Chapter 1

THE NATURE AND CAUSES OF RIPARIAN VEGETATION CHANGE

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Introduction

The vegetation that dominates an area reflects a complex interplay of many factors. Some of the factors--hydrology, soil, and climate--are abiotic. Others, including human activities and the actions of other animals, are biotic in nature. The extent and character of the vegetation cover, in turn, will have consequences on both the quantity and quality of water in Berkeley's creeks. During the past 200 years, since the settlement of the area by Europeans, changes in certain of the factors mentioned above have led to a great alteration of the vegetation cover around Berkeley's riparian areas. This report examines the changes that Berkeley's natural vegetation has undergone during the past 200 years and speculates on the hydrologic effects of the changes.

Pre-Spanish Conditions

Before the arrival of the Europeans in the early 1770's, the Costanoan Indians occupied the East Bay Area (Clarke, 1952). Long before the Spaniards arrived, the Indians practiced controlled burning. Use of fire for clearing of brush allowed the native inhabitants easier access to edible seeds. Collection of these seeds aided in the dispersal of favored plants. The use of buckeye (*Aesculus californica*) nuts may have furthered the spread of that species along stream channels (Clarke, 1952).

When the Spaniards arrived, virtually the entire plain and hill areas of Berkeley consisted of perennial bunch grasses, giving the appearance of a prairie landscape with woody vegetation crowded in canyons and following stream courses (Derrenbacher, 1966). Father Crespi of the First Spanish Expedition to the East Bay Area described a region of grass-covered hills. The land lacked trees and firewood except near the stream channels, which were heavily wooded (Clarke, 1952); the landscape was such that, "scattered over the places [were] many old oak trees which alone in the early days broke the dreary monotony of the plains and hills" (Berkeley Advocate, 1892). The major grass species were *Stipa pulchra*, *Poa scabrella*, *Danthonia californica*, *Koeleria cristata*, and *Melica imperfecta* (Clarke, 1952). The appearance of the prairie landscape was colored by several species of wildflowers, with different types blooming throughout the year. Characteristic flowering herbs included lupine (*Lupinus* sp.), buttercup (*Ranunculus* sp.), dandelion (*Taraxacum* sp.), brodiaea (*Brodiaea* sp.), poppy (Papaver sp.), honeysuckle (Lonicera sp.), and sunflowers (Helianthus sp.). Shepherd's purse (Capsella bursa-pastoris) bloomed in January, dandelion in February, poppy in March, buttercup in April, cream cup (Platystemon californicus) in May, sunflowers in June, honeysuckle in July, clematis (Clematis sp.) in August, aster (Aster sp.) in September, blue curl (Trichostema sp.) in October, nightshade (Solanum sp.) in November, and mistletoe (Phoradendron sp.) in December. These wildflowers, blooming at different seasons, provided a year-round break to the monotony of the open grasslands (Carlin, 1909).

Dense riparian strips typically extended from below the crest of the East Bay Hills downslope to the alluvial plain below. In these areas the established woody vegetation and shrubs shaded out the ground layer of grass, leaving an understory of thickets and shade-tolerant species (McBride, 1983, pers. comm.). Nowhere did tree growth extend to the crest of the hills, however, since water availability there was low and wind stress was high (Figure 1a) (Clarke, 1952). The shrubby coyote bush (Baccharis pilularis), rather than trees, dominated in the highest reaches of the canyons and creeks. Coyote bush also established itself on dry, southwest facing slopes, being exposed to full afternoon sunlight. On northeast facing slopes, on the other hand, where desiccation was minimized due to the presence of shade, morning fog, and nocturnal dew, plants requiring more moisture predominated (Clarke, 1952).

The riparian zones from the alluvial plains up to just below the crest of the hills were continuous, wooded strips with maximum widths at the mouths of the creek canyons, where inflow of water was greatest and persistent shade minimized evapotranspiration (Figure 2a). The width of the zones of riparian vegetation was determined by the availability of water, but in no case did these forested zones extend more than 30 to 50 feet past each bank of the creek (McBride, 1983, pers. comm.). Just as the width of the riparian strips varied in accordance with the local water availability along the specific stretch of the creek in question, so too did the species composition vary in response to the conditions of the microhabitats along the creeks. The coast redwood (Sequoia sempervirens), for example, requires high water availability year-round. It can thus be assumed to have been restricted to groves around permanent water sources. Such areas were found at mid- and high-elevations on slopes, where fog drip during the summer kept the vegetation well watered during the "dry" season when streamflow was minimal.

