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# Litterfall Deposition in Subtropical Woodlands, Northeastern Mexico

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***Abstract***
*Litterfall and litter decomposition are key fundamental processes in nutrient cycling of woodlands ecosystems at the Tamaulipan thornscrub of northeastern Mexico, which is characterized by a wide range of taxonomic groups exhibiting differences in growth patterns, leaf life spans, textures, growth dynamics, and phenological development. During two consecutive years (November 2004 to October 2006), monthly litterfall and their respective components were quantified at three county sites (Los Ramones, China, Linares) located at the state of Nuevo Leon. At each site, litterfall deposition was quantified in an undisturbed thornscrub experimental plot (20 m x 20 m). At each plot, seven (replications) litter traps were scattered over the entire area. Each trap covered an area of 0.16 $m^2$ (0.4 m x 0.4 m) and was placed approximately 0.3 m above the soil level to intercept litterfall. At each sampling date, the collected litter was sorted manually into the following categories: leaves, branches (<2 cm in diameter), reproductive structures (flowers, fruits and seeds), and others (unidentified, fine plant residues such as bark, pieces of insect bodies or feces). The samples were then dried to a constant weight at 65$^o$ C for 72 h. Total litterfall production was significantly higher in China (13,431 kg $ha^{-1}$) followed by Linares (9,576 kg $ha^{-1}$) and Los Ramones (8,945 kg $ha^{-1}$). Leaves represented the main component varying from 5,995 to 9,166 kg $ha^{-1}$ followed by branches that ranged from 1,004 to 2,202 kg $ha^{-1}$, and reproductive structures that varied from 700 to 1,329 kg $ha^{-1}$. The contribution of other litterfall components such as bark, insects feces and other debris ranged between 417 and 1,082 kg $ha^{-1}$. Differences in spatial and temporal litterfall deposition among sites might be related to plant phenology, community plant structure and environmental variables such as extreme temperatures and heavy rainfall events.*

## Introduction

Litterfall and litter decomposition are key fundamental processes in nutrient cycling of forest ecosystems (Pausas, 1997; Baker III *et al*., 2001; Isaac and Nair, 2006). In addition to this processes, throughfall and stemflow are the main sources to maintain soil fertility to the forest floor (Silva and González, 2001; Vasconcelos and Luizâo, 2004). Despite of the great number and well documented floristic studies carried out at the Tamaulipan thornscrub or subtropical

thornscrub woodlands, northeastern Mexico, little studies have been carried out to address the spatial and temporal patterns of litterfall deposition, in spite of the importance of this process for nutrient cycling in this type of vegetation which is distinguished and dominated by a wide range of taxonomic groups exhibiting differences in growth patterns, leaf life spans, textures, growth dynamics, and phenological development (Reid *et al*., 1990). This is of key importance in forest communities where sustainable litterfall production is an essential part of the aboveground net primary production and depends upon the nutritional status of soil, such as those found in the northeastern region of Mexico, whose vegetation depends on the biogeochemical cycles of plant nutrients contained in plant detritus (Vasconcelos and Luizâo, 2004). Therefore, this region provides an opportunity to investigate litterfall production of native vegetation in order to gain a better understanding of how to sustain and improve productivity in response to changes in resource availability. Thus, the aim of this study was to assess the spatial and monthly pattern of litterfall throughout two annual cycles and to characterize and quantify the seasonal constituents of the litterfall production in three representative sites of the subtropical thornscrub woodlands, northeastern Mexico.

## Materials and Methods

### Study Site

The study was carried out at three research sites: Los Ramones county (24°47´NL, 99°32´WL), China county (25°40´NL, 99°27´WL), and Linares county (25°31´NL, 99°17´WL). These sites are located in the state of Nuevo Leon, northeastern Mexico and are representative of the main type of vegetation known as the Tamaulipan thornscrub (SPP–INEGI, 1986). The dominant soils are deep, dark-gray, lime-gray, lime-clay vertisols, with montmorillonite, which shrink and swell noticeably in response to changes in soil moisture content. For the three sites, in general, the climate is typically subtropical and semi-arid with a warm summer. Mean monthly air temperature ranges from 14.7°C in January to 22.3°C in August, although daily low and high temperatures of -2°C and 45°C, respectively, are common during the winter and summer, respectively. Average annual precipitation is 805 mm with a bimodal distribution. Peak rainfall months are May, June and September.

