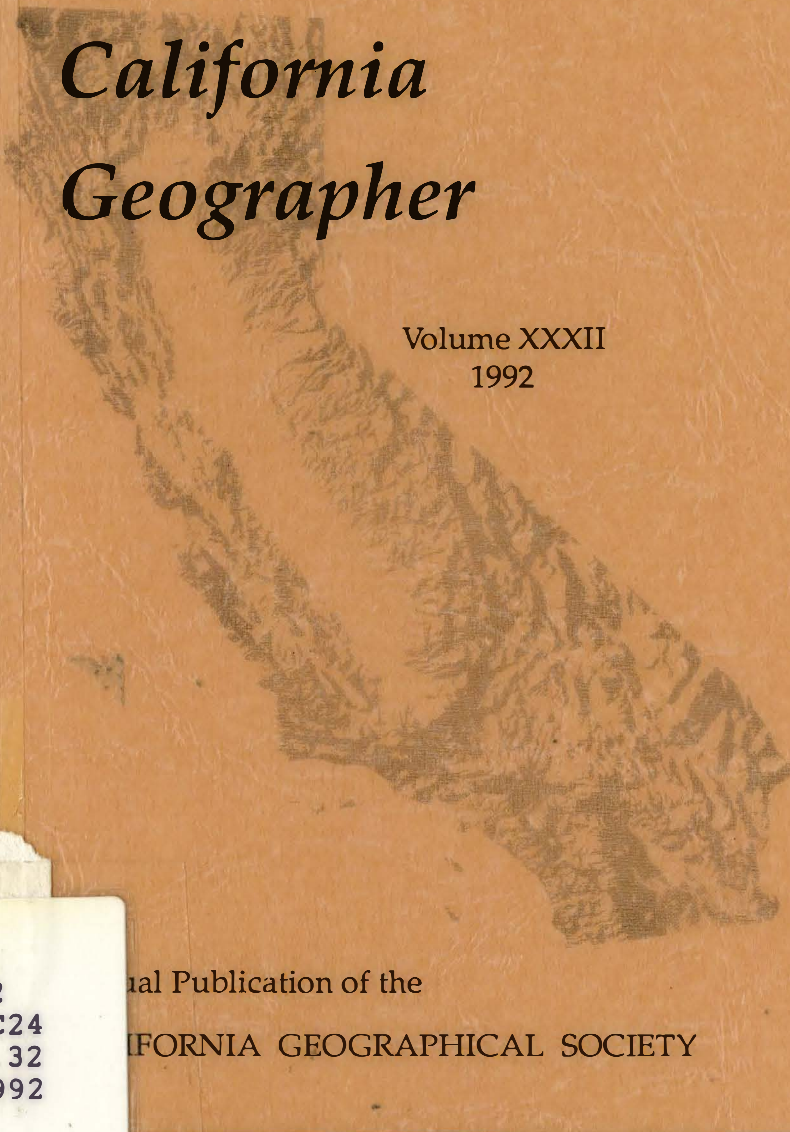
The California Geographer



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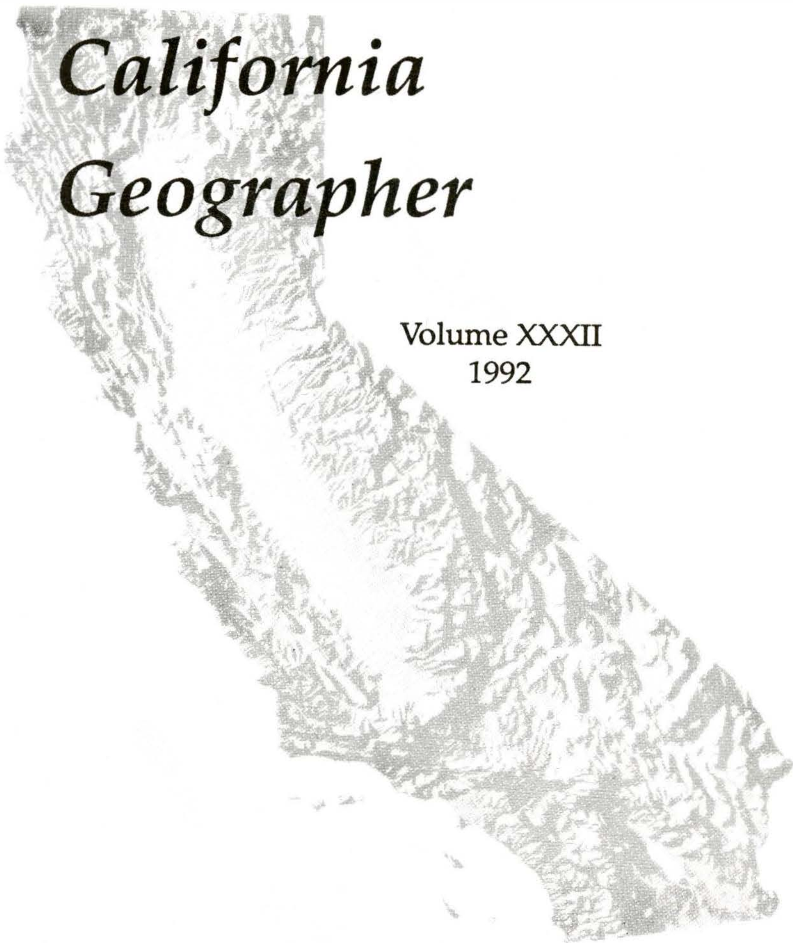

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Submit three copies of manuscripts, type-written and double-spaced. Manuscripts also submitted on disk are preferred, either as an ASCII file, or in most commonly used word processing programs. Manuscripts should conform to the general guidelines published each year in the March issue of the *Annals of the Association of American Geographers*. All photographs, diagrams, and maps should be numbered as figures and must be camera-ready. Graphics should be no more than seven by four and a half inches. Submission of a manuscript without supporting graphical materials will delay the reviewing process.

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CALIFORNIA GEOGRAPHICAL SOCIETY
Vol. XXXII, 1992

LANDFILL SITING AND ABANDONED COAL MINES IN CONTRA COSTA COUNTY, CALIFORNIA

Martin Mitchell

Historical geography and its methodology can on occasion contribute to the solution of contemporary problems. Colten has recently identified nineteenth and early twentieth century hazardous waste sites for the state of Illinois to supplement the implementation of the Resource Conservation and Recovery Act (RCRA) passed by the Congress in 1976 (Colten 1988). The recent efforts of California's Contra Costa County to solve its solid waste disposal problem provide another excellent illustration of the potential for historical geography. In this case, the proposal to locate a landfill near an area of abandoned coal mines raised a number of critical environmental issues, such as the threat of the abandoned workings serving as conduits for leachate and methane should the landfill's control systems fail, thus possibly impacting adjacent properties. Although this particular landfill site was ultimately not selected, the research described demonstrated the compatibility of the proposed land fill and the historic mining sites. It also brought to light many details of a little known facet of early resource utilization in California, namely, coal production in an era of industrialization based on steam power.

Contra Costa County, located in the eastern portion of the San Francisco Bay Area, recognized the need to increase landfill capacity for non-hazardous solid wastes because existing facilities will reach capacity in the early 1990s (Central Contra Costa County Sanitary District 1985). Consequently, the East Contra Costa Sanitary Landfill was to be sited in the canyon lands of Stewartville Ridge located along the north side of Mt. Diablo about six miles south of Antioch (Figure 1). The proposed project encompassed 850 acres, of which 330 acres were to be filled with 71 million cubic yards over an anticipated 40 year period

Mr. Mitchell is a doctoral candidate in the Department of Geography at the University of Illinois at Urbana-Champaign.

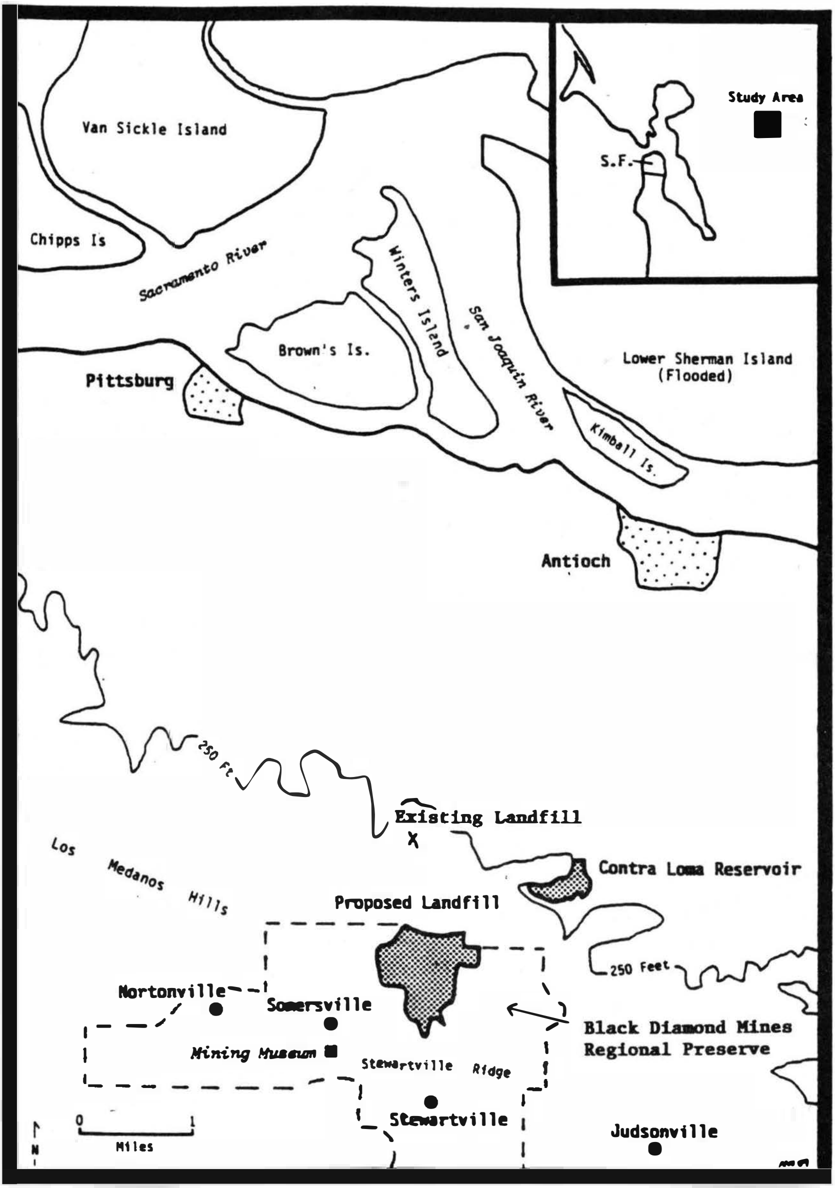

Figure 1. Location of the Proposed East Contra Costa Sanitary Landfill

filled with 71 million cubic yards over an anticipated 40 year period (Contra Costa County 1986). The site possessed four distinct advantages: (1) as an upland, a Dredge and Fill Permit under Section 404 of the Clean Water Act would not be required because it was located outside the jurisdiction of the US Army Corps of Engineers;* (2) proximity to a controlled access highway (SR 4) facilitated connections to the eastern, central, and western sections of the county; (3) the mouth of the canyon faced northeasterly, away from the residential sprawl of a growing Antioch; and (4) an existing landfill under the same ownership, albeit a much smaller facility, is located 0.5 miles north of the proposed site.

The landfill site is flanked to the west, south, and east by park land, the Black Diamond Mines Regional Preserve, and to the northeast by Contra Loma Reservoir. The Regional Preserve, which includes the abandoned townsites of Stewartville and Somersville, was created in 1974 and owes its origin to nineteenth century coal mining. Currently, the park emphasizes open space activities such as hiking, picnicking and horseback riding upon a landscape that abounds with relicts from the old coal mining days. Abandoned mines, railroads, townsites, and an old cemetery are among its attractions. The nearby Contra Loma Reservoir provides a reserve drinking water supply for the Contra Costa Water District and is a regional park.

The East Bay Regional Park District and the Contra Costa Water District were concerned that abandoned mine tunnels could underlie the proposed landfill, thus providing conduits for the movement of landfill gases or leachates into the reservoir or into the park district's Underground Mining Museum, located about three quarters of a mile southwest of the proposed landfill (Contra Costa County 1987). The park district was especially concerned about tunnels resulting from coal production during the late 1890's. The underground workings at Somersville (near the museum) and Stewartville (closest to the landfill site) were of prime importance. The mines of Judsonville and Nortonville were too far away to affect the landfill site.

The objectives of this study were therefore to reconstruct the positions of the mine workings relative to the landfill's location and to reconstruct the economic and operating scenarios, with particular emphasis on the late 1890's.

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* Attempts by another landfill operator (Acme Fill Inc.) to expand an existing landfill in Martinez located in jurisdictional wetlands was denied by the US Army Corps of Engineers in 1984. The message to industry and local government was clear: no future landfills in wetlands.

Methodology

The data base consisted of USGS quadrangles, California State Mining Bureau Mineralogist's Reports, Contra Costa County documents, academic and trade journals, and field observations. Mine entrance locations, the length and direction of slopes, shafts, adits, and gangways are described in detail in the State Mineralogist's Reports. These data were plotted on a series of scaled cross-sectional diagrams, and compared with the landfill's proposed location. The economic and operating scenarios were gleaned from the same sources with particular emphasis being placed on sources contemporaneous with the mining activity.

Location of Workings

Coal was originally discovered in this area by rancher William Israel in 1859 (*Mining and Scientific Press* 1876). The coal is part of the 800-foot thick Domengine Formation, composed of sandstone, slate, shale and coal. The Domengine was formed during the middle Eocene when the area was marked by marshlands and low lying topography (Contra Costa County 1986). The subsequent uplift of Mt. Diablo resulted in an outcrop of coal that is manifested as a gentle arc trending east-west across the northern reaches of Mt. Diablo. The dip ranges from 25° to 32°, flattening towards the San Joaquin River to the north (Mineralogist 1888; Mineralogist 1894). The topography today consists of steep uplands covered with annual grasses with chaparral and oak woodland on north facing slopes. The area is also the northern limit of the Coulter Pine (Waters 1978).

The coal is sub-bituminous (lignite) and occurs in four distinct layers, known as the Clark, Little, Belshaw, and Black Diamond veins, that are stratigraphically 400 feet apart from top to bottom. (Although technically the term "vein" applies to metallic ores and not sedimentary deposits, "vein" rather than "seam" is customarily applied to the deposits on Mt. Diablo.) The uppermost (Clark) and the lowermost (Black Diamond) veins, typically three to five feet thick (excluding bone), constituted the primary commercial beds. The intervening seams were of variable thickness, and mined occasionally (Contra Costa County 1986; Mineralogist 1920).

The proposed landfill site is on the north side of Stewartville Ridge approximately 0.65 miles from the Somersville mines (Mineralogist 1888). The Clark vein (uppermost) intersects the southern border of the landfill at an elevation of roughly 250 feet, about 600 feet below the surface.

Somersville Complex. Mining began in the early and middle 1860's by the Eureka, Manhattan, Union, Independent, and Pittsburg mining companies (Figure 2). In general, the mines had 30° entrance slopes that trended southward (away from the landfill site) until the targeted coal vein was struck. Subsequently a counterslope following the seam's dip was extended both up and down dip. The latter was towards the landfill. Water infiltration in the mines, a problem below about 350 feet elevation, and the inability to provide adequate ventilation, limited mining depths to about 335 to 325 feet elevation.

The Independent Mine was the only exception. The Clark vein was accessed by means of a 710 foot shaft which placed the bottom at elevation 9 feet. The lower 24 feet constituted a sump for drainage purposes. An adit (near horizontal tunnel) was then driven 420 feet south until striking the Clark vein. Extractions proceeded updip because water infiltration, which the Mineralogist described as being "a large stream", inhibited operations at lower depths (Mineralogist 1888). The pumping costs, coupled with the 710-foot lift to the surface, prevented profitable operations.

The Mineralogist ridiculed the Independent Mine's situation, stating that simple measurements and computations "would have served them well" because the locations of outcrops and dip angles were already known (Mineralogist 1888). The company went bankrupt, and by 1873 was controlled by the Pittsburg Mine Company which also bought out the Eureka, Manhattan, and Union Mines, and by 1876 was the dominant operator in Somersville (Figure 3) (Contra Costa County 1873).

The Pittsburg Mine consisted of workings stemming from the Pittsburg Slope, Rankin Shaft, Davis Slope, and the Little Slope (Figure 2). Based on examination of the State Mineralogist Reports, the eastern portion of Pittsburg's property was worked from gangways emanating from the Pittsburg Slope/Rankin Shaft complex. Other entrances, both from Pittsburg's original property and its acquisitions, which accessed workings located either in the western and/or central portions of the property are of no concern to this study, because they were directed away from the proposed landfill.

