Chapter 3

STREAMBANK STABILIZATION IN BERKELEY: THE CASE FOR RIPARIAN RESTORATION

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> Each stream is a dynamic open system whose water-land interface is great compared to that of even a lake with a heavily dissected shoreline. Future management techniques for bank stabilization in such dynamic systems will necessitate having the stream maintain itself, rather than employing all sorts of physical constraints of natural processes.
>
> --Stern and Stern, 1981

Introduction

Creeks are part of the natural landscape of Berkeley. They serve as public recreation areas, as wildlife habitats, as study sites for scientific research, and as a natural reminder of an older Berkeley. For these and other reasons it is desirable to maintain and in some cases repair Berkeley creeksides. Neglect and misuse of some creek areas has led to increased streambank erosion. Methods must be implemented that will restore these areas and preserve the waterways.

Riparian restoration is just one of many methods to achieve bank stability. This paper explores the pros and cons of this solution, versus other means of curbing streambank erosion in Berkeley.

Erosion: Definition and Causes

Streambank erosion is the process by which flowing water undercuts banks, and the material composing the streambank falls into and is removed by stream water (Hauge, 1977). The erosional process may either be natural, occurring under natural environmental conditions (including high rainfall and local flooding), or accelerated, most often exacerbated by humans. Accelerated erosion is caused by clearing of streamside vegetation, or by disturbing stream flow patterns. Problems increase in direct proportion to disruption in natural drainage areas (Highway Research Board, 1973).

In Berkeley, natural vegetation has been replaced by manicured lawns and exotic ornamentals. Impermeable roadways cover thousands of acres of once-absorptive watershed, accelerating runoff and increasing peak streamflows. These conditions make accelerated erosion a threat (California Department of Conservation, 1979). Without care and planning the banks of Berkeley creeks may crumble and wash away, destroying the habitat and beauty that they afford.

Accelerated erosion may be caused by debris in or across the stream, alterations to the floodplain, devegetation of the banks, nearby construction activities, urbanization of the watershed, or human interference with the stream itself. The degree of erosion is dependent on the degree of harmful activity, as well as on the environmental factors that govern the stream in question.

Obstructive debris is deposited in streams primarily by bank failure, but also by the felling of trees, falling limbs, and landslides that reach the stream (Keller and Swanson, 1978). In some cases debris will stabilize a streambank by creating falls, runs, or hydraulic jumps and zones of concentrated turbulence, which dissipate stream energy and decrease flow rates. But floating debris most often destabilizes banks when it directs streamflow against the banks and encourages lateral migration. At times of high flows, debris batters the banks, increasing erosion and leaving banks unprotected against future erosional events. Debris may also block streamflow, thereby causing bank erosion as the stream migrates laterally to avoid the blockage (Cleveland, 1977).

Another cause of streambank erosion is devegetation (Cleveland, 1977). Removal of vegetation, to improve access, for purposes of construction, or even to replant, exposes the soil to the power of the stream. A related cause of erosion is vegetation change. The stream environment is adapted to a particular form of vegetation: a particular root system holding the bank, a certain litter matting the soil. Changes in the environment inevitably make way for erosion.

Alteration of the floodplain induces changes in runoff patterns, lateral movement of groundwater into the stream, and ultimately patterns of stream discharge (Stern and Stern, 1980). Urbanization of the watershed also increases runoff (from roofs and pavement) into the stream, affecting flow patterns. When streamflow is increased, cutting power of the stream likewise increases. This leads to incision or lateral migration by the stream. All of these human-induced changes cause some variation in the normal direction and velocity of the stream, leading to bank erosion.

Perhaps the most underrated cause of streambank erosion is man's interference with the stream itself. Culverts, retaining walls and other means of bank stabilization often lead to the problem they are meant to prevent (Stern and Stern, 1980). Bank stabilization prevents stream meandering, thereby constraining channel migration. When flows are so contained, the stream works down instead of out, increasing its depth and eroding its bed. Eventually, bank stabilization structures are undercut, bed load is increased, and further erosion can occur downstream.

