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Comparison of litterfall input to streams

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Allochthonous organic matter is an important source of energy for many streams and the major energy source for woodland streams or streams with well developed riparian corridors of vegetation (e.g., Cummins et al. 1983). Litterfall may be defined as allochthonous material entering streams from riparian vegetation. It may include leaves and leaf fragments, floral parts, bark, wood (branches and twigs), cones and nuts, fruits, and other plant parts (Bray and Gorham 1964). Litter may reach streams by direct fall or lateral movement (blowing or sliding down the stream banks). The relative amounts of material reaching streams by these 2 routes vary considerably. Lateral movement may vary with wind patterns, aspect, bank slope, and other site-specific factors (Wallace et al. 1992). For example, lateral movement accounted for about 24% of total litter input to 4 southern Appalachian streams (Webster et al. 1995), about 66% in a Douglas fir-hemlock forest stream in the western US (Sedell et al. 1982), but only about 10% in a eucalyptus forest stream in Australia (Campbell et al. 1992). The composition of litterfall varies with vegetation type and location. As a general average, non-leaf litterfall for forests around the world is about 30% (Bray and Gorham 1964) but may be up to 70% in some forests in southeastern Australia (Blackburn and Petr 1979, Briggs and Maher 1983).

In temperate deciduous forests, the bulk of litterfall occurs in autumn but material may continue entering streams by lateral movement over the remainder of the year. Needle-fall from coniferous evergreen trees varies considerably with species and location and may range from distinctly seasonal to irregular throughout the year (Bray and Gorham 1964). Litterfall from tropical wet forest trees and shrubs is usually non-synchronous and leaves enter streams relatively evenly over the entire year (Stout 1980).

In streams with broadly developed valleys or in lowland systems, litter may be entrained from the floodplain as streams rise during periods of increasing discharge (Cuffney 1988). Conversely, litter may be deposited on the floodplain as streams retreat during falling hydrographs (Post and de la Cruz 1977, Shure and Gottschalk 1985). Floodplain entrainment/deposition cycles of litter during changing hydrographs may also occur in smaller, montane streams (Wallace et al. 1992) and tundra streams (Peterson et al. 1986). Thus floodplain areas may be sources or sinks for litterfall depending on hydrodynamics, topography, sediment loads, and other factors (Cuffney 1988). In some floodplain systems, litterfall may be largely processed on the floodplain and the resulting particles entrained by streams during high flows (Smock 1990).

The objectives of this chapter are to summarize data on direct fall and lateral movement of litter to streams that were included in the earlier site-description chapters, and to analyze whether patterns of direct litterfall to these streams might be explained on the basis of local or spe-

TABLE 1. Order, latitude, and litter inputs for the 33 streams analyzed. NI = No information.

Stream	Order	Latitude (degrees)	Litterfall $(g^{-2} y^{-1})$	Lateral movement $(g^{-2} y^{-1})$	Total litter input $(g^{-2} y^{-1})$	Cover type
Satellite Br, North Carolina	1	35	492	137	629	Mixed deciduous forest
Walker Br, Tennessee	1	36	459	106	565	Mixed deciduous forest
Buzzards Br, Virginia	1	37	528	NI	528	Mixed deciduous forest
August Cr, Michigan	1	42	448	NI	448	Mixed deciduous forest
WS10–1973, Oregon	1	45	537	667	1204	Coniferous forest
WS10–1974, Oregon	1	45	567	1111	2789	Coniferous forest
Devil's Club Cr, Oregon	1	45	736	NI	736	Coniferous forest
Rattlesnake Sp, Washington	1	47	242	NI	242	Shrub cover
First Choice Cr, Quebec	1	50	417	344	761	Mixed deciduous forest
Breitenbach, Germany	1	51	700	NI	700	Mixed deciduous forest
Caribou Cr 2, Alaska	1	65	37	NI	37	Mixed deciduous forest
Caribou Cr 3, Alaska	1	65	37	NI	37	Mixed deciduous forest
Canada St, Antarctica	1	78	0	0	0	Open
Hugh White Cr, North Carolina	2	35	506	71	577	Mixed deciduous forest
Deep Cr, Idaho	2	43	3	NI	3	Shrub/grass cover
Bear Brook, New Hampshire	2	44	594	NI	594	Mixed deciduous forest
Beaver Cr, Quebec	2	50	217	56	273	Mixed deciduous forest
Monument Cr, Alaska	2	65	62	19	81	Mixed deciduous forest
Creeping Swamp, North Carolina	3	35	696	NI	696	Mixed deciduous forest
Kings Cr (prairie), Kansas	3	39	100	18	118	Shrub/grass cover
White Clay Cr, Pennsylvania	3	40	313	NI	313	Mixed deciduous forest
Mack Cr, Oregon	3	45	730	NI	730	Coniferous forest
Keppel Cr, Australia	4	37	677	68	745	Mixed deciduous forest
Fort R, Massachusetts	4	42	384	NI	384	Mixed deciduous forest
Kuparuk R, Alaska	4	70	0	500	500	Shrub/sedge cover
Sycamore Cr, Arizona	5	33	17	3	20	Shrub cover
Kings Cr (forest), Kansas	5	39	357	369	726	Mixed deciduous forest
Lookout Cr, Oregon	5	45	730	NI	730	Coniferous forest
Muskrat R, Quebec	5	50	30	11	41	Mixed deciduous forest
Ogeechee R, Georgia	6	32	843	3520	4363	Mixed deciduous forest
Matamek R, Quebec	6	50	16	3	19	Mixed deciduous forest
McKenzie R, Oregon	7	45	218	NI	218	Coniferous forest
Moisie R, Quebec	9	50	2	1	3	Mixed deciduous forest