The Pittsburg/Rankin gangways extended laterally into the eastern portions of the Pittsburg Company's land. The Mineralogist stated that the first gangway ran "both ways on the bed [Clark vein] through the property". The report also noted that this uppermost gangway crossed a fault with a 150-foot upthrow 900 feet east of its origin, and then pro-

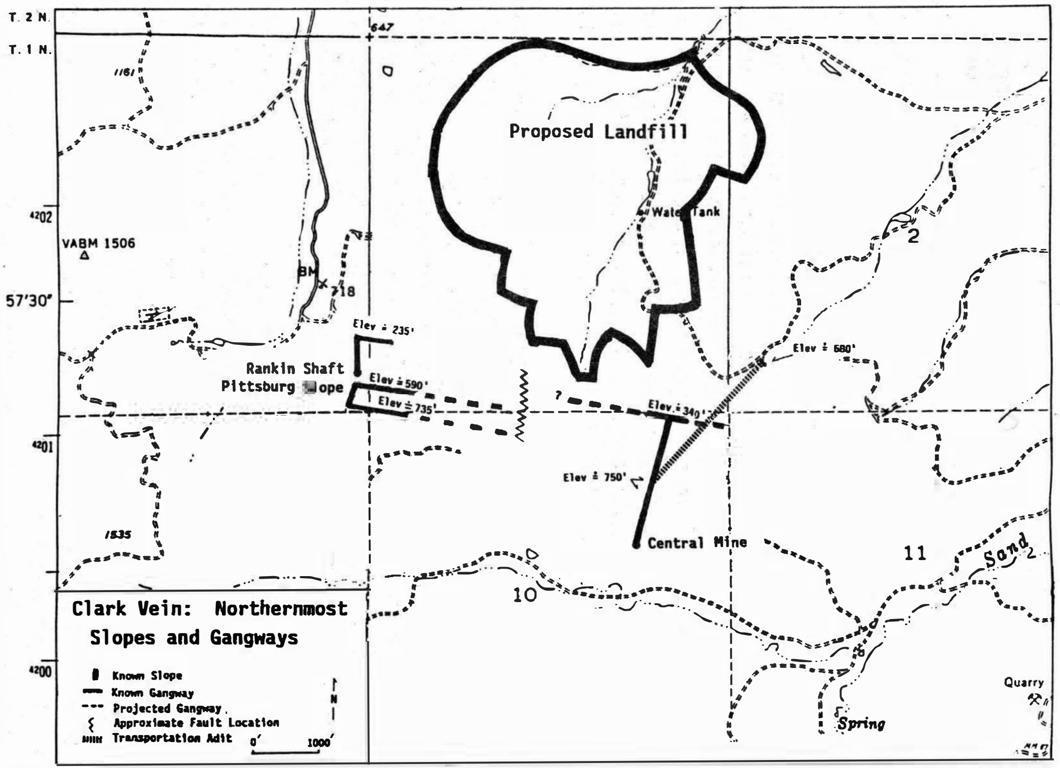


Figure 2 (Sources: State Mineralogist 1888, 1892, 1894, and 1896)

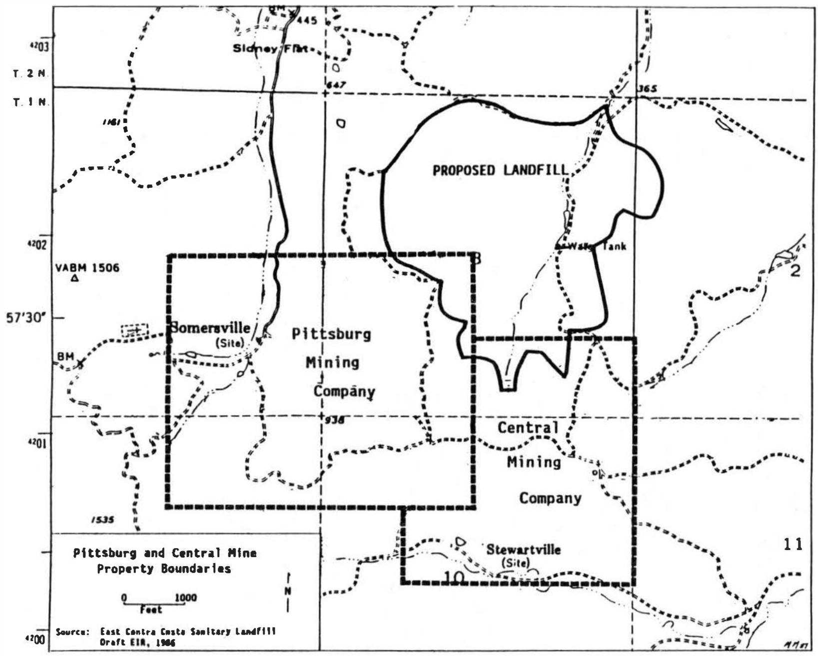


Figure 3

ceeded until it encountered another fault with an upthrow of "not less than 300 feet" (Figure 4) (Mineralogist 1888). The Mineralogist did not mention any further crossing of this fault on any of Pittsburg's gangways, nor any connection to the workings of the Central Mine, its neighbor immediately to the east (intermine connections were commonly reported). Subsequent Mineralogist Reports in 1890, 1893, 1894, and 1896 made no mention of an eastern crossing of this 300-foot upthrow.

The 600-foot deep Rankin Shaft was constructed between 1889 and 1891 at a point 100 feet north of the Pittsburg Slope's hoisting works to access the Clark and Little veins from the south (Mineralogist 1893). Starting at the bottom at elevation 235 feet, a tunnel was driven 600 feet north to the Clark vein from which a gangway was driven 500 feet east (Figures 4 and 5) (Mineralogist 1896). Later in 1896, the Mineralogist said "though great amounts of coal have been mined from this bed in old workings above water level (elevation 350 feet) there exists a vast amount of coal yet to be obtained in the eastern portion of the property" (Mineralogist 1896).

There are no direct statements indicating that diggings extended well into the company's eastern holdings (toward the landfill site) and the

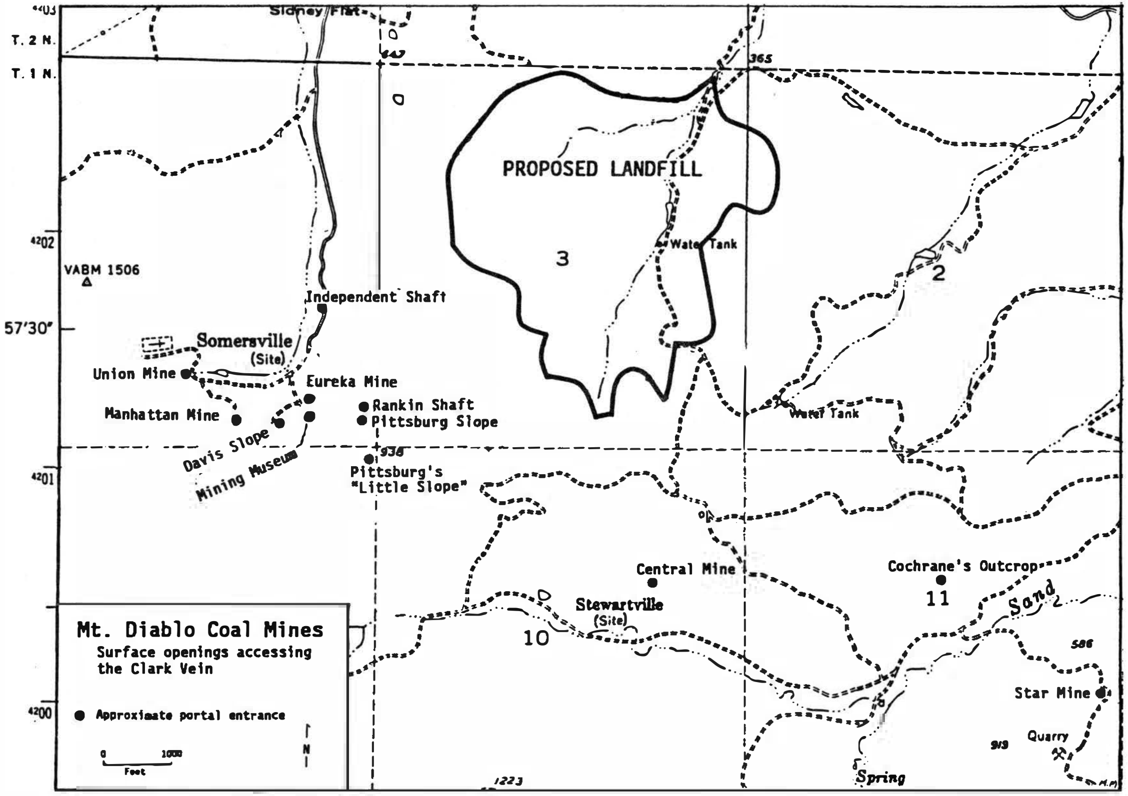


Figure 4. (Sources: State Mineralogist 1888, 1894, and 1896)

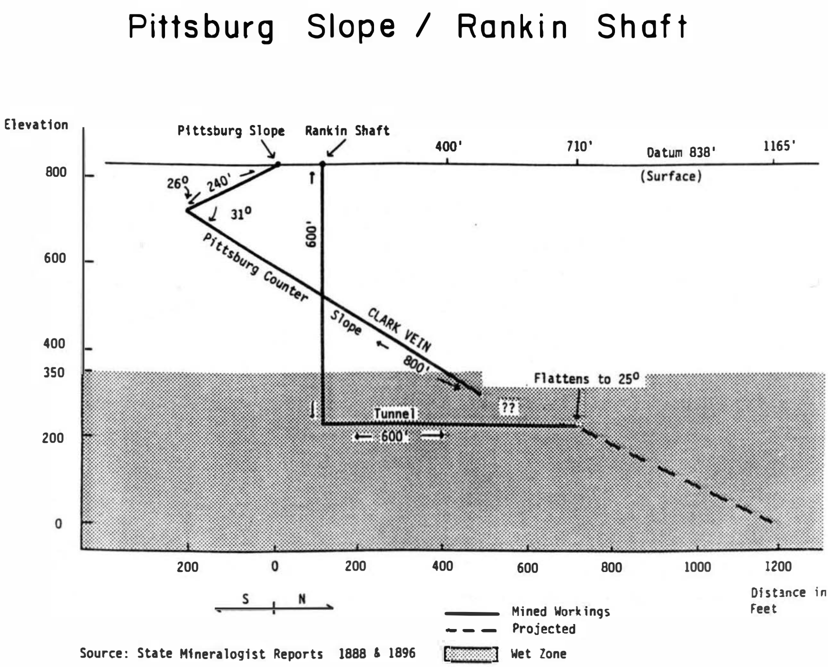


Figure 5

available evidence suggests they did not. The Mineralogist indicated that work was mainly concentrated in the central and western portions of the property, and that some of the workings mined the deeper Black Diamond vein (Mineralogist 1893; 1894; 1896). In 1893 it was stated that there were, for example, roughly 200 acres of untouched coal in the central and western parts of the claim (Mineralogist 1896). It should be noted that the 300-foot upthrow was located in the eastern part of the property and the "untouched coal" to the west could be accessed from existing workings secured by the company's previous acquisitions. It is most likely that there was no later expansion to the east.

Stewartville Complex. Mining at Stewartville largely focussed on the holdings of the Central Mining Company, which operated from 1867 to 1898 (Figure 3). The adjacent Cochrane and Star Mines were short lived shallow operations that were generally directed away from the landfill site (Figure 2) (Mineralogist 1893; 1894; 1896). The Central Mine initially worked the Black Diamond vein, but quickly abandoned it due to poor quality coal. An adit was subsequently driven 1030 feet north to the

Clark vein from a new south portal at Stewartville and gangways were then driven 375 feet west and 275 feet east (Figure 6). The adit was extended through the ridge in 1870 (Mineralogist 1888). This new outlet shortened cartage by nearly two miles, and was used until a railroad spur was built from Judsonville in 1881 (Sullivan and Waters 1980).

Meanwhile, the coal was worked updip 450 feet, whereas the total distance to the outcrop was stated at 700 feet (Mineralogist 1888). A 900 foot slope was later extended down the dip of the Clark vein and by 1894 "the entire coal was extracted" (Mineralogist 1894). A tunnel was driven 218 feet south from the bottom of the 900 foot slope to the Little vein, but was abandoned due to water infiltration (150 cu.ft./hr.) and poor ventilation. The Central Mine also opened a 1200-foot slope along the Black Diamond vein in the early 1890's, from which tunnels were extended to work the Belshaw vein (Figure 6) (Mineralogist 1894). The Central Mine was worked heavily from "top to bottom" along all four veins, but lateral extensions were not reported beyond 375 feet east or west of the main adit.

Ventilation problems in the lower workings were dealt with by means of driving four foot square ventilator shafts at 55° angles to the surface. A possible ventilator shaft was identified at the landfill site's southern border and subsequently confirmed by excavation (S and J Investments 1987).

Production for the period 1867-1876 was never large at the Central Mine, especially when compared with some of the other mines (Table 1).

Table 1.
Total Production at Various Mines 1867-1876
(tons)

Central Mine	61,000
Eureka Mine	93,000
Pittsburg Mine	277,000
Union Mine	225,000

Data presented in the text does not include production used for on-site boilers which for the Somersville and Stewartville mines collectively averaged between 12,000 and 16,000 tons per year.

(Mineralogist 1888)

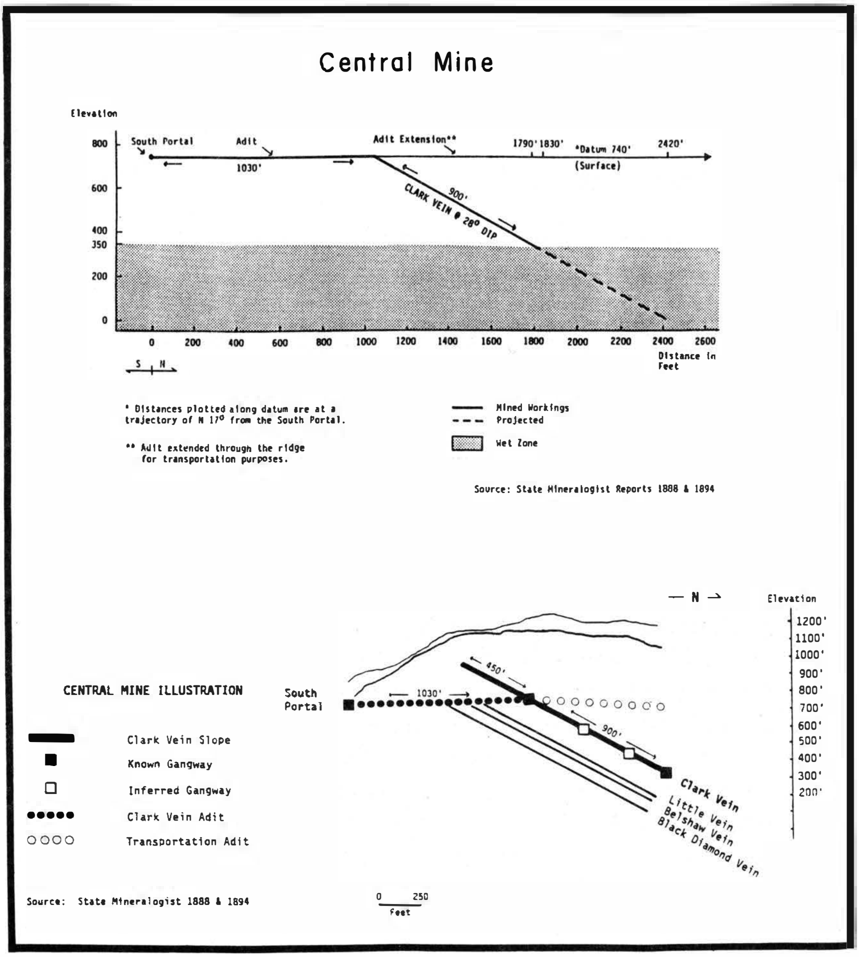

Central Mine
Elevation
800
600
400
350
200
0
South Portal
Adit
1030'
Adit Extension**
1790' 1830'
*Datum 740'
(Surface)
2420'
900'
CLARK VEIN @ 28° DIP
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
Distance in Feet
S N
* Distances plotted along datum are at a trajectory of N 17° from the South Portal.
** Adit extended through the ridge for transportation purposes.
Mined Workings
Projected
Wet Zone
Source: State Mineralogist Reports 1888 & 1894
N
Elevation
1200'
1100'
1000'
900'
800'
700'
600'
500'
400'
300'
200'
CENTRAL MINE ILLUSTRATION
South Portal
1030'
450'
900'
Clark Vein
Little Vein
Belshaw Vein
Black Diamond Vein
Clark Vein Slope
Known Gangway
Inferred Gangway
Clark Vein Adit
Transportation Adit
Source: State Mineralogist 1888 & 1894
0 250
Feet

Figure 6.

In 1876 the Central Mine stopped work on a regular basis, but experienced spasmodic production for the next twenty-two years. Although about 1,000 tons per month were produced in 1889, the mine was reported as idle in 1890 (Mineralogist 1890a; 1890b).

The Central Mine was in operation again in 1894, but production from it and the adjacent Star Mine (located about one mile southeast of Central) was reported at 3,000 tons per month (Mineralogist 1894). The workings were on the Belshaw and Black Diamond veins. The Central Mine finally closed in 1898 (Sullivan and Waters 1980).

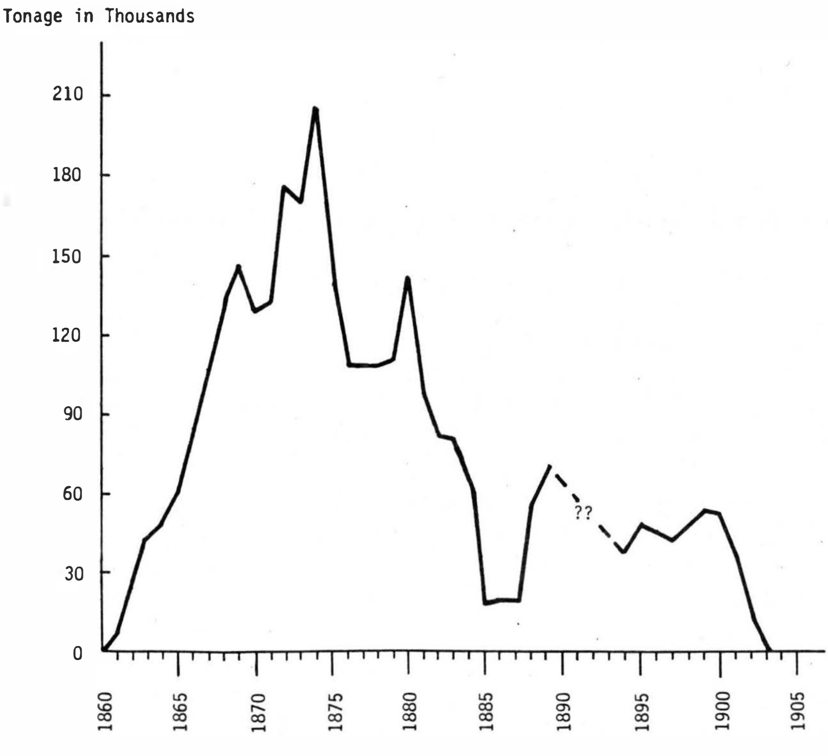
Operational Context: 1860-1902

Mining commenced in the early 1860's and by the end of the decade supported towns such as Somersville and Stewartville. Industrial expansion in nearby San Francisco prompted a demand for coal, the main energy source during the era of the steam engine. The Mt. Diablo coal, although poor in quality, was nonetheless accessible and close to market. Consequently, production throughout the Mt. Diablo district intensified during the 1860's and early 1870's, peaking in 1874, with an output of approximately 206,000 tons (Figure 7). Subsequently production dropped rapidly and never recovered to the levels of the early 1870's. This decline of production resulted from the availability of high quality and relatively cheap imported coal and high mining costs due to water infiltration problems in the deeper workings.

