Restoration and Reclamation Review
Student On-Line Journal
Vol.7, No.4, Fall 2001
Department of Horticultural Science
University of Minnesota, St.Paul, MN

Efforts to restore the Mattole River and its watershed

Chad Buran

Introduction

Up and down the Pacific Coast of the Northwest United States, the salmon and steelhead populations have been severely impacted by the increased timber harvesting and road construction along the streams that the fish depend on for spawning. The Mattole River is one example of how these activities have descimated the fishery. The efforts to restore the Mattole watershed is one of the first citizen-initiated watershed restoration projects in North America. For more than twenty years, the inhabitants of the watershed have worked to improve the ecological health of streams, fisheries, forests, and soils of the watershed. The Mattole Salmon Group (MSG) was formed by citizens of the watershed in the 1970s in response to the decline in the Mattole salmon fishery. The initial restoration efforts began in 1980, to provide substitute spawning habitat. In the mid-1980s, the Mattole Restoration Council (MRC) was founded to link the various restoration efforts already underway and to coordinate those efforts in the context of the whole basin. These groups have used a variety of restoration techniques to improve the spawning habitat and the health of the Mattole River.

The objective of this paper is to describe the restoration approaches that these two Mattole River groups have used and to review the success of these techniques in this location. I will also describe how techniques have been used in different contexts in the watershed and how they have worked in under various conditions of river flow in these locations.

Geographic Setting and Historical Context

The Mattole River drains a 304-square-mile (787-square-kilometer) watershed in the Coast Ranges of northwestern California. The 62-mile-long (100 km) river empties into the Pacific Ocean near the village of Petrolia. The river-flows are fed by annual precipitation of 60 to 200 inches (1.52 m to 5.08 m) per year flowing from over 74 tributary streams (Zuckerman, 1997). The watershed is characterized by generally steep terrain that is underlain by highly unstable fractured sedimentary rock and has a high rate of tectonic activity in the area. These characteristics result in a landscape shaped by history of landslides, mass movement, and other forms of erosion. These conditions create an extraordinary natural disturbance regime and a high degree of background erosion. Vegetation of the watershed includes various successional stages of Douglas fir (*Pseudotsuga menziesii*) mixed with hardwood forest and coast redwood (*Sequoia sempervirens*) near the headwaters, with ridgetops and hillsides being dominated by fescue and oatgrass coastal prairie.

The Mattole and Sinkyone peoples were the first human inhabitants, with a culture centered on the river and the resources it provided, including the annual salmon runs. The 1850s marked the arrival of the Euro-American settlement and the end of the region's native culture from disease or warfare. These new settlers began a tradition of ranching and other forms of agriculture. Salmon harvest continued, but at sustainable levels.

Large-scale logging of the coniferous forests began during the post World War II construction boom that raised the value of Douglas fir timber, making logging more attractive. This demand for lumber for building and a tax on the value of standing timber encouraged landowners to cut their trees. Finally, areas that were formerly inaccessible were opened to logging and road construction with the development of the crawler tractor. Between 1947 and 1988, more than 90% of the old-growth coniferous forest in the watershed was logged, and an extensive network of roads were constructed (Zuckerman, 1997). The streams of the basin were destabilized by indiscriminate road building and forest practices, such as the skidding of logs down stream channels. In 1955 and 1964, at the peak of the logging boom, two of the largest floods in recent history began major changes in stream morphologies. Three years after the 1964 flood, suspended sediment yields in the Mattole River averaged 16,370 tons per square mile (6320.46

tons per square km) of watershed area, or nearly .25 inches (6.35 mm) per year averaged across the watershed's area (Zuckerman, 1997). The estimated historical erosion rates in the Mattole are five-hundredths of an inch per year. About 1970, large landowners began to divide their holdings into 40- to 200-acre parcels and develop residential housing. This chain of developments led to the decrease in the stream's sediment transport capacity, allowing sediment to fill the stream channel and covering high-quality spawning habitat for salmonid species.

