Sanches et al., 2005].

[4] Litter decomposition dynamics in tropical systems also appear to be closely related to seasonal and interannual cycles of rainfall and temperature. Compared to temperate forests, decomposition dynamics are rapid in the tropics...
because of high rainfall and temperature [Cornejo et al., 1994; Aerts, 1997]. In seasonal tropical forests, forest floor litter mass can increase substantially during the dry season because drought stimulates leaf litter production and inhibits decomposition [Gaur and Pandey, 1978; Morellato, 1992; Sundarapandian and Swamy, 1999; Austin and Vitousek, 2000]. As soon as rainfall ensues during the transition between the dry and wet seasons there can be a transient pulse of litter decomposition [Wieder and Wright, 1995], which can have a proportionally large effect on the magnitude and direction of annual net ecosystem CO₂ exchange [Saleska et al., 2003; Vourlitis et al., 2005].

[5] Given the importance of litter dynamics in tropical forest C and N storage and cycling, we quantified the production of leaf, stem, and reproductive (flower plus fruit) litter over January 2001–2007 in a semideciduous forest located in the rain forest-savanna ecotone of the southern Amazon Basin. This period coincided with an El Niño (2002)/La Niña (2003) cycle [Tolan, 2007], which caused short-term declines (El Niño) and increases (La Niña) in rainfall in the tropical Americas [Poveda et al., 2001]. The main objectives of this study were to quantify litter production and detect interannual patterns of litter production and forest floor litter mass, estimate litter decomposition, and determine how these processes correlate with temporal variations in rainfall.

2. Material and Methods

2.1. Site Description

[6] This study was conducted in the southern portion of the Legal Amazon Basin in an upland (terra firme) forest located approximately 50 km northwest of Sinop, Mato Grosso, Brazil (11°24.75’S:55°19.50’W). The forest is located 423 m above sea level in a climatic transition between Amazonian rain forest and savanna that spans between 9°S and 14°S in northern Mato Grosso [Ackerly et al., 1989]. Vegetation within this ecotone consists of savanna (cerrado), transitional vegetation (cerradão), and Amazonian forest, which on the southern fringes of the Amazon Basin near Sinop is recognized as dry (mata seca) or semideciduous mesophytic forest [Eiten, 1972; Ratte et al., 1978; Ackerly et al., 1989]. Tree species at the study site are typical of semideciduous Amazonian forest [Ackerly et al., 1989; Lorenzi, 2000, 2002] and include Protium sagotianum Marchland, Dialium guianense (Aubl.) Sandwith, Hevea brasiliensis Müll. Arg., Brosimum lactescens (S. Moore) C.C. Berg, Cordia alliodora (Ruiz and Pav.) Oken, Toomina schomburgkii Planch and Triana, and Qualea paraensis Ducke. There are approximately 94 species and 35 families of trees with a diameter ≥10 cm (Table 1); however, nearly 50% of all individuals are within the Burseraceae (P. sagotianum), Clusiaceae (T. schomburgkii), and Moraceae (B. lactescens) families. The maximum canopy height is 25–28 m and the density and basal area of trees ≥10 cm diameter is 483 ha⁻¹ and 22.5 m² ha⁻¹, respectively (Table 1). Leaf area index varies between 4 and 5 m² m⁻² in the wet season and 2–3 m² m⁻² in the dry season (Table 1) reflecting the semideciduous nature of the forest [Vourlitis et al., 2004; Sanches et al., 2005].

[7] Soils are acidic (pH = 4.2), sandy (94% sand), well-drained nutrient-poor quartzarenic neosols with low organic matter content (2%). Concentrations of available P (5.2 µg g⁻¹) and exchangeable cations (Ca and Mg) in the surface (0–20 cm) soil are similar to other Amazonian forests with comparable substrate [Thompson et al., 1992].