Coast live oaks (Quercus agrifolia) and California bays (Umbellularia californica) were the predominant trees along the upper stretches of the creeks. They were found in association with less abundant and more zonally restricted species. Vegetation requiring large amounts of moisture but able to tolerate low water availability during the summer was concentrated at the mouth of the creek basins, above the alluvial plains where moisture would be absorbed, and closer to the water of the stream banks (McBride, 1983, pers. comm.). Such species included maple (Acer macrophylla), alder

(Alnus sp.), willow (Salix laevigata), sycamore (Platanus racemosa), hazel (Corylus cornuta), and cottonwood (Populus sp.). Members of the shrub layer of the riparian strips included thimbleberry (Rubra parviflora), current and gooseberry (Ribes spp.), poison oak (Rhus diversiloba), ceanothus (Ceanothus sp.), and coffeeberry (Rhamnus sp.) (Clarke, 1952). Other species of trees such as the bay and the madrone (Arbutus menziesii) required less moisture, good drainage, and could tolerate dry periods; they were thus more prominent on higher grounds away from the creek bank and on the high grounds of the upper basin areas. Other types, such as coast live oak, needed good drainage but also required nearby and year-round moisture; thus, they dominated on the alluvium below the canyons, where permeability was good and a perched water table was close to the surface (McBride, 1983, pers. comm.).

The soils of the lower plain areas near San Francisco Bay are clay and clay loam alluvium. Soils of these types have very poor drainage, and combined with the perched water table, they present water-logged conditions (see paper by Romanucci, this report). Grasses, which tolerated poor drainage better than many trees and shrubs, dominated the lower plains (Clarke, 1952). At the margin of San Francisco Bay, where conditions were more saline, grassland gave way to salt marsh. Patches of woody riparian growth, however, did persist along streams virtually to the bay margin (Figure 2a). These patches were restricted to the natural levees of the creeks, elevated above the waterlogged plains. This environment allowed coast live oak and coyote bush to avoid the waterlogged conditions below the levees but also limited the vegetation there to those species able to tolerate periods when the lower creek channels were totally dry. In addition to coast live oak and coyote bush, Salix lasiolepis is known to be able to tolerate dry spells and was found on plains near the bay in Palo Alto (Clarke, 1952). Therefore, we cannot discount the possibility that this species of willow was also present in the lower riparian areas.

The Early European Period

When the Spaniards arrived in the East Bay, they actively sought out grassland areas in order to graze their cattle (Workers of the Writers' Program of the Work Project Administration, 1941). Soon after the Europeans settled the area native perennial bunch grasses began to be replaced by exotic herbs and grasses. The major exotic species include Avena fatua, Bromus mollis, Lolium multiflorum, Medicago polymorpha, Erodium cicutarium, and Geranium dissectum. Other introductions include Hordeum murinum, Medicago hispida, Brassica nigra, Chenopodium album, Amaranthus retroflexus, and Rumex crispus (McBride, 1969). A major source of the exotic seeds was ships' ballast, which was changed upon landing. Cattle, other domesticated animals, and packing materials also served to introduce alien seeds (Burchum, 1957). In any case, the native perennial bunch grasses were largely replaced by the opportunistic and aggressive exotic annuals during the period from the 1850's to 1860's (McBride, 1983, pers. comm.). Presently, less than 5% of the remaining grasslands in the East Bay Hills consists of native species (Clarke, 1952).

The introduced annual grasses, once established, rapidly displaced the native bunch grasses. The growth pattern of the native grasses left spaces between clumps of growth, leaving open niches for the exotic annuals to become established (Burchum, 1957). Cultivation has also caused elimination of much of the native grasses (Clarke, 1952). It is possible that the native species could have competed successfully with the introduced species in the absence of grazing animals. Grazing doomed the native grasses, however, since they were more palatable to cattle, which removed the native grasses and allowed annuals to replace the natives (Burchum, 1957). Furthermore, the exotic species evolved in the Old World with grazing and were more tolerant of grazing pressure than the natives (McBride, 1969). After overgrazing by cattle helped replace native perennial grasses by exotic species, the native types never recovered.