The salmon runs were devastated. Salmonid health is among the indicators of watershed health. Based on surveys by the U.S. Fish and Wildlife Service in 1959 and the California Department of Fish and Game in 1964, the estimated historical spawning runs in the Mattole were 10,000 Chinook salmon and 4,000 coho salmon (Zuckerman, 1997). By the early 1980's, the estimated Chinook salmon run had fallen to 3,000, and continued to drop to a low of 100 in 1990-1991, with coho salmon falling similarly (Zuckerman, 1997). Both species were classified at "high risk for extinction" by the American Fisheries Society.

Evolution of the Restoration Effort

The initial restoration efforts for the watershed were motivated by the 1970s decline of the Mattole salmon fishery. Local citizens began to notice a drop in the number of returning spawning salmonid. A high priority was not assigned to Mattole restoration because of the river's relative small size compared with river systems of the region and its location and distance from populated areas, according to government agency policy. The citizens of the Mattole watershed decided to initiate restoration processes and formed the Mattole Watershed Salmon Support Group, now renamed the Mattole Salmon Group (MSG), to improve the fall Chinook and coho salmon habitat and populations in the river (Zuckerman, 1997).

A lack of clean, sediment free spawning gravel was the main problem facing the recovery of the salmonid populations. In 1980, MSG's first response was to create substitute spawning habitat through a series of gravel-lined hatchboxes. Returning adult spawners were captured, held until ripe, had eggs and milt taken, and these fertilized eggs were incubated in the small-scale streamside hatchboxes. This hatchbox program increased the egg-to-fry survival rate from 15% to better than 80% (Zuckerman, 1997). MSG has also, along with the Coastal Headwaters Association (CHA), have created a training program for residents to survey and monitor streams for spawners, carcasses, and redds (nests). Funding for hatchbox breeding has come from the California Department of Fish and Game (CDFG), foundations, and private donations, allowing the program to continue every year since 1980. Funding has also been generated for six seasons by the Salmon Stamp Fund, a self-imposed tax on commercial salmon fishers administered by the CDFG. Chinook have been trapped and spawned every year but two, and coho approximately half of the years the program has been in operation.

From the beginning MSG knew the hatchbox program was only a stopgap measure until the population could began to function as they did before the presence of human populations in the watershed. Restoration began by trying to improve spawning habitat through a series of instream structures. MSG installed scour structures to create deeper, better covered pools. The CHA placed riprap by hand along a stretch of the headwaters where the river was cutting into the banks. Some examples of these structures created are discussed in the MRC's *Dynamics of Recovery* (MRC, 1995). Other projects included stabilizing active landslides and streambanks with anchored woody debris and plantings. Three miles of the Mattole Canyon Creek had a stream channel that had been engineered into a calculated meander sequence according to a method developed by D.L. Rosgen, trying to model the historical patterns (Zuckerman, 1997). Revetment structures of logs and boulders were built to guide the water into a channel of calculated sinuosity (curvature) and width. Areas around structures were planted with willows to provide riparian cover and anchor the banks. MSG has worked with agencies such as the

CDFG, California Conservation Corps, and State Coastal Conservancy to complete these and other projects.

It soon became clear that the focus of the effort would need to expand in scale. In the fall of 1983, the first Mattole Restoration Newsletter challenged people living in the drainage imagine a future rich with fine timber, abundant fish, productive grasslands, and rich and varied plant and animal communities. Shortly thereafter, the Mattole Restoration Council (MRC) was founded to link the various restoration efforts already underway and to coordinate those efforts of landowners and residents toward these goals.

One of MRC's first projects, started in 1987, was to study upslope erosional sources throughout the watershed. Land ownership data and tributary drainage were mapped for the watershed, then erosional features were mapped and categorize by recruited residents to determine which sites would be addressed. The result was a catalog of erosional sources and prescriptions entitled *Elements of Recovery* (Zuckerman, 1997). Roads made-up three-quarters of the erosional features that introduce a new array of processes that do not exist in areas without roads. There is an estimated 3,310 miles (5326.93 km) of active and abandoned roads in the Mattole basin (MRC, 1995). Only 100 miles (160.93 km) are maintained by the county, with an estimated 25 miles (40.23 km) maintained by the Bureau of Land Management (BLM) (MRC, 1995). In the King Range National Conservation Area, the MRC closed and rehabilitated three and one-half miles of road above one of the most intact tributaries (Zuckerman, 1997). The project relied on techniques and expertise developed at Redwood National Park. Bulldozers and excavators were used to pull up previously laid fill and placed it against cut banks or other areas needing filling. Stream crossings are dug out to their original contours and as much of the original topsoil is reused to recreate the surface. The result is a more stable landscape with less potential to contribute sediment to the Mattole River.