[8] Being within a major climatic transition, the climate of this region is intermediate to Amazonian rain forest and savanna [Vourlitis et al., 2002]. For example, average annual temperature at Sinop is 24°C while average annual temperature for cerrado (Brasilia, Distrito Federal) and rain forest (Porto Velho, Rondônia) is 21 and 26°C, respectively. Rainfall near Sinop is approximately 2 m a⁻¹, while rainfall for cerrado and rain forest is 1.5 and 2.2 m a⁻¹, respectively, and Sinop experiences a 3–5-month dry season, which is longer than rain forest (0–3 months) but comparable to cerrado [Vourlitis et al., 2002; Priante-Filho et al., 2004; Vilani et al., 2006].

2.2. Field Measurements

[9] Aboveground litter production (>1 mm diameter) was measured from January 2001–2007 in 20-randomly located 1 m² square collectors. Litter traps were constructed of 1 mm mesh nylon fabric attached to a wooden frame and were elevated off the ground to avoid soil and water contamination [Sala and Austin, 2000]. Litter accumulated in each collector was retrieved monthly, washed with distilled water, separated into leaves, twigs, and reproductive (flowers and fruits) fractions, dried at 65–70°C for 72 h, and weighed on a digital balance. Litterfall is expressed as the dry mass per unit ground area over a period of one month (Mg ha⁻¹ month⁻¹).

[10] Forest floor mass (litterpool) was collected monthly between January 2002–2007 within a 25 × 25 cm quadrat that was randomly placed adjacent to each litterfall collector (n = 20). Litter was collected, washed with distilled water, dried at 65–70°C for 72 h, and weighed on a digital balance. Forest floor mass is expressed as the dry mass per unit ground area (Mg ha⁻¹).

[11] Average monthly measurements of air temperature were made at the top of a 40 m tall tower (12–14 m above the forest canopy) using a shielded relative humidity sensor (HMP-35, Vaisala, Inc., Helsinki, Finland). Precipitation was measured every 30 min at the top of the eddy flux tower using a tipping-bucket rainfall gauge (TE-525; Texas Electronics, Inc., Dallas, TX, USA). However, gaps in data collection precluded use of the rainfall data measured on-site [Vourlitis et al., 2008].

2.3. Data Analysis and Derived Quantities

[12] Litter production and the forest floor litter mass were sampled on a monthly basis, but unfortunately data for some months are lacking (~18% and 27% of all litter production and forest floor litter mass data, respectively). Time series analysis consisting of auto-regressive, integrated moving average (ARIMA) models were used to fill gaps in the litter production and forest floor litter mass time series [Edwards and Coull, 1987]. These models recognize the temporal autocorrelation in time series data and predict a value of a given variable based on previous values, and are used to
Table 1. Selected Structural Characteristics of the Amazonian Tropical Transitional Forest Located Near Sinop, Mato Grosso, Brazil

<table>
<thead>
<tr>
<th>Structural Characteristics (Units)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum canopy height (m)</td>
<td>28</td>
</tr>
<tr>
<td>Density (trees ha⁻¹)</td>
<td>483</td>
</tr>
<tr>
<td>Species richness (species)</td>
<td>94</td>
</tr>
<tr>
<td>Basal area (m² ha⁻¹)</td>
<td>22.5</td>
</tr>
<tr>
<td>Average trunk diameter (cm)</td>
<td>21.0</td>
</tr>
<tr>
<td>Roughness length (m)</td>
<td>2.4</td>
</tr>
<tr>
<td>Zero plane displacement height (m)</td>
<td>22.5</td>
</tr>
<tr>
<td>Average (±SD) LAI (m² m⁻²)</td>
<td></td>
</tr>
<tr>
<td>wet season</td>
<td>3.8 ± 0.9</td>
</tr>
<tr>
<td>wet-dry transition</td>
<td>3.0 ± 0.9</td>
</tr>
<tr>
<td>dry season</td>
<td>2.8 ± 0.6</td>
</tr>
<tr>
<td>dry-wet transition</td>
<td>4.1 ± 0.8</td>
</tr>
</tbody>
</table>

