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Restoring Large Woody Debris to Streams

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Introduction

The role of large woody debris in streams has become better understood in recent years. Large woody debris (LWD) is an important structural and functional component of stream ecosystems (Ramquist 1995, Richmond and Fausch 1995). LWD can consist of a wide range of types and sizes including logs, coarse roots, and smaller branches (Ramquist 1995). Research over the past two decades has shown that LWD improves fish habitat by increasing types and sizes of pools, sediment storage, and scour (Skaugset et al. 1996). Wallace et al. (1995) explained that LWD also causes the "formation of stair-step profiles that result in the rapid dissipation of stream energy in high gradient systems." Prior to 1970, LWD was believed to have negative effects on fisheries by blocking upstream migration of some species (i.e. anadromous salmonids) and by depleting oxygen in streams. Thus, clearing and snagging of woody debris in streams occurred in U.S. streams and rivers, especially in the late 1800’s and early 1900’s when timber harvesting was most intense. As a result, there is much less LWD in streams and rivers than what occurred historically. Recent studies showing that LWD is important and beneficial to fish habitat have caused fishery and forestry managers to re-evaluate woody debris practices. LWD also provides colonization areas for different types of invertebrate organisms in streams, and high densities of invertebrates on logs attract fish that feed on these invertebrates (Ramquist 1995).

Over the years, some streams have been affected by human development, especially in areas of the United States where the surrounding forests have been harvested. Streams have been straightened, shortened, diverted, encroached upon, cleaned out, and altered for different reasons. For example, in the late 1800’s to the early 1900’s, many streams were cleared and snagged of LWD for logging, navigational, and aesthetic purposes that were not believed to harm stream ecosystems (Ramquist 1995). Consequences of these alterations included increased erosion and sedimentation, decreased abundance of aquatic organisms, and a loss of natural aesthetics. However, these undesirable results are not inevitable. If proper hydrologic engineering and placement of LWD is followed, a stream can in time recover its function and aesthetics and be restored to its natural state (U.S. DOT 1979).

The objective of this paper is to discuss and describe the techniques of placing LWD in streams to restore natural conditions and enhance fish habitat. I will also describe what ecosystems this technique has been used in, compare it to other stream debris restoration practices, and finally describe the successes and/or failures of this technique of stream restoration.

Adding Large Woody Debris: A Restoration Technique

Stream and fishery biologists have realized the value of large woody material as fish habitat, since large woody material represents a multi-functional value through pool formation, added cover, and the stabilization of critical spawning areas such as gravel beds (House et al. 1990). One of the most common methods of adding woody debris has been the process of felling (cutting down), yarding (dragging to the stream), and bucking (hoisting into position) both conifers and hardwoods, and then properly securing the LWD in the active channel that is being restored (House et al. 1990). Projects completed from 1984-1987 relied completely on the use of natural materials, primarily woody debris taken from on-site riparian zones but some offsite areas as well (House et al. 1989). House et al. (1990) described a stream restoration project located at the Nestucca River Basin, with its major tributary system Elk Creek located in Tillamook County, Oregon. All large woody debris structures were secured by pinning the debris with rebar and cabling to surrounding anchoring materials and entrenching the ends into the bankside (House et al. 1990).

There were some economic decisions that had to be made for the restoration of Elk Creek in Oregon because the equipment to perform the stream restoration had to be rented. Track-mounted excavators were used to install logs at a cost of $90-$100 per hour. The total Elk Creek restoration project costed $46,200 (including equipment and labor) in which approximately 2 km of the Nustucca River and Elk Creek were treated with 119 log structures (House et al. 1990). On another project, the restoration of Testament Creek in Oregon, a timber sale contract was modified at a cost of $50 per tree bole to pay loggers to place non-merchantable wood debris into the stream. A medium sized caterpillar tractor was also rented at approximately $50-$60 per hour to assist in placing the LWD into the stream (House et al. 1989).

Richmond and Fausch (1995) conducted studies of the addition of LWD as a restoration technique in eleven undisturbed streams draining sub-alpine old-growth forests in north central Colorado. Old growth trees were felled and placed into streams at angles to assess how orientation affects streamflow characteristics and channel morphology, and how both characteristics affected piece stability. LWD placement was grouped into four classes on the basis of the angle relative to the direction of streamflow. These four classes were the following: 0° (parallel to flow), 90° (perpendicular to flow), and 45° and 135° (two diagonal orientations). The LWD was classified further into four categories used to describe its stream position: touching the left or right banks only, touching neither bank, or touching both banks simultaneously.