Streambank erosion can occur to varying degrees and be accelerated by seemingly insignificant changes in the watershed. Proper stream management calls for an analysis of the entire watershed and stream system.

The Present Condition of Berkeley Creeks

Berkeley creeks are susceptible to high rates of erosion, but the characteristics of the streams and banks help deter the process (McColl, pers. comm.). Some characteristics are: width and depth of stream, gradient of stream, gradient of the adjacent slopes, and riparian vegetation.

The creeks in Berkeley are small streams. A small stream is one which can be waded or used only by small pleasure boats (Stern and Stern, 1980). Since stream flow is not great in a small creek, natural erosion is held in check. In the lowlands, stream gradient is low, helping to reduce flow velocities and decrease the abrading power of water against the banks.

Another factor of bank stability is soil type. The Berkeley Hills are mantled by a variety of soil types, but montmorillonitic clay is dominant (McColl, pers. comm.). Montmorillonitic clay has a high plastic limit, is highly cohesive, and has a tendency to adhere. These factors make banks composed of this clay far less erodible than banks composed of other sediments (Brady, 1974).

Finally, the vegetation that hugs the Berkeley creeksides is often dense, casting a protective shield that prevents erosion by pelting rains and slows groundwater flow to the stream, reducing peak streamflows and further protecting the banks from erosion.

Possible Problems, Possible Solutions

There is still the potential for problems of streamside erosion to occur in Berkeley. Much of the length of the local creeks is culverted or buried under streets. Some segments in the hills and backyards remain open. The gradient of the streams and their adjoining banks are great in the hills, and could lead to serious erosional problems. Coupled with these circumstances and the heavy rains of the past two years, we may soon have to implement bank stabilization procedures. Already local flooding has overtopped banks, scoured the sides, and incised the streambeds. Last year alone, due to heavy rains, Berkeley creeks incised an incredible six inches (Leopold, pers. comm.). Figures of incision are not yet available for this year.

There are several methods of combating streambank erosion. These include mechanical means--use of structures or chemicals to stabilize banks--and natural means--using rocks, vegetation or fallen trees to secure the soil. All methods are viable under certain circumstances, if one considers the economic and ecological costs involved.

A. Structural - Grade stabilization structures are used to decrease the slope of moving water and further decrease the velocity of flow (EPA, 1973). Structural constraints, such as checkdams and drop spillways, decrease flow velocity of the stream. A checkdam, constructed of concrete or wood, blocks water flow and helps control flow rates. Drop spillways divert the water and decrease stream energy. Wire netting, applied to the streambank, or gabions--permeable wire mesh baskets filled with rocks--piled against the eroding surface, trap debris, reduce flow velocity and slow bank erosion.

The costs of these structures fall mainly to labor, as material costs are reasonably low. Gabions are the most expensive to use. A 3x3x6 foot box costs about thirty dollars (Williams, pers. comm.). Even labor costs can be kept down, if workers from such agencies as the California Conservation Corps are employed.

B. Chemical - There are many bank stabilization chemicals on the market. The economic and ecological costs are variable. These chemicals work by binding soil particles into cohesive mats, and also as chemical mulches, abiding in plant germination and growth. Some products and their properties are listed in Table 1.

Product	Soil Stabilizer	Chemical Mulch	Problems
Aerospray 52 Binder	X	X	
Aquatin		X	stored above freezing
Curasol AE	X	X	treated surface traffic free
Curasol AH	X		avoid heat or frost
DCA-70	X	X	soil separates below 40°F
Liquid Asphalt		X	sticks to shoes
Petroset SB	X	X	keep away from children
Terra Tack		X	highly toxic

Table 1. Chemical Means of Erosion Control.
Source: USDA, 1975.

