WATERSHED RESTORATION IN THE NORTHERN SIERRA NEVADA: A BIOTECHNICAL APPROACH[1]

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Abstract: A cooperative erosion control project was initiated in 1985 for the North Fork Feather River watershed in California's northern Sierra Nevada due to widespread accelerated erosion. Resulting sedimentation problems have impacted fish, wildlife and livestock resources, and have created operational concerns for hydroelectric facilities located downstream. In response, concerned groups met to develop a restoration plan. A Memorandum of Agreement was signed and a Coordinated Resources Management Planning Committee was formed to facilitate the planning and implementation process. The watershed restoration program was initiated with a small demonstration project that was implemented in Red Clover Creek. The objective was to demonstrate structural and nonstructural methods that reduce erosion, restore riparian vegetation, and improve habitat for fish and wildlife, and to develop a planning process for future projects. A 4-year monitoring pro-gram was initiated to provide data for a cost and benefit analysis. The planning process, improvement measures, and some preliminary monitoring results are presented.

In recent years there has been a growing interest among professionals, politicians and the public in improving watershed conditions in California. This is in response to the critical need for additional high quality water to foster urban growth, agricultural expansion, industrial, recreational, and energy-producing uses in the state. This trend is reflected in the growing importance of cumulative effects assessment, legislation contained in Section 208 of the Federal Water Pollution Control Act, and the amended Clean Water Act of 1987. California is presently developing a nonpoint source pollution control plan, which includes both toxics and sediment, in response to this legislation (State Water Resources Control Board 1988). In addition, the State Water Resources Control Board has required an assessment and monitoring study to determine the adequacy of current Best Management Practices (BMP's) contained in Forest Practice Rules for protection of water quality (State Water Resources Control Board 1987). These institutional signals may be indicative of the changing political climate regarding water quality control at both the federal and state level.

Since degraded riparian areas can be major contributors of sediment to streamflow, much of the growing interest in improving water quality has focused on restoration and management of streamside zones. Increased demand for recreational resources, aesthetics and good water quality, and the recognition of widespread degradation have provided the impetus to develop and implement techniques to repair degraded riparian habitats. A wide variety of techniques are available which are documented in manuals, symposia proceedings, and research papers.

Institutional incentives for riparian restoration lag far behind available technology. The manner in which upstream managers and downstream users interact in the restoration process has not been reconciled. The responsibility for implementing restoration measures has largely been left to landowners, making spot treatment of major watershed problems a common remedy. Site specific projects can create additional watershed problems, and in some cases, lead to project failure due to inadequate consideration of physical and biological factors from the watershed perspective. The ability of one landowner or organization to gather the needed preproject information and to bear the responsibility of implementation alone is unrealistic and infeasible.

Restoration at the watershed level is complex and seemingly impossible due to discontinuous land ownerships, the difficulty in assessing causes and solutions, and the great expense in stabilizing degraded sites. It can be accomplished, however, through extra effort and organization. Coordination of parties most likely to benefit through the planning and implementation process seems to spawn the most successful projects. This paper summarizes the process used to implement such a riparian enhancement project in California.

Background

The North Fork Feather River (NFFR) watershed is located on the west slope of the northern Sierra Nevada. It drains 5,058 square kilometers of variable terrain (Langridge 1984), and has long been recognized for its recreational and aesthetic value. This watershed is an

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important component of California's vast water distribution network, produces a significant amount of hydroelectric power, and provides extensive fishing, hunting, grazing, timber, mining, and aesthetic values. Most of the timbered areas are managed and administered by the Plumas National Forest, while the large alluvial valleys are predominantly privately owned.

Land use by man is largely responsible for the accelerated erosion conditions apparent in this watershed today. Extensive mining, grazing, timber harvesting, pioneer settlements, and burning and cultivation of meadows has reduced vegetation cover, leaving uplands and streambanks barren and vulnerable to erosional processes. This has resulted in a network of hydrologically unstable channels due to increased overland flow and sediment discharge.