While the erosion study was conducted, the MRC produced a watershed map comparing the extent of old-growth coniferous forests in 1947 and 1988, revealing that 91% of these forests had been harvested since the logging boom began (Zuckerman, 1997). A moratorium was issued as a result of the findings by the MRC on logging in the ancient forests until systems of harvest are devised that maintain the structure and characteristics of old-growth. Significant areas of remaining old-growth identified in the study have been protected and purchased by two of MRC's member groups, the Sanctuary Forest Land Trust and Mill Creek Watershed Conservancy.

The next area of interest focused on the estuary areas where the Mattole River meets the Pacific Ocean. Lack of cool, deep water, riparian canopy, and woody debris in the lower river may contribute to young salmon mortality during the summer in the lower river, and would be a potential threat to the recovery of the salmon population. The 5-year study, *Dynamics of Recovery* was compiled with biology, geomorphology, and hydrology data from the lower river, with upslope condition analysis for the estuary-lagoon area. The most significant finding was that change is part of the natural order for the lower river, including channel migration, scour, and deposition (MRC, 1995). This notion of the river migrating across a floodplain was a reminder of how the river might affect future restoration projects.

The watershed was identified as the unit for analysis from the results of the *Elements of Recovery* erosion survey, the MRC's old-growth map, and the*Dynamics of Recovery* estuary study. This conclusion was a new concept because few had collected data on watershed level or had considered the system as a whole. In the Mattole watershed, most land management activities depend on landowners and residents recognizing good stewardship and practicing it on their own lands. Private landowners account for 85% of the land base in the watershed (Zuckerman, 1997). As a result, the need for stewardship and restoration must be communicated to a wide variety of landowner types. The formation of the Mattole Watershed Alliance, in 1991, more broadly represented the basin's residents and landowners.

Significant Aspects of the Mattole Restoration Effort

One of the most significant aspects of the Mattole River restoration is the fact that the entire process is community driven, from the technical research to the actual in-stream restoration practices. Local citizens have been motivated to take ownership of the watershed and monitor the restoration providing good data and follow-up. The citizen involvement has been instrumental in spotting needs for maintenance before a project fails completely and to the changing conditions in the field. The local schools are involved in the restoration and college students have come to do term projects or graduate research. All of this active interest in the restoration of the watershed has made the projects more attractive to agency partnership involvement.

In 1991, MRC adopted a policy that all on site restoration projects would include a plan for monitoring and evaluation, done through field observation, such as tree survival rates for reforestation, or through photographic and video documentation for channel modifications. Much of this monitoring is conducted by trained members of the watershed's community. Interpretation of these data is used in the design of future MRC restoration projects. An example,MRC's Douglas fir reforestation project survival rates have typically ranged from 70 to 80%. When seedlings are planted on a south-facing aspect showed significantly lower survival rates, coordinators decided to install shade devices on new trees planted on that site (Zuckerman, 1997).

Most of the restoration work in the Mattole watershed has addressed very localized problems, such as a particular slide, unstable bank, or logged hillside without natural revegetation. There is the appearance of the spot treatment of a problem, but the MRC is approaching these problem areas in a systematic approach based on the early erosion, old-growth, and estuary studies. Although a series of small projects can add up to a significant impact in a watershed context. By targeting the high priority areas, the watershed is protected from catastrophic impacts that could reverse all the progress that has been made to date. Luckily, contaminants that could be detrimental to the salmonid population recovery have not been associated with incoming sediment.

Lower River and Estuary Study

Over the past five decades, the estuary has been degraded so it provides marginal habitat. The water is much shallower than it once was, temperatures in summer are elevated beyond what is allowable for salmonids, and cover and shade are lacking. The extent of deep pools and the amount of large woody debris is inadequate to provide complex habitat. The degradation has made survival for juvenile salmon very difficult in the estuary. Any habitat improvements in the lower river will significantly aid in the recovery of the ecosystem conditions. A study released by Humboldt State University in the late 1980s, showed that juvenile Chinook salmon are at higher risk of mortality in the lower reaches of the river, including the estuary (Zuckerman, 1997). This study initiated the report *Dynamics of Recovery* by the MRC to build on what was learned the factors affecting salmonid population health and the previous MRC report *Elements of Recovery*, that identified the largest upstream sources of sedimentation and devised strategies to reduce their contribution.