*Density, species richness, and average trunk diameter data are for trees with a diameter breast height >10 cm. Leaf area index (LAI) data are from Sanches et al. [2005].

both forecast and to interpolate time series [Edwards and Coull, 1987]. ARIMA models were fit to the time series using and iterative Box-Jenkins approach where (1) autocorrelation and partial autocorrelation analysis were used to identify whether auto-regressive, moving-average, or mixed models were required for the given time series, (2) coefficients of the model were calculated using maximum likelihood techniques, and (3) autocorrelation and partial autocorrelation analysis were used to identify whether auto-regressive, moving-average, or mixed models were required for the given time series, (2) coefficients of the model were calculated using maximum likelihood techniques, and (3) autocorrelation and partial autocorrelation analysis were used to identify whether auto-regressive, moving-average, or mixed models were required for the given time series, (2) coefficients of the model were calculated using maximum likelihood techniques, and (3) autocorrelation and partial autocorrelation analysis were used to identify whether auto-regressive, moving-average, or mixed models were required for the given time series, (2) coefficients of the model were calculated using maximum likelihood techniques, and (3) autocorrelation and partial autocorrelation analysis were used to identify whether auto-regressive, moving-average, or mixed models were required for the given time series.

3. Results and Discussion

3.1. Rainfall and Temperature

[15] Annual rainfall varied between 1861 and 2645 mm during the January 2001–2007 study period (Figure 1a), and only 2001 and 2006 experienced a rainfall that was within 100 mm of the long-term (30 year) average of 2037 mm [Vourlitis et al., 2002]. Of particular interest was the El Niño event of 2002 [Tolan, 2007], when rainfall was more than 175 mm below the long-term average, and the subsequent La Niña event of 2003 when rainfall was more than 600 mm above the long-term average. These rainfall variations are consistent with those observed for Columbia [Poveda et al., 2001] and areas in the northern Amazon Basin [Meir and Grace, 2005] under El Niño/La Niña cycles. Defining the dry season as the number of consecutive months when rainfall <50 mm [Shuttleworth, 1988], the dry season extended over 5 months in 2001, 2002 and 2004 and 4 months during the other years. Rainfall was consistently <50 mm in May–August, but rainfall was also <50 mm in April (2001–2002) and September (2004) during the years with a longer dry season. Peak rainfall generally occurred in the months of December–February, but there were large monthly variations in rainfall (Figure 1a). For example, rainfall in January 2003 exceeded 600 mm, accounting for 25% of the total annual rainfall for 2003, while rainfall in March and December 2005 combined exceeded 1000 mm, accounting for 50% of the total rainfall for 2005 (Figure 1a).

[16] Air temperature also varied over seasonal and interannual time periods, and on average air temperature was lower during the dry season than the wet season (Figure 1b). Average annual temperature varied between 24.6°C in 2004 to a maximum of 27.3°C in 2002, which is slightly higher compared to the long-term (30 year) average of 24.1°C [Vourlitis et al., 2002], and wet years tended to have lower average annual temperatures (Figure 1b).

3.2. Litter Production

[17] The average (±se; n = 20) monthly leaf litter production varied between 10 and 135 g dry mass m⁻² month⁻¹ over the study period (Figure 2), and in general leaf litter production was significantly higher during the dry season (Figure 2). Leaf litter accounted for the majority of
the litter produced, comprising 70–90% in the dry season and 55–70% in wet season of total litter production. These seasonal patterns cause leaf litter production to be negatively correlated with rainfall during the wet seasons and positively correlated with rainfall of the previous 6–7 months (Figure 3), indicating that increases in rainfall will stimulate leaf production during the wet season but a larger pulse of leaf litter production during the dry season. The magnitude and seasonal pattern of leaf litter production observed here, as well as the proportion of leaf litter to the total litter produc-

Figure 1. (a) Total monthly rainfall and (b) average monthly temperature for January 2001–2007. Intervals between vertical dash lines represented a year.