### Litter Sampling Frequency and Deposition

At each site, litterfall deposition was evaluated in an undisturbed thornscrub experimental plot (20 m x 20 m). At each plot, seven (replications) litter traps were scattered over the entire area. Each trap covered an area of 0.16 $m^2$ (0.40 m x 0.40 m) and was placed approximately 0.30 m above the soil level to intercept litterfall. Contents of traps were collected at approximately 30 day intervals between November 18, 2004 and October 21, 2006. At each sampling date, research site and trap, the collected litter was manually sorted into the following categories: leaves, reproductive structures (flowers, fruits and seeds) twigs or branches (<2 cm in diameter), and others (unidentified, fine plant residues such as bark, pieces of insect bodies or feces). The samples were then dried to a constant weight at 65°C for 72 h and weighed to the nearest milligram. Litter deposition at each sampling date is reported on a kg $ha^{-1}$ basis.

### Statistical Analyses

To detect significant differences among sites in litter deposition, a one-way analysis of variance design was used at each sampling date. Separate analyses were made for each of the main constituents of the litterfall and for the total litter deposition. Differences were validated using the Tukey's honestly significant difference (HSD) test and were considered statistically significant at $P$=0.05 (Steel and Torrie, 1980). Litter deposition data were transformed using the following equation: $\sqrt[2]{y+1}$ ; where "$y$" is a dependent variable (Ott, 1984). Assumptions of normality for litter deposition data at a given sampling date were tested using the Kolmogorov-

Smirnov test (Steel and Torrie, 1980). All applied statistical methods were according to the SPSS (Statistical Package for the Social Sciences) software package (standard released version 9.0 for Windows, SPSS Inc., Chicago, IL).

**Results and Discussion**

Results of this study have shown that there were significant differences among sites in the deposition of leaves (eight sampling dates out of 24: Jan-17-05, Feb-16-05, Mar-17-05, Apr-18-05, Sep-21-05, Oct-17-05, Jul-18-06 and Aug-18-06), branches (three sampling dates out of 24: Feb-16-05, Aug-17-05 and May-18-06) (Table 1). Likewise, significant differences among sites in seven (Aug-17-05, Oct-17-05, Nov-18-06, Feb-21-06, Apr-18-06, May-18-2006 and Aug-18-06) out of 24 sampling dates were also detected in the deposition of others constituents of litterfall (Table 1). Similarly, sites differed statistically in the deposition of total litterfall in eight (Jan-17-05, Feb-16-05, Mar-17-05, Sep-21-05, Oct-17-05, May-18-06, Jul-18-06, and Aug-18-06) out of 24 sampling dates (Table 1). The deposition of reproductive structures did not differ significantly among sites during the experimental period (Table 1).

On a monthly litterfall deposition basis, Figure 1 shows the seasonal variation of litterfall deposition. During the experimental period, minimum litterfall deposition values registered were 74 (Los Ramones; Feb-16-05), 90 (Linares; Feb-16-05) and 330 kg ha$^{-1}$) (China; Aug-19-06) kg ha$^{-1}$. On the other hand, maximum litterfall deposition were 731, 1,395 and 1,787 kg ha$^{-1}$ for Los Ramones (Nov-18-04), China (Aug-17-05) and Linares (Jan-17-05), respectively. The higher litterfall deposition observed in Linares on Jan-17-05 could be associated to freezing temperatures (-2.0$^{o}$C) registered in this county site on December 24, 2004, as a result of a stationary cold weather front, which could caused leaf death and consequently abscission of leaf tissue. Moreover, on this particular date, leaves contributed to about 82% of the total litterfall deposition. Conversely, higher ($P$<0.05) litterfall deposition detected in China county with respect to Los Ramones and Linares county for the sampling dates of Feb-16-05, Mar-17-05 and Apr-18-05 may be related to the shedding of plant structures as an important ecological process in subtropical woodlands which reduce surface area for transpiration (Strojan *et al*., 1979) or to trigger vegetative or reproductive buds during the spring season.

