Input and Storage of Benthic Detritus in an Alaskan Subarctic Stream

C. A. Cowan and M. W. Oswood*

Institute of Arctic Biology, University of Alaska, Fairbanks, AK 99701, USA

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Summary. Allochthonous leaf litter input and storage of benthic detritus were measured in Monument Creek, a second-order interior Alaskan stream. Litter input was very low, totaling 62.5 g ash-free dry weight (AFDW) • m⁻² • y⁻¹ in 1980. Peak input coincided with autumnal leaf fall. Benthic detritus storage was similarly low. CPOM (coarse particulate organic matter, > 1 mm) ranged from 2.8 to 28.9 g AFDW • m⁻², peaking in mid-September. MPOM (medium particulate organic matter, 250 µm - 1 mm) ranged from 3.7 to 10.9 g AFDW • m⁻², peaking in May. SPOM (small particulate organic matter, 80 - 250 µm) ranged from 2.0 to 9.0 g AFDW • m⁻² and also peaked in May. Compared to streams in temperate regions, Monument Creek is receiving and storing less energy from the surrounding forest.

Introduction

Plant detritus from terrestrial sources in an important trophic input to most stream ecosystems, (Cummins 1974; Minshall 1978) and has been the focus of considerable research in the past decade (Bird and Kaushik 1981). Benthic detritus is both a food resource (Cummins and Klug 1979) and a habitat (Malmqvist et al. 1978; Short and Ward 1981; Cummins et al. 1981) for benthic organisms. Input of leaf litter has been measured in a variety of stream types at various latitudes but none exceed 55°N (Anderson and Sedell 1979; Minshall 1978; Bird and Kaushik 1981). Benthic detritus storage has been quantified in temperate and alpine regions (Cummins et al. 1981; Short and Ward 1981) but neither leaf litter input nor benthic detritus storage have been reported for any streams in arctic or subarctic regions. In this study, we report the quantity and phenology of allochthonous detritus input and benthic detritus storage in Monument Creek, a subarctic stream in interior Alaska (USA).

We recently reported processing (decomposition) rates of leaves of the three major riparian tree species (alder, birch, and willow) in Monument Creek and patterns of invertebrate colonization of 5 g leaf packs of these tree species (Cowan et al. in press). The objectives of the present investigation were:

1. To describe the seasonal patterns of detritus input and benthic storage;
2. To examine the seasonal patterns in abundance of three detritus particle size classes: CPOM (coarse particulate organic material, > 1 mm), MPOM (medium particulate organic material, 250 µm - 1 mm) and SPOM (small particulate organic material, 80 µm - 250 µm) and;
3. To compare the input and benthic storage of detritus in Monument Creek with that reported for streams elsewhere.

We hypothesized that growing conditions in the subarctic restrict terrestrial primary production and thus limit the quantity of leaf litter entering and stored in the stream.

Materials and Methods

Study Site

The study site is located on Monument Creek, a second-order tributary of the Chena River, approximately 115 km NE of Fairbanks, Alaska, near the Chena Hot Springs resort area (65°N, 146°W). A map of the study area and detailed temperature and study site information are presented in Cowan et al. (in press). The site is 25 m long on its shortest side and averages 12.5 m in width (9 - 25 m). Stream surface area at the study site varied with discharge, but averaged 327 m². Discharge measurements (over the ice-free season) ranged from 0.34 m³ • s⁻¹ to 3.47 m³ • s⁻¹ (k = 1.45 m³ • s⁻¹; n = 8) although higher values (not measured) occurred during spates. Stream water temperature ranged from 0°C (October – May) to 10°C (midsummer 1980). Winter ice cover was extensive, beginning with surface ice in late September. By mid-January, greater than 75% of the stream surface area was frozen from surface to substrate. Ice cover persisted until May.

The site is at an elevation of 480 m, approximately 300 m below timberline. The riparian vegetation consists primarily of stands of wil-
low (Salix alaxensis (Anderss.) Cov. ssp. alaxensis and Salix arbusculoides Anderss. var. glabra Anderss.) and alder (Alnus tenuifolia Nutt.), and scattered paper birch (Betula papyrifera Marsh.), balsam poplar (Populus balsamifera L.), quaking aspen (Populus tremuloides Michx.), and white spruce (Picea glauca (Moench.) Voss). Vegetation height is generally short to moderate (1 m to 15 m). The canopy does not cover the entire width of the channel.