Increased sedimentation and poor water quality have produced problems for landowners, managers, and resource users. Livestock producers have less forage production to support cattle on floodplains due to lowered water tables associated with downcutting stream channels. Recreationists find fish populations are reduced due to lack of overhanging vegetation, poor water quality and warm water temperatures. Inadequate cover of riparian vegetation has reduced nesting and rearing habitat for waterfowl and other wildlife species. Hydroelectric producers must contend with increased sedimentation in reservoirs which creates operational and environmental concerns. These effects are symptoms of the degraded state of this watershed.

Planning

Coordinated Resource Management Planning(CRMP)

A cooperative, interagency effort was started in 1985 in response to the accelerated erosion prevalent in the watershed. Fourteen federal, state, and local agencies, and private sector groups met and later signed a Memorandum of Agreement (MOA). This document outlined the commitments of each group in developing and implementing a watershed erosion control plan. It became evident that a process was needed to coordinate the interactions and contributions of participating groups, and to streamline bureaucratic constraints. Therefore, the MOA participants elected to use the CRMP process to facilitate planning at the local level. Plumas Corporation, a non-profit economic development organization, was appointed the project coordinator.

The CRMP process is often used to solve complex resource management problems that involve multiple landowners and special interest groups extending over large geographic areas (Anderson and Baum 1987). This approach integrates the needs of participants into an action plan. Since decisions are made by consensus, conflicts are minimized. Contributions of participants are leveraged to provide benefits at an affordable cost. It is also widely used by public land management agencies which enhances project credibility, and may provide additional funding opportunities.

Such a planning process can be used effectively to address riparian problems from a watershed or "big picture" perspective. Success, however, depends upon completion of a thorough pre-project survey to determine geomorphological, hydrologic and biologic characteristics of the area, in addition to historical and current land uses.

River Basin Study

A River Basin Study (RBS) is being conducted by the USDA Soil Conservation Service (SCS) to evaluate and prioritize sources of erosion in the watershed, and to identity cost effective restoration measures. Results will be used to develop a restoration plan which identifies critical areas, and as a means to secure additional project support. The local CRMP committee is responsible for guiding the RBS so that high priority areas of concern are emphasized accordingly. A draft report has been submitted and is presently in the review process (USDA Soil Conservation Service 1988).

Demonstration Project

The CRMP committee decided to implement a small demonstration project in the headwaters of the watershed as a first step in developing a regional erosion control plan. The project was designed to test and evaluate the effects of several erosion control techniques on streambank stability, sediment reduction, and the recovery of riparian vegetation. In addition, the project would provide an opportunity to establish a workable planning process for future cooperative projects.

Site Description

Potential sites for the demonstration project were surveyed by an interdisciplinary field team and a 1.5 kilometer stretch of Red Clover Creek was selected. It is located 40 kilometers east of Quincy, California, on the eastside of the Sierra Nevada crest. The creek flows through Red Clover Valley which is a highly erodible alluvial valley at an elevation of 1,676 meters. It drains about 250 square kilometers of terrain and contributes large amounts of sediment to the East Branch North Fork Feather River (EBNFFR) system (Mitchell 1986), which is the focus of the study. The valley is privately owned and is surrounded by lands administered by the Plumas National Forest.

The climate is relatively dry and valley soils are poor due to a history of wind and water erosion. The vegetation is composed predominantly of undesirable shrubs and grasses such as sagebrush, rabbitbrush, and cheatgrass. Sparse willows line old stream channels and many native herbaceous perennials have been replaced by less desirable weedy species due to the impact of land use and lowering of the water table. The actively eroding stream channel is 15-18 meters wide and has vertical cut banks 2-4 meters in height. Vegetation cover and mix of species have significantly declined since the turn of the century due to loss of floodplain and streambank vegetation, limited ground water storage, and variable precipitation (Lindquist and Filmer 1988, Mitchell 1986).