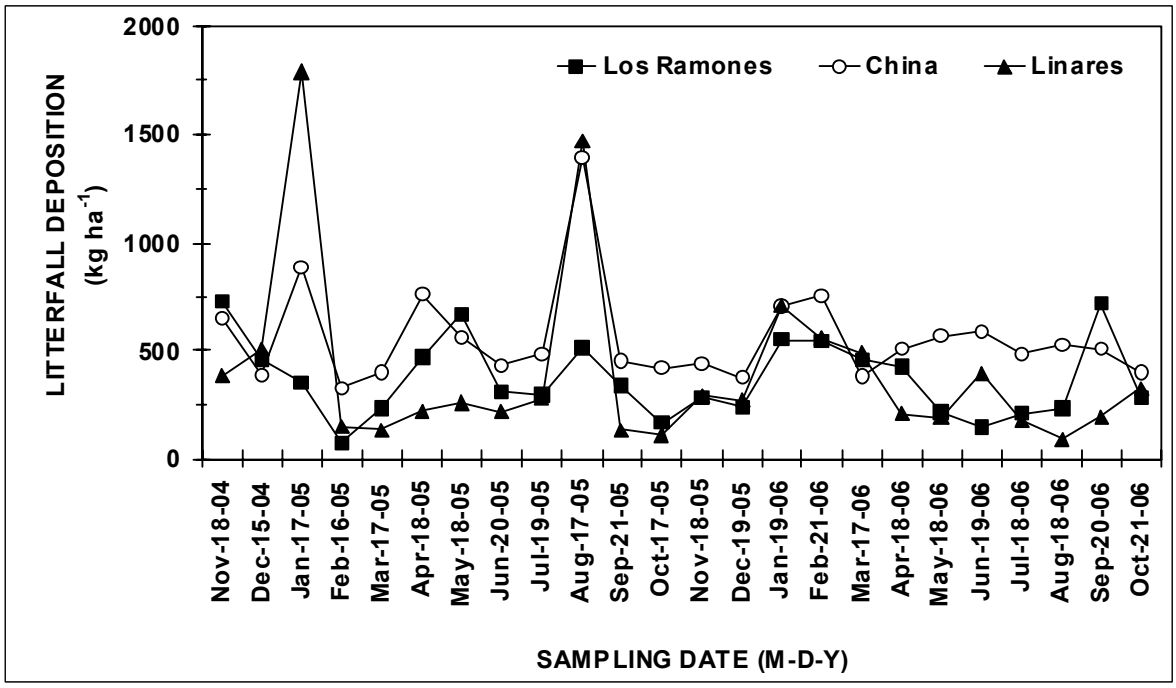


**Figure 1.** Litterfall deposition pattern at research sites, northeastern Mexico.

**Table 1.** *F* and *P* values from one-way ANOVA to detect significant differences among sites on the deposition of litterfall constituents at different sampling dates. Statistically significant probabilities ($P \leq 0.05$) are shown in boldface.