Figure 2. Average (±SE; n = 20) leaf, stem, reproductive (flower plus fruit), and total litter production for January 2001–2007. Solid symbols are measured values, and open symbols are interpolated or forecast values calculated using auto-regressive, integrated moving average (ARIMA) models.
Figure 3. Cross correlation coefficients for monthly leaf, stem, reproductive, and total litter production, forest floor litter mass, the decomposition rate constant (k), and litter decomposition as a function of monthly rainfall. For these analyses, the litter time series was lagged against monthly rainfall. \( N = 72 \) months for litter production and 60 months for forest floor litter mass, \( k \), and litter decomposition.

** \( (p < 0.05) \); ** \( (p < 0.01) \); *** \( (p < 0.001) \).

Stem litter production varied between 2 and 40 g dry mass \( m^{-2} \) month\(^{-1} \) (Figure 2), and while there was substantial month-to-month variability, stem litter production was typically higher during the peak of the wet season (January) and the dry-wet season transition (September–October; Figure 2), presumably because storms during these periods produced high winds that damaged tree stems and branches [Morellato, 1992]. Stem litter production was positively correlated with rainfall of the current month, negatively correlated with rainfall of the previous 5–6 months, and positively correlated with rainfall of the previous 11 months (Figure 3), and accounted for nearly 30% of the total litter produced during the wet season and 10–15% of the total litter produced during the dry season (Table 2).

Reproductive litter production (flowers plus fruits) exhibited large monthly and interannual variations and ranged between 0 and 37 g dry mass \( m^{-2} \) month\(^{-1} \) (Figure 2). Reproductive litter production was positively correlated with rainfall of the current month, negatively correlated with rainfall of the previous 2–5 months, and positively correlated with rainfall of the previous 8–11 months (Figure 3), and peaked in September with sustained production into December (Figure 2). Leaf expansion and stem radial growth typically occur during the wet season, but during the dry season, leaf abscission and/or mobilization of water stored in trunks allows trees to re-hydrate, which stimulates flower and fruit production [Reich and Borchert, 1984; Brietsprecher and Bethel, 1990; Borchert, 1996]. Reproductive litter production accounted for <10% of the total litter in January–August and 13–26% in September–December.

On an annual basis mean (±SE; \( n = 20 \)) total litterfall varied between 8.07 ± 0.36 Mg ha\(^{-1} \) in 2002 to as high as 10.54 ± 0.63 Mg ha\(^{-1} \) in 2006 (Table 2). Most of the litter was in the form of leaf litter (65–83%), while stem and reproductive litter production accounted for 16 and 12% of the total annual litter production, respectively (Table 2). During the 2002 El Niño there was an almost complete cessation of reproductive litter production (Figure 2 and
Table 2. Annual (±SE; n = 20 Plots) Average Litter Production, Forest Floor Litter Mass, and Litter Decomposition of a Tropical Semideciduous Near Sinop Mato Grosso, Brazil

<table>
<thead>
<tr>
<th>Year</th>
<th>Litter Production (Mg ha⁻¹ a⁻¹)</th>
<th>Forest Floor Litter Mass (Mg ha⁻¹)</th>
<th>Decomposition Rate Constant (k, a⁻¹</th>
<th>Net Decomposition (g m⁻² month⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaf</td>
<td>Stem</td>
<td>Reproduction</td>
<td>Total</td>
</tr>
<tr>
<td>2001</td>
<td>6.75 ± 0.31</td>
<td>2.25 ± 0.36</td>
<td>1.46 ± 0.36</td>
<td>10.46 ± 0.72</td>
</tr>
<tr>
<td>2002</td>
<td>6.76 ± 0.27</td>
<td>1.04 ± 0.11</td>
<td>0.27 ± 0.04</td>
<td>8.07 ± 0.36</td>
</tr>
<tr>
<td>2003</td>
<td>6.23 ± 0.27</td>
<td>1.41 ± 0.25</td>
<td>1.23 ± 0.21</td>
<td>8.87 ± 0.59</td>
</tr>
<tr>
<td>2004</td>
<td>7.12 ± 0.46</td>
<td>1.48 ± 0.19</td>
<td>1.17 ± 0.16</td>
<td>9.76 ± 0.64</td>
</tr>
<tr>
<td>2005</td>
<td>7.34 ± 0.35</td>
<td>1.39 ± 0.18</td>
<td>1.56 ± 0.23</td>
<td>10.29 ± 0.61</td>
</tr>
<tr>
<td>2006</td>
<td>8.02 ± 0.33</td>
<td>1.72 ± 0.32</td>
<td>0.80 ± 0.17</td>
<td>10.54 ± 0.63</td>
</tr>
</tbody>
</table>