The availability of inexpensive high quality coal from abroad was due to the attractiveness of California wheat to foreign markets. Inbound ships could carry Welsh or Australian coal rather than a full or partial load of ballast and depart California fully loaded with wheat (*Mining and Scientific Press* 1876; 1891). Qualitative tests conducted in the 1870's by San Francisco's Spring Valley Water Company revealed that 100 pounds of Mt. Diablo coal provided between 23,600,000 and 26,333,000 foot pounds of energy whereas 100 pounds of coal from Wales, Australia or British Columbia ranged from 34,000,000 to 40,000,000 foot pounds, per hundredweight. Even Washington coal, which averaged 29,000,000 foot pounds per hundredweight, was better than the local coal (Mineralogist 1888).

Water infiltration became problematic in the Mt. Diablo mines below elevation 350 feet (Table 2) (Mineralogist 1894; 1920). Operators employed pumps, but the costs incurred precluded profitable workings much below the watermark of 350 feet. The Pittsburg Mine (Rankin Shaft) and the Central Mine had their lowest profitable workings at elevations 235 feet and 340 feet respectively. Only the Independent Mine,

Mt. Diablo Coal District
Annual Coal Production
1860 - 1905



Although 67 tons were removed in 1914
from Nortonville, 20th Century
production esentially ceased in 1902

?? Data Missing: 1890-1893

Figure 7.
(Sources: State Mineralogist 1888, 1894, and 1927)

Table 2.
Infiltration Rates (Selected Mines)
(gals./day)

Davis Slope (elev. 590')	3,590
Star Mine (elev. 340')	17,952
Central Mine (elev. 340')	26,928

Infiltration rates for the Pittsburg Slope and the Rankin Shaft were not reported. The Mineralogist noted, however, that a 500 gallon tank and a steam powered hoist were used to drain the Rankin Shaft.

(Mineralogist 1894; 1896)

which went bankrupt, attempted to operate at elevations well below the water level, between elevations 9 feet to about 275 feet.

When the watermark and sea level contours of the uppermost Clark vein were plotted relative to the position of the proposed landfill, it became clear that a major network of mine workings is not likely to be under the landfill site (Figure 8). Mineralogists' records place the lowest workings on the Central Mine at 340 feet whereas the Clark vein is at about sea level at the southern fringe of the landfill site.

Although the Mt. Diablo Mining District from 1875 to 1902 was characterized by declining production, consolidation of land holdings, and intermittent operations, there were occasional rises in output (Figure 7). These increases often coincided with strikes in mines abroad or in Washington Territory. For example, labor problems in Australia and British Columbia during 1890 caused coal prices in San Francisco to rise over thirty per cent (*Mining and Scientific Press* 1891).

The *Mining and Scientific Press* reported during the Spanish-American War in 1898 that the British declared coal contraband. Meanwhile, the U.S. Navy awarded contracts which fostered short-term investment in coal lands along the Pacific Coast (*Mining and Scientific Press* 1898). This situation probably influenced a short-lived production increase at the Pittsburg Mine around the turn of the century. Production from 1898 to its 1902 closure was 210,000 tons, the equivalent to about seventy per cent of the company's production at the height of the Mt. Diablo coal boom between 1872 and 1876. This surge was responsible for an attempt to re-open the Independent Shaft, but the pro-

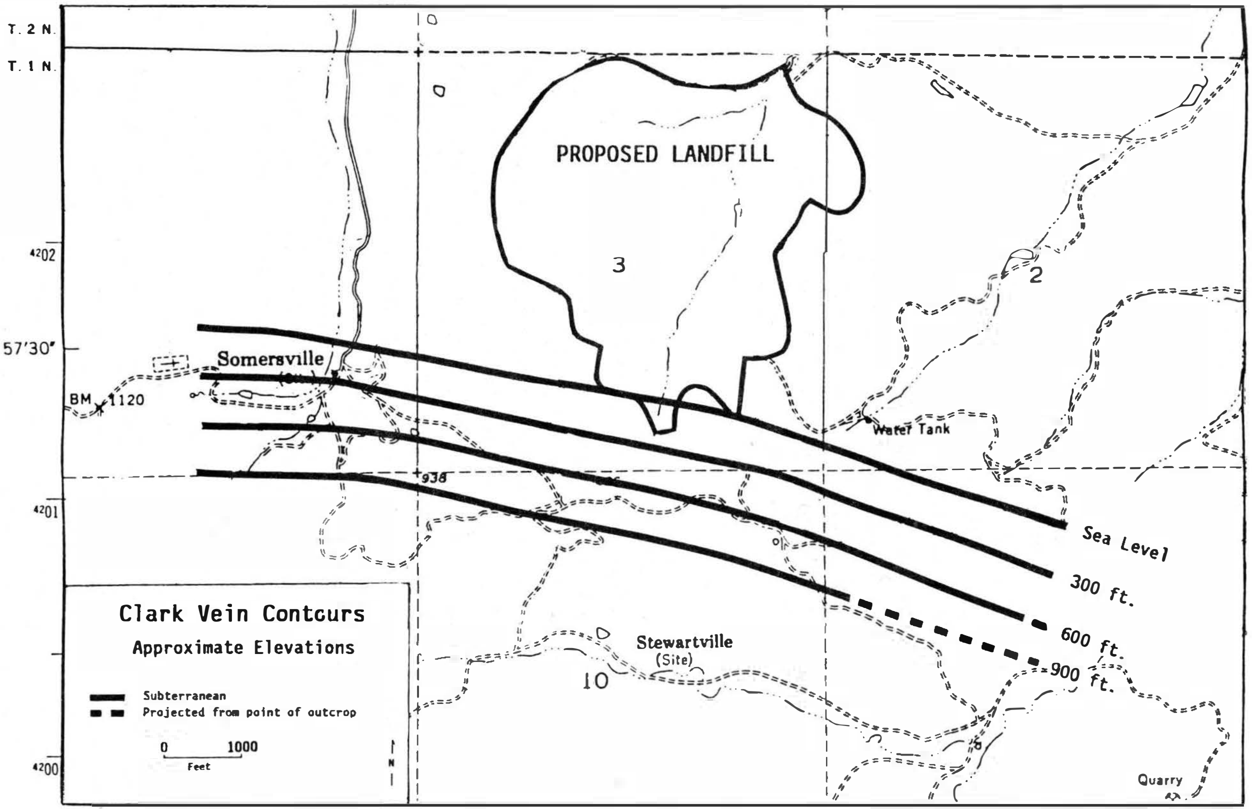


Figure 8. (Sources: State Mineralogist 1888, 1892, 1894, and 1896; and Contra Costa County Community Development Department 1987)

ject was abandoned on account of heavy pumping costs (East Bay Regional Park District 1987). The consolidation of holdings, especially in Somersville, no doubt allowed the Pittsburg Mine to maximize economies of scale in deploying its capital assets. An effect of this situation was the opening of the Davis Slope and the Rankin Shaft in the early 1890's and the abortive attempt to re-open the Independent Shaft in 1901. Despite these last minute attempts, the Pittsburg Company never fully returned to its peak operation level of the 1870's. The company became the Mt. Diablo coal mining district's last survivor until it closed in 1902. An era had come to a close.

Although the decline in coal mining was attributable to better quality imports and increased local production costs, a final factor in closing the Mt. Diablo mines was the development of oil produced in California. Oil priced at $1.40 per barrel could deliver the same amount of energy for $4.66 as a ton of coal priced at $7.50. The *Mining and Scientific Press* in 1900 concluded the yield of California oil would be "enormous in the not too distant future," a prediction that was indeed realized.

Conclusion

A network of underground mine tunnels did not underlie the proposed landfill site. Indeed, the only probably infringement of past mining activities on the site was the instance of old ventilation shafts along the southern portions of the proposed landfill, a situation that could be mitigated easily through the use of concrete plugs or restricting the ultimate fill elevation. This area was not mined because operations in the late 1800's were hindered by the high cost of extraction below elevation 350 feet due to water infiltration and the difficulty of providing adequate ventilation. Meanwhile, the ability to import large quantities of higher quality coal both from abroad and from Washington nullified the only advantages of Mt. Diablo coal, proximity to market and lack of competition. Finally, the advent of oil as an energy source eliminated the market factors that had sustained operations during the Mt. Diablo District's later years.

As for the proposed landfill, the County Board of Supervisors eventually failed to approve the landuse entitlements due to a complex set of political circumstances which are well beyond the scope of this paper, but would provide fertile ground for a study on local government decision making. However, the coal mining problem exemplifies how the geographical approach can be used to determine whether a past landscape constitutes a significant impact on a present day endeavor. This situation is important because since 1972 the California Environmental Quality Act (CEQA) has demanded that significant environmental impacts, associated with privately funded projects requiring a permit from a regulatory agency, be identified and mitigated to less than significant levels during the discretionary review process (Friends of Mammoth vs. Board of Supervisors of Mono County 1972; State of California 1986a; 1986b). In this case, the locational reconstruction of past mining activities and an examination of the economic, technological and physical factors that promoted or constrained production found that the past landscape, though a legitimate concern, did not pose a significant environmental impact to the present day landfill proposal.

Acknowledgements

Much gratitude is extended to Mr. Charles Zahn (BS Geography, University of Wisconsin, a principal planner for the Contra Costa County Community Development Department) for his support in pursuing the facts to the problem. I would also extend thanks to Dr. John Thompson (University of Illinois) for his advice on preparing the manuscript and Dr. David Lantis (CSU Chico) for reading an earlier version of this paper at the 1989 APCG meeting in Fairbanks, Alaska.

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GEOMORPHOLOGY OF PIEDMONT VERNAL POOL BASINS, CALIFORNIA

Guy King

Vernal pools are small, shallow hardpan-floored depressions in valley grassland environments that fill with water during the winter (Holland and Jain 1977). These ephemeral lakes are unique biological islands with communities containing over 200 plant species including rare and endangered species (Holland and Jain 1981; Holland 1978). Vernal pools occur under mediterranean climatic regimes in California, southern Oregon, the Baja Peninsula of Mexico, South Africa, and Chile (Thorne 1984). California's vernal pools occur within and on the flanks of the Great Valley, the lowlands of the Transverse and Coast Ranges, the coastal plateaus of southern California, and the Modoc Plateau of northeastern California (Jokerst 1990; Lathrop and Thorne 1976).

A widespread area of vernal pool occurrence in California is along the piedmont between the floodplain of the Sacramento-San Joaquin River System and the Sierra Nevada-Cascade Mountains (Holland and Griggs 1976). Piedmont vernal pools occur on alluvial fan, volcanic mudflow, and lava deposits (e.g., Jokerst 1990; Jokerst 1983; Schlising and Sanders 1983). The most common piedmont vernal pool environment is developed on early to mid-Pleistocene alluvial fan deposits, which are referred to by many workers as "terrace soil" pool environments. Piedmont vernal pools on the "terrace soils," including those of the study area, have been studied by various workers (e.g., Holland and Dains 1990; McDonald 1976).

This purpose of this study is to examine the nature and origin of the depressions that piedmont vernal pools occupy. This study is important for two reasons. The first is that this research adds to the general body of knowledge about vernal pools. California's vernal pools have re-

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ceived considerable scientific attention because of their ecological uniqueness and concern over their increasing destruction, mostly due to urbanization. However, the majority of research that has been done on vernal pools has been biologically oriented. Very little research has been done on vernal pools as landforms.

The second reason the results of this study are important concerns the geomorphology of lake basins in general (e.g., Harding 1942, Hinds 1943, Selby 1985). Piedmont vernal pools are a type of small, shallow lake basin. They can be geomorphically compared to other areas of small lakes such as playas in deserts and savannas (Goudie 1991). This study of piedmont vernal pools adds to the existing body of literature on the geomorphology of lake basins.

This paper is divided into four parts. The first part covers the physical geography of piedmont vernal pools of the study area. The second describes the overall morphometry of the pool basins. The third part covers the morphology of the pools. The last part of this study examines the various theories for the origin of piedmont vernal pools.

Study Area

The Vina Plains Preserve area, located in Tehama County between Chico and Red Bluff, was selected for this study because it is representative of piedmont vernal pool environments (Figure 1). The Preserve consists of two tracts: the larger Main Unit and the smaller Wurlitzer Unit. The Main Unit's vernal pools are studied in this paper (Figure 2). The Main Unit is a 619 hectares tract purchased by The Nature Conservancy in 1982 (Vina Plains Docent Committee 1988). It is an area consisting of four fenced pastures that are no longer grazed by cattle. The Main Unit of the Vina Plains Preserve is part of The Nature Conservancy's California Critical Areas Program which was set up to protect 8900 hectares of eleven most threatened ecosystems in the State.

The general terrain of the Vina Plains Preserve area consists of a dissected alluvial fan apron produced by Deer Creek which flows out of the Cascade Range about seven kilometers north of the Preserve. This alluvial apron is of low to moderate relief with elevations that begin at approximately 60 meters above sea level on the floodplain of the Sacramento River and rise up to about 130 meters above sea level at the base of the Cascade Range. Geologically, the area consists of alluvial fan deposits which have been mapped as fanglomerate or the Red Bluff Formation (Olmstead and Davis 1961; Burnett et al. 1969; Harwood et al. 1981). These deposits are composed of material eroded from the adjacent upslope Tuscan Formation and consist of cobble and boulder sized

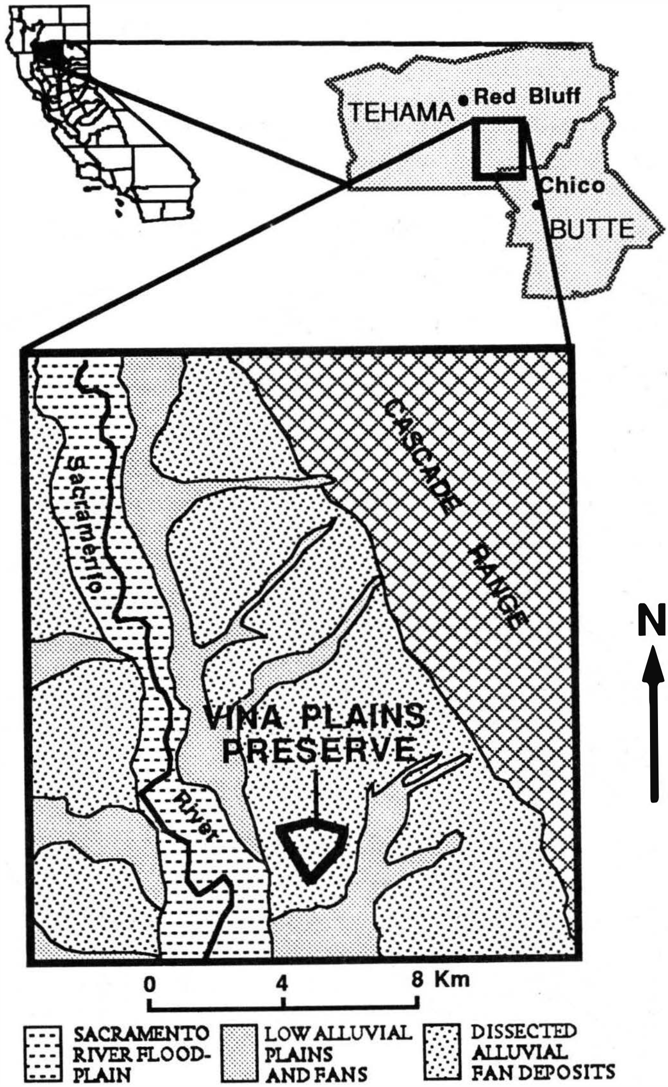


Figure 1. Major Landform Units of the Vina Plains Area

Source: F. H. Olmsted and G. H. Davis, 1961, *Geologic Features and Ground-Water Storage Capacity of the Sacramento Valley, California,* U. S. Geological Survey Water Supply Paper 1497.