Input of Forest Debris
Three modes of allochthonous input to the stream were measured; input to the water surface, input to the bank immediately adjacent to the stream, and downslope movement of forest debris. Input to the stream surface and adjacent banks was measured with 0.327 m\(^2\) wooden litter trays (wooden frames with wire mesh (1 mm openings) bottoms). Downslope movement was measured with trays identical in size, but closed on all sides (including top and bottom) except the upslope end. Ten of each tray type were secured at randomly selected locations within the stream channel (stream surface input) or along the stream bank immediately adjacent to the water’s edge. We assumed that forest debris reaching this region had a high probability of eventually entering the stream through wind action or fluctuating water levels. Input was monitored from 3 September 1979 to 20 October 1980. Tray contents were removed bi-weekly during spring and summer and weekly during the fall; litter trays were removed during winter ice cover. Samples were divided into “resistant” (twigs and woody material) and “non-resistant” (leaves, needles, etc.) fractions. Spring samples contained little woody material but did contain catkins from riparian trees and, consequently, were divided into “catkins” and “other” (leafy and woody) material.

Leaf litter was oven dried at 50°C for 24 h, cooled in a desiccator and weighed to the nearest mg on a Mettler P163 single pan balance. Dried material was burned in a muffle furnace at 500 °C for 12 h, cooled in a desiccator and reweighed, providing the ash-free dry weight. Standing crop of wood debris was not determined.

Detritus Standing Crop
Techniques for quantifying benthic detritus vary considerably. Investigators have used stream transects (Fisher and Likens 1973; Malmqvist et al. 1978) or quadrats (Fahy 1972; Naiman and Sedell 1979), artificial substrates (Wakefield et al. 1980), coring devices (Fisher 1977; Malmqvist et al. 1978; Short and Ward 1981), frame nets (Cummins et al. 1981), surber samplers (Fisher and Likens 1973) or box samplers (Fisher 1977), with detritus removal accomplished by a variety of pumps, dip nets, catch nets and/or sieves. We used a portable invertebrate box sampler (Ellis and Rutter Associates), (Merritt and Cummins 1978). The box sampler is large enough for effective sampling of large substrate material, yet small enough to permit reasonable replication within a site, revealing microhabitat variation in benthic detritus storage and associated macroinvertebrate fauna. Standing crop of benthic detritus was monitored from 12 June 1980 to 9 June 1981. Benthos samples from 4 randomly selected locations were taken bi-weekly during the spring and summer, and weekly during the fall. Winter ice cover (with ice to the substrate over much of the stream) and sub-zero temperatures prohibited sampling between late November and early May. The box sampler enclosed a 0.1 m\(^2\) area of substrate. The area enclosed was stirred to a depth of approximately 10 cm, dislodging invertebrates and detritus particles which were carried by stream flow into 350 μm and 80 μm mesh nets in a series. Stirring continued until no further particles were visible in the enclosed water column (usually 2 – 3 min). Nets were backwashed into enamelled pans, and contents preserved in Kahles fluid. Shallow areas (<5 cm deep) could not be sampled due to lack of flow through the sampler. The sampler was modified for deep water (greater than 30 cm) with a collapsible sheet metal extension which, when in place, permitted sampling in areas up to 0.8 m deep (the greatest depth in the study site).

In the lab, preserved samples were transferred to 95% ethanol and examined at 12X with a dissecting microscope for removal of macroinvertebrates and wood debris >1 mm diameter. Sorted samples were gently rinsed through a series of three Nitex sieves, (pore sizes 1 mm, 250 μm and 80 μm) resulting in three size fractions. Loss of soluble components of detritus in preservatives was not estimated. Fractionated material was dried at 50°C for 48 h, cooled in a desiccator and weighed to the nearest mg. Dried material was burned in a muffle furnace at 500°C for 12 h, cooled in a desiccator and reweighed, providing the ash-free dry weight. Standing crop of wood debris was not determined.

Fig. 1. Seasonal input of leaf litter to the stream, showing proportions collected via each mode of entry. Values are means ± 95% Confidence Interval. Annual input (1980) includes summer 1980 data (not shown). Summer data are incomplete.