Stabilization Measures

An improvement plan was developed for the demonstration site by technical members of the CRMP committee. The objective was to provide a realistic plan for treating the riparian system, which includes the channel, streambanks and uplands. Practical and cost-effective techniques were selected from a variety of options, based on materials and expertise available, cost, and aesthetic values. A biotechnical approach, which includes use of both engineered (structural) and biological (nonstructural) methods, was used (Gray and Leiser 1982). Methods selected are described in the following sections.

Structural Improvements

Check Dams—Four loose rock check dams were designed to reduce both the channel gradient and downcutting of the streambed. They were built at points determined by the channel gradient and location of bedrock anchor points. Each dam raises the water level about 1 meter which forms a pond on the upstream side of each dam. The ponds reduce the velocity of the flow, which decreases the erosional energy of the water and causes deposition of suspended sediments. Over time the streambed elevation will rise as deposition continues, and streambank erosion will be reduced as riparian vegetation becomes established. The recharge of the water table will enhance the production of vegetation in the floodplain.

Revetment—Pine revetment was installed to demonstrate an economical approach to stabilizing streambanks in place of more expensive rock riprap. A 30 meter section of the channel was lined with pine tree tops, that were inverted, overlapped and cabled into the top and toe of the bank. The structure traps sediment, prevents further bank erosion, and enables vegetation to become established along the cut banks. This rounds and narrows vertical banks, and over a period of time the structure is totally concealed. This method has been used with success in Oregon (Sheeter and Claire 1981) and in Modoc County with juniper, but pine was used exper-imentally in this case due to the absence of significant amounts of juniper in this area.

Nonstructural Improvements

Revegetation—A revegetation plan was implemented to accelerate streambank stabilization. The following treatment variables were compared: survival rates of four hardwood species including coyote willow (*Salix exigua*), mountain alder (*Alnus tenuifolia*), black cottonwood (*Populus trichocarpa*), and quaking aspen (*Populus tremuloides*); two plant forms (unrooted stakes vs. rooted liners); and two planting seasons (fall vs. spring). Treatments were composed of various combinations of these variables based on availability of materials, species native to the valley and planting feasibility (Lindquist and Filmer 1988)

Fencing and Land Management—5 kilometers of exclosure fencing were installed around the project, creating a 26-hectare riparian pasture. The fence was designed to control livestock and vehicular access, and to protect monitoring equipment. The fencing will be used to develop a rotational grazing system to control forage use on eroding uplands and in the riparian zone. Identification of improved land management practices is a vital component of riparian restoration.

Monitoring Program and Preliminary Results

A 4-year monitoring program was developed to annually evaluate the erosion control measures used and to assess costs and benefits. It is not intended to be a comprehensive evaluation due to budget and time constraints, but it includes variables that are of interest to CRMP members. The cost evaluation portion of the analysis will include labor, monitoring and maintenance expenses derived from implementation of the project. Preliminary results are provided below in some cases, and the others are expected to be available in 1989.

Channel Cross Sections

The effects of improvement measures on channel configuration, streambed elevation and sediment entrapment are being evaluated with cross sections of the channel. Permanent transects have been established every 16 meters along the creek in the study area and in control sites. The data will be used to evaluate the effectiveness of these measures in accelerating stream recovery.

Revegetation Success

Survival rates of planted liners and stakes were identified after the first growing season for both fall and spring plantings. These values were used to compare which species, season of planting and form of plant responded best to conditions in the demonstration area. This information was then correlated with the proximity of each planting area to either stream or water table moisture zone (Lindquist and Filmer 1988).

Preliminary results indicate that willow stakes can be planted in either fall or spring with similar rates of success, whereas liners respond best to spring planting. The location of plantings in relation to available soil moisture seems to be a major factor determining first year survival (Lindquist and Filmer 1988).