Later European Period and Present Vegetation

Despite the change in the species of grasses, the general appearance of the Berkeley Hills as a rolling grassland did not change drastically until grazing was stopped (McBride, 1983, pers. comm.). Old photos and early historical accounts leave no doubt that throughout the latter decades of the 19th century the Berkeley Hills remained primarily grassland with shrubs and trees only in stream channels and low areas where water was readily available (Figure 1a).

Prior to the arrival of the Spaniards the Berkeley Hills were grazed extensively by native animals, including tule elk and deer. Perhaps as early as Spanish times, and certainly during the years following the Gold Rush, grazing pressure increased, due to the introduction of domestic species, and overgrazing became a factor in vegetation change. By the late 1860's, however, the grazing that had helped suppress the growth of shrubs had been eliminated on the western slope of the Berkeley Hills. Fire was a natural and periodic occurrence in the area. It was a factor in brush suppression until Gold Rush times, when it was reduced in frequency. The elimination of grazing and fire permitted brushy species like coyote bush quickly to invade the once-dominant grasslands to the extent that the general appearance of the Berkeley Hills assumed the appearance of a woodland interspersed with patches of grass. As early as 1881 it was noted that "Berkeley is becoming a forest; it is impossible to look in any direction without seeing groups of eucalypti, poplars, pines, spruces, cedars, and cypresses interspaced with meadows and fruit orchards" (Sutliff, 1881).

The introduction of exotic annual grasses was a factor in allowing the spread of shrubs. While the exotic grasses were well adapted to grazing, these annual species could not compete with shrubs in the absence of grazing. Cattle trampling and browsing of the tree and shrub seedlings maintained the annual grasslands, but after grazing ceased the exotic grasses were outcompeted by the expanding riparian vegetation (McBride, 1969). The annuals were less well adapted to compete with trees since, unlike the native perennials, the annuals had to set down new roots each year. Therefore, after each successive year the tree roots became more developed, while the yearly renewed root systems of the

Figure 1a. Strawberry Canyon in the 1870's. Note the dominance of grassland, with woody vegetation restricted to the low-lying areas and the north-facing slopes.

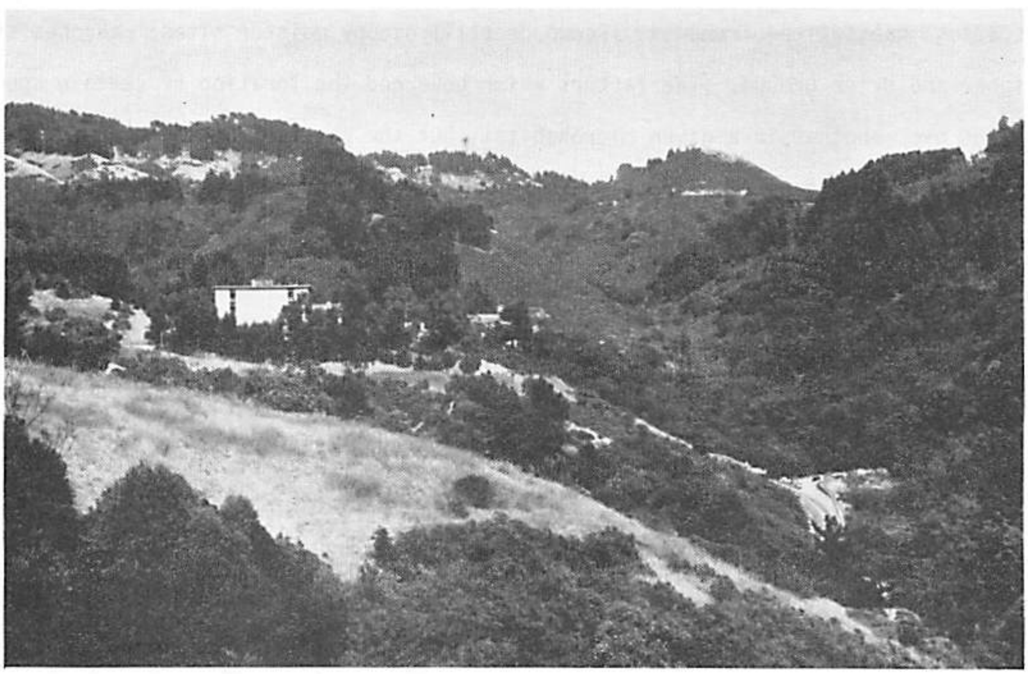

Figure 1b. Strawberry Canyon as it appears in 1983. Notice the increased density of trees and shrubs from that of earlier photos.