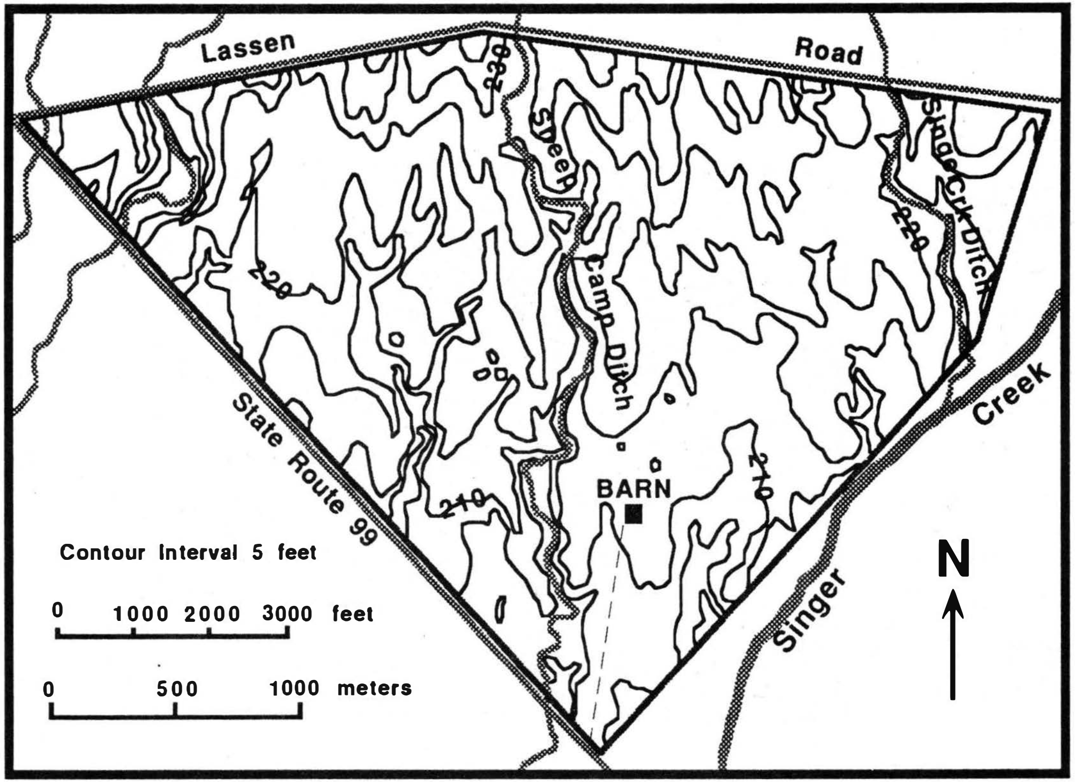


Figure 2. Topography of Vina Plains Preserve Main Unit

andesite rocks in a sand, silt, and clay matrix. Age of the alluvial fan deposits is estimated to be early to mid-Pleistocene.

The highly weathered soils of the Vina Plains Preserve reflect the geological antiquity of their parent material (U.S. Department of Agriculture 1967). Tuscan Series soils are found in upland areas between stream channels and vernal pool basins. They make up most of the soils found on the Preserve. The Tuscan Series are reddish-brown cobbly loams with clay hardpans at a depth at less than 76 centimeters. The hardpan is exposed at the surface in scattered areas of the Preserve. Anita Series soils are the other major soil type found on the Vina Plains Preserve. They are found in poorly drained areas such as vernal pool basins. The Anita Series consists of dark gray clayey soils with a hardpan that can be as deep as 90 centimeters. When dry, Anita soils form deep desiccation cracks extending from the surface down as far as the hardpan layer.

The climate of the Vina Plains area is a mediterranean regime. Red Bluff's average annual temperature is 17.5° Centigrade, while its average annual precipitation is 560 millimeters. Red Bluff has a July average temperature of 28.7° Centigrade and precipitation of 1.02 millimeters, while in January its average temperature is 7.5° Centigrade. and precipitation is 109 millimeters (National Oceanic and Atmospheric Administration 1974).

The biotic community of the Vina Plains Preserve consists of grassland, intermittent stream, and vernal pool environments with a total of 287 identified plant species (Broyles 1987). The grassland environment makes up most of the Preserve area. It is dominated by annual grasses and forbs such as soft chess (*Bromus mollis*), ripgut (*Bromus diandrus*), zorro fescue (*Vulpia myuros*), goldfields (*Lasthenia californica*), tidy tips (*Layia fremontii*), johnnytuck (*Orthocarpus erianthus*), and filaree (*Erodium brachycarpum*). Perennials include lowland shooting star (*Dodecatheon clevelandii* subsp. *patulum*), and Brodiaea (*Brodiaea californica*). Mammals of the grassland environment include the deer mouse (*Peromyscus maniculatus*), meadow mouse (*Microtus californicus*), pocket gopher (*Thomomys bottae*), Jackrabbit (*Lepus californicus*), and the coyote (*Canus latrans*) (Vina Plains Docent Committee 1988).

The intermittent stream environment of the Vina Plains Preserve occupies a very small area of the Vina Plains Preserve. It consists of segments of four drainage channels used as irrigation ditches by local ranchers. In the flowing water zone, cattails (*Typha angustifolia*), yellow waterweed (*Ludwigia peploides*), and common monkey-flower (*Mimulus guttatus*) are found (Vina Plains Docent Committee 1988). Common plants in the "seep zone" adjacent to the flowing water include the

Bollander's water-starwort (*Callitriche heterophylla* subsp. *bolanderi*), and the June centaury (*Centaurium floribundum*) (Broyles 1987).

The vernal pool environment of the Vina Plains Preserve contains a rich and diverse biota. The smaller, shallower pools referred to as "hogwallows" are dominated by flora that includes goldfields (*Lasthenia fremontii*), meadowfoam (*Limnanthes douglasii* var. *rosea*), popcorn flowers (*Plagiobothrys stipitatus* var. *micranthus*), and downingia (*Downgias ornatissima*) (Broyles 1987). These "hogwallows" are characterized by rings of flowering plants as they desiccate in the spring. The large pools at Vina are dominated by flora such milkweed (*Asclepias fascicularis*), water shamrock (*Marsilea vestita*), white-flowered narvarretia (*Narvarretia leucoucephala*), and downingia (*Downingia bella* and *D. bicornuta*). The Vina Plains Preserve vernal pools contain rare and endangered plants such as the Hoover's surge (*Chamaesyce hooveri*), orcutt grasses (*Orcuttia pilosia* and *O. tenuis*), and Greene's orcutt grass (*Tuctoria greenei*) (Broyles 1987). Vina's larger vernal pools also contain an abundance of invertebrates that include crustaceans and aquatic insects (Vina Plains Docent Committee 1988; Alexander 1976).

Morphometry of Vernal Pool Basins

A morphometric analysis of the Vina Preserve vernal pool basins was performed to determine if there are any overall trends in pool orientation or shape. Distinct trends in pool morphometry are indicative of what geomorphological processes formed the basins. Students from the author's field techniques course at California State University, Chico mapped the pools during the spring of 1990 and 1991. The field mapping was accomplished using magnetic compass and pacing methods. The field mapping of the larger pools was supplemented by mapping from aerial photographs. All areas over 30 square meters of free standing water were mapped as vernal pool basins with the exception of pools resulting from human activities. A total of 43 vernal pools were mapped on the Vina Plains Preserve (Figure 3).

Pool length, width, perimeter, area and orientation were determined from field measurements (Table 1). Pool length was measured along the line bisecting the pool in its longest direction. Pool width was determined by measuring the longest line at right angles to the length bisecting line. Perimeter and area were measured for the highest identified pool shoreline. Pool orientation was measured from 0 to 179 degrees azimuth.

Pool elongation and circularity are two morphometric variables derived from the field data. They are complementary measures of shape

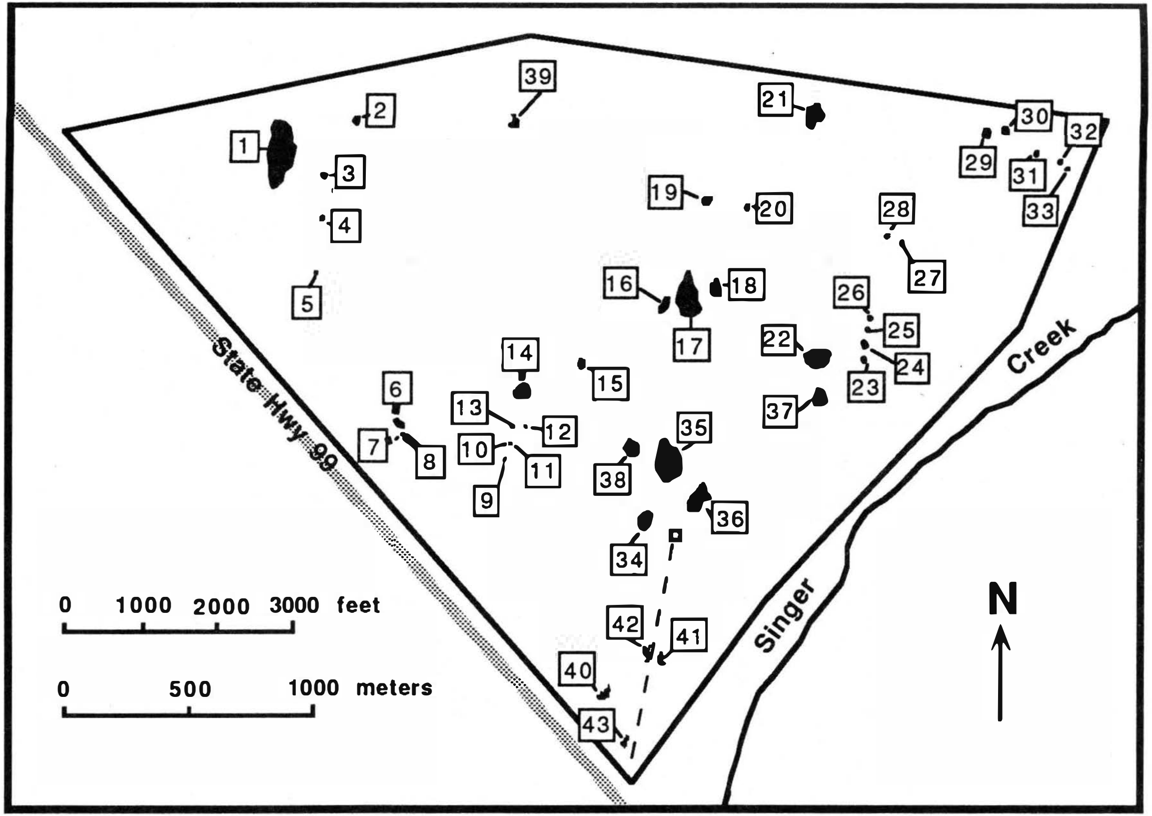


Figure 3. Vernal Pools of the Vina Plains Preserve Main Unit

Pool #	Width (m)	Length (m)	Perim (m)	Area (sm)	Elong	Circul	Orient
1	146	313	735	24155	0.56	0.56	6
2	21	33	79	465	0.73	0.93	73
3	17	37	90	465	0.66	0.72	140
4	25	27	78	460	0.91	0.96	3
5	10	15	45	158	0.93	0.99	6
6	12	35	77	321	0.58	0.68	146
7	8	10	27	56	0.84	0.97	89
8	5	9	22	37	0.81	0.97	0
9	7	9	26	51	0.95	0.98	7
10	5	10	24	46	0.76	0.98	172
11	8	15	37	107	0.77	0.99	0
12	5	10	24	42	0.73	0.88	8
13	12	20	50	195	0.78	0.97	8
14	86	87	266	5484	0.86	0.95	91
15	16	82	192	762	0.38	0.26	131
16	27	84	196	1449	0.51	0.48	41
17	80	228	577	17419	0.61	0.65	173
18	34	88	222	1565	0.51	0.40	179
19	24	40	128	901	0.85	0.69	55
20	15	17	60	204	0.96	0.71	156
21	67	78	253	2332	0.70	0.46	155
22	75	125	296	6210	0.65	0.77	98
23	11	37	84	311	0.54	0.55	159
24	15	30	90	419	0.78	0.66	135
25	11	24	72	242	0.72	0.59	155
26	5	12	38	70	0.77	0.60	130
27	8	16	58	186	0.93	0.70	140
28	9	18	57	195	0.86	0.75	160
29	52	61	176	2039	0.84	0.82	3
30	23	34	116	841	0.96	0.79	130
31	15	21	61	186	0.72	0.63	140
32	8	27	62	130	0.47	0.43	8
33	12	27	63	158	0.52	0.50	147
34	56	65	180	2500	0.86	0.75	24
35	120	190	459	12661	0.52	0.43	167
36	58	107	326	3347	0.67	0.47	46
37	61	72	276	3921	0.99	0.65	82
38	48	68	185	2499	0.83	0.91	174
39	36	61	265	960	0.57	0.17	0
40	33	60	169	731	0.51	0.32	48
41	23	43	151	518	0.60	0.29	5
42	23	76	159	620	0.37	0.31	5
43	20	50	116	495	0.50	0.46	30
Data Min	5	9	22	37	0.37	0.17	0
Data Max	146	313	735	24155	0.99	0.99	179
Average	32	58	156	2272	0.72	0.67	86
Standard Dev	31.89	60.83	149.94	4776	0.17	0.23	66

Table 1. Morphometry of Vina Preserve Vernal Pools

(Gardiner 1975). Pool elongation is equal to 2 X (A/3.14)/L where A pool area and L= pool length. Pool circularity is equal to 12.57 X A/P^2 where A = pool area and P = pool perimeter. Pool circularity is used as a measure of pool compactness or crenulation. Both elongation and circularity values range between 0 (a straight line) and 1 (a circle).

The Vina Preserve pools were classified according to area (Figure 4). Pools over 10,000 square meters were classified as large pools. The biggest pool (#1) is 24,155 square meters with the other two large pools (#17 and #35) being 17,419 and 12,661 square meters respectively. Medium vernal pools are between 10,000 and 1000 square meters. There are 10 medium pools ranging between 6210 (#22) and 1449 square meters (#16). Vernal pools at the Vina Preserve under 1000 square meters were classified as small pools. There are 30 small pools ranging between 901 (#19) and 37 square meters (#8).

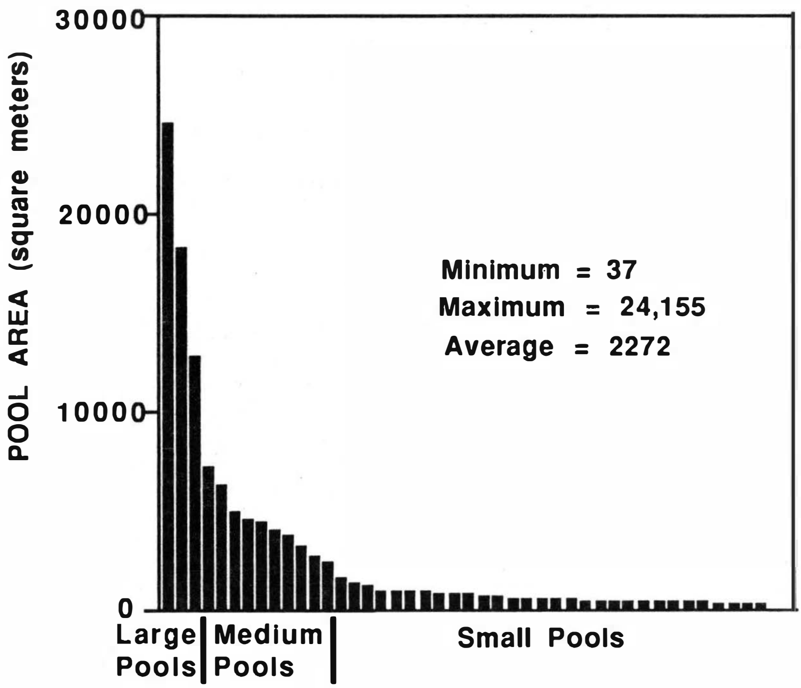
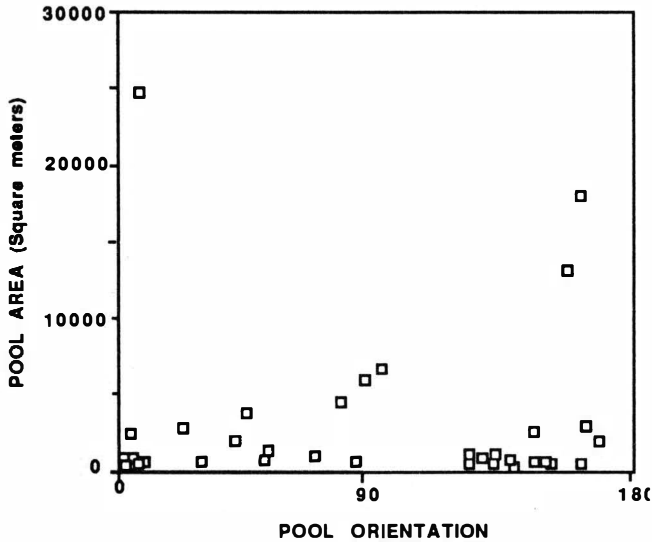


Figure 4. Areas of Vina Preserve Vernal Pools

The Vina Preserve vernal pools as a group show no strong trends in orientation and shape. As indicated on Table 1, Vina pool orientation ranges from north-south to east-west. However, the three large pools and many of the medium pools are oriented in a north-south direction



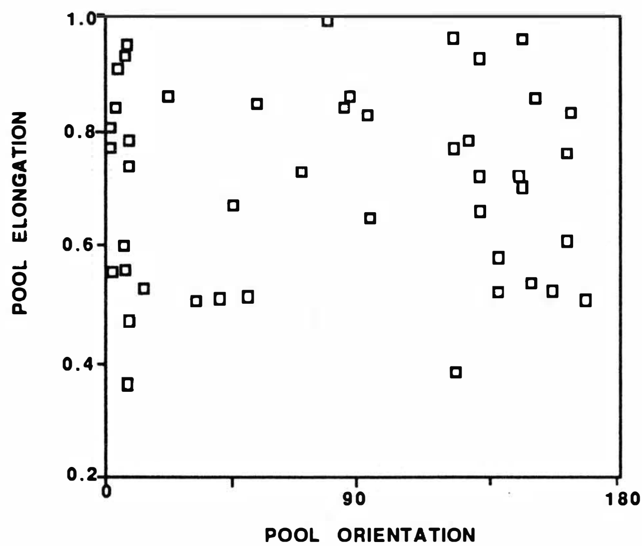


Figure 5. Vernal Pool Orientation Plotted Against Area and Elongation

(Figure 5-top). The elongation of the small Vina pools is for the most part unrelated to their orientation (Figure 5-bottom). The large pools on the Vina Preserve are highly elongated, while the small and medium pools greatly range in elongation values (Figure 6-top). The circularity values for the Vina pools indicates a wide range in compactness (Figure 6-bottom). However, the large pools have low circularity values which is a reflection of their high elongation values.