aND, not determined.

Table 2) suggesting that a decline in rainfall inhibited reproduction in this semideciduous forest, which is in contrast to results reported for rain forests in Southeast Asia [Meir and Grace, 2005]. The annual rates of litter production observed here are similar to those published for several lowland tropical forests [Ewel, 1976; Morellato, 1992; Wieder and Wright, 1995; Sundarapandian and Swamy, 1999; Clark et al., 2001; Luizão et al., 2004; Malhi et al., 2004].

3.3. Forest Floor Litter Mass

[21] Forest floor litter mass exhibited a steady decline from a high of 1122 g dry mass m⁻² in March 2002 to a low of 324 g dry mass m⁻² in June of 2005, with a gradual increase thereafter (Figure 4). This long-term trend in forest floor mass appeared to be closely related to temporal trends in total litter input (Figure 2), as forest floor litter mass was initially high in 2002 following high litter input from the previous year, declined in subsequent years (2002–2004) as litter input decreased, and increased again in 2005–2006 when litter input increased (Table 2 and Figure 4). Forest floor litter mass declined during the wet season from an average (±95% CI) seasonal peak of 668 ± 120 g/m² in January to 572 ± 135 g/m² in May, reached a secondary peak in September following the dry season flush of leaf litter, and declined to a seasonal minimum value of 525 ± 77 g/m² by December (Figure 5). However, substantial overlap of the bootstrapped confidence intervals indicate that seasonal variations in forest floor litter mass were not statistically significant, and cross correlation analysis revealed that monthly variations in forest floor litter mass and rainfall were not significantly correlated (Figure 3).

[22] The average annual (±se) forest floor mass varied between 6.01 ± 0.24 Mg ha⁻¹ in 2004 to a maximum of 8.04 ± 0.36 Mg ha⁻¹ in 2002 (Table 2), which is similar to that reported for many other tropical forests [Morellato,
were large, ranging between 0.030 month
Sundarapandian
season; however, in other field manipulative studies, plots
plots that received supplemental water during the dry
Vitousek
3.4.
intervals were calculated by bootstrapping.

reported that
Wright
observed for tropical systems. For example,
during the dry season is opposite of what is typically
between species or as a function of environmental factors
quantify variation in the rate of litter decomposition
Figure
G04007
2002 and 0.297 month
our monthly values of
the seasonal trend in leaf litter production (Figure 3). While
during the wet season (Figure 5). Monthly variations in
were significantly negatively correlated with rainfall of the previous 6 – 7 months, which is similar to
the seasonal trend in leaf litter production (Figure 3). While
our monthly values of \( k \) are similar to those reported
for other tropical forests \([Alhamd \ et \ al., \ 2004; \ Alvarez-\ Sanchez \ and \ Enriquez, \ 1996; \ Sundarapandian \ and \ Swamy, \ 1999; \ Wieder \ and \ Wright, \ 1995]\), the relatively higher values of \( k \)
during the dry season is opposite of what is typically observed for tropical systems. For example, \( Wieder \ and \ Wright \ [1995] \) and \( Alvarez-\ Sanchez \ and \ Enriquez \ [1996] \)
reported that \( k \) was usually higher in the wet season or in
plots that received supplemental water during the dry
season; however, in other field manipulative studies, plots
exposed to partial rainfall exclusion (~50% of the total
monthly rainfall) had a similar \( k \) to plots receiving full
rainfall. Furthermore, significant rates of decomposition can
occur in litter humidity and moisture contents as low as 32
and 5%, respectively, which is lower than the ambient
relative humidity and the surface (0–30 cm) soil moisture
observed for the transitional forest during the dry season
\([Vourlitis \ et \ al., \ 2002, \ 2008]\). Thus, it is conceivable that
moisture conditions in the surface litter layer during the dry
season were conducive for rapid microbial degradation of
surface litter.

