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Pipers Creek: Salmon Habitat Restoration in the Pacific Northwest

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Conventional stream restoration practice often assumes that bank and instream restoration will not be successful until excessive stormwater flows are first controlled upstream. However, construction of stormwater retrofits may be too expensive or infeasible. In a large watershed, it may take many years to implement all planned retrofits. Can instream habitat improvements ever be implemented before stormwater flows are controlled? Experience in Pipers Creek suggests it may be possible, using relatively simple techniques, to maintain or even improve fish populations in advance of stormwater retrofitting in a salmon stream, thus restoring the stream from the bottom up (see Table 1 for the restoration "prescription").

Pipers Creek is a small stream that winds 1.5 miles along a downtown Seattle park (Figure 1). The 1,920 acre watershed is more than 50% impervious. The creek runs through a wooded ravine surrounded by high-density (averaging 10 housing units per acre) residential and commercial development. Storm flows can reach 300 cfs with about a five-year storm. Base flows are a mere 1.5 cfs. Small urban streams like Pipers Creek once provided important freshwater habitat for coho salmon, cutthroat trout, and steelheads.

Table 1: The Pipers Creek "Prescription"

Location: Seattle, WA
Watershed size: 1,920 acres
Degree of Imperviousness: > 50percent

Restoration Step	Application in Pipers Creek
Control Urban Hydrologic Regime	■ Erosion control projects ■ Source control BMP ■ Educational programs ■ Within pipe detention
Remove Urban Pollutants	■ No retrofits
Restore Instream Habitat Structure	■ Create pools/riffles ■ Confine and deepen low flow channels ■ Provide structural complexity
Stabilize Channel Morphology	■ Restore tight meander pattern ■ Stabilize channel to accommodate bankfull discharge
Replace / Augment Riparian Cover	■ Provide instream overhead cover ■ Revegetate streambanks
Protect Critical Stream Substrates	
Recolonize Stream Community	

Previous Restoration Efforts

The Pipers Creek Watershed Action Plan, developed in 1990, identified public education, regulatory, operating and maintenance, public works, and monitoring projects to restore and enhance the creek. The identified projects included restoration of stream habitat. An earlier effort to prevent stream erosion and trap sediments involved constructing fourteen boulder control structures (large stacked boulders with two- to three-foot wide notches extending from the creek bottom to the structure's top—see Figure 2). Even with the structures, the creek still showed severe degradation due to uncontrolled stormwater flows. For example:

- Many of the boulder control structures had failed as boulders shifted or as the notches became plugged with sediment. Several structures with notches greater than two feet wide were not trapping any sediment at all.
- The stream bottom was covered with fine grained silts.
- Low flow channels within the stream became braided, and the stream channel had lost most of its meanders.
- Very low diversity of flora and fauna was reported, with few taxa of aquatic insects present. However, Pipers Creek still had some crayfish and cutthroat trout present.

Bottom-up Restoration Approach

Therefore, a second restoration strategy was undertaken. The concept was to reconstruct elements of instream habitat and reinforce them to withstand high flows. Thus, during periods of low flow, the stream would return to the reconstructed flow pattern and continue to provide habitat. The goals were to do the following:

- Increase the channel length during low flow periods
- Increase roughness during high flow periods
- Keep the bottom from being scoured
- Provide easier fish passage
- Improve the aesthetic value of the stream
- Increase the number of pools and riffles

Fallen rocks from the boulder control structures and nearby available logs were used to make the required structural changes. A design team representing a range of disciplines planned and supervised the project. Installation was completed in 1991 using the Seattle Conservation Corps at a total cost of $35,000 for one mile of stream. Project organizers estimate that restoration costs for similar streams might range from $50,000 to $90,000 per mile (see Table 2 for descriptions of the structural elements).

Findings

The immediate response of the stream to the restoration project was successful. Gravel in the streambed became cleaner and insect populations also appear to have increased. The percentage of stream area containing pools nearly doubled from 16% to 32% and the total pool volume was greatly increased. There was an eight-fold increase in the fish population nine months after the project was completed (primarily steelheads). Adult chum salmon returned for the first time since 1975 (Table 3).

However, within two years of completing the project, uncontrolled stormwater flows were causing damage to many of the log deflectors. An implication is that one either has to be prepared to maintain the log structures (e.g. be prepared for occasional maintenance using an inexpensive workforce like the Conservation Corps), or use rocks. (In fact, double layers of rock are now used in Pipers Creek wing deflectors.) However, in some cases, even where log deflectors were washed away, the low flow channel continued to hold its shape. In contrast, project planners expect log drop structures to last much longer than log wing deflectors, e.g., for 20 to 25 years. This is somewhat different from the conclusion of research described in article 148. That study found a high failure rate for log structures in general, and a particularly high failure rate for check dams.

Additional instream structures have since been added to Pipers Creek. The number of returning adult chum salmon in 1995 was greater than 100. Monitoring is expected to continue for several years to come, since project planners expect that macroinvertebrate populations will likely cycle up and down for a while. Consequently, fish populations are also expected to be variable until the system "settles down." In 1996, the Pipers Creek approach will be applied to a tributary of Pipers Creek.