In summary, the morphometric evidence from the Vina Preserve vernal pools indicates that: 1) small Vina pools vary greatly in orientation and shape, 2) medium pools have less variation in morphometry than the small pools, and 3) three large pools are strongly similar in morphometry. The Vina pool morphometric evidence suggests that as Vina pools enlarge they become elongated in a north-south direction.

Morphology of Vernal Pool Basins

The Vina vernal pool basins are morphologically very similar to playa lake basins found in the deserts of the Western United States (e.g., Neal and Motts 1967; Neal 1970; Motts 1970). The morphology of the Vina pools is illustrated by the topography of the largest pool basin (#1). A transit survey determined that this vernal pool basin, like playa lake basins, is very shallow (Figure 7). The pool's maximum depth, measured between the highest shoreline and the deepest part of the pool basin, is only about 30 centimeters. The floor of the largest pool is essentially flat like a playa's, varying only a few centimeters in elevation from its center to its outer edges. The pool's clayey silty floor is very smooth like a playa's with large desiccation cracks developed on it in many places during the summer (Motts 1970). These desiccation cracks can extend down to the clay hardpan layer.

Unlike playas, the largest pool and most other large and medium Vina pools have gravel deposits present on their floors. These gravels consist mostly of rounded andesitic cobbles. Their density of coverage varies from low concentrations (0-5 per square meter) in the pool center to high concentrations (20-40 per square meter) at the edges of the pool. The gravels are concentrated on the north and northwest sides of many of the Vina vernal pools. There is no evidence in the form of tracks or trails that the gravels are "playa scrapers" (i.e., gravels moved by winter-storm winds across wet playa surfaces). These gravels appear to be lag deposits remaining behind after the finer-grained sand, silt, and clays of the underlying alluvial fan deposits have been removed from the pool basin. These lag gravels indicate an erosional origin of the Vina

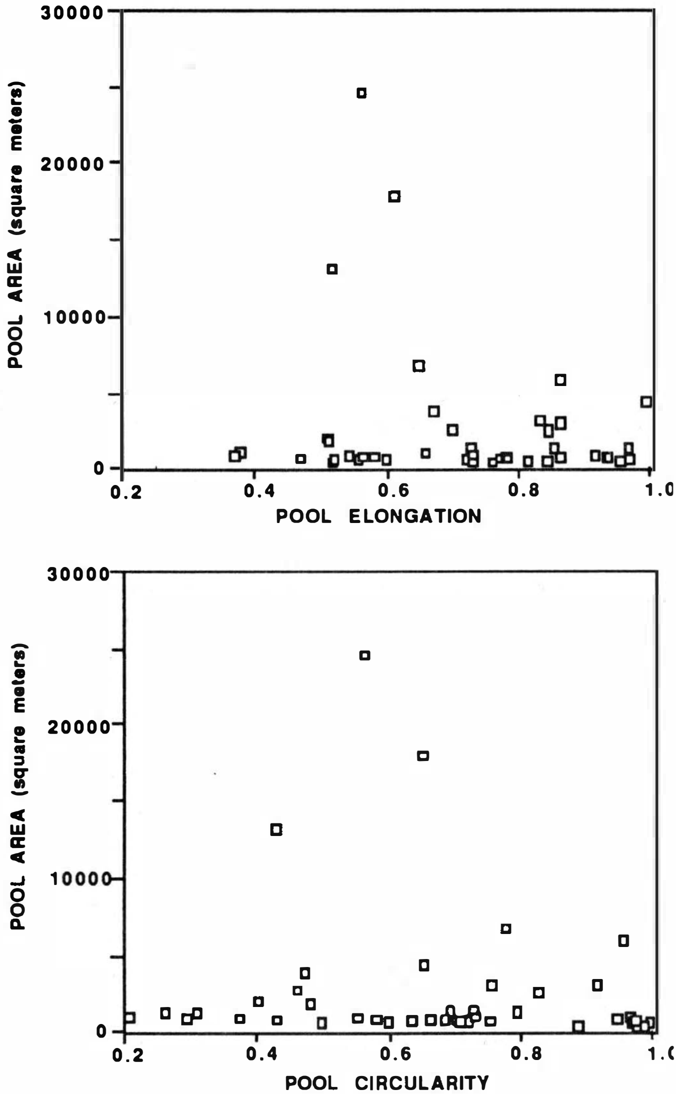


Figure 6. Vernal Pool Shape Plotted Against Area

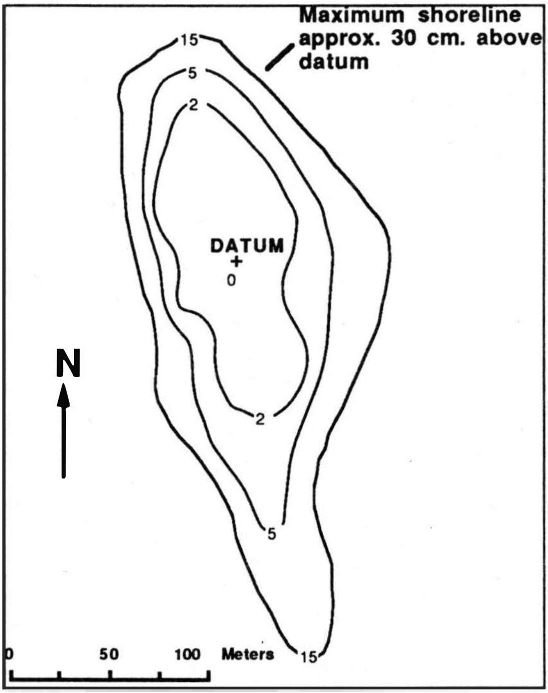


Figure 7. Floor Topography of the Big Pool, Vina Plains Preserve
Elevation contours in cemtimeters above datum.

vernal pool basins. They are concentrated at the edges of pools because of deposition of lacustrine silts and clays in the pool centers. Further evidence for the erosional origin of the Vina vernal pool basins is the surface exposure of the claypan layer on floors of many of the large and medium pools. Since the claypan originates from clay accumulation in a B horizon its exposure on the pool floors can only be due to the A horizon being eroded away. Like the lag gravel deposits, the claypan is mostly exposed at the edges of the pools on the north and northwest pool sides.

All the large and medium vernal pools on the Vina Plains Preserve display distinct shorelines around their basins. These shorelines are marked either by a "trim line" developed in the grass cover or by a shore terrace. Vina vernal pools do not exibit the multiple shorelines that are common around playa lake basins. The single shoreline of vernal pools is tied to the basin overflow elevation. Almost all large and medium pools at Vina have well-developed overflow channels at their south ends. These overflow channels usually have high concentrations of lag gravels lining their bottoms.

There is some evidence of "old" vernal pools at the Vina Preserve whose overflow channels have eroded below their basin rims. A good example of an "old" pool is located just northeast of pool #14. This pool no longer ponds up surface water, though its shoreline is still marked in places by small terrace remnants. The pool's surface is now covered by grasses that are common to the well-drained upland environment.

Theories on the Origin of Vernal Pool Basins

There are five theories that have been proposed to explain the development of California piedmont vernal pools. The first involves depressions between mima mounds which are small conical shaped hills that occur in many areas of the piedmont, particularily in the southern part (Nikiforoff 1941; Arkley and Brown 1954; Jenny 1976). There are many theories concerning mima mound origin. A popular one is that they are due to gopher activity (Arkley and Brown 1954). While the Vina Preserve does not exhibit well-developed mima mound topography, it does display in places evidence of patterned ground phenomena with low, wide mounds separated by depressions connected together with drainage channels. Some of the small vernal pools in the northeastern part of the Preserve are formed in this way. However, the large and medium pools of Vina are too big to be depressions between mima mounds. The bigger Vina pools may have started out as depressions between mounds, but there must be some other mechanism that caused the Vina pools to increase in size.

The second proposed theory for piedmont vernal pool formation entails pools developed in depressions associated with fracture systems in volcanic mudflow formations such as the Tuscan and Mehrten (Schlemon et al. 1973; Jokerst 1990). These fracture systems may also be present in the Vina Plains Preserve alluvial fan deposits, which are derived from reworked Tuscan Formation sediments. The fracture systems could cause the patterned ground found in the Preserve. However, like depressions between mima mounds, the depressions along mudflow fracture systems are also very small. The large and medium pools at the Vina Preserve resulted from some other process or processes.

The third theory for piedmont vernal pool formation in California concerns depressions developed on floodplains of ephemeral streams (Jokerst 1990). These depressions are a result of major flooding of the floodplain which commonly leaves an undulating landscape of alluvial deposits. At Vina, pool #38 is a good example of a vernal pool developed on the floodplain of Sheep Camp Ditch. However, the majority of vernal pools at the Vina Preserve are not associated with any stream floodplains. For instance, the three large pools (#1, #17, #35) are too big to be developed on any of the ephemeral stream floodplains found on the Vina Plains Preserve.

The activities of grazing animals causing enlargement of vernal pools is the fourth theory for vernal pool development. Prior to 150 years ago the piedmont grasslands were grazed by large herds of antelope. During the last 150 years the piedmont grasslands have been extensively grazed by cattle introduced by settlers of european ancestry. In grassland and savanna environments, grazing animals tend to gather around any depressions containing water. Their trampling of the muddy ground around these depressions is thought to cause "...physical removal of sediment in and on their bodies" (Goudie 1991). The large pools of the Vina Preserve contain evidence of trampling by cattle, but how much this has affected the development of the pool basins is unknown.

The fifth theory that has been proposed for piedmont vernal pool formation involves aeolian deflation (Broyles 1987). In this theory, the Vina pools were excavated by wind removal of fine grained sediments from the pool floors during past Holocene dry periods, such as the Altithermal. Evidence that supports this is the fact that the elongated large and medium Vina pools are oriented parallel to the prevailing south-southeast winds of the Vina Preserve area (National Oceanic and Atmospheric Administration 1974).

Hydroaeolian Planation Origin for Vernal Pool Basins

Of all the theories for vernal pool basin formation described above, the deflation theory seems the most acceptable. Additional evidence that supports the deflation theory comes from playa research which suggests that deflation is an important factor in the formation of their basins (Blackwelder 1931; Goudie 1991). A major deflation mechanism observed on playas is the formation of small concave upward shaped mud saucers or "mud curls" which are then destroyed and removed by the wind (Motts 1970). The removal of deflated playa sediments can take place in the summer, or winter during dry years (Young and Evans 1986). Mud curls are common on the Vina pool floors after they dry up in the spring, but whether these mud curls are being deflated under the present climatic regime of the Vina Preserve area is unknown. The lack of recent deposits of deflated material on the north end of the pools, such as lunette dunes (Goudie 1991), supports the theory that deflation was greater during a past dry climatic period.

If deflation is no longer excavating the vernal pool depressions on the Vina Plains Preserve, then there should be more evidence of "old" pools basins that no longer hold water. The preservation of "relict" deflation basins seems unlikely in the relatively wet winter environment of the Vina area, since pool overflow would erode through the pool's rim and hence destroy the pool. Some pool forming process other than deflation must be present to explain the diversity and magnitude of the pools that occur on the Vina Plains.

The best candidate, other than deflation, for an active pool forming process is lake wave action. Studies have shown that wind-generated waves are a major force in the growth of shallow lake basins (e.g., Prouty 1952; Price 1970; Osterkamp and Wood 1987). On the Vina Preserve there is evidence to suggest that lake wave action is a dominant force in the enlargement of the pool basins. First, as previously stated, all the large pools are oriented parallel to the prevailing south-southeast wind direction of the Vina Plains area. Secondly, relatively steep slopes on the north sides of large and some medium vernal pools indicate slope retreat in a downwind direction. Lastly, the high density of lag gravel deposits and exposure of clay hardpan on the north-northwest end of the pool floors (e.g., #14, #16, #22) also indicates pool growth in a downwind direction.

The origin of the vernal pool basins at the Vina Plains Preserve is more than likely polygenetic. Studies of playas have shown that both wind deflation and lake wave action are major factors in their formation. The progressive enlargement and flattening of playa basin floors by wind and water is referred to as *hydroaeolian planation* (Currey 1990). The vernal pools on the Vina Plains have so many topographical and sedimentological similarities to playa basins that it seems highly probable that *hydroaeolian planation* also is the key factor in their formation.

A major difference between playas and vernal pools on the Vina Preserve is that overall playas are aggradational landforms versus vernal pools which are degradational landforms. Most playa basins in the American West are formed of extensive fine-grained alluvial deposits, thousands of meters deep in many cases, which have accumulated in the bottom of tectonic depressions for over a million years. Deflation plays a role in the formation of these playa basins, but thick deposits of lacustrine sediments beneath playas indicates that they are dominantly aggradational landforms. Vina vernal pool basins on the other hand are degradational landforms that are eroded into alluvial fan deposits. Evidence of degradation consists of the extensive lag gravel deposits and surface exposures of claypan on the vernal pool floors. The very thin lacustrine deposits in the pool basins indicates that most of the fine-grained sediments are removed through deflation or via suspension in pool overflow discharge.

Conclusion

Piedmont vernal pools on the Vina Preserve originate as small depressions formed in either low areas of patterned ground or along ephemeral stream floodplains. Where topographic conditions are favorable, Vina pool depressions enlarge in a downwind direction. Evidence for pool enlargement consists of lag gravel deposits and claypan exposures concentrated on the downwind side of the pool floors, and relatively steep slopes on the downwind sides of pool basins. Grazing animal activity might also contribute to enlargement of pool basins.

Piedmont vernal pool topography is the result of *hydroaeolian planation* processes which have varied in intensity through time because of climatic change. The relative importance of deflation versus lake wave action processes in the formation of Vina pools is unknown. However, given the lack of aeolian deposits adjacent to the pools, deflation processes under the present climate of the Vina Preserve area are probably less important than wave action.

This study of the geomorphology of piedmont vernal pool basins is preliminary. Much more research needs to be done. Current deflation rates of the pool floors need to be sampled. Also, the rates of shoreline retreat need to be measured along with the amounts of suspended sediments in the pool overflow discharge.

California piedmont vernal pool basins are a type of small, shallow lake basin. They are geomorphically similar to small lake basins found in many different environments throughout the world. Examples include the playa lakes on the high plains of Texas (Osterkamp and Wood 1987), the oriented lakes of northern Alaska (Price 1970), and the Carolina Bays of the Atlantic Coastal Plain (Prouty 1952). Piedmont vernal pools are particularily similar to small playa lake basins found in desert and grassland environments (Goudie 1991). California's piedmont vernal pools, like playas, have complex geomorphic histories that are difficult to decipher.

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THE CLIMATE OF DEATH VALLEY

Steven G. Spear

Death Valley is world–famous for extremes in climate, particularly for its very high summer temperatures and overall lack of precipitation. While it is true that Death Valley may become excessively hot in the summer, the winters are frequently quite cool. Although annual average rainfall is less than 50mm at Furnace Creek on the valley floor (all data are from National Park Service records unless otherwise stated), there are places within a very short distance that receive far more rain and even frequent snow.

Since Death Valley is one of the hottest and driest places on earth, one would think that its climate is well–documented. Such is not the case. There are several brief published accounts of narrow aspects of Death Valley's climate (Court 1954; Ecklund 1933; Felton 1965; Geiger 1965; Harrington 1892; Hunt 1975). However, none of these represent a detailed summary of the climate and they are often buried in more general works. It is hoped that this work is a step in filling this void. Climatic data for Death Valley are incomplete both in terms of area and of time. Precipitation data have been collected from many parts of the region but at different times for different places and often only for certain months of the year. Only Furnace Creek (the National Park Service Visitor Center) has a complete record of any length (from 1911 to the present) and there are certain problems even with this record. Most of the data for Furnace Creek consist only of temperature and precipitation records. Evaporation data are incomplete and data on wind, humidity, sunlight and clouds are minimal. The temperature and precipitation records were collected at Furnace Creek (Greenland Ranch) and then the nearby Visitor Center from 1911 to 1934 and from 1961 to the present. From 1935 to 1960, the information was collected at Cow Creek, the ranger residence several kilometers northeast. In 1959 Furnace Creek re-

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ceived 47mm of precipitation while Cow Creek received 44mm. While such minor discrepancies will certainly not have much of an effect on the vegetation, landscape or human activities, it is a small but significant difference.

Variation in data between this paper and other publications is due to the length of time over which data were collected. The numbers averaged over the period of 1911 to 1965 will vary from the numbers averaged over the period from 1911 to 1992 because the first set of data does not include the figures derived from 1966 to 1992 which may have been either higher or lower than the average thus changing the overall mean. Ideally, all the numbers should represent averages from the first day records were kept until today. Obviously, this is not always possible.

Temperature

Temperature data of any reliability are available only for Furnace Creek. Daily ranges in January, the coldest month, are 3–18°C. July is the hottest month and the average daily range is 31–47°C. This makes Death Valley, in the summer, one of the world's most consistently hot places (see Table 1).

The lowest temperature ever recorded was –9°C and the highest ever was 57°C. Both of these records were set in 1913! That same year, Death Valley received a record rainfall (also matched in 1983)! A strange year indeed. Although the 57°C was a world record at the time, it was later surpassed, (but only once) by a temperature of 58°C in Libya in 1922 (Griffiths & Driscoll 1982). The highest ground temperature of 94°C was set in 1972 when the air temperature was 53°C.

The very high temperatures in Death Valley have been the subject of brief discussion in the literature. Just after the record temperature in 1913, several authors wrote about its possible causes (Wilson 1915; Palmer 1922). Others have been suspicious of the 57°C reading ascribing it to faulty equipment (Court 1949; Ludlum 1963). Since the air temperature regularly tops 50°C, the additional few degrees are certainly within the realm of possibility. However, in more recent years, with improved equipment, no similar temperatures have occurred.