The first portion of this study focused on how the lower river has oscillated over time. A series of aerial photographs taken between 1942 and 1993 demonstrated that the river swings back and forth within certain bounds. The photos enabled researches to plot the location of the main channel as it has changed over the last half century. Research showed river flows above a certain level or some other large disturbance, such as a major earthquake or a dramatic change in land use, are required to trigger significant rearrangement of the stream channel.

The second half of the study focused on an evaluation of past stream related structures placed in the lower river. The placement of artificial structures in streams to enhance habitat has become a significant part of larger strategies to rebuild diminished populations of salmonids in Washington, Oregon, and California. Recently, due to frequent loss of such structures during high flows and the high initial cost of installation, these efforts have come into question. In-stream structures are designed to mitigate habitat losses and can never replace natural elements of watershed health. In some instances, structures have provided a few functions needed for healthy watersheds. The following are three evaluations from all projects that have been undertaken in the lower 4.5 miles (7.24 km) of the Mattole since the early 1970s that can be considered in stream structure work. All references are from the MRC's*Dynamics of Recovery* (MRC, 1995).

Chambers Flat Bank Protection Structures 1977-1984
Rock wing deflector were installed to protect a valuable alluvial terrace from scour losses. Large quarry rock was placed along the north bank to create eighteen small wing deflectors. The structures worked effectively to protect 400 yards of the bank where they have been established for more than a decade and through two large storm events. One structure was completely lost and two others were altered in one flood event. Of the 18 structures place, six resulted in the creation of wide scour pools from 3 to 6 feet (1-2 m) deep with moderate complexity and shade from riparian vegetation overhang. The project has turned one of the least hospitable stretches of the lower river into good habitat. These structures were effective in protecting a long stretch of bank from erosion. They accomplished this without altering stream flow patterns or redirecting flow toward another problematic area.

Rex's Wing Dam 1977-1986
Rex's Wing Dam was constructed to protect an eroding 16-foot-high bank a few yards from a home and prevent further losses to the river. Using two ton or more quarry rock the landowner built a wing deflector up to the level of the alluvial terrace. It was about 20 feet wide at the base and protruded roughly 20 feet into the active river channel at an angle of 80 degrees into the flow. The river has scoured a pool averaging ten feet deep on the upstream and lateral side. From the point of view of bank protection, the structure must be considered successful. It has become one of the most stable points in the lower river. A new bar has formed downstream of the structure and riparian vegetation now extends from the bank out onto the bar. The pool has become one of the three most significant pools in the lower river, the two others are from natural bedrock outcrops. The pool has been used extensively in the summer and fall for juvenile steelhead. Given the longevity of the structure and the key role it has come to play in providing bank protection, salmonid holding and rearing habitat, riparian revegetation, and channel stability and consequent bar formation, the project has been a success.

Estuary North Bank Structures #2 1991
The aim was to scour pools along a stretch of low-flow channel by building a series of substantial structures of large woody debris and boulders. Using more and larger woody debris and half- to two-ton quarry rock, six structures were built along a stretch of the river where juvenile salmonids congregate after mouth closure. Structures were constructed of two large boulders with a large log pinned to them and additional rock and wood elements were attached. Scour has occurred at the toe of each structure, some more than others. High water caused the loss of one structure and one was moved into the channel. Juvenile salmonids utilized the habitat around these structures throughout the summer. The four remaining structures still have considerable value as complex habitat in an area where almost none existed. Even the remnants of the failed structure that is lodged in the channel has value there. This project showed structures in the lower river need to be massive and carefully designed and constructed. It also showed that fewer large structures are far better than a number of smaller ones.

This evaluation of past projects indicated that location and construction are important considerations in installing structures in the lower Mattole River. Locating structures to encourage pool formation are best near scouring flows such as those of outside bend of meanders, straight stretches, or confined channels. The structure will have greater stability when they are well-keyed into the bank. If built near a cold water source the structure can provide good habitat for over-summering salmonids. The construction of structures are best built to be massive, complex and "messy" and composed of boulders and complex large woody debris.

