

Evaluating riprapping and other streambank stabilization techniques

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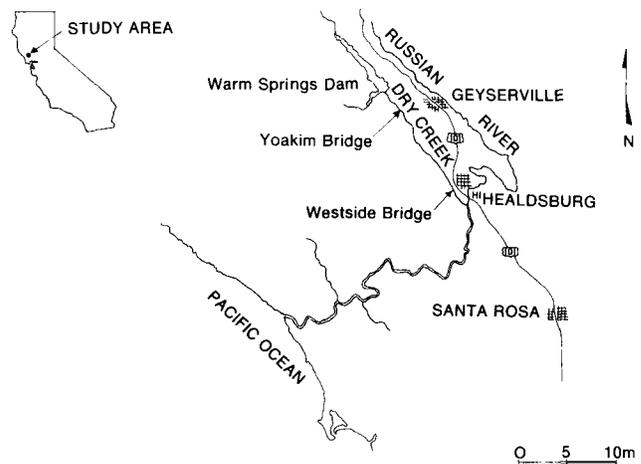
Stabilization of streambanks along creeks and rivers throughout California is an important means of protecting agricultural land from erosion. Riprapping, willow planting, and other methods of bank stabilization effective in curtailing erosion are often considered limiting to the establishment of native riparian woodlands. Recent research has suggested that retention of natural woodlands is an important means of preventing bank erosion. Therefore, stabilization techniques that do not prevent the establishment of riparian woodland species should provide additional streambank protection. The study reported here evaluates the influence of several streambank stabilization methods on the establishment of riparian woodlands and compares treated areas and native streamside woodlands with regard to species composition and density.

The lower 14-mile section of Dry Creek, from Warm Springs Dam to the Russian River in Sonoma County, was the study site. Dry Creek is typical of many streams that pass through vineyards, orchards, and grazing land in the North Coast Range, where conversion of riparian woodlands to farmland, upstream logging of forested lands, and gravel extraction from stream channels have led to severe bank erosion. The stream channel of lower Dry Creek, once a little over 30 meters wide, is now over 150 meters wide at many locations, primarily because of bank erosion from gravel extraction. Farmers in the Dry Creek valley have applied most of the streambank stabilization methods used throughout California: riprapping with car bodies, rocks, concrete rubble, or tires; fencing with hog wire, chain link, or wood; and planting willows or bamboo. Because of land ownership changes, we were unable to obtain dates of installation; the age of materials used and size of reestablished trees reflect a range from recent installation to efforts made 50 years ago.

Bank stabilization treatments have been installed in various locations along Dry Creek, primarily at meanders to absorb the erosional energy of the stream, deflect the current, or both. These treatments were positioned either at the base of the bank or along the entire vertical face of the bank at the meander or slightly upstream from the curve. Some were installed primarily to prevent banks from collapsing after the retreat of flood waters. These are not situated with respect to the meander patterns *per se* but are found at the tops of steep banks where flood plains are eroding.

The vegetation of the riparian zone along Dry Creek is typical of streams in the central California coastal ranges. Sandbar willow (*Salix hindsiana*), mule fat (*Baccharis viminea*), young white alder (*Alnus rhombifolia*), cottonwood (*Populus fremontii*), and other willows (*S. laevigata*, *S. lasiolepis*, *S. lasiandra*) form patches within the stream channel. Under natural conditions a succession of woodlands occurs in which willow and cottonwood dominate the streambanks, then are replaced by mixed riparian species dominated by Hind's walnut (*Juglans hindsii*), California box elder (*Acer negundo* ssp. *californicum*) with occasional

buckeye (*Aesculus californica*) and Oregon ash (*Fraxinus latifolia*). On higher elevation flood plains, the mixed riparian woodland is succeeded by a woodland dominated by oaks (*Quercus agrifolia*, *Q. lobata*) and California bay (*Umbellularia californica*).