| | **Litter Constituent** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | Leaves | | Reproductive Structures | | Branches | | Others | | Total | |
| | F | *P* | F | *P* | F | *P* | F | *P* | F | *P* |
| Nov-18-04 | 0.61 | 0.55 | 0.63 | 0.54 | 0.29 | 0.75 | 2.80 | 0.09 | 0.90 | 0.43 |
| Dec-15-04 | 1.05 | 0.37 | 0.82 | 0.46 | 0.02 | 0.98 | 0.57 | 0.58 | 0.26 | 0.77 |
| Jan-17-05 | 10.02 | **0.001** | 0.65 | 0.53 | 1.33 | 0.29 | 0.17 | 0.85 | 8.43 | **0.003** |
| Feb-16-05 | 5.80 | **0.01** | 1.66 | 0.22 | 4.16 | **0.03** | 0.41 | 0.67 | 5.20 | **0.02** |
| Mar-17-05 | 5.23 | **0.02** | 0.59 | 0.56 | 1.57 | 0.24 | 0.27 | 0.76 | 5.29 | **0.02** |
| Apr-18-05 | 3.71 | **0.05** | 0.02 | 0.98 | 0.88 | 0.43 | 1.55 | 0.24 | 2.33 | 0.13 |
| May-18-05 | 2.01 | 0.16 | 0.41 | 0.67 | 0.42 | 0.66 | 0.43 | 0.66 | 1.07 | 0.36 |
| Jun-20-05 | 2.14 | 0.15 | 0.10 | 0.90 | 1.24 | 0.31 | 2.60 | 0.10 | 1.33 | 0.29 |
| Jul-19-05 | 2.62 | 0.10 | 3.15 | 0.07 | 1.44 | 0.26 | 1.71 | 0.21 | 2.13 | 0.15 |
| Aug-17-05 | 1.24 | 0.31 | 0.33 | 0.72 | 4.34 | **0.03** | 6.48 | **0.01** | 2.29 | 0.13 |
| Sep-21-05 | 3.50 | 0.**05** | 0.11 | 0.89 | 0.21 | 0.81 | 3.09 | 0.07 | 3.48 | **0.05** |
| Oct-17-05 | 4.68 | **0.02** | 0.10 | 0.90 | 0.43 | 0.66 | 5.47 | **0.01** | 5.23 | **0.02** |
| Nov-18-05 | 0.55 | 0.59 | 1.67 | 0.22 | 1.56 | 0.24 | 3.53 | **0.05** | 1.83 | 0.19 |
| Dec-19-05 | 0.37 | 0.70 | 2.95 | 0.80 | 0.89 | 0.43 | 1.08 | 0.36 | 1.36 | 0.28 |
| Jan-19-05 | 0.17 | 0.84 | 0.16 | 0.85 | 0.43 | 0.65 | 1.55 | 0.24 | 0.21 | 0.81 |
| Feb-21-06 | 1.90 | 0.18 | 0.40 | 0.68 | 0.31 | 0.73 | 5.77 | **0.01** | 1.32 | 0.29 |
| Mar-17-06 | 0.24 | 0.79 | 0.27 | 0.76 | 1.92 | 0.17 | 0.73 | 0.50 | 0.25 | 0.78 |
| Apr-18-06 | 2.15 | 0.15 | 0.39 | 0.68 | 0.14 | 0.87 | 4.67 | **0.02** | 1.16 | 0.33 |
| May-18-06 | 2.31 | 0.13 | 0.43 | 0.65 | 12.36 | **<0.001** | 6.69 | **0.007** | 4.68 | **0.02** |
| Jun-19-06 | 2.63 | 0.10 | 2.94 | 0.08 | 0.69 | 0.51 | 0.48 | 0.62 | 2.64 | 0.10 |
| Jul-18-06 | 4.01 | **0.04** | 0.68 | 0.52 | 1.09 | 0.36 | 1.63 | 0.22 | 4.03 | **0.04** |
| Aug-18-06 | 7.87 | **0.004** | 0.57 | 0.57 | 2.20 | 0.14 | 4.33 | **0.03** | 7.45 | **0.005** |
| Sep-20-06 | 3.07 | 0.07 | 1.05 | 0.37 | 0.32 | 0.73 | 0.40 | 0.68 | 2.74 | 0.09 |
| Oct-21-06 | 1.94 | 0.18 | 0.13 | 0.87 | 0.21 | 0.81 | 2.71 | 0.10 | 0.91 | 0.42 |

In addition, results are also related to the low contribution of leaf tissue in the plant community of Linares due to the frost registered in December, which might have caused leaf and plant tissue death and consequently, a lag time in leaf production.

Although no significant differences in litterfall deposition was detected on Aug-17-05 among sites (Figure 1), the trend to rose an increase in Linares and China sites may be related to the strong winds effects of the Hurricane Emily occurred in this region on July 20, 2005. Branches represented the main constituent of litterfall on this sampling date and its contribution was 59%, 39% and 6% of the total litterfall deposition observed in Linares, China and Los Ramones, respectively.

On an annual basis, total litter deposition during the experimental period (November 2004 to October 2006) at Los Ramones, China and Linares was 4,472, 6,715, and 4,788 kg $ha^{-1}$ $year^{-1}$, respectively. Leaves represented the main component with a deposition that ranged from 65 to 68% of total annual litter production. Branches at Los Ramones, China and Linares was 11, 15 and 23%, respectively, of total annual litter production. Reproductive structures (flowers, fruits and seeds), deposition ranged from 7 (Linares) to 15% (Los Ramones) of total annual litter production. The contribution of others constituents of litterfall ranged from 4 (Linares) to 8% (China) of total annual litter deposition.