Water Table Recharge

The effect of improvement measures on the shallow water table is being monitored with 24 piezometers (wells). They are located on transects crossing the demonstration area and in downstream control areas, and extend from the streambank to points 160 meters into the floodplain (Patzkowski 1987). Piezometer data will be used to create monthly groundwater contour maps, and to determine the influence of the project on the shallow water table near the stream and in the adjacent floodplain (Gilbert and Sagraves 1987). These data will be correlated over time with changes in floodplain vegetation composition and cover.

Preliminary data indicate that a difference in groundwater gradient and direction of flow is evident between control and test wells. Control areas exhibit a relatively sharp gradient with flow directed toward the stream course, indicating the meadow is draining. In the vicinity of the ponds, however, the groundwater gradient has been significantly reduced and flow tends to mound around the check dam ponds at certain times of the year (Gilbert and Sagraves 1987). Therefore, depressions and low areas far from the channel have experienced a dramatic increase in forage production due to the increase in water table elevation.

Floodplain Vegetation Response

Permanent vegetation transects have been established in conjunction with piezometers to collect species composition and cover data. This information will be used to establish trends in the response of vegetation to shallow water table levels over time. A database is being developed to correlate these two effects. Increased vegetation cover and diversity benefits wildlife and livestock, and protects soils and streambanks from erosional processes.

Fisheries Response

The response of fisheries to improvement measures is being monitored by electroshocking techniques (Longanecker 1988). Sampling stations within the study area and a control location 3 kilometers downstream have been identified. Pre-project data identified very few fish in either the control or the demonstration area. Post-project data collected in 1986 indicate a dramatic increase in fish within the study area, while numbers remain low in the control. Data from 1987 seem to confound the analysis since fish numbers in both sites are similar. This is in response to accelerated fishing pressure in the ponds within the study area, and the building of dams by beaver in the control site downstream, which simulates the study treatments.

Photo-Monitoring

Permanent photo-monitoring stations have been established along the channel in the demonstration area. They will be used to pictorially document the effect of the project on changes in channel alignment and establishment of riparian vegetation.

Conclusions

Planning

Restoration of riparian zones using a watershed-wide approach requires coordination of groups most likely to benefit and a pooling of resources to be successful. Prohibitively high expenses associated with large scale projects, and the legal complexities when many land owners are involved, make coordinated planning the most realistic approach. Planning processes such as CRMP are valuable in organizing and facilitating such projects, and can also create additional funding opportunities.

Restoration projects should not be attempted until enough background and inventory information is collected. Obtaining a "big picture" perspective during the planning process that includes pertinent physical, biological, and historical information will greatly increase the chances for project success. Monetary losses and potential environmental consequences of project failure are also avoided.

Demonstration Project

Though only preliminary results are available, much improvement can already be visually detected. Reduced water velocity has resulted in sediment deposition behind the check dams and along the banks, which has encouraged the reestablishment of riparian vegetation. The raised water table has increased forage production in the floodplain, and water backed up by the dams has enhanced fish and waterfowl habitat. Control of livestock grazing within the riparian pasture has stimulated production and vigor of poor condition perennial grasses and forbs. Monitoring data collected will be used to validate these observations, and to develop a cost and benefit evaluation of the project.

A vast array of techniques are available for restoring degraded riparian zones. Taking the time to develop a sound, realistic plan, and to select appropriate methods will minimize project costs and provide the best opportunity for success. Engineered structures are appropriate in certain situations but they are expensive and should be replaced by or used in conjunction with nonstructural methods when possible. In some instances, merely changing current land management practices can provide desirable results without any additional measures (Elmore and Beschta 1987). The ability of vegetation to stabilize a degraded site should not be overlooked or underestimated in restoration planning.

Finally, all improvement measures will require maintenance whether they are sophisticated structures or simply fencing and planting. This is especially important the first few years after implementation. To ensure project longevity, anticipated maintenance requirements should be included in the planning process when tasks are delegated to participating groups.

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