[24] Average (±SE; \( n = 20 \)) annual values of \( k \) varied
between 0.97 ± 0.05 \( a \)^{-1} in 2002 and 1.81 ± 0.08 \( a \)^{-1} in
2004 (Table 2), corresponding to a mean residence time of
litter on the forest floor of \((1/k)\) of 1.03 and 0.55 years,
respectively. These values are comparable to those published
for a variety of tropical forests \([Wieder \ and \ Wright, \ 1995; \ Smith \ et \ al., \ 1998; \ Austin \ and \ Vitousek, \ 2000; \ Barajas-Guzmán \ and \ Alvarez-Sánchez, \ 2003; \ Luizão \ et \ al., \ 2004]\).

[25] Net decomposition varied substantially over monthly
timescales but had a less discernable seasonal and interannual
pattern (Figure 4), and cross correlation analysis revealed
that monthly patterns of decomposition were not signifi-
cantly correlated with monthly patterns of rainfall (Figure 3).
Net decomposition varied between −202 \( g \) \( m^{-2} \) \( \text{month}^{-1}\)
in December 2004, depicting net forest floor accumulation,
and 403 \( g \) \( m^{-2} \) \( \text{month}^{-1}\) in September 2006 (Figure 4), and
was highest during the dry-wet season transition period
(September–November) and lowest during the wet season
in December (Figure 5). Annual rates of decomposition
varied between 10.81 ± 0.98 \( Mg \) \( ha^{-1} \) \( a^{-1}\) in 2004 to
12.39 \( Mg \) \( ha^{-1} \) \( a^{-1}\) in 2003 and 2006 (Table 2), which is
comparable to that reported for a forest near Manaus
\([Grace \ et \ al., \ 2001]\).

4. Conclusions

[26] Overall, our results suggest that rainfall variability
directly altered litter production dynamics of the semide-
ciduous forest studied here and indirectly altered forest floor
litter mass and decomposition kinetics through its effect on
litter production. Seasonal and annual variations in litterfall
dynamics were coincident with associated variations in
rainfall. On a seasonal basis, the cross-correlation between
rainfall and litter fall components varied markedly and
could be explained in part by seasonal patterns in phenology,
while on an annual basis, a decline in rainfall caused by
El Niño almost completely eliminated reproductive litter
production. Temporal trends in the forest floor litter mass
were not well correlated with rainfall but reflected annual
inputs of litter. Similarly, temporal trends in decomposition
were not significantly correlated with rainfall even though
the rate constant of decomposition \((k)\) was correlated with
rainfall and coincident with leaf litter production. Thus,
future changes in seasonal and/or interannual rainfall
patterns, whether in response to El Niño \([Poveda \ et \ al., \ 2001]\)
or to anthropogenic climate change \([Giorgi \ et \ al., \ 2001]\), will likely have important direct and indirect
consequences for the litter dynamics of Amazonian semi-
deciduous forest.
References


Alvarez-Sanchez, J., and R. B. Enriquez (1996), Litter decomposition in a FAPEMAT, the Coordenacão de Aperfeic ¸ oamento de Pessoal de Nivel Superior (CAPES), and the Brazilian Institute for Space Research (INPE). Luciana Sanches was supported by a CAPES fellowship (process 0107/03 – 4).


Read, L., and D. Lawrence (2003), Litter nutrient dynamics during succession in a tropical forest of the Yucatan: Regional and seasonal effects, Ecosystems, 70, 913–922.


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