C. Matting - All matting types are used to hold down the soil on the banks and encourage growth of vegetation. Some products, such as the Excelsior Blanket, Fiber Glass Matting and Glassroot (a fiber glass "angel hair" mulch) are synthetic and biodegradable. Other products meld more into the environment that they protect. Some mattings are of jute netting, straw, hay, or wood chips (USDA, 1975).

D. Earth Stabilizers - Some bank stability problems can be solved using cheap, readily available materials. A common method used locally (Williams, pers. comm.) is to tie cut brush to the bank. This creates friction and reduces stream velocity along the stream-bank interface. Check dams may be constructed of woven willow branches. Cribbing, where redwood logs are tied parallel to the bank, literally holds the soil in place. Rip-rap, rocks piled one upon the other, is probably the most common form of bank stabilization in use. These types of erosion control are labor intensive. But for this kind of work, labor is cheap. Available for such projects are the California Conservation Corps, the Tree Project (based in Alabama), and members of Circuit Riders Productions of Santa Rosa. (Rates range from $5 - $7/hour when work is part of training programs in land management) (Prunuske, pers. comm.).

E. Vegetation - The use of vegetation to stabilize banks is probably the easiest and least expensive means available. The material is often close by, if willow or alder cuttings are used, or easily purchased. Small liner plants in cardboard containers, 1 x 1 x 6 inches, that hold roots in place, are sold for fifty cents to two dollars a box (Prunuske, pers. comm.). The cheapest method to vegetate an area is by seeding. For some plants mulches or fertilizers may be necessary.

In choosing the right vegetation for use in bank stabilization the needs of the plant must be considered. Plant growth is limited by climate and site conditions. Some species require fertilization, lime or other soil amendments, mulching, low-grade slopes or extra topsoil (Highway Research Board, 1973). The purpose of the planting must be considered - is this a temporary measure, or permanent? Is the planting ornamental or strictly stabilizing?

Plant characteristics are another factor. One must consider the plant's geographical range, preferred soil and pH, growth habits, longevity, ability to spread, seasonality, and altitude. Add to this the plant's susceptibility to winter-kill, drought or inundation, shade, traffic, insect pests and disease. Furthermore, one must consider seed dormancy properties, growth rate, maintenance and aesthetics in choosing the right vegetation for an area (Highway Research Board, 1973).

The easiest way to determine which plants are most adaptable to bank stabilization is to look at the local creeks themselves. The natural vegetation is well adapted to our climate, to native insect pests, to disease, and to soil. A poster put out by the East Bay Municipal Utilities District advocates the use of native plants because they require less water. It is clear that grass-covered banks make a protective matting to deter erosion; native grasses are best because they compete well with weed growth (Highway Research Board, 1973). Tree-lined channels have been found to be less erodible, narrower, and steeper than sparsely vegetated banks (Zimmerman et al., 1967). The living vegetation rooted in the banks prevents erosion aboveground by creating roughness in the streambed, and belowground, by increasing resistance to erosion of soil and alluvium (Cleveland, 1977).

Desirability of Riparian Restoration

What makes riparian restoration a better process for bank stabilization than structural or chemical means? Vegetation along waterways does not just secure the banks; it is a haven for wildlife (Erman et al., 1977). A bufferstrip of at least thirty meters of vegetation is recommended to maintain the insect fauna of a stream. Other wildlife is equally protected by, and needful of, riparian strips along waterways--for hiding places and food sources. Most chemical stabilizers, on the other hand, are toxic to wildlife. Construction activities degrade the environment and disrupt the habitat of most species. The only structures found to be of use to wildlife are retaining walls or spillways that extend out into the stream. After erosion has advanced and undermined these structures, the gaps left by streamflow provide valuable habitats for fish and aquatic insect life (Erman et al., 1977).