At Los Ramones, litterfall annual distribution showed a constant monthly deposition of about 400 kg $ha^{-1}$ without significant peaks. At China, four main deposition peaks were identified: winter 2005, spring 2005, summer 2005 and winter 2006. These peaks contributed to 22% of total annual litterfall deposition. In contrast at Linares, two significant deposition peaks were detected. One corresponds to winter 2005 and the second one to summer 2005. These peaks represented 34% of total annual litterfall deposition (Figure 2).

It has been documented that litter production in forest ecosystem is determined by climatic condition, species composition, and successional stage (Vogt *et al*., 1986; Haase, 1999; Sundarapandian and Swamy, 1999). As in this study, seasonal differences in biomass production may be related to climatic fluctuations and/or changes in plant phenology (Palma *et al*., 2000). In general, results of the present study have revealed that during wet months (August and September) when rainfall was heavy and there were branches and fruits were the main litter constituents whereas in the dry and winter months there was a greater contribution of leaves. Climatic conditions affected the spatial and seasonal litterfall deposition. Further studies are recommended to characterize the decomposition and nutritional dynamics of litterfall constituents in order to understand the role of biogeochemical nutrient cycling in subtropical woodlands.

**References**


Baker III, T.T., Lockaby, B.G., Conner, W.H., Meier, C.E., Stanturf, J.A., and Burke, M.K. (2001). Leaf litter decomposition and nutrient dynamics in four southern forested floodplain communities. Soil Science Society American Journal, 65:1334–1347.

Haase, R. (1999). Litterfall and nutrient return in seasonally flooded and non-flooded forest of the Pantanal, Mato Grosso, Brazil. Forest Ecology and Management, 117:129–147.

Isaac, S.R. and Nair, M.A. (2006). Litter dynamics of six multipurpose trees in a homegarden in Southern Kerala, India. Agroforestry Systems, 67:203–213.

Ott, L. (1984). An introduction to statistical methods and data analysis. 775 p. 2nd Edn., Duxbury Press. Boston, Massachusetts.

Palma, R.M., Defrieri, R.L., Tortarolo, M.F., Prause, J. and Gallardo, J.F. (2000). Seasonal changes of bioelements in the litter and their potential return to green leaves in four species of the Argentine subtropical forest. Annals of Botany, 85:181–186.

Pausas, J.G. (1997). Litter fall and litter decomposition in *Pinus sylvestris* forests of the eastern Pyrenees. Journal of Vegetation Science, 8:643–650.

Reid, N., Marroquín, J., and Beyer-Münzel, P. (1990). Utilization of shrubs and trees for browse, fuelwood and timber in the Tamaulipan thornscrub, northeastern Mexico. Forest Ecology and Management, 36:61–79.

Silva, C.I. and González, R.H. (2001). Interception loss, throughfall and stemflow chemistry in pine and oak forests in northeastern Mexico. Tree Physiology, 21:1009–1013.

SPP–INEGI. (1986). Síntesis geográfica del estado de Nuevo León. Secretaría de Programación y Presupuesto, Instituto Nacional de Geografía e Informática, México.

Steel, R.G.D. and Torrie, J.H. (1980). Principles and Procedures of Statistics. A Biometrical Approach, 632 p. 2nd Edn., McGraw-Hill Book Company. New York, NY.

Strojan, C.L., Turner, F.B., and Caster, R. (1979). Litter fall from shrubs in the northern Mojave desert. Ecology, 60:891–900.

Sundarapandian, S.M. and Swamy P.S. (1999). Litter production and leaf-litter decomposition of selected tree species in tropical forests at Kodayar in the Western Ghats, India. Forest Ecology and Management, 123:231–244.

Vasconcelos, H.L. and Luizáo, F.J. (2004). Litter production and litter nutrient concentrations in a fragmented Amazonian landscape. Ecological Applications, 14:884–892.