Erosion control study

We studied several examples of each method of streambank erosion control for each position described, measuring one example of each method where it had been installed to deflect the current from the streambank and where channel migration had not occurred. Criteria for sample selection were: (1) Sufficient time had elapsed after installation to allow species to occupy the site, as indicated by either (a) 20 to 30 percent of the surface covered by sediments or (b) age of materials, suggesting that the treatment had been in place for at least 20 years. (2) Sites were adjacent to the stream and thus were particularly amenable to colonization by riparian species because of water available during the summer growing season. Whenever the type of treatment precluded these criteria, we have noted the exceptions in the treatment descriptions. At each site, we established a transect (5 by 30 meters) parallel to the streamflow to record the riparian seedlings (less than 1.5 meters tall), saplings (greater than 1.5 meters tall, but less than 10 cm in diameter at breast height), and trees (greater than 10 cm in diameter at breast height), as well as the diameter of each tree. We also estimated the amount and depth of sediment accumulation.

For comparison, we tallied riparian seedlings, saplings, and trees in nontreated areas, using the point-quarter method (surveying a total of 143 points) in flood plain woodlands and 10 rectangular plots (in a nested pattern) in bank woodlands. We also sampled, in nested rectangular plots, the portions of the nonstabilized streambanks that are dominated by the native grape (*Vitis californica*) rather than trees.

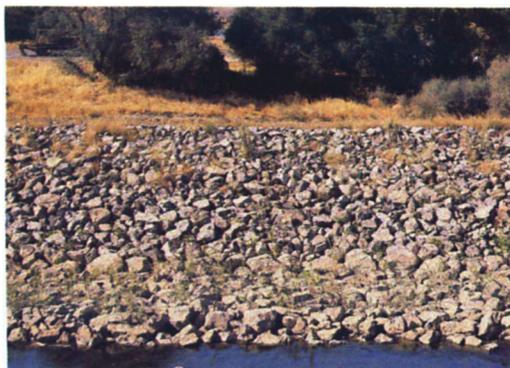
Car body riprapping



Car bodies, often in four or five tiers, are laced together by cables in stacks as long as 100 meters against cut banks. Sediment collects inside, providing a substrate for tree growth. In older stacks, only 20 percent of the car body surface is now exposed.

We found Oregon ash and box elder saplings and trees up to 40 cm in diameter, as well as red willow trees on older treatment sites. Development of tree cover is leading to a mixed riparian woodland type.

Rock riprapping



Riprapping with small rocks, used in a few areas along Dry Creek, requires a near paving of the banks with stones and leaves little space for sediment accumulation. We found no shrubs or trees established in any of the rock riprapped sites.

Concrete rubble and tire riprapping



Concrete rubble, in irregular pieces as large as 1 by 3 meters dumped onto the surface of cut banks, limits space for roots but collects some sediment.

Tree density averaged only one per 100 square meters, as compared with five per 100 square meters in car bodies. Sandbar and arroyo willow were well established. The presence of arroyo willow and absence of mixed riparian species may indicate droughty conditions resulting from shallow soil. Where concrete rubble riprapping is used, it

appears likely that willow-dominated woodlands will become naturally established, but not the successional more advanced mixed riparian woodland.

Used tires have been dumped onto cut banks at a few locations with no apparent effort to secure them. Most are washed away the following winter. Since no sediment accumulates, seedlings do not become established. Along other streams, where tires have been woven together with cables into a blanket and secured to cover the banks, they have controlled erosion and allowed riparian species to become reestablished.

Hog-wire and chain-link fencing



Hog-wire and chain-link fences at the base of cut banks reduce stream velocity and collect floating debris, further absorbing erosional energy. Seedlings become established at the base and lower slopes of cut banks behind the fences.

The species observed (white alder, Oregon ash, Fremont cottonwood, sandbar willow, and red willow) suggest rapid development of the mixed riparian type. In all areas surveyed, we found saplings or trees of at least three riparian species.

Wood fencing



Wooden fences built along lower Dry Creek in earlier years effectively protected cut banks. They were often 3 to 6 meters tall, over 50 meters long, and constructed with large-dimension lumber.

Establishment of vegetation behind these wooden walls differs according to the angle of the banks. Where they are steep, with a narrow space between the fence and bank surface, the shade-tolerant native grape dominates, growing through and descending down the front of the fence, improving its energy absorption.

Where cut banks are less steep, the available light and space has allowed yellow willow to become well established. The yellow willow may have been planted: this is the preferred species for planting, and it occurs naturally at a low frequency along Dry Creek. Although we found no evidence of further succession in the sample transect, we expect this process to lead eventually to a mixed riparian woodland.