While these are the records at Furnace Creek, there are undoubtedly similar or greater extremes in the immediate area. Furnace Creek is about 30m higher than Badwater. Thus Badwater could at times be expected to be about one degree warmer due to adiabatic warming.

TEMPERATURE RECORDS AT FURNACE CREEK

Month	Average	Average Maximum	Average Minimum	Record High	Record Low	Average Diurnal
Jan.	11	18	4	31	-9**	14
Feb.	16	23	8	33	-3	15
Mar.	19	27	12	38	-1	15
Apr.	24	31	17	44	2	14
May	29	38	22	49	6	16
June	36	43	27	52	9	16
July	39	47	31	57*	11	16
Aug.	39	45	30	52	18	15
Sept.	33	41	27	49	5	14
Oct.	25	33	17	45	0	16
Nov.	17	24	9	36	-4	15
Dec.	12	19	4	30	-7	15
Means	25	32	17			15

Figures are in °C

*Record High **Record Low

Table 1. Temperature Records at Furnace Creek
This is a month–by–month summary taken from National Park Service Records from 1911–1983

Likewise, Telescope Peak, a very few kilometers southwest could be as much as 34°C cooler.

There are many factors contributing to Death Valley's high temperatures. Death Valley is at a latitude of about 36 degrees north of the equator. This is far enough south so that the sun spends a significant amount of time high in the sky during daytime hours.

Locations at the same latitude such as Tulsa, Nashville and southern Europe are not nearly so hot so there are obviously other factors to consider.

At Badwater, Death Valley is about 87m below sea level. This is the lowest elevation in the western hemisphere. All the air moving to Badwater must sink and therefore heats adiabatically. In addition to angle of incidence and altitude, albedo plays an important role in determining temperature. The albedo of Death Valley is probably about average. Most of the rocks are dark colored and have a dark coating of desert varnish. However, the playa on the floor of Death Valley is a high-albedo surface. However, Death Valley ends up with a higher than average absorption due to its lack of cloud cover. Because Death Valley is clear and cloudless much of the year, more energy reaches the surface and it becomes hotter.

To the west of Death Valley lie a formidable series of mountain ranges which effectively block the moderating flow of moist Pacific air. Cool summer Pacific air (and relatively warmer winter air) does not reach Death Valley without modification as it crosses the the north-south oriented mountains to the west. Dry air heats and cools more readily than humid air. Thus Death Valley becomes hotter in summer and cooler in winter than the lands directly on the coast to the west.

In summary, Death Valley is hot because it is fairly far south, very low, very clear, blocked from moist air by mountains and its surface materials are not overly reflective.

Rainfall

There are more precipitation data available for Death Valley than other climatic data. Precipitation measurements have been taken in many different places throughout the area but they are not always from comparable time periods. Furthermore, information may have been lost at the more remote stations due to high evaporation rates, infrequent checking of rain gauges and vandalism.

Death Valley's rainfall distribution is bimodal with most precipitation coming in the winter months and a smaller amount occasionally in late summer. The winter rainfall comes from large Pacific middle latitude wave cyclonic storms passing over the region. Precipitation from such storms is usually in the form of light rain on the valley floor and heavier rain and snow in the upper elevations. This general pattern may vary somewhat as snow may fall on the floor of the valley and past winter storms have caused numerous wash–outs destroying roads and buildings. Summer rainfall is more localized and usually more intense. It is the result of moisture–bearing tropical air from the south being forced over the local mountains as the air moves toward the interior. The total amount of precipitation is highly variable. The amount received in the wettest year can be seven to eight times that received in the driest year.

At Furnace Creek, annual rainfall has varied from 0–115 mm. There are many months that usually receive no rainfall but during most years, at least a little rain falls from December through March. Table 2 shows the total annual rainfall at Furnace Creek from 1911 to 1991. Only once did it not rain at all in a year's time: 1929. Twice, in 1913 and again in 1983 it rained a record 115 mm. From these data, 1911 to 1991, the average annual precipitation at Furnace Creek is 48.5mm/yr. Other places in the Monument receive different amounts of precipitation. Although data from these remote stations is sparse, generally the valley floor to the south of Furnace Creek receives less precipitation and the mountains and valley floor to the north receive more precipitation (see Appendix A and Figure 1).

Many factors affect the amount and type of precipitation that falls in the Death Valley area. Although the winds do generally blow from the Pacific Ocean towards Death Valley, the cold ocean hinders evaporation which in turn produces a generally drier climate throughout central and southern California. Secondly, and more importantly, high mountain barriers to the west isolate Death Valley from its Pacific moisture source. Even though it is only 290km from the sea, moisture from winter storms must cross over the coastal ranges (1,700m in altitude). Then the winds must cross the Sierra Nevada Range (4,400m)—the highest in the contiguous 48 States. After that, the winds must also cross the Inyo Mountains (3,200m) and finally the Panamint Range (3,000m) before they reach Death Valley. By that time, there is very little moisture left in the air mass. Death Valley is a rain shadow desert produced by the Sierras and other high mountains to the west.

After a cold front passes, high pressure frequently builds to the northeast of Death Valley and this tends to block or divert subsequent storms. Thus due to mountain barriers, general wind circulation patterns and the fact that air moving into Death Valley must flow downhill and thereby warm up and dry out, the floor of Death Valley is a very

Year	mm	Year	mm	Year	mm
1911	36 (a)	1938	87	1965	84
1912	36	1939	87	1966	20
1913	115 (b)	1940	61	1967	35
1914	42	1941	107	1968	41
1915	33	1942	24	1969	87
1916	57	1943	64	1970	58
1917	11	1944	52	1971	24
1918	28	1945	49	1972	57
1919	13	1946	71	1973	58
1920	74	1947	22	1974	88
1921	15	1948	8	1975	38
1922	45	1949	88	1976	107
1923	60	1950	25	1977	71
1924	11	1951	18	1978	102
1925	15	1952	98	1979	45
1926	21	1953	2	1980	81
1927	45	1954	66	1981	44
1928	22	1955	13	1982	56
1929	0 (c)	1956	20	1983	115 (b)
1030	37	1957	59	1984	103
1931	20	1958	52	1985	24
1932	4	1959	44	1986	32
1933	7	1960	47 (d)	1987	95
1934	39	1961	37 (e)	1988	98
1935	36	1962	20	1989	11
1936	67	1963	61	1990	33
1937	27	1964	27	1991	39
				ANN. MEAN:	49

(a) 1911 data incomplete, not included in averages
(b) wettest years, 1913 and 1983
(c) driest year
(d) possible error in station records
(e) due to station move from Cow Creek to Furnace Creek, both averaged together

Table 2. Furnace Creek Precipitation 1911–1991

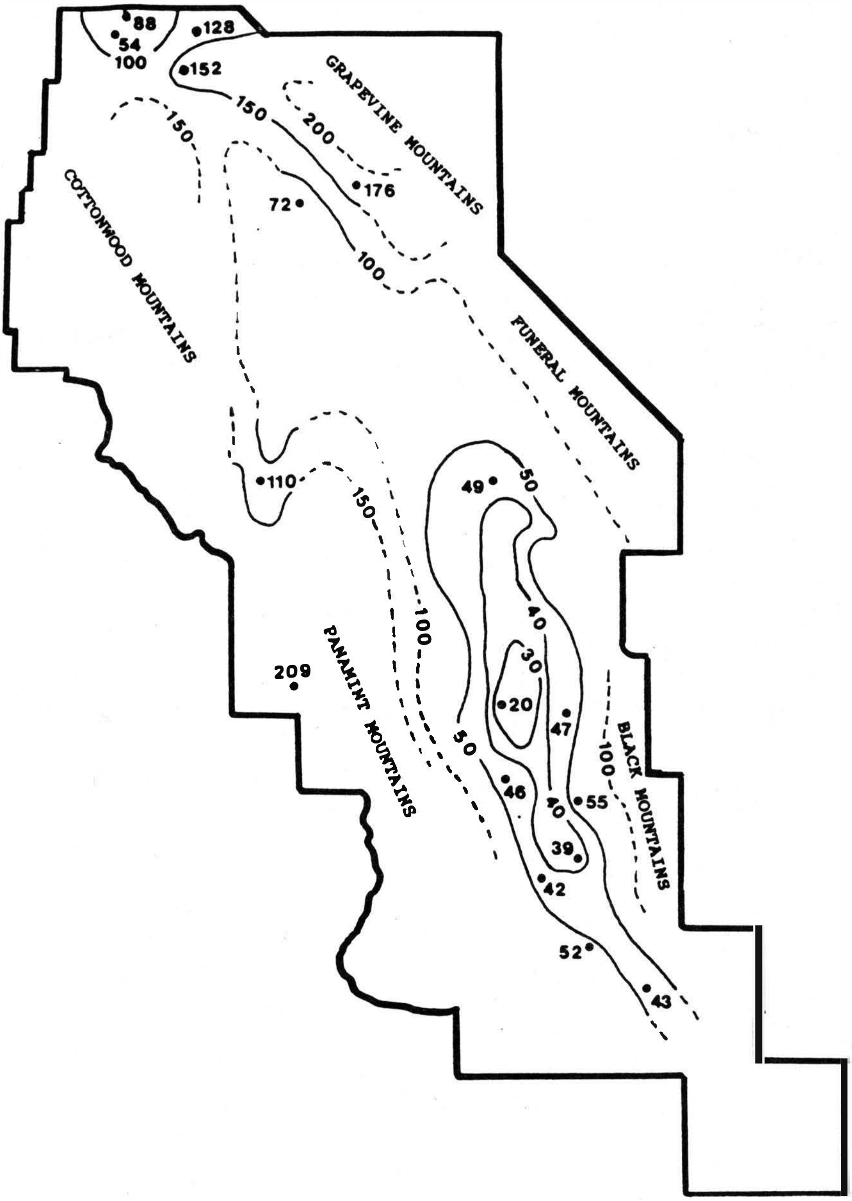

Figure 1. Average Annual Rainfall in Death Valley National Monument
(Figures are in mm)

arid place. However, the rainfall around the edges of the Death Valley region is far more variable.

In Death Valley, it is not uncommon to find orographic conditions combined with either cyclonic or convection conditions because of the many high mountains. Each front that passes in the winter must rise over the ranges thus producing such a combination. In summer, moist tropical air occasionally finds its way as far north as Death Valley. This air is heated by Death Valley's extreme heat and it rises as it moves against the mountains. The air rising orographically in the winter frequently rises against the western slopes while in the summer the air often rises against southern or eastern slopes. Since the less frequent summer moist air is heated more severely, it rises faster producing more intense rain but of shorter duration than the winter storms.

Other Moisture Elements

Evaporation. By any precipitation standards, Death Valley is dry. When one considers evaporation in addition to the scant rainfall, Death Valley becomes hyper–arid. Although information is available only from Furnace Creek and for only a few years, evaporation rates can easily exceed 3,300mm per year. The main cause of this high evaporation rate is, of course, the high temperatures. But clear weather, high angle of incidence of incoming sunlight, high absorption rates and wind in most seasons are also contributing factors. Table 3 is a monthly summary of evaporation for Furnace Creek (For comparison, the precipitation is also included).

Humidity, Clouds, Haze. While records for these three elements of atmospheric moisture are virtually nonexistent, some generalizations can be made. Humidity is usually higher than one might imagine. Although data are only available for the year 1983, the relative humidity in January ranged from 8–75 per cent and the relative humidity for July ranged from 3–28 per cent. In the summer, a desert haze is quite common. Most of the year Death Valley is essentially cloud–free. Alto–stratus clouds with nearly complete sky coverage occur at times in winter with the passage of the large cyclonic storms. In the summer, cumulo–nimbus clouds may occur in association with thunderstorms. Generally, Death Valley has about 300 cloud–free days each year.

MONTH	EVAPORATION (mm)	PRECIPITATION (mm)	DEFICIT (E–P) (mm)
Jan.	115	5	110
Feb.	155	8	147
Mar.	247	6	241
Apr.	317	3	314
May	401	1	400
June	504	1	503
July	520	3	517
Aug.	426	2	424
Sept.	348	3	345
Oct.	253	3	250
Nov.	141	5	136
Dec.	64	5	59
TOTAL:	**3,491**	**45**	**3,446**

Table 3. Evaporation at Furnace Creek

The degree of aridity at any location is best determined by noticing the difference between precipitation and evaporation which are both measured in similar units. In Death Valley, evaporation exceeds precipitation by a factor of 77 times.

Wind

Death Valley lies within the general westerly wind belt of North America. This flow from west to east is accentuated in the summer by the development of a strong high pressure area off the Pacific Coast and by a thermal low pressure area in the southwestern Great Basin area of southern Nevada, eastern California and northwest Arizona. Death Valley lies in the northwest corner of this thermal low. The strong west to east wind in summer is distorted by this low pressure zone and the surrounding mountains. In winter, the winds are less controlled by the high pressure zone in the Pacific than by the passage of the large cyclonic storms. After the passage of these storms there is often residual high pressure over central Nevada to the northeast of Death Valley. Most of the strong winds that occur in Death Valley are thus north to south or less commonly south to north. Obviously, the orientation of the mountains plays a significant role in controlling the wind's direction. Detailed velocity measurements are only available for 1983 and are not available in summarized form but in both January and July, the wind velocity, taken on an hourly basis, ranged from 1–48 kph.

How Does Death Valley Compare with Other Deserts?

Many geographers over the years have attempted to devise climate classification schemes whereby areas of similar climate can be grouped together according to temperature, rainfall and other characteristics (see for example, Thornthwaite 1948). There is no place quite like Death Valley either in terms of the specifics of its climate or the reasons for it. Locations exhibiting the greatest similarity include the deserts of Arabia, Australia, northern Africa (Sahara) and northwestern Mexico. Death Valley differs from these in several respects. First, Death Valley is noticeably cooler in the winter than most of these areas. Secondly, Death Valley is dry primarily because of the rainshadow effect of the mountains while the other deserts mentioned are dry mostly due to descending tropical air masses.

In general, when compared to the world's other deserts, Death Valley is hotter in summer and cooler in winter than deserts found in tropical areas. But Death Valley is hotter in summer *and* winter than most middle–latitude deserts such as the Gobi in Asia. Overall, Death Valley is about equal in aridity with other deserts except on the valley floor where it is distinctly drier.

Appendix A

Precipitation Summary of Death Valley.

Station	Elevation (meters)	Data Base (years)	Average Annual Precip.	Range
Furnace Creek*	–58	1911–1991	49	0–115
Wildrose**	1,341	1967–70, 72-76	209	81–279
Grapevine Ranger Sta.	701	1974, 76–78 80, 82, 83	152	69–266
Grapevine Canyon	914	1979, 82, 83	128	66–224
Klare Spg.	975	1978–80, 82, 83	176	26–115
Titus Cyn. Mouth	244	1974, 76–80	72	26–115
Ubehebe Crater	792	1979–80	54	52–57
Big Pine Road	805	1977–80, 82, 83	88	22–163
Emigrant Ranger Sta.	658	1977–80 82, 83	110	72–179
Ashford Jct.	0	1973–76, 81	43	10–67
Bennett's Well	–76	1973–76	46	12–68
Copper Cyn.	–73	1976, 81	55	40–70
Mormon Pt.	–15	1973–76, 81	39	8–69
Salt Tanks	–73	1973–76, 81	42	3–78
Tule Spg.	–79	1981	20	20
Warm Spgs. Jct.	–61	1973, 75, 81	52	35–72
Badwater	–85	1974–76	47	11–78

*Measured at Greenland Ranch 1911–1934 and 1961–present. Measured at Cow Creek 1935–1960.
**Snow measured separately, not melted.

The mean figures are mapped in Figure 1.

Acknowledgement

Unless otherwise cited, all of the data presented herein was obtained from the National Park Service archives in the Research Library at Furnace Creek. The personnel at the Visitor Center were very cooperative in letting me pour through their records.

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C G S

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Come Taste this Cool, Clean Water: History of California's Groundwater Quality Monitoring Program

Sheryl Luzzadder-Beach

By what standards do we assess water quality? How are those standards developed, and over what geographic areas? Groundwater monitoring programs must be designed with specific purposes and goals in mind. Otherwise, the data collected are not meaningful, and are of little use (Ward 1981; Beach 1987, 1990). California's first groundwater quality monitoring goals were mandated by the 1949 California Water Code (Beach 1990). This paper chronicles and assesses the steps California's Department of Water Resources (CDWR) took to meet its broad legislative mandate. Those steps included identifying needs and creating priorities, setting goals, and implementing a groundwater quality monitoring program. California's Groundwater Quality Monitoring Program (GWQMP) offers a successful model of a flexible and robust system that has allowed California to assess, delineate, and maintain the quality of its groundwater resources for the past four decades (University of California Water Quality Task Force 1988). As California and other regions face new water quality challenges, resource managers can look to this monitoring program for guidance.

Legislative Authorization

California's Water Quality Monitoring Program, including both surface and groundwater quality monitoring, was established when Section 229 was added to the California Water Code in 1949. Section 229 states that the California Department (then Division) of Water Resources shall

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> . . . investigate conditions of all waters within the State, including saline waters, coastal and inland, as related to all sources of pollution of whatever nature and shall report thereon to the legislature and to the appropriate regional water pollution control board annually, and may recommend any steps which might be taken to improve or protect the quality of such waters (CDWR 1952).

Beginning in 1950 CDWR conducted studies to determine the extent and geology of California's principal groundwater basins before monitoring actually commenced. CDWR published the results in *Groundwater Basins in California,* one of the first comprehensive reports on California's geohydrology (CDWR 1952). This geohydrological information was collected for planning the monitoring program, and to create a database of California's groundwater systems for future investigations. Begun in 1950, this database would later become California's Water Data Information System (WDIS). These geohydrological investigations also produced the first base map of California's primary regions of groundwater storage (CDWR 1952). The map was intended for establishing a naming and numbering system for California's groundwater basins, and to serve future planning needs for groundwater studies (CDWR 1952).