Aside from maintaining the natural environment of a stream, it could be argued that an aesthetically pleasing means of bank stabilization is desirable. Concrete chutes and spillways are ugly to most people. Mattings of fiberglass and chemical stabilizers (often in odd colors) are made of synthetics and can be visually obtrusive. These methods do not preserve the natural beauty that we associate with riparian environments. Applying riparian vegetation serves the dual purpose of stabilizing eroding banks and pleasing our aesthetic sense.

Feasibility of Riparian Restoration

Is riparian restoration a feasible means of bank stabilization? It certainly is cost-effective. Some plantings can be carried out in a few hours with material at hand (Prunuske, pers. comm.). If one chooses wisely, it is possible to use species that need little or no maintenance and care, further decreasing costs. Projects for riparian restoration can be conducted by members of forestry training programs, cutting labor costs down to the bone. If the eroding bank is in one's backyard, a little neighborly help and an afternoon should take care of the problem.

Many groups support the use of riparian restoration, and help in planning restoration programs is readily available. The California Native Plant Society advocates the use of native species to bind the stream banks. Circuit Riders Productions of Santa Rosa, and Hydrological Consultant Phil Williams of Phil Williams and Associates, San Francisco, suggest the use of mature riparian vegetation and tree plantings to stabilize eroding banks. Riparian restoration has been used in Wildcat Canyon to preserve the environment (McBride, pers. comm.). Riparian restoration is a much favored and widely used method of streambank stabilization.

Suggestions for Riparian Restoration

The following table is a list of possible plantings and some of their attributes for streambank stabilization (Table 2). All species on the list are considered unsusceptible to disease or air pollution, and can withstand sustained temperatures of 18^{O}F with no damage (Lenz and Dourley, 1981). This list is drawn from the flora currently found in the Berkeley Hills and along riparian strips, and is by no means all-inclusive.

PLANT NAME	ATTRIBUTES
Big Leaf Maple (Acer macrophylum)	resistant to oak root fungus, attractive, deciduous
Alder (Alnus rhombifolia) (A. rubra)	attracts birds, heat and wind tolerant, fast growing, deciduous
Madrone (Arbutus menziesii)	highly resistant to oak root fungus, attractive, evergreen
Incense Cedar (Libocedrus decurrens)	tolerates high temperatures, poor soils, drought; resistant to oak root fungus, long lived, evergreen
California lilac (Ceanothus spp.)	drought tolerant, beautiful, fragrant blossoms, evergreen
Mountain mahogany (Cercocarpus spp.)	free from pests and disease, drought tolerant
Dogwood (Cornus alba)	thrives in many soils and locations, rampant growth, spreads rapidly, attractive, deciduous
California buckwheat (Eroginum spp.)	spreading fibrous root system, grows from seed, attractive
California juniper (Juniperus californica)	does well in poor soil, withstands wind, pests, disease; evergreen
Lupine (Lupinus spp.)	attractive, long-flowering
Digger pine (Pinus sabiniana)	drought tolerant, evergreen
Western sycamore (Plantanus racemosa)	tolerates high temperatures and wind, excellent shade tree, deciduous
Poplar (Populus spp.)	spreading root system, attractive, deciduous
Coast live oak (Quercus agrifolia)	resistant to heat, cold, water or drought, fast growing, attractive, evergreen
Coffeeberry (Rhamnus californica)	no pests or diseases, tolerates any soil, drought tolerant, good for birds, good deer browse, attractive, evergreen
Gooseberry (Ribes spp.)	attractive, but spiny, produces edible fruit
California blackberry (Rubus ursinus)	fast growing, good erosion control, establishes quickly and permanently
Elderberry (Sambucus spp.)	good for wildlife, produces edible fruit
California bay (Umbellularia californica)	propagates by seed or cuttings, prefers and creates cool, moist conditions; evergreen

(continued)

PLANT NAME	ATTRIBUTES
Coast redwood (Sequoia sempervirens)	long lived, attractive, propagates by seed or cuttings; evergreen
Willows (Salix spp.)	prefer streambanks, very attractive, good bird habitat
Flowering currant (Ribes spp.)	attractive, fragrant blossoms

Table 2. Suggestions for Riparian Restoration

Source: Munz and Keck, 1968; Lenz and Dourley, 1981.

