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Large Wood for Stream Habitat Restoration in Sand-bed Channels: Harder Than It Looks!

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Structures made from large wood (LW) material have been used for controlling stream erosion for many decades and are increasingly being used to restore or rehabilitate stream habitats. Incising, sand-bed streams provide a particularly rigorous test of the large wood approach due to widely varying flows and rapid erosion and sedimentation common to such systems.

Warmwater streams in the Southeastern United States have remarkably high levels of biodiversity and are important ecological resources, but much of the fauna is imperiled by habitat degradation. Channel incision, a worldwide problem occurring in both urban and rural landscapes, is one of the most pernicious drivers of current stream habitat degradation. In the absence of bedrock or large bed material, incision triggers explosive channel erosion, with width rapidly increasing three- to six-fold, and elevating watershed sediment yield by an order of magnitude (Shields et al. 1995). Fish communities shift toward patterns typical of small, hydrologically unstable headwater streams, with populations dominated by small-bodied, short-lived opportunists (Shields et al. 1998).

Stabilization of incising, warmwater streams can prompt partial recovery of fish communities, particularly when the structures and methods used are designed to address habitat-limiting factors (Shields et al. 1998). LW exerts a major influence over stream morphology in unmanaged fluvial systems and is an important component of aquatic habitat in warmwater streams.

Stabilization of eroding banks or habitat rehabilitation using structures composed entirely or partially from LW has been described for streams in many parts of the U.S., Canada, and Australia (Shields et al. 2004). However, placing structures in incised, sand-bed channels of smaller streams presents a different set of challenges. In addition to basic differences in ecology, available wood tends to be smaller. Material coarser than fine gravel for ballast is unavailable and channel

Figure 1. Typical meander bend along Little Topashaw Creek, Mississippi shown just prior to, during, and six months after placement of large wood structures.

erosion rates (relative to channel width) are higher. Channel width-depth ratios are an order of magnitude smaller (typically <10), so storm flows tend to be deep, and structures are more frequently submerged. Since LW rapidly decomposes in humid, temperate climates (Roni et al. 2002), long-term success is contingent upon the creation of suitable habitat for plants that will secure and stabilize the channel margins over the longer term (Jacobson et al. 1999).

In order to test concepts for low-cost rehabilitation of habitats associated with a severely incised, meandering sand bed stream, we constructed 72 LW structures along eroding banks of an incised, sand-bed stream (figure 1). We monitored fishes and their habitats before and after construction within the modified reach, upstream, and downstream for a total of five years. We also monitored the response of the stream channel and the status of the LW structures. Findings should be relevant to those interested in restoring similar and less severely disturbed stream systems.

Methods

We selected a 2-km reach of Little Topashaw Creek, a 37 km^2 fourth-order stream in north central Mississippi to meet the criteria of rapid bank erosion driven by incision processes, sandy bed material, an abundant supply of bed material from upstream, sources of LW for construction, sufficient channel width, nearby sources of native plant and animal colonists, and an aquatic ecosystem clearly limited by lack of pool and woody debris habitat components. One of the most important criteria was that the reach had to be in an advanced stage of incised channel evolution (Simon 1989), which implied that bed erosion processes would be relatively minor and that deposition of sediments derived from upstream incision would occur adjacent to eroding banks, especially when encountering introduced LW.

Seventy-two LW structures were constructed along 1500 m of eroding bank using woody debris or harvested trees (Shields et al. 2004). Within-channel LW loading was increased by a factor of 20. During the first winter following construction, about 4,000 black willow (*Salix nigra*) cuttings were planted on point bars and in sediment deposits. Effects of modification on physical habitat quality and fish were quantified by semiannual sampling at base flow during 1999-2003 inclusive.

Results

During the first year following construction, only 4 of the 72 structures failed. However, after three years, 36% of the structures were destroyed, and 35% were damaged (table 1). Initially, local scour adjacent to the structures and backwater from small beaver dams resulted in greater baseflow depths and higher levels of habitat heterogeneity based on the variances of water width and depth. Mean water depth in the treated reach was 2-4x that in the untreated downstream reach. However, as LW structures failed, conditions in the treated and untreated reaches converged.

Fish numbers (catch per unit of effort) and species richness increased following LW addition in both treated and untreated reaches, but differences between the two reaches were not significant ($p > 0.1$) (figure 2). These responses were consistent with previous observations and a conceptual model of response to

	As built (2000)	After one year (2001)	After two years (2002)	After three years (2003)
No. of remaining structures	72	68	50	46
No. of remaining structures located in bends	39	38	30	27
No. of remaining structures located in straight reaches	33	30	20	19

Table 1. Number of large wood structures remaining 1, 2, and 3 years after installation.

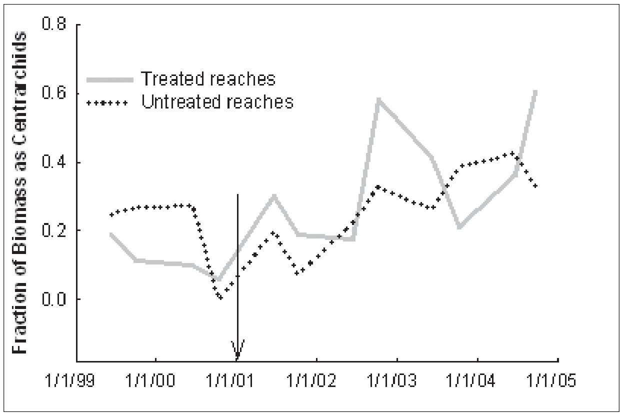

Figure 2. Relative abundance (biomass) of centrarchids in treated and untreated reaches of Little Topashaw Creek before and after LW addition. Approximate date for LW addition is shown by the vertical arrow.

addition of pool habitats in incising warmwater streams—patterns of relative abundance shifted toward those typical of less-degraded streams (Shields et al. 1998).

Conclusions

Since lightly degraded sand bed streams typically contain high levels of LW, rehabilitation of damaged streams should often feature LW addition. However, effects of LW addition are likely to be short-lived unless compatibility with the overall geomorphic and ecological context is insured. Since LW tends to be mobile and to decay rapidly in small, warmwater streams, LW projects must be planned and designed so that perennial woody plants colonize sediment deposits within the LW structures, and new LW is recruited to maintain loading levels within treated reaches as added LW breaks up and decays. Evidently cover and velocity shelter associated with LW formations are extremely important for recovery of species assemblages in incised channels, since organisms cannot retreat to the floodplain for velocity refuge except during rare events (Crook and Robertson 1999). LW structures hold potential for rehabilitating reaches of small (drainage area < 200 km^2) sand-bed streams in post-degradational stages of incised channel evolution. Application of this approach on a regional basis could trigger unprecedented recovery of stream corridor ecosystems at much lower cost than other practices (Shields et al. 2004).

Additional information about this study and Topashaw Creek is available from our Web page at: http://msa.ars.usda.gov/ms/oxford/nsl/wqe_unit/topashaw.html.

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