Influence of large woody debris on stream insect communities and benthic detritus

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Abstract

We examined the extent to which benthic detritus loadings and the functional feeding group structure of stream insect communities respond to channel modifications produced by experimental addition of large woody debris (LWD, entire logs) to Stony Creek, Virginia. Benthic detritus loadings per sample did not change after LWD additions, but large increases in pool habitats created by LWD increased net detritus by an estimated 27 kg (25%) in the 250 m of stream receiving LWD. A large increase in the proportional area of pool habitats may result in a dominance of collector-gatherers and corresponding decreases in shredders and scrapers. Functional feeding group community structure in pools was similar spatially and temporally. Riffles were spatially convergent, but differed temporally. Community structure was significantly different between pools and riffles. The results indicate possible large scale influences in overall community structure due to channel alterations by LWD, but little within-habitat change.

Introduction

Invertebrate communities in forested, temperate streams are thought to be structured on the basis of detritus processing with several functional feeding groups evolved to capitalize on energy leakage of the larger particle detritivores (Cummins, 1974; Vannote et al., 1980). Allochthonous inputs (especially leaves) appear to be a very important energy source driving community structure (Minshall, 1967). Anderson et al. (1978) found that invertebrate standing crops in leaf debris were two orders of magnitude higher than on wood. This relationship appears to remain intact for detritus trapped in the substratum as well (Egglishaw, 1964; Rabeni & Minshall, 1977; Flecker, 1984).

Because the majority of a stream’s energy input comes in a relatively short pulse from autumn litterfall (Cuffney & Wallace, 1989), the retention capacity of structures such as LWD becomes very important for providing a food reservoir throughout the year. Experimental additions of whole-leaf detritus in a Pacific Northwest stream resulted in greater abundance of the collector-gatherer and collector-filterer functional feeding groups (sensu Cummins, 1973) than before additions (Richardson & Neill, 1991). The presence of LWD increased retention of coarse particulate organic matter. This allowed for more complete leaf processing at the site by shredders. Subsequently, more fine particulate organic matter was made available, which secondarily supported higher densities of collector-gatherers and collector-filterers (Richardson & Neill, 1991).

Relative to other non-mineral substrates, the residence time of LWD is much longer and it provides a
stable base that resists disturbances. It often maintains a dominant influence in structuring channel morphology (Keller & Swanson, 1979; Bilby, 1984; Andrus et al., 1988; Hilderbrand et al., 1997) and sediment retention (Megahan, 1982). It also provides a major storage mechanism through the physical capture of entrained organic materials in debris dams and by slowing throughput (Bilby & Likens, 1980; Speaker et al., 1984; Smock et al., 1989; Trotter, 1990). These properties may increase an aquatic system’s stability, resiliency and resistance to disturbance.

Secondarily, LWD can influence retention, thereby potentially affecting invertebrate communities by increasing the amount of depositional areas and changing the proportional abundance of pool and riffle habitats. However, little information exists regarding secondary effects. The purpose of this paper is to report relations found between benthic detritus dynamics, experimental additions of LWD and the benthic macroinvertebrate community of a small forested stream in the middle Appalachians.

Methods

The study stream, North Fork Stony Creek (hereafter referred to as Stony Creek), is a third order, low gradient (~5%) stream at approximately 920 m in elevation in the Appalachian Mountains of southwestern Virginia (Figure 1). The creek is surrounded by a mature, second growth mix of soft- and hardwood forest, and dominant substrates are small and large gravels. We selected an 600 m reach in the Jefferson National Forest for LWD additions. This reach was divided into two, 250 m sections, separated by a 50 m buffer. The upstream section served as an unmanipulated reference, while we added LWD (entire logs) to the downstream section (systematic placement section).

Prior to manipulation, we demarcated pool and riffle habitat units following descriptions by Bisson et al. (1982) and constructed an accurate stream map (using ARC/INFO) for each study section. Runs were classed with riffles, glides were classed with pools and the major pool-forming element (e.g. LWD, boulder) was recorded. Preexisting LWD was also measured and recorded. The stream was re-mapped 1 year after LWD additions. Pool and riffle area were calculated based on these maps, which enabled us to estimate the total weight of benthic detritus retained in each habitat type.

Location and positioning of logs were subjectively determined by our judgements of how best to enhance stream habitats. The log positions used included: 1. positions based on orientation of the log axis to the stream bank in 45° intervals (upstream, perpendicular and downstream; excluding parallel to bank); and 2. orientation to the water surface (dam with entire log submerged or ramp with one end protruding onto bank). Prior to additions, we marked log positions and the length of log needed at a particular site was determined. Selected trees were felled at least 10-m from the stream bank, stripped of limbs and cut to a minimum 4-m length and 25-cm top diameter. Limbs were removed to maintain uniformity between logs. We used a front-end loader with a hydraulic winch to position logs in the stream. Logs were not keyed or otherwise pinned to the channel. Heavy equipment was operated in the riparian zone, but did not enter the channel. We added 50 logs in the systematic placement section of Stony Creek, representing seven local tree species.

We sampled benthic macroinvertebrates and detritus using a 0.1 m² portable invertebrate box sampler (PIBS, Ellis-Rutter Associates, Punta Gorda, Florida, U.S.A.) with 350 um mesh net. Sampling occurred during late May, before LWD additions and 1 year after LWD additions, also in late May. We collected five paired riffle samples and three paired pool samples per section at randomly determined locations. Members of a pair were collected in similar local habitat conditions to minimize variability. To ensure adequate representation of all habitat types, different pairs were taken in different habitats within pools or riffles (e.g. heads, tails and centers of pools). During collection, the substrate was disturbed to a depth of 8–10 cm and