annual grasses could not compete with the woody vegetation (McBride, 1983, pers. comm.). The result is the present dominance of forest vegetation in the Berkeley Hills (Figure 1b).

Supplementing the spread of native trees and shrubs into the grasslands was the introduction of exotic plants into former grassy areas. Some of the planted types actually seem to be better adapted to the area than the natives. Blue gum (Eucalyptus globulus), Monterey pine (Pinus radiata), Scotch broom (Cytisus scoparius), and French broom (C. monspessulanus) are perhaps the most conspicuous introductions in the hill areas. Monterey pine and blue gum are often planted in extensive groves. Blue gum has been so successful in the area that it now covers large patches of the hills, though it is largely restricted to the Orinda Formation where ground water is most abundant (Stine, 1983, pers. comm.).

Both Scotch and French broom are now abundant in the canyons on both low and high ground. In addition, there are many more exotics present in the hills today than there were when extensive introductions began during the 1870's and 1880's (McBride, 1983, pers. comm.). Although introduced trees and shrubs displace native species in many areas that the natural vegetation might otherwise occupy, the woody exotics are often found in patches and groves. The introductions do not alter the natural succession of grassland to woody vegetation since both natural and planted species have increased the amount of area each covers at the expense of grasses (McBride, 1983, pers. comm.).

The native species of the riparian strips still show the same distributions according to the different species' habitat requirements. Redwoods still occupy moister sites; madrones still are found on higher and drier ground. The factors which governed the location of certain species still favor one plant over another in a given microhabitat, but the restrictions on woody vegetation moving into grasslands have been reduced. Trees and shrubs have taken over former grass-covered areas with the species determined by environmental factors.

The area of Berkeley below the base of the hills is one of the few regions where the acreage covered by riparian vegetation has declined. The riparian vegetation decline in these spots is attributable to the culverting of the creeks and vegetation removal for development in the City of BErkeley. In these areas exotics and ornamental plants occupy areas not cemented over. In those few spots of the city where the creeks are not culverted or planted exclusively to ornamentals, the old native vegetation mingles with exotics (Figure 1b, 2b). Although native to the hill areas in the past, many of the species now found in the unculverted areas would not have occupied these areas in the past. For example, in the city areas where Codornices Creek is still unculverted (see map, p. viii), redwoods could not have existed so far down the hillside in the past when the creeks were seasonal, as they could not have attained sufficient moisture year-round. The redwood's presence, as well as the extension of other riparian species downslope at the present time is made possible by the continuous water availability in the creeks. Flow in the creeks throughout the year is now sustained by