CDWR first concentrated its data gathering efforts in areas of significant beneficial groundwater use, i.e., developed areas and agricultural areas. Many other groundwater basins were initially left out for lack of information or significant beneficial groundwater use. CDWR envisioned, however, that new areas would be explored and added to the monitoring program (CDWR 1952), and indeed they have. In 1956 CDWR declared that its monitoring "program is flexible and monitored areas will be added or eliminated as changing conditions dictate" (CDWR 1956).

After the preliminary geohydrological studies, groundwater quality monitoring commenced in 1953 and 1954. Groundwater basins distributed in nine regions were monitored in 1953 and 1954 (Figure 1, CDWR 1956). The results of these first monitoring efforts were reported in *Groundwater Quality Monitoring Program in California* (CDWR 1956). The report was the first of its kind to be presented to the Legislature and the Regional Water Pollution Control Boards (CDWR 1956). The report also outlined the monitoring program, including its objectives, and the methodology that formed the structure of the Groundwater Quality Monitoring Program.

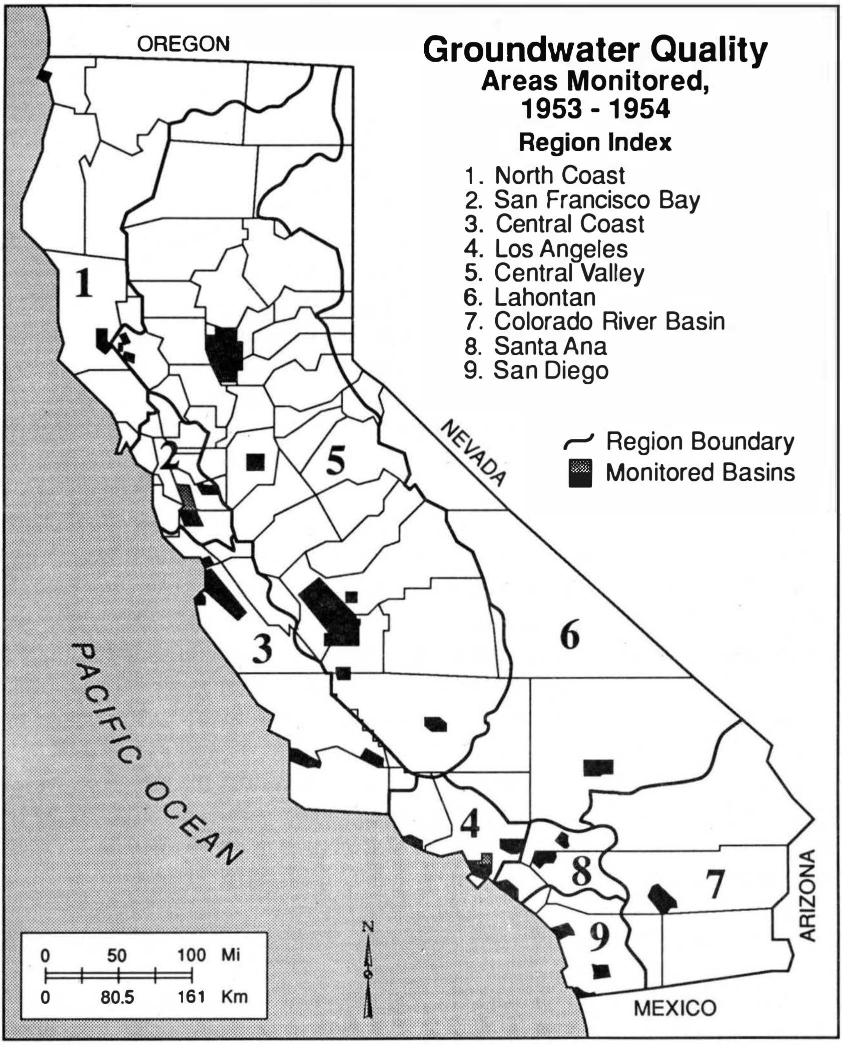

Figure 1
General Location of Groundwater Quality Basins Monitored by the California Department of Water Resources in 1953 and 1954.

Monitoring Program Objectives

Even in the early 1950's CDWR recognized that groundwater was a "vitally important portion of California's water supply," and that population growth increased the risk of its "pollution and degradation" (CDWR 1956). Nearly fifty percent of California's water needs were served by groundwater at that time (CDWR 1956). Following the extensive investigation into California's principal groundwater basins (CDWR 1952), CDWR also recognized that because of groundwater's "widespread occurrence and relatively slow rate of movement, . . . long term observations and records" would be necessary to fulfill the program's main objectives (CDWR 1956). These objectives included: 1) providing current mineral groundwater quality data; 2) detecting "significant changes in groundwater quality"; and 3) delineating areas affected by significant groundwater quality changes (CDWR 1956). The main purpose of this monitoring was evaluating the water's suitability for beneficial use; i.e., domestic, municipal, and agricultural consumption.

Drinking water criteria were first adopted by the State of California in the early 1950's, based on standards established by the United States Public Health Service in 1946 (Table 1, CDWR 1956). All values listed in Table 1, except for fluoride, lead, selenium, and arsenic, are suggested guidelines. The latter four constituent levels are mandatory grounds for rejection of the water supply for human consumption. The State left the option for other agencies to add constituents and limits to the list as necessary (CDWR 1956).

Groundwater quality determination was made mainly for mineral constituents. Heavy metals and radioactivity were recorded for a short time, and pesticides were added to the program in the 1970s. Though they remain as standards, metals, pesticides and radioactivity were dropped by CDWR as other agencies including California's Regional Water Quality Control boards began sampling for them, to avoid duplicating sampling efforts and expenditures.

Criteria for irrigation waters were adopted from recommendations by Prof. L. D. Doneen, U. C. Davis. Constituents of concern included: "Total dissolved solids, chloride, percent sodium, and boron concentrations for three general classes of irrigation waters" (CDWR 1956). The Department's use of the three classifications (Class I: Excellent to Good; Class II: Good to Injurious; and Class III: Injurious to Unsatisfactory) was criticized as "simplistic" (CDWR 1978). Its critics, however (Doneen included) "could not agree upon a mutually acceptable replacement" (CDWR 1978).

Table 1. LIMITING CONCENTRATIONS OF MINERAL CONSTITUENTS FOR DRINKING WATER

United States Public Health Service
Drinking Water Standards, 1946

	Parts Per Million
Fluoride (F)	1.5
Iron (Fe) + Manganese (Mn)	0.3
Magnesium (Mg)	125
Chlorine (Cl)	250
Sulphate (SO_4)	250
Lead (Pb)	0.1
Selenium (Se)	0.05
Hexavalent Chromium (Cr^{+6})	0.05
Copper (Cu)	3.0
Arsenic (As)	0.05
Zinc (Zn)	15
Phenol	0.001
Dissolved Solids	500 (1,000 permitted)

Source: CDWR 1956

The task of defining agricultural water use guidelines was especially difficult because of wide geographic variations of climate, soil, crop, and moisture balance combinations. In 1974, the University of California Committee of Consultants produced "Guidelines for Interpretation of Water Quality for Agriculture." CDWR adopted the "Guidelines" in October of the same year (CDWR 1978). The "Guidelines" were updated in January 1975 by the UC-Committee of Consultants, and crop tolerance tables for salinity and permeability were added in September 1976 (CDWR 1978).

In addition to the agricultural guidelines (CDWR 1978), CDWR continues to defer to the U. S. Public Health Service for water quality criteria. The "California Domestic Water Quality and Monitoring Regulations" were officially adopted by the California Department of Health in December 1977 (CDWR 1978).

Monitoring Program Methodology

CDWR first gave sampling priority to areas where there were "existing or potential water quality problems" (CDWR 1956). Suspected pollution sources included "waste discharges, . . . improper refuse disposal, poorly sealed or improperly constructed wells, overdraft conditions, connate brines, or seawater intrusion" (CDWR 1956). Despite the mention of "pollution" in Section 229 of the Water Code, the program was not initially set up for pollution detection. Rather, the emphasis was on establishing a data base for later comparisons (Clawson 1987). For example, ambient conditions were determined for areas targeted for later development, in order to provide background data for future comparisons and to detect significant water quality changes (CDWR 1956). This established the background for an extensive, long term groundwater quality data base, compiled in the Water Data Information System (WDIS).

CDWR's task of establishing its monitoring program was accomplished in steps. As previously mentioned, the first monitoring well networks concentrated on basins with known or potential problems (Figure 1). Later, monitoring was expanded to all major basins in California.

Once monitoring commenced in a basin it was important to establish good areal coverage; therefore, more wells than would later be necessary were sampled. As more geologic information became available, from well drillers' reports for example, basin coverage was modified to include water sources (aquifers) of these wells (Clawson 1987). The number of wells sampled in the basin was reduced after wells representative of the same source aquifers were identified. Therefore, "only the minimum number of wells believed necessary to evaluate groundwater conditions (was) incorporated in the program" (CDWR 1956). However, CDWR did not specify this "minimum number" of sample wells.

One might suspect, and correctly, that the formula to derive the "minimum number" of monitoring wells included the availability of funds (Clawson 1987). The Dickey Act of 1949 set up the Water Pollution Control Boards and provided funding for the State Departments of Water Resources, Fish and Game, and Health to conduct water quality investigations (Clawson 1987). Funds, however, were limited to the point where state agencies could not drill their own monitoring wells. Monitoring was limited to existing wells, both publicly and privately owned (Clawson 1987). This situation exists to this day, with few exceptions. The well selection process, therefore, was not spatially ideal because the State could not always monitor where it needed to.

Monitoring well selection was and is limited by a number of variables related to choosing from a population of existing wells. These variables include: availability of water well drillers' reports, representativeness, antecedent analyses, and physical ability to access and sample the well (CDWR 1956).

A well drillers' report (log) is needed to identify a well's source aquifer, depth, and construction. Without a log, an interview with the well's owner may provide needed information. Unfortunately, many extra hours would have to be expended to gather information in this way. Well drillers are currently required to file logs with CDWR, saving precious research time and providing invaluable geologic information. The store of well logs also ensures speedy replacement if a monitoring well representing a certain aquifer or water supply is taken out of production (Clawson 1987).

The "representativeness" of a well is determined partially on the basis of the well driller's report. Based on geology, depth, and construction information, how well does the sample well represent the water source in question?

Background geochemical information (from antecedent analyses) for a well can also help determine its source. In the absence of a log, often a well's source was determined by comparing its water quality to adjacent wells for which logs existed. This meant sample points could be established despite the lack of a well driller's report. Also, antecedent analyses formed a basis for comparison to detect future significant groundwater quality changes. Other factors CDWR considered for "final selection of observation wells" included well owner permission and cooperation, physical access to the well site, a tap close to the well itself, and the well's pumping schedule (CDWR 1956).

Once sample sites were established, water quality samples were drawn beginning in 1950 (CDWR 1952). As is current practice, CDWR collected groundwater quality samples once per year, during summer "irrigation season when there is maximum pumpage" (CDWR 1956). It was also foreseen that problem wells could be sampled more frequently if necessary (CDWR 1956).

The summer collection schedule was adopted to ensure that the sample drawn would be representative of the water being applied to crops. If a sample of a domestic water supply was taken, the tap was run until the well pump turned on. The pump was allowed to run for at least five minutes, to clear water from the pipes, casing, and water tank. If an agricultural well was not pumping, the sampler had the option of starting it up (with owner permission) and clearing the casing in order to take a sample. It was and is important to sample while a well pumps, because water residing in a casing or tank may take on some of the characteristics of the material it contacts, depending, in part, on the water's pH and temperature.

Furthermore, samples were (and are) taken from the tap, sprinkler head, or discharge pipe nearest the well itself, to again avoid chemical alterations caused by the water's contact with pipes and water tanks, and possible water softener or fertilizer treatment. A more representative sample temperature is achieved in this way, as well as better geochemical veracity. Finally, a sample is obtained of the water's baseline conditions as it is applied to a crop or consumed by the public.

Conclusion

California has had a groundwater quality monitoring program for four decades. The program successfully met its original goals: to determine background (ambient) mineral groundwater quality for waters intended for beneficial uses. CDWR, indeed, has compiled a vast and valuable data base, currently stored in its Water Data Information System. These water quality data are valuable for their continuity in both time and space, important constants when one is making comparative studies. CDWR continues to monitor for current conditions and changes, and is in a good position for meeting future water quality challenges.

Because the monitoring program was designed to be flexible, CDWR has been able to concentrate monitoring efforts where they have been most needed, and has continued to maintain an extensive monitoring network across the state. Actual monitoring network design was left to the individual district offices, where those most familiar with the respective regions and their resources could decide when and where to monitor. Attempts to standardize spatial sampling procedure had been made by a central committee in 1969 and 1986. The recommendations were met with resistance by the district offices, however, who argued that they were more familiar with the resources, and that the resource was simply too variable geographically to standardize spatial sampling to the extent recommended by the committees (Clawson 1987; Steel 1987). These arguments are acknowledged and validated in current expert opinion survey methodology for resource management and decision-making (Tobin and Rajagopal 1990). Standardizing would reduce the program's flexibility, the very feature that made it successful for nearly four decades.

In the past decade, California's attention has moved to water quality issues beyond assessing, delineating and maintaining of its waters. For example, California counties are currently grappling with interbasin transfer issues and impacts, with mixed results. Senate Bill 867, The California Groundwater Management Act, was introduced to create locally managed groundwater districts, intended in part to regulate groundwater export from these districts and prevent damage to groundwater supplies (Porter 1992, Tehama County 1992). Possible degradation of water quality is as important a concern as declining water tables. California ground water law only prohibits interbasin transfers for beneficial use if there is permanent damage to recharge (supply) of streams or aquifers in the source region. In other words, groundwater may be exported from a basin if it is considered "surplus water", as summarized by Meyers and Tarlock:

> Any water not needed for the reasonable beneficial uses of those having prior rights is excess or surplus water. In California surplus water may rightfully be appropriated on privately owned land for nonoverlying uses, such as devotion to a public use or exportation beyond the watershed . . . (Meyers and Tarlock 1971).

Water quality degradation and its impacts on those users with prior rights is therefore an important and relevant consideration. California's program's background information on groundwater quality and quantity should allow planners to model possible impacts before interbasin transfers and possible damage occurs. Determining and modeling these impacts is beyond the scope of this paper, but is a recommended area for future research.

As the California Department of Water Resources' example has demonstrated, the initial expense of running a well-designed and flexible monitoring program can be balanced by long-term benefits gained through improved information. Our ability to anticipate and react to groundwater quality changes, pollution events, or to model future scenarios is therefore improved. As resource managers we can all look to this proven model for future planning needs.

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OWENS VALLEY'S ABANDONED LANDSCAPES

Robert A. Sauder

Currently, agriculture accounts for more than eighty per cent of the water used in the arid West, but this usage is under attack. Persistent migration to western cities, coupled with declining federal interest in financing huge water projects, ensure that pressures for water transfers out of agriculture will increase as competition for existing supplies intensifies (Knudson 1987). With the West's water supply now largely appropriated, agricultural communities throughout the region may in future years be forced to protect their way of life in the face of mounting demands for water in the region's growing urban areas.

Perhaps the most publicized water transfer in the history of the West involved Los Angeles' diversion early in this century of Owens River water, resulting in the eventual abandonment of agriculture in Owens Valley. Much has been written about the manner in which Los Angeles acquired water rights in Owens Valley (Hoffman 1981; Kahrl 1982; Nadeau 1950), but overlooked in the literature is an examination of the patterns of rural livelihood that had evolved in the valley prior to the Los Angeles water diversion. This analysis draws on the abandoned landscapes of Owens Valley to uncover past relationships between the valley's settlers and their arid environment. It also illustrates what could happen to other agricultural communities as rural-to-urban water transfers in the West become more common.