Vogt, K.A., Grier, C.C., Vogt, D.J. (1986). Production, turnover and nutrient dynamics of the above- and below-ground detritus of world forests. Advances in Ecological Research, 15:303–377.

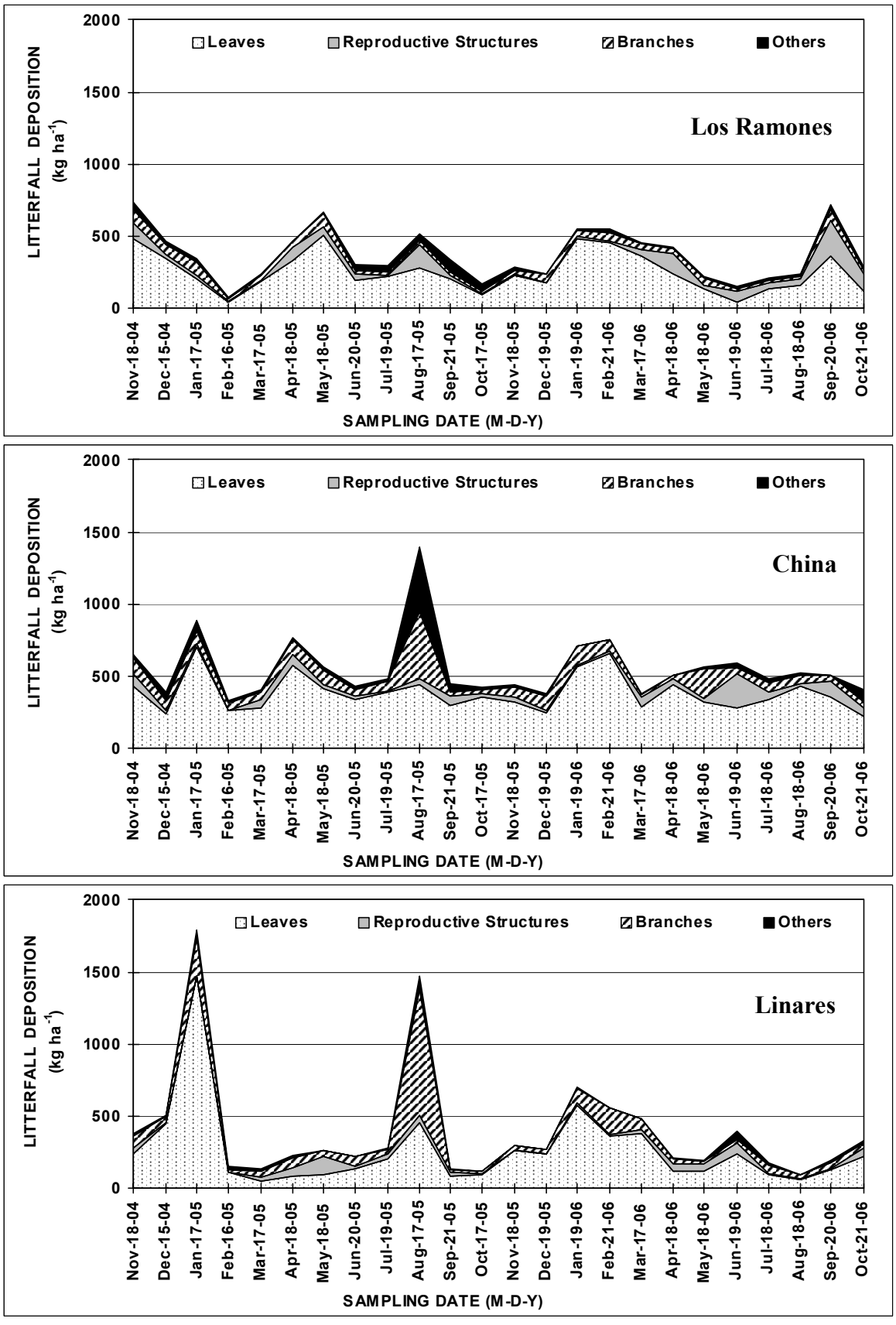


**Figure 2.** Seasonal contribution of litterfall constituents at research sites, northeastern Mexico.