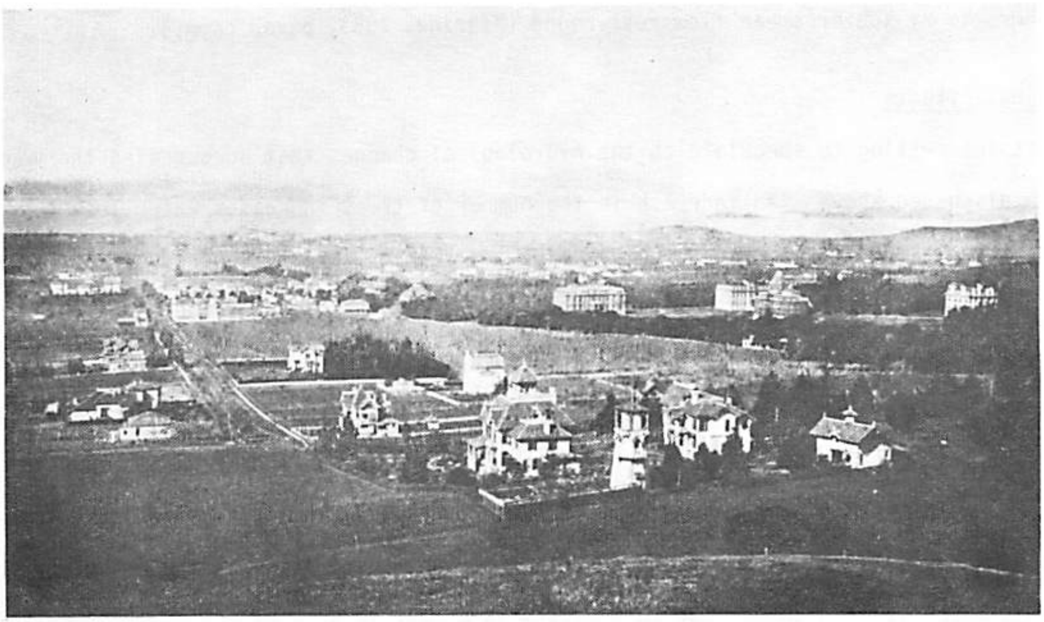

Figure 2a. Berkeley looking towards the west over the University Campus from the hills, ca. 1880. Note the patches of riparian vegetation along the lower creek margins.

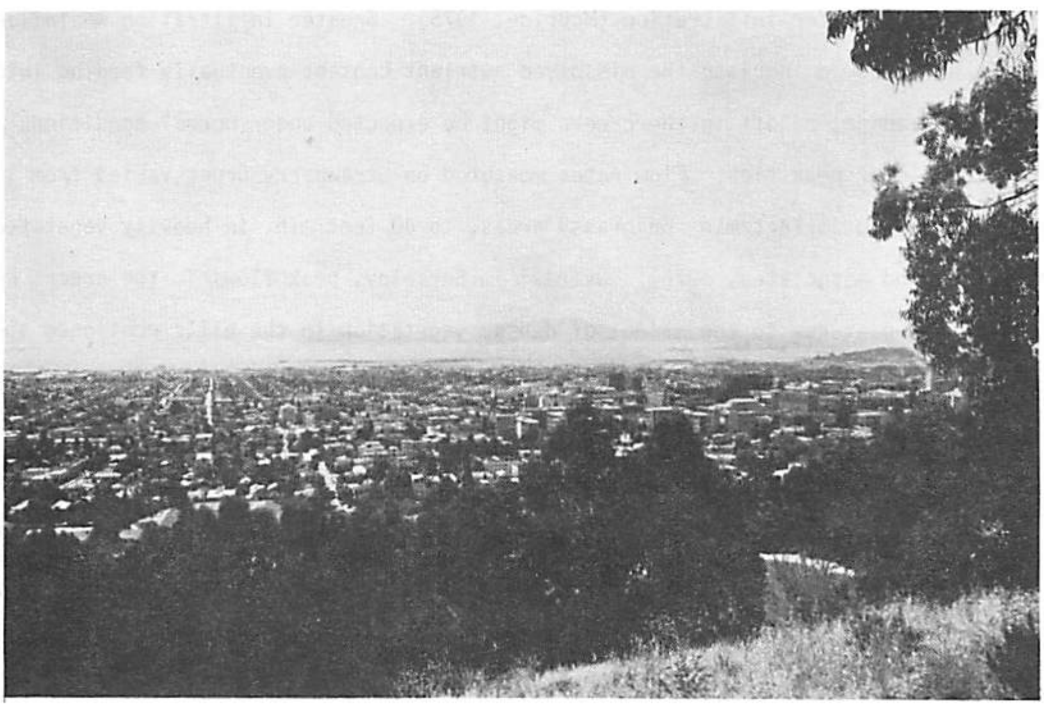

Figure 2b. Berkeley looking west towards the bay over the University Campus, 1983. Notice the extent of development in the city areas and the ornamental plantings in patches and along streets.

the increased runoff due to the greater amount of impervious surface that exists today; but more important to maintaining sustained flow in the creeks is lawn and garden watering, which feeds water into the creeks by subterranean flow year-round (McBride, 1983, pers. comm.).