Conclusion

The problem of streambank erosion in Berkeley is an ever-present threat. Due to bad weather and road work in the hills recently, the hillside streams are undergoing accelerated erosion, resulting in loss of wildlife habitat, safe recreation areas, and natural beauty. The harmful effects of erosion in the hills will eventually reach the lowlands. This may cause flooding and sedimentation problems that will clog waterways and spill over onto the city streets.

This paper has examined many means of implementing bank stabilization, including riparian restoration. THis method is by far the most economical and environmentally feasible method presented in this paper. Furthermore, it is recommended by engineering firms and environmentally-oriented groups. These people recognize the need to repair and maintain the creeks in Berkeley, to preserve a bit of nature in the city's backyard.

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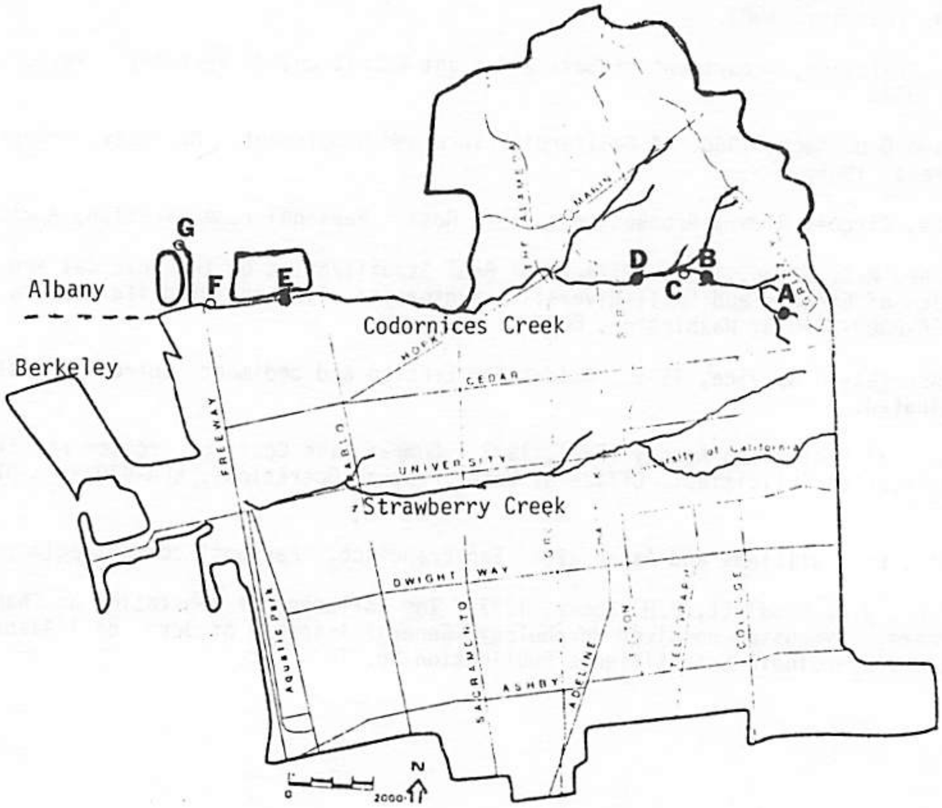

Figure 1. Codornices Creek of Berkeley, showing locations sampled.

Source: Master Plan Revision Committee, Berkeley Planning Department, 1975.

● 1983 Testing Sites

A South Watershed Area (below Fairlawn Rd)

B Codornices Park (at bridge)

D Live Oak Park

E 9th & Harrison (UC Village)

○ Other Testing Sites

C Rose Garden, (Grove,1969), (Berkeley,1970)

F Eastshore Highway, (Grove,1969),(Berkeley,1970)

G Golden Gate Fields , (see Neila Imlay's Paper, 1983)