According to Richmond and Fausch (1995), the apparent function of each LWD piece was classified as "forming pools, storing sediment, providing overhead cover for salmonids, providing bank stability, catching other organic debris, or having no apparent function." The position and orientation of LWD changed with streamsize, which influenced its role in pool formation. Few pieces spanned the entire channel in larger streams, which explained why there was a lower percentage of pool formation there. Approximately 10% of the 1412 LWD pieces functioned to form pools, while 14% of the LWD functioned as cover (Richmond and Fausch 1995).

Another common method of adding LWD to streams is the cutting or girdling of riparian, streamside trees, and thus not having to use expensive equipment to drag the LWD into the stream. Emmingham et al. (1996) described an experiment of adding "suppressed" conifers of the riparian zone to the stream to promote a healthy fish habitat. Studies indicated that LWD from conifers was usually more available (abundant) and also was less prone to decay than most hardwood species (Emmingham et al. 1996, House et al. 1990). Emmingham et al. (1996)

explained that the study was conducted to determine the best techniques for releasing the conifers into the nearby stream, and how to maintain a future supply of LWD to the stream. The study was conducted in six riparian areas in Oregon and Washington, with three on federal land, and three on industrial private land. Fifty understory conifers were marked at each area. Two-thirds of the conifers at each site were cut, while the other third were left as controls. The controls were left to determine the growth rate of the riparian trees. Both diameter and height growth rates had increased in treated areas three years after the canopy was thinned, while only an increase in diameter was determined in untreated areas (control areas). Three-year mean diameter growth was 1.7 cm in areas where the overstory was removed compared to only 0.6 cm in the untreated areas. This study showed that releasing conifers in small clearings in riparian zones enhanced conifer survival and thus will contribute to a future supply of conifers to the nearby stream. This process can significantly contribute to stream restoration and improve fish habitat.

Restoring LWD to streams to improve and promote healthy fish habitat does not always require direct human intervention (O'Connor and Ziemer 1989, Swanson et al. 1976). Maintaining an adequate riparian zone along the streambanks will naturally contribute to the addition of LWD to the stream. Swanson et al. (1976) expressed that LWD enters the stream by a variety of interrelated mechanisms, which allows debris to enter streams by a "chain reaction of events." A large percentage of stream debris is comprised of tree tops, large limbs, and whole trees being blown down, usually occurring during storm events. It is often difficult to pinpoint an exact mechanism that triggered LWD to enter a stream channel. Streambank erosion, mudslides, and windthrow have been shown to work together as well as individually on triggering LWD to fall into streams. Studies have also shown that LWD may fall directly into the stream or along adjacent streambanks and eventually slide into the stream. Swanson et al. (1976) have concluded that streams occurring in narrow, steep walled valleys tend to receive more LWD than streams flowing through similar forests on broad, flat plains.

Large Woody Debris Additions vs. Other Approaches

There are other habitat improvement measures used to restore stream habitats. The most commonly used are: large rocks placed in the stream; current deflectors; and check dams. The primary purpose of large rocks is to develop scour holes in the stream channel as resting places and cover for fish. However, large rocks are only effective where the velocity exceeds two to three feet per second. Also large rocks are not always available, and if they are, take much more manpower to place in desired locations than LWD does. The advantage of rocks compared to LWD is that the rocks are usually very stable if large enough. "Habitat" rocks must be large enough to resist displacement during periods of high streamflow (e.g. floods). A rock of approximately one thousand pounds will resist movement in current velocities of up to ten feet per second, while a rock of two thousand pounds will resist movement in velocities up to approximately thirteen feet per second. Another advantage of rocks over LWD is that the rocks will not wear away or decay and fall apart as fast as LWD will (USDOT 1979).

Current deflectors create large scour holes and pools by forcing streamflow into a narrow part of the channel. Streamflow responds very similar to current deflectors and LWD additions, whereas each creates pools that promote high quality fish habitat. These rocks are usually just placed into the stream at a determined location, but positioned so they deflect water in a desired fashion. Creating current deflectors is a fairly simple procedure, provided a suitable supply of rocks is available nearby. Large woody debris has been shown to deflect current effectively when no rocks are available. Logs and sawed timber are considered to be excellent materials for deflectors if they can be kept submerged; if exposed to repeated saturation and drying, however, they decay very rapidly. Therefore, using large rocks is usually an advantage when available because they are more likely to maintain permanent structure and function (USDOT 1979).