cial topography, latitude, stream order, and riparian vegetation.

Methods

Litterfall data used in this analysis were drawn from 33 sites. Only 18 of the 33 sites had lateral movement data so the quantitative analyses were limited to direct litterfall. Linear regression was performed on direct litterfall versus stream order, latitude, and annual precipitation. Differences in litterfall among groups of vegetation cover types were tested with ANOVA followed by the LS means procedure.

Results

The present data set includes information from 33 sites ranging in latitude from 78°S to 70°N, but most of the sites are between 32° and 65°N on the North American continent (Table 1). Direct litterfall varied over a broad range from 0.0 g m^{-2} y^{-1} in Canada Stream (Antarctica) and the Kuparuk River (Alaska), to 843 g m^{-2} y^{-1} in the Ogeechee River (Georgia) (Table 1). Lateral movement values were available for only 18 sites and ranged from a high of 3520 g m^{-2} yr^{-1} in the Ogeechee River to 3 g $m^{-2}y^{-1}$ or less in Sycamore Creek (Arizona) and the Matamek and

Errata for Benfield, E. F. Comparison of litterfall input to streams.

Figure 1 should be replaced by the figure below.

Units in Table 1 caption should be g m $^{-2}$ y $^{-1}$

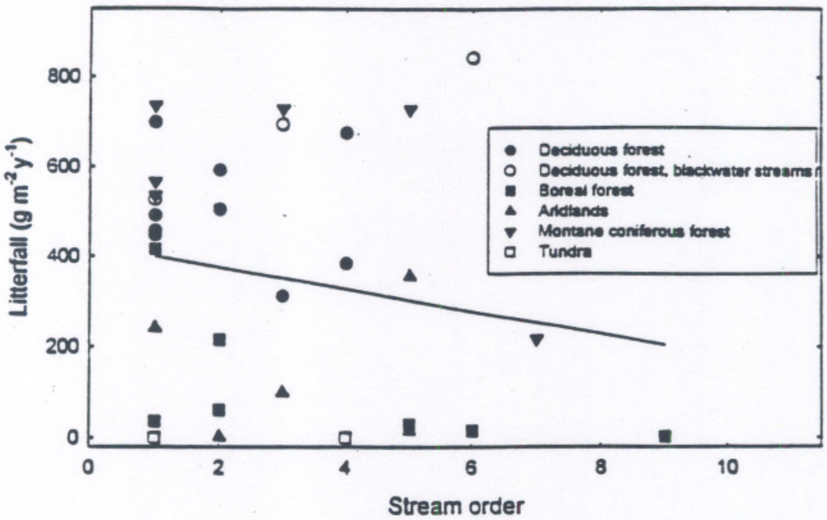

FIG. 1. Linear regression of litterfall vs. stream order ($p = 0.29$, $r^2 = 0.04$, $n = 33$).