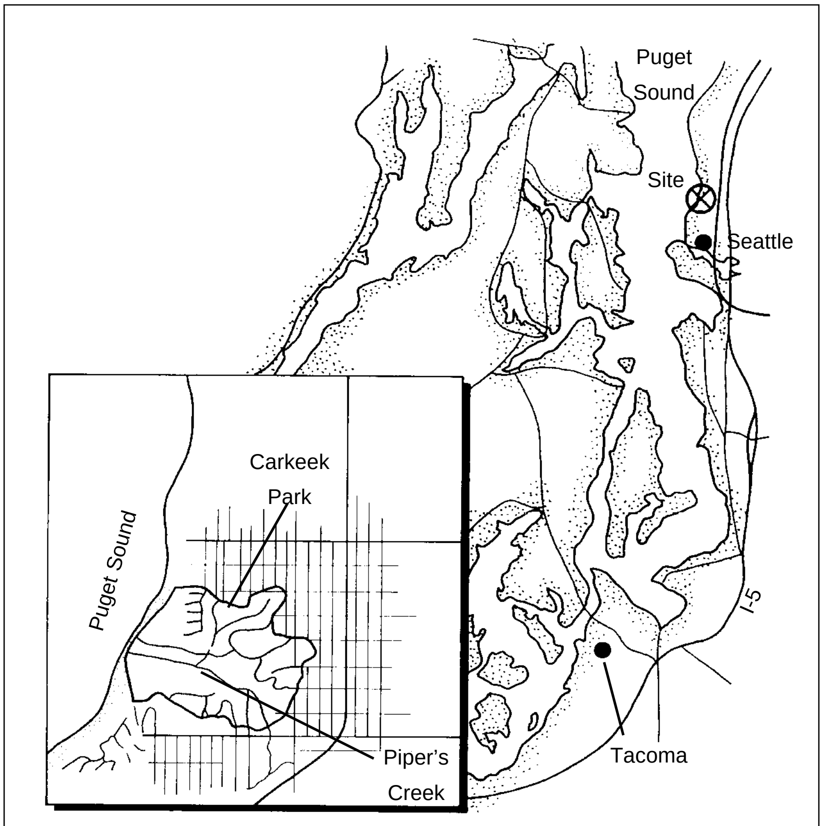

Figure 1: Piper's Creek site vicinity/location map
(Adapted from Shapiro & Assoc.)

While the results from Pipers Creek are intriguing, there are still many questions to be answered about bottom-up stream restoration. To begin with, more data are needed on how long the instream habitat structures can withstand uncontrolled flows. One study of habitat structure failure rates (article 148) looked at fairly large streams subjected to high flows. Additional data from urban streams would be valuable. Second, will the bottom-up approach work well in other regions with other types of fish and is it practical if fish barriers exist? Finally, does bottom-up stream restoration benefit all indigenous fish species or only those that are more tolerant of urban stream conditions?

Some answers to this last question can be found in a 1986 study of urban fish communities in Washington. Scott and his colleagues found urban streams in Washington state had very different fish population dynamics, even where total biomass levels were similar. The impacted stream population consisted largely of young cutthroat trout, while the pristine stream had a population of diverse ages and species. Cutthroat trout, which have returned to Pipers Creek, appear to be less sensitive to the impacts of urbanization than are coho salmon and nonsalmonid fish (which have not returned to Pipers Creek.) In the urbanized stream, Scott found

Table 2: Elements of Instream Restoration for Pipers Creek

- **Vertical control of channel bottom**—rigid structures that prevent bottom scouring yet allow passage for large fish.
- **Bank protection at outside of bends**—boulders or logs hung over the bank and anchored in place; heavy plantings of bankside vegetation.
- **A tight meandering pattern for low flow**—deflectors of logs or rocks.
- **Step downs**—drops in elevation to form pools and riffles.
- **Define low flow path**—the end result of the above manipulations should be a low flow path that recurs after every storm event.

Table 3: Measures of Success at Pipers Creek

Parameter	Before Project	After Project
Percent rocks with periphyton	0%	50%
Percent of stream area containing pools	16-17%	32%
Number of fish in upper reach	94	>800*
Number of returning adult chum salmon	None since 1975	>300 (1993-94); >100 (1995)

* almost all cutthroat trout, nine months after project completion

nonsalmonids only, e.g., threespine sticklebacks, in the lower reaches of the stream.

In fact, Scott and colleague found that the percentage of cutthroat trout in urban stream fish populations was directly related to the degree of imperviousness—the higher the level of imperviousness, the more cutthroat trout made up the community. Furthermore, chums (which have returned to Pipers Creek) spend a relatively short time in the stream; spawned in December-January, by June they are out in the ocean. In contrast, Coho salmon (which have not yet returned) live in the stream usually two years before migrating. Also, Cohos prefer pools 30 inches or more in depth, with a velocity of less than 0.5 cfs. In urban streams natural pools tend to fill with sediment and most of the techniques for recreating pools in streams produce turbulent flow to scour out the pool.

While it's probably impossible to restore fish populations in highly urbanized streams to pre-development conditions, the question remains: what is a reasonable restoration goal? It remains to be seen whether Coho salmon can ever be restored to urban streams. Still, following the progress of bottom-up stream restoration in Pipers Creek as it moves along the continuum from "damaged" to "healthy" will help in setting interim restoration goals. However, even if a habitat only approach proves effective, stormwater retrofit control may continue to be necessary for other reasons.

References

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