Hydrological Effects

It is interesting to speculate on the hydrological changes that accompanied the vegetation alterations discussed above. An increase in the number of trees increases water losses due to evaporation but at the same time increases fog drip inputs. Denser forest also reduces soil evaporation through greater infiltration and deep seepage, lowered maximum ground temperatures and reduced wind speeds at the ground. The water not lost to evaporation from the canopy and soil surfaces is distributed between evapotranspiration and runoff (Kramer and Kozlowski, 1979). One might expect that the result of the replacement of grasses by higher growing vegetation is an increase in evapotranspiration, reducing the supply of groundwater that would otherwise find its way into the creeks. The presence of blue gum greatly increases the loss to evapotranspiration on the Orinda Formation and other areas where it is planted, but this effect is offset to some extent by the eucalyptus' contribution to fog drip.

At the ground surface, the denser vegetation of today also reduces erosion by protecting the surface from the impact of rainfall, by roots holding the soil particles together, and by reducing surface flow due to greater infiltration (McBride, 1975). Greater infiltration would lead to greater deep seepage, which would increase the dissolved nutrient content eventually feeding into the creeks. Because of deep seepage, runoff in the creeks might be expected under normal conditions to be more prolonged with a lower peak flow. Flow rates measured on Strawberry Creek varied from 100 feet/min in developed areas, to 75 feet/min on grassy areas, to 40 feet/min in heavily vegetated areas (Garrett, Eckbo, and Associates, 1976). Overall in Berkeley, peak flows in the creeks have increased from levels of the past due to the effect of denser vegetation in the hills mentioned above being offset by the development of impervious surfaces and roadcuts (McBride, 1983, pers. comm.). Greater peak flows endanger streamside vegetation because of increased channel and bank scouring, and the loss of streamside vegetation increases the water temperature of the creeks through the loss of the shading effect of riparian vegetation. The increase in water temperature also reduces the oxygen-holding capacity of the water (Kramer and Kozlowski, 1979). Increases in the amount of organic matter and sediment washed into the creeks may further reduce oxygen levels in the water through decomposition consumption.

Considering the complexity of the factors affecting the hydrology of Berkeley's creeks, any simple interpretation of the effects of vegetation change cannot be considered conclusive. Due to the interactions and offsetting nature of different factors, any conclusions about changes in water quality and quantity in the creeks should be verified by actual testing under controlled conditions.

REFERENCES CITED

1. Berkeley Advocate, December 1892. Special Holiday Edition, pp. 1-3.

2. Burchum, L.T., 1957. California Range Land: Sacramento, Division of Forestry, Department of Natural Resources, State of CAlifornia, 261pp.

3. Carlin, 1909. A Berkeley Year: Oakland, Fox Press, 112pp.

4. Clarke, William Carey, 1952. The Vegetation Cover of the San Francisco Bay Region in the Early Spanish Period: Berkeley A.B. thesis, 220pp.

5. Derrenbacher, William Ernst, 1966. Plants and Landscape: An Analysis of Ornamental Plantings in Four Berkeley Neighborhoods: Berkeley, M.A. thesis, 232pp.

6. Garrett, Eckbo, and Associates, 1976. Strawberry Canyon University of California, Berkeley: A Landuse and Vegetative Study: San Francisco, Office of Architects and Engineers, 65pp.

7. Kramer, Paul J. and Theodore T. Kozlowski, 1979. Physiology of Woody Plants: New York, Academic Press, 811pp.

8. McBride, Joe Rayl, 1969. Plant Succession in the Berkeley Hills: Berkeley, Ph.D. thesis, 73pp.

9. _____, 1975. Readings in Ecological Analysis: Evaluation of Vegetation in Environmental Planning: Berkeley, Department of Landscape Architecture, 40pp.

10. _____, Professor of Forestry, University of California, Berkeley. Personal communication, February 28, 1983.

11. Stine, Scott, Lecturer in Geography, University of California, Berkeley. Personal communication, May 1983.

12. Sutliff, Albert, 1881. A Description of the Town of Berkeley: San Francisco, Bacon and Co., 24pp.

13. Workers of the Writers' Program of the Work Projects Administration, 1941. Berkeley: The First Seventy-Five Years: Berkeley, Gillick Press, 159pp.