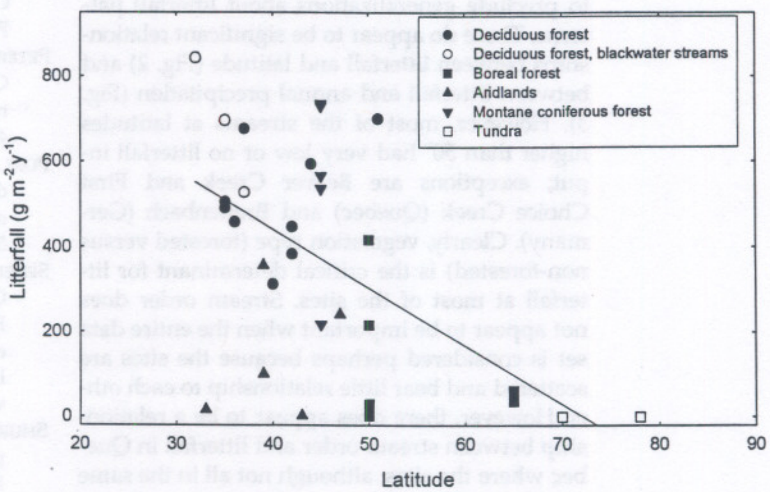

FIG. 2. Linear regression of litterfall vs. latitude ($p < 0.001$, $r^2 = 0.30$, $n = 33$).

input is a mixture of leaves and needles, and Monument Creek (Alaska) receives a mixture of alder, birch, and willow. Within the mixed deciduous sites, litterfall ranged from 2 g $m^{-2}y^{-1}$ in the 9th order Moisie River to 843 g $m^{-2}y^{-1}$ in the 6th order Ogeechee River. As in the case for the whole data set, there was no consistent relationship between stream order and litterfall among the streams draining mixed deciduous forests.

The 2nd-most-frequent site type was coniferous forest (6 of the 33 sites), all of which were in the Oregon Cascade Mountains. Litterfall ranged from 218 g $m^{-2}y^{-1}$ in the 7th order McKenzie River to 730 g $m^{-2}y^{-1}$ in Devil's Club Creek (1st order). A 3rd- and 5th-order stream in the area each had litterfall of 730 g $m^{-2}y^{-1}$. The remaining sites ("other") are hot/arid or cold/arid sites that drain vegetation types composed of shrubs, grasses, sedges, or some mixture. The Antarctic site has no vegetation. There was no significant difference between mean litterfall in streams draining mixed deciduous and coniferous sites, but both were significantly different from the "other" sites (ANOVA, LS means procedure, $p < 0.01$).

The great diversity of vegetation, latitude, and stream order incorporated in this data set seems

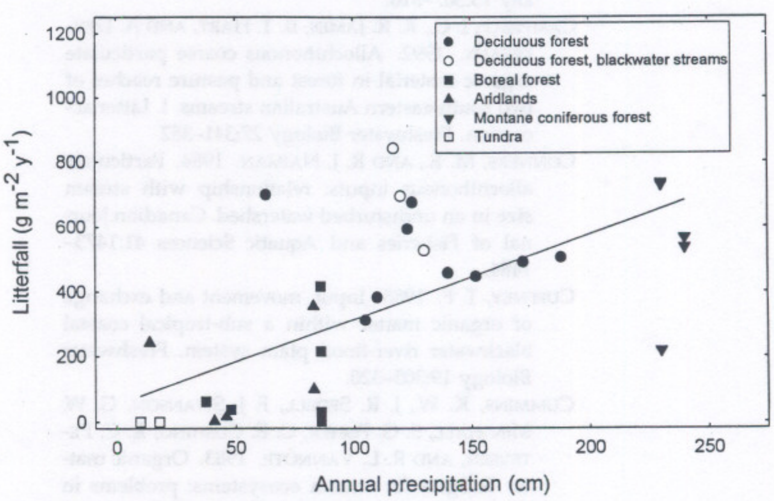

FIG. 3. Linear regression of litterfall vs. annual precipitation ($p < 0.001$, $r^2 = 0.44$, $n = 33$).

STREAM ORGANIC MATTER BUDGETS

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