Willow planting



Yellow willow is commonly planted on the flood plain to develop a root mass that holds the soil. Sandbar willow is planted at the base of cut banks to absorb the energy of flowing water and prevent undercutting.

Our tallies in a yellow willow planting from the mid-1950s indicate that succession to the oak/bay woodland type is occurring. The numerous seedlings of both coast live oak and California bay (30 of each per 100 square meters) appear quite vigorous in the understory of yellow willow and can be expected to form a dominant crown cover within the next 30 years. Hind's black walnut will be a minor component of this type (five saplings found per 100 square meters). We did not sample sandbar willow plantings because of their narrow width.

The density and species composition within the yellow willow transect are substantially different from those in the other treatment areas. The high density of yellow willow results from its sprouting nature, but its clumped pattern provides enough light and ground surface for oak, bay, walnut, and willow seedlings and saplings. The species composition suggests that a rapid succession to climax riparian woodlands occurs in such plantings because of the light shade and less disturbed seedbed surface, as well as their location at the top of the flood plain with lower flood frequency.

Bamboo planting

Bamboo clumps up to 20 meters long, planted at the base of cut slopes, have extensive matted root systems that have prevented further erosion, but their dense cover restricts establishment of native riparian species. We found no such species within the bamboo plantings.

Undisturbed areas



We classified the riparian woodlands occurring outside the treatment areas along Dry Creek into four major types on the basis of dominant tree species: willow, cottonwood/willow, mixed riparian, and oak/bay woodland. Cottonwood/willow and mixed riparian woodlands are common; willow and oak/bay woodlands occur infrequently.

Although we found few tree seedlings in the woodlands along Dry Creek, numerous saplings were present, varying

in composition with the woodland type. The absence of seedlings may be caused by the thick cover of giant periwinkle (*Vinca major*), in most of the woodlands sampled.

Grape-dominated areas occur primarily on steep, eroded banks where subsequent channel migration has allowed establishment. The presence of saplings in these areas suggests succession to a riparian woodland type. However, climbing grapevines frequently kill young saplings, suggesting that, at most, only a sparse woodland will develop.

Conclusions

Our observations suggest that both the stabilization technique and the harshness of the site determine the success of establishment. Similarities in species composition and density of several of the treatments with the undisturbed woodlands suggest that the same set of factors influences establishment in both instances. Differences in stabilization effectiveness and establishment may occur on other streams where stream characteristics (velocity, soil texture, and duration of flow) or installation techniques (such as securing tires by cables) differ.

Bank stabilization with car bodies, wire fencing, and willow planting have not prevented the establishment of native riparian woodland species along Dry Creek. Wood fencing and the use of concrete rubble have led to the establishment of willow types without further successional development so far. Tire and rock riprapping and bamboo planting, in contrast, have not provided environments where native riparian species can become established.

The success of any of these techniques in stabilizing a bank and in promoting establishment of vegetation depends on the location. Upper bank treatments may temporarily stabilize an eroding slope, but their poor environment for seedling establishment discourages riparian woodlands (unless willow plantings are used). Lower banks appear to be quickly colonized by riparian species once erosion stops.

These findings suggest that several factors influence the establishment potential on stabilized areas: the erosional environment, available soil moisture (determined by sediment depth and texture), light, competition, position of the bank (flood frequency), and flow velocity. These same processes affect establishment on nonstabilized portions of the stream.

Before any establishment can occur, the treatment must promote a shift from an erosional environment to one in which either further erosion is curtailed or sediment accumulates. The success of these stabilization methods also depends on the velocity of streamflow. Most treatments have withstood the average annual flood peak of 10,000 cubic feet per second on Dry Creek but major floods have taken out sections of streambanks protected by tire riprapping, fencing, and willow planting.

The lack of current seedling establishment at most of the treatment areas sampled reflects the short period in which conditions are suitable for the establishment of riparian species. This trend is similar to the trend observed in the undisturbed riparian woodlands, where few seedlings are found.

Similarly, except for the riprap treatments, density and species composition of the stabilized areas do not vary greatly from those of the undisturbed banks surveyed. This is not to imply that bank stabilized areas are now or will become the same as undisturbed woodlands. It does, however, indicate the potential of different bank stabilization treatments to allow for the natural reestablishment of riparian species.

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