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FACTORS AFFECTING THE APPLICABILITY OF THE AET MODEL FOR DECOMPOSITION IN ARID ENVIRONMENTS¹

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There is considerable interest in the applicability of the model developed by Meentemeyer (1978), which predicts decomposition as a function of actual evapotranspiration (AET) and lignin, to environments other than forests. Whitford et al. (1981b) discussed exceptions to the Meentemeyer AET model in deserts and clearcut forests and concluded that in these environments, biological activity that is relatively independent of AET, such as activity of soil microarthropods and termites, accounts for the deviations (higher rates) from the model. We recently completed a study of decomposition in a semiarid desert-grassland transitional area that provides another independent test of the AET model.

Our study was conducted at the site of the proposed nuclear waste isolation pilot plant 40 km east of Carlsbad, New Mexico, USA. Rainfall averages ≈ 260 mm/yr with most precipitation occurring in late summer and autumn, and in late spring. We used litter characteristic of three plant communities: creosotebush, *Larrea tridentata*, shinnery oak, *Quercus harvardii*, and a mixture of two grasses: black gramma, *Bouteloua eripoda*, and burrograss, *Scleropogon brevifolia*.

The creosotebush community is on shallow, sandy-loam soils. The shinnery oak community is on deep, sandy, unstable soils which form dunes, and the grass community is on shallow, silty-loam soils. Forty bags of each litter type, containing 10 ± 0.2 g of litter per bag, were placed on the soil surface in the plant community from which the litter was collected. Litter bags were 20×20 cm fiberglass screen, 1.5-mm mesh size. Ten bags were collected at 1 mo, 3 mo, 6 mo, and 1 yr; mineral soil was separated from the remaining litter, and the litter was dried, weighed, and burned in a muffle furnace to obtain organic matter loss. Lignin content of samples of the original collections was estimated by the Van Soest method (Van Soest 1963). We used rainfall data from the National Oceanic and Atmospheric Administration station at Potash Company of America, 30 km northwest of the site, to estimate actual evapotranspiration. The average lignin contents of the litter species were, *Q. harvardii*: $10.8 \pm 0.5\%$; *L. tridentata*: $9.5 \pm 0.7\%$; and mixed

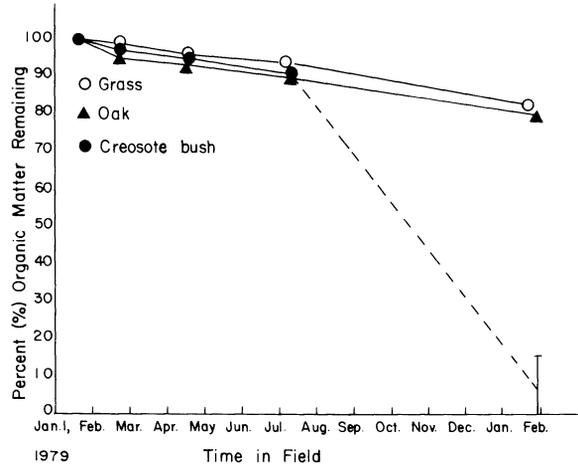


FIG. 1. Comparison of organic matter loss of three litter types in semi-arid ecosystems in southeastern New Mexico.

grasses: $7.26 \pm 0.4\%$. We compared the mass loss constant k for the three litter types, where $-k = \frac{\ln(X_t) - \ln(X_0)}{t}$, using $t = 1$ yr, $X_0 =$ original mass, and $X_t =$ mean mass remaining at the end of 1 yr. The observed and predicted k 's respectively, were: *L. tridentata*: -2.604 and -0.23 ; *Q. harvardii*: -0.23 and -0.22 ; mixed grasses: -0.24 and -0.19 . The Meentemeyer model predicted mass losses of 20.8% for *L. tridentata*, 20.54% for *Q. harvardii*, and 21.3% for the mixed grasses. The observed values, ± 1 SD, were $92.63 \pm 8.4\%$, $19.85 \pm 1.34\%$, and $17.38 \pm 1.53\%$, respectively. The pattern of mass losses from the litter bags shows that creosotebush litter disappeared approximately at the rate predicted by the AET model only until autumn (Fig. 1).

Although no litter bag sets were scheduled for collection and mass loss measurements in October 1979, we examined all litter bags for integrity of the mesh and for termite activity. Active groups of termites were observed in most of the creosotebush litter bags, but no termites were seen in the litter bags containing oak leaves or mixed grasses. When the litter bags were collected in January 1980, all of the creosotebush litter bags contained large quantities of termite gallery material. We therefore conclude that the extremely high loss of creosotebush litter was due to transport of the leaf material to the below-ground nests of the termites, *Gnathamitermes tubiformans*. If we extrapolate the mass loss of creosotebush in the absence of termite feeding, we obtain an estimate of 17.5% at the end of 1 yr. Fowler and Whitford (1980) reported that *G. tubiformans* did not eat or harvest creosotebush litter from fiberglass mesh bags, but their study was conducted during a period of heavy rainfall and when large quantities of dead ephemerals and grasses were avail-

able. Data from this study demonstrate the importance of these termites as detritivores in the creosotebush habitats. The apparent lack of termite feeding on the shinnery oak leaves and mixed grasses may be due to the chemical nature of the material or to the low densities of termites in those habitats (D. T. Schaefer, Jr. and W. G. Whitford, *personal observation*).

Except for the feeding of termites on the creosotebush leaf litter, Meentemeyer's model provided an excellent prediction of decomposition of the oak, *Q. havardii*, and predicted slightly higher decomposition of mixed grasses than observed. Why should the AET model work in these arid systems yet greatly underestimate decomposition in other arid systems (Whitford et al. 1981b)? One factor that appears to be potentially important is the extremely low density of microarthropods in the heavy shallow soils in the creosotebush and grass habitats of the Carlsbad site and the virtual absence of oribatid mites in all of the soils of the Carlsbad site (N. Z. Elkins et al., *personal observation*). The physical properties of the soil could affect not only the microarthropod fauna, but also deep moisture storage and water vapor movements. Water vapor movement has been suggested as a factor in the diurnal migration patterns of microarthropods, especially oribatids, into surface litter in dry desert soils (Whitford et al. 1981a). If these soil factors eliminate the activity of detritivorous micro- and macroarthropods, then mass loss would occur only via microbial activity, which happens only during periods when the litter and soil are moistened by rainfall (K. Suberkropp and T. Arsuuffi, *personal communication*).

Another variable to be considered is the quantity of litter per unit area. The data reported in Whitford et al. (1981b) are for 20 g of litter per bag, which produced an accumulation (depth of litter) equivalent to 2 cm. Whitford et al. (1980) have demonstrated that the decomposition of creosotebush litter varies as a function of initial litter quantity and that decomposition is slow at low initial quantities. The 10 g quantities used in this study were probably insufficient to modify the microclimate of the soil litter interface. The absence of a favorable microclimate would mitigate against activity of soil organisms except immediately following rain.

Any combination of these factors is sufficient to

cause decomposition to proceed as a physical process which varies as a function of actual evapotranspiration. Deviations in decomposition of grasses from that predicted by AET models could be the result of the silica content of the grasses, C:N ratio of this material, or other chemical characteristics of the substrate.

This study clearly demonstrates that the Meentemeyer (1978) model does work in deserts or arid areas under certain conditions. Further, it supports the contention of Whitford et al. (1981b) that we need to know more about the factors that influence the activity of soil biota in arid ecosystems before we will be able to make general predictions about decomposition in such environments.

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