Check dams are low structures built across streams perpendicular to flow. Check dams decrease the slope and velocity of a stream to control erosion. The plunge pool below a check dam provides excellent fish habitat, and the gravel bar created just downstream has been shown to provide an excellent spawning bed for most species of fish. Check dams may be made out of rocks. However, LWD has been used as well and has proven to provide similar outcomes in improving fish habitat (USDOT 1979).

Evaluation of the Success of Adding Large Woody Debris to Streams

LWD has an effect on local scour and pool development (House et al. 1989, House et al. 1990, Richmond and Fausch 1995, Skaugset et al. 1996, and Wallace et al. 1995). Although, on average, only 14% of LWD pieces functioned as cover for many aquatic species, smaller streams, and larger streams with low gradients, had a higher percentage of pieces functioning as overhead cover. It was also mentioned that the more LWD present in a stream, the more overhead cover present for trout habitat (Richmond and Fausch 1995).

Ramquist (1995) discussed the effect that LWD had on fish populations by stressing that no sunfish, crappies, hognose suckers, or yellow perch were observed at sites that lacked LWD. Fish taxa richness was significantly greater at LWD sites as well. At sites containing LWD, the majority of sunfish, smallmouth bass, log perch, and white suckers appeared to be interacting directly with the LWD habitat. However, there was little to no association between structure or LWD habitat and cyprinids and some darter and shiner species. A relatively large percentage of sunfish (42%) and smallmouth bass (47%) utilized LWD as cover and/or shade as compared to other species of fish (Ramquist 1995). These results show that LWD has a positive effect on most fish species in that it provides cover and increases food supply for many species.

House et al. (1989) expressed that their stream rehabilitation project seemed to have achieved structural, habitat, biological, and economic success which had resulted in the creation of preferred salmonid habitat. Furthermore, LWD structures increased gravel substrate, instream cover, pool habitat, total usable habitat, and water volume. These are all necessary components of preferred salmonid habitats. Evaluations have also shown that woody debris structures can dramatically increase channel aggregation and therefore help re-establish riparian vegetation. Wallace et al. (1995) reported that the addition of LWD had immediate and significant effects on stream habitat. Stream depth increased, current velocity decreased, and both coarse and fine particulate organic matter increased dramatically. Invertebrate community structure was impacted significantly as well. Abundance and biomass of scrappers and filterers decreased, collectors and predators increased, while overall shredder biomass changed very little, if any. Whether this is a positive impact or a negative impact is not known.

Although restoring LWD to streams has numerous benefits, there are some noticeable drawbacks as well. One of the most prevalent drawbacks is the increase in soil erosion due to the removal of riparian trees for placement in streams (Richmond and Fausch 1995). House et al. (1989) reported that the use of heavy equipment in the process of restoring LWD to streams often causes severe soil compaction. Soil compaction can prohibit plant growth and decrease a sufficient future supply of LWD for the stream.

Another problem that may occur is that LWD may not always remain in the location that it was placed. Violent flushing events (i.e. floods) can quickly remove LWD that was placed in a specific location. This debris may be transported downstream to a different location where it may still function as preferred fish habitat, or it may wash up on shore where it poses no specific function. Flushing occurs either by flotation during high water or by transport in debris torrents as large volumes of organic debris, soil, rocks, and water are "sluiced out" of channels (Swanson et al. 1976).

Conclusion

The addition of large woody debris to streams to improve fish habitat can be considered a success. To maintain a continuous addition of LWD to streams in the future, healthy riparian zones should be maintained along stream ecosystems. The best long-term and least costly method of restoring stream habitat for fish communities is through an aggressive riparian management policy that provides a buffer strip capable of continuously supplying optimum numbers of all sizes of large woody debris essential for healthy fish habitats. Natural disturbances such as windthrow, blowdown, and streambank will naturally place LWD into streams if aggressive riparian management policy is undertaken (House et al. 1989).

Large woody debris does provide preferable habitat for fish communities as well as other communities such as invertebrates. Ramquist (1995) described LWD's role in a stream ecosystem explaining that even though LWD may consist of only a small percentage of total habitat in some streams, it provides very important structural and functional benefits to fish. Even though restoring LWD to streams has some significant drawbacks, the benefits of creating healthy fish habitat outweigh the shortcomings. The beneficial role that LWD has on stream ecosystems makes restoring LWD to stream a special concern for management and protection.

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