Prior Appropriation

Owens Valley, situated on the western margin of the Great Basin between the lofty, glaciated peaks of the Sierra Nevada and the dry, barren landscape of the Inyo-White Mountains, is drained by the Owens River (Figure 1). Numerous perennial snow-fed streams flowing off the Sierra contribute to the valley's relatively abundant water resources, whereas

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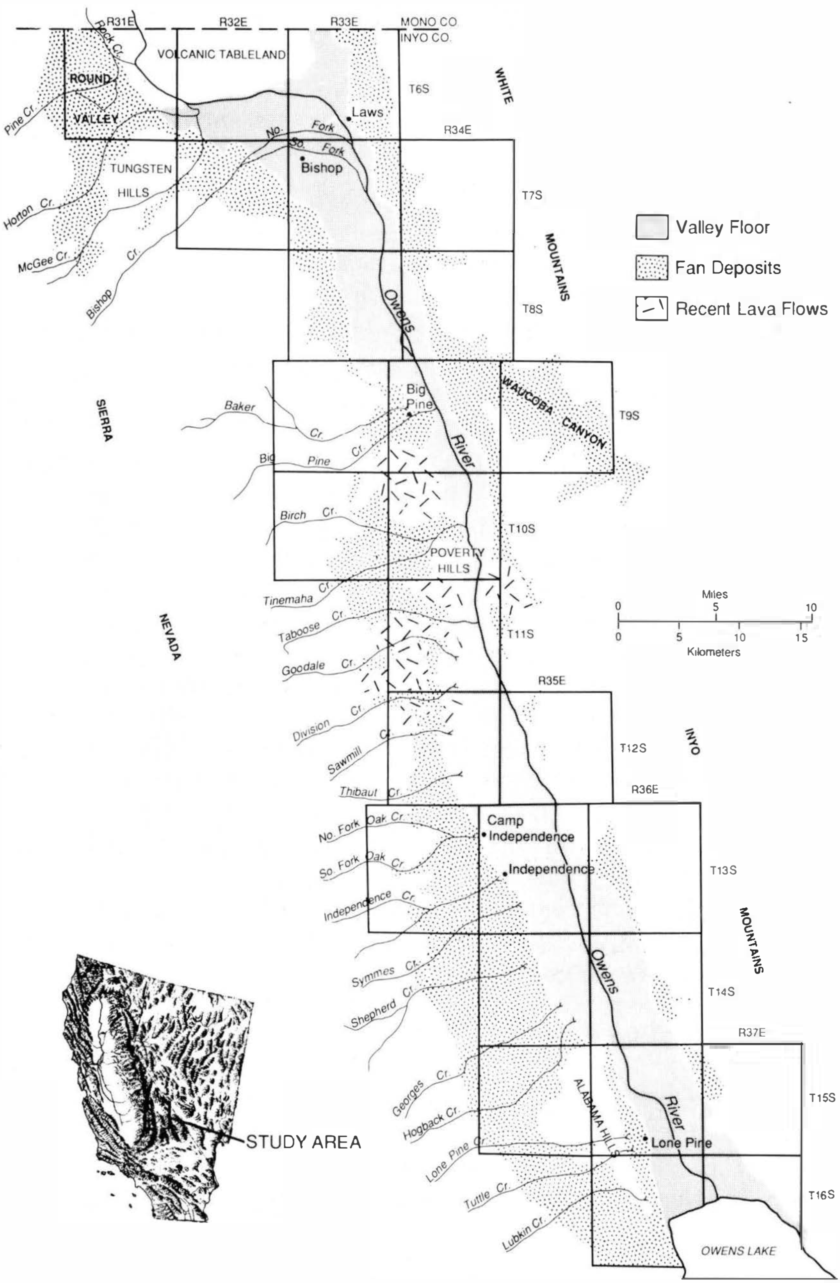

Figure 1. Owens Valley, California

streams draining the Inyo-White Range are intermittent in flow and convey little runoff. Many of the Sierra streams, particularly those south of Poverty Hills, sink into the loose detrital material of the valley floor before reaching the Owens River, thereby contributing to the vast reservoir found beneath the surface. While the streams of the Sierra are largely responsible for the valley's water supply, the range also casts a rain shadow across the valley floor as it captures and depletes moisture-bearing winds off the Pacific Ocean. Although annual precipitation is variable, the valley averages between five and six inches (130-150 mm) per year, making agriculture without irrigation impossible.

Stockraisers trekked into Owens Valley in the early 1860s, and permanent settlement began soon afterward. Like most settlements scattered outside of the Mormon realm in the West, Owens Valley settlement was stimulated by markets provided by nearby mining activities (Sauder 1990). Although mining contributed initially to the West's economic development, irrigated farming sustained the region's economic growth. Consequently, demands for irrigation water led to the region's water laws and institutions. Borrowing from the custom of western miners' use of water, pioneer settlers adopted the doctrine of appropriation, or the right to appropriate water in the public domain (Wilkinson 1986). Under this doctrine a seniority system developed based upon the premise "first in time, first in right"; that is, the first person who came to a stream and claimed a portion of its flow had priority to exploit the water. Unlike the riparian doctrine adopted by the more humid eastern states, where water could legally be used only on land bordering a stream, the doctrine of appropriation allowed the appropriators to divert water to any location so long as it was put to some approved beneficial use. While this system of prior appropriation explains the large amounts of water historically utilized by western agriculture, it has also proved conducive to long distance rural-to-urban water transfers in the West (Wahl and Osterhoudt 1985).

The Sacrifice of Owens Valley

The Los Angeles Aqueduct was designed in the early 1900s to channel by gravity the unappropriated water of the Owens River 233 miles south to the rapidly growing Los Angeles metropolis. In order to gain undisputed hold on the valley's unused water supply, both surface and underground, Los Angeles began purchasing land and appurtenant water rights to the relatively undeveloped south half of Owens Valley. The initial diversion of Owens River water in 1913 had little impact on the valley's existing agriculture, because most farming and settlement were located north of the proposed diversion site. Since the city had tapped the river below the valley's leading center of agriculture, under ordinary circumstances both farmers and city dwellers would receive their needed allotments of water. But in the early 1920s, a prolonged drought began to tax the city's ability to supply itself with water. Runoff from the Sierra was far below normal, and by the time Owens Valley farmers made their diversions, there was little water left to supply the Los Angeles Aqueduct. The city's only recourse for augmenting the aqueduct's supply, short of the construction of a major reservoir above the valley, was to purchase additional land with water rights in the valley's north end.

Consequently, Los Angeles implemented in 1922 a wholesale policy to purchase farms and appurtenant water rights from whomever was willing to sell, causing neighbors to become bitterly divided (Walton 1986). Many landowners were uncertain whether to accept an attractive offer, while others were determined to hold on to their properties. Soon the reversion of northern valley lands to desert conditions, with dying trees and dilapidated houses, created a feeling of despair and insecurity among the remaining farm population. Nearby valley towns—Bishop, Big Pine, and Laws—were increasingly deprived of their economic base (McClure 1925). Los Angeles' purchases quickly impaired the value of remaining properties, for once the process of land abandonment began there was little outside interest in the valley's real estate. By 1924, federal and state land banks refused to make loans. Even the most stalwart owners were eventually compelled to sell to the city, for they found themselves confronted with a condition of isolation, surrounded by desolation, and a realization that they could no longer hold on without their neighbors.

By 1925 Owens Valley's economy was "suspended on a wire of doubt" (Walton 1986). Residents had lost control of the ability to direct their own lives; they could only respond to the city's actions. In order to avoid potential water conflicts, Los Angeles proceeded to acquire nearly all land and appurtenant water rights in the valley, including town properties. Laws eventually lost its critical mass for survival and largely ceased to exist. The towns of Bishop and Big Pine, as well as Independence and Lone Pine, were saved from extinction by the growing number of tourists taking advantage of the eastern Sierra's scenery. Los Angeles owns today 99 per cent of the valley's land, making the valley a tributary province of the city it helped build (Nadeau 1961).

Abandoned Landscapes

A unique form of urban blight settled over Owens Valley as most of its productive farmland, no longer irrigated, was abandoned. The number of farms in Inyo County dropped from 521 in 1920 to 201 in 1935 as the amount of irrigated acreage declined.[1] By 1935 the destruction of agriculture in the Bishop region was nearly complete (Figure 2). Geographer Ruth Baugh described the changes that occurred there between 1916 and the mid-1930s:

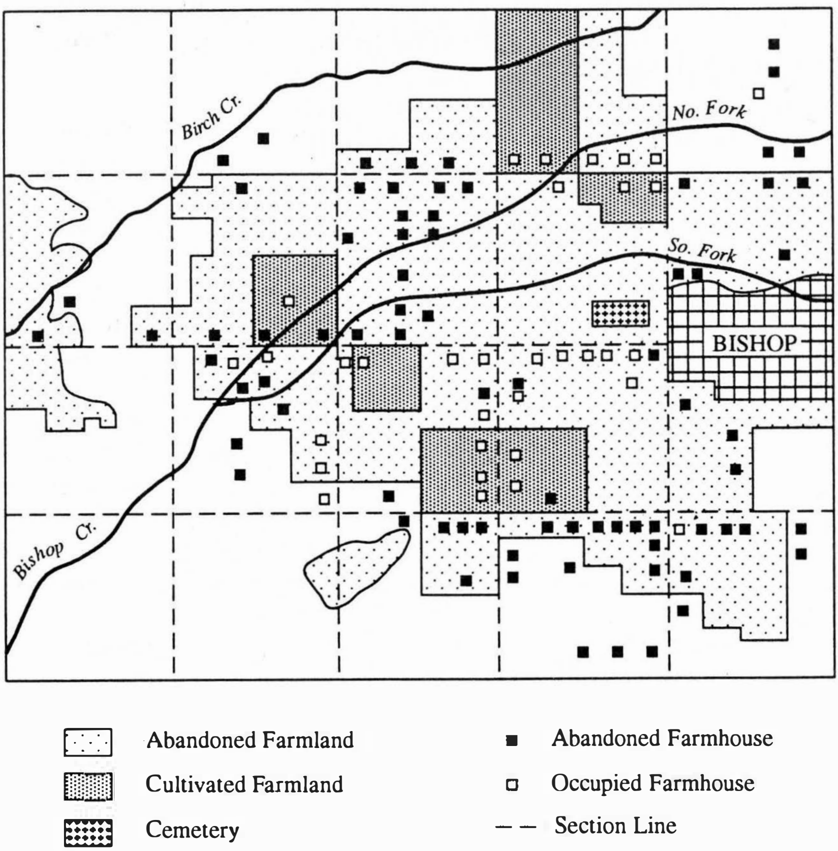

Figure 2. Abandoned farms in the West Bishop district in 1935.
Source: Adapted from Baugh, 1937

1. Since Owens Valley was the only significant region of Inyo County that was cultivated, farm statistics for the Owens Valley are nearly synonymous with those for the county.

> From the railroad station at Laws to the town of Bishop and west to Red Hill one traveled [in 1916] tree-lined roads through a district almost continuously cultivated; green fields bordered by wide irrigating canals alternated with stretches of damp pasture lands. A verdant land, Owens Valley presented a scene of substantial economic well-being and human contentment. How different today the area, vacant and desolate! (Baugh 1937).

Baugh also noted that there was little evidence in the town of Bishop, the valley's largest service center, that agricultural products had been sold in the valley (Baugh 1937). Dying orchards, empty schoolhouses, abandoned farm houses and farm buildings were now common landscape features (Figure 3). Los Angeles, the new landlord of Owens Valley, removed most traces of abandoned rural life as quickly as possible; houses and barns were bulldozed or burned and many trees and orchards were either cut down or uprooted in order to hide from passing motorists the despoliation it had wrought (Figure 4).

But before this precipitous decline, substantial development took place in Owens Valley, and subtle landscape features survive today that remind one of the hardship and toil undertaken by former residents to make this arid land bloom. Viewed from the air, relict field patterns are still etched into the floor of Owens Valley (Figure 5). Their rectangular shape was determined by the public land survey of the mid-1850s and the nineteenth-century public land measures designed for disposal of the public domain, while their expanse reflects the breadth of farming that once prevailed in the valley. With the spread of mining activities beyond California's Mother Lode into the western Great Basin in the late-1850s, the demand for farm products in the region increased, setting the stage for pioneers to improve the rectangular units which they had selected for settlement.

The transition to farming in what originally was a grazing frontier did not go smoothly. As land continued to be brought under the plow during the early 1870s, and new claims filed on the public land that stockmen had formerly used as open range, the destruction of growing crops by free-ranging stock resulted. Fencing would be needed to keep stock out of the newly sown fields, but in an arid, treeless region such as Owens Valley, fence materials were difficult and expensive to acquire. When Owens Valley was initially settled, barbed wire had not yet been invented, and when it did appear on the market in 1874, it was prohibitively expensive for most pioneers (Chalfant 1933). In Round Valley some farmers encircled their fields with substantial stone walls (Figure 6).

Figure 3. Dying trees and the invasion of rabbit brush mark the location of a former farmstead in the Warm Springs district southeast of Bishop

Figure 4. Tree Stumps located near Owens River Canal in the Sunland district southwest of Bishop

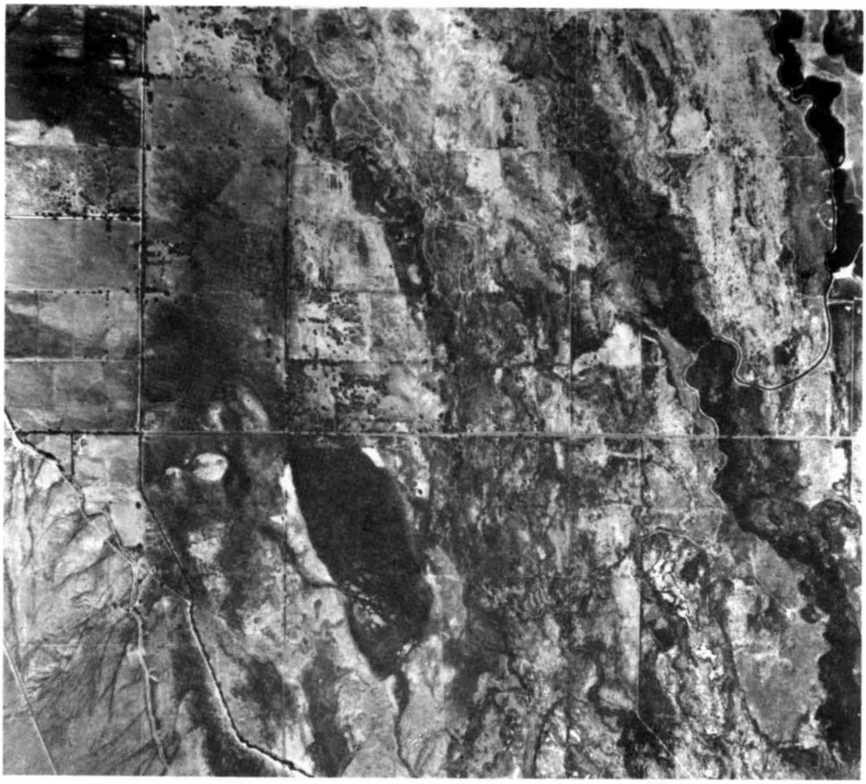

Figure 5. Abandoned fields south of Bishop. Roads and relict field boundaries conform to the original public land survey of the valley, completed in 1856. Source: Bureau of Land Management, 1977

In order to increase the supply of fencing material, black locust trees were introduced into the valley in the late 1860s (Earl 1976). Cottonwood trees also were planted for the same purpose. But the establishment of tree plantations for fencing was uncommon. There was little time for extensive tree culture when most pioneer efforts were devoted to crop production. Commonly, however, trees were planted along roads and as wind breaks around fields (Figure 7). In the early 1890s the *Inyo Independent*, a weekly newspaper published in Independence, reported on the improvements taking place around Bishop:

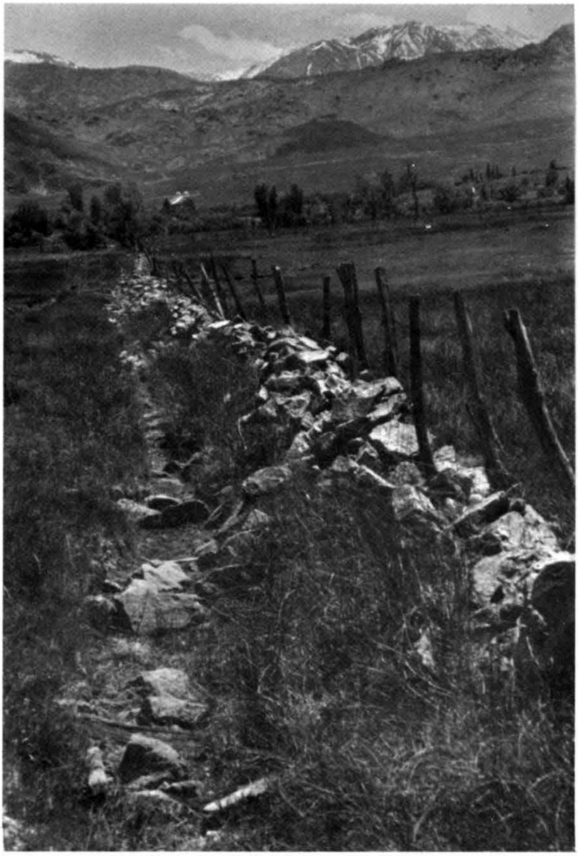

Figure 6. A relict stone fence in Round Valley

> Shade trees are planted there more than any place else in the county, and already long stretches of well shaded roads make lovely drives. Wisely did the settlers plant trees extensively; and now . . . the whole country for several miles west, north and south of Bishop is richly wooded. Without those groves of trees, no matter how highly cultivated the land might be, the country would still retain much of the original desert aspect (Anon. 1892).

The trees in the valley that have survived to the present still ward off the valley's heat and aridity (Figure 8).

Many of the late-nineteenth century improvements in the northern half of Owens Valley were linked to Congressional approval of the

Figure 7. Tree-lined roads and fields south of Bishop in 1931.
Source: Spence Photo Collection, University of California, Los Angeles

Desert Land Act in 1877. The new land law was designed to encourage reclamation of the western public lands, and its passage resulted in the extension of a number of irrigation canals, all claiming a portion of the Owens River's flow (Sauder 1989). Ditch companies were formed and often incorporated, and farmers purchased shares of stock, with each share carrying the right for the use of a specified amount of water. Canal construction was done by the farmers themselves during the winter season using a team of horses and a primitive cast-iron scoop called a Fresno scraper. Most of these partnerships built comparatively small ditches that irrigated only the lowlands, while the higher alluvial slopes remained unwatered. By 1901 water from the Owens River was diverted through eighteen main ditches and canals, as well as some smaller ones, totaling nearly 200 miles in length (Anon. 1901). Most were located in the north end of the valley because the larger number of farmers and the more concentrated form of settlement there made their construction on a cooperative basis feasible (Figure 9). Much of the new land brought under irrigation by the desert land canals was devoted to alfalfa production to support stockraising in the valley.

The trend away from general farming toward increased emphasis on stockraising was not enthusiastically endorsed by valley newspapers. The *Inyo Independent* commented that

Figure 8. Lombardy poplars planted by pioneer settlers still provide tree-lined drives in the West Bishop region

> While it is very desirable to have capital invested in the county, yet if that capital is to be used in buying out small farmers in order to make big stock ranches, we would be better without it than with it (Anon. 1887).

A shift toward more intensive farming such as fruit production was recommended, and one of the most ambitious fruit raising efforts was undertaken by the Owens Valley Improvement Company on land it had purchased on Shepard Creek about five miles southwest of Independence. At this location the company subdivided 16-25 acre ranches, installed a sophisticated irrigation