From the evaluations of past in-stream structures and the intent to improve biological diversity and productivity the following specific long-range goals were adopted: 1) to reduce sediment load entering the river and 2) to increase riparian cover from the mouth upstream. Some short range goals were also developed: 1) increase pool depths; 2) increase cold water available to salmonids; 3) increase habitat complexity and 4) increase cover and shading of the river. These goals seem logical in the terms of a watershed approach to restoration.

Research
Students and faculty from Humbolt State University have continued to monitor and conduct research on the Mattole River and its tributaries, building on the work of the MRC. In 1982, John B. Hamilton began work on his thesis project studying the performance of rock deflectors for rearing habitat improvement. Using a series of 37 triangular wing deflectors placed along the course of Nooning Creek, a tributary of the Mattole, Hamilton discovered that after over wintering only five of the original 37 deflectors (14%) were still present and functional**.** Overall, half (51%) of the structures had failed totally during the first winters high flows. Four (11%) deflectors were intact and apparently nonfunctional. Nine (24%) were either partly destroyed or gone entirely, yet appeared to have functioned on modifying the channel (Hamilton, 1983). There were no significant differences in change in mean-wetted width, mean depth/width ratio, or mean velocity between treatment and control sections. The change in mean depth was greatest difference that could be detected. Despite an apparent increase in depth, the expected response of fish did not occur. The reasons are not entirely clear.

What the Future Holds
Most of the restoration work in the Mattole watershed has addressed very localized problems. This gives the appearance of the spot treatment of a problem, but the MRC is approaching these areas based on priority and funding available with the idea many small structures will add up to a substantial restoration. By targeting these high priority areas, MRC is proceeding in a productive fashion and with the strong backing of watershed citizens. This is what has been so unique to the Mattole watershed restoration. A strong partnership of citizen based groups, educational institutions, and government agencies has given this restoration a unique character in stream restorations. The published monitoring and evaluation data for this restoration project is unfortunately lacking for an otherwise productive project. With continuing the approach to addressing the problems on a watershed basis the Mattole River restoration should continue to be an important model for watershed restoration.

Literature Cited:
Gore, James A. 1985. The Restoration of Rivers and Streams. Butterworth Publishers, Boston.

Hamilton, John B. 1983. Performance of Rock Deflectors for Rearing Habitat Improvement on a Tributary of the Mattole River, Northern California. Thesis. Humboldt State University.

House, Freeman. 1999. Totem Salmon. Beacon Press, Boston.

Hunter, Christopher J. 1991. Better Trout Habitat: A guide to Stream Restoration and Management. Island Press, Washington, D.C.

Kershner, Jeffery L. 1997. Setting Riparian/Aquatic Restoration Objectives within a Watershed Context. Restoration Ecology 5: 15-24.

Kondolf, G. Mathias. 2000. Some Suggested Guidelines for Geomorphic Aspects of Anadromous Salmonid Habitat Restoration Proposals. Restoration Ecology 8: 48-56.

Kondolf, G. Mathias. 1995. Five Elements for Effective Evaluation of Stream Restoration. Restoration Ecology 3: 113-136.

Kondolf, G. Mathias. 1995. Evaluating Stream Restoration Projects. Environmental Management 19: 1-15.

McDonnell, Jeffery J. 1996. Watershed Restoration Management. American Water Resources Association Symposium Proceedings.

Mattole Restoration Council. 1995.   Dynamics of Recovery- A plan to enhance the Mattole Estuary. Mattole Restoration Council. Petrolia, California.

MRC. Mattole Restoration Newsletters. Spring/Summer 2001.

MRC. Mattole Restoration Newsletters. Winter/Spring 2000.

Naiman, Robert J. 1998. River Ecology and Management. Springer-Verlag New York, Inc.

Zuckerman, S. 1997. Thinking like a watershed: Mattole River of California.pp.216-234. In: Watershed restoration: principles and practices. J.E. Williams, C.A. Wood and M.P. Dombeck (eds.). American Fisheries Society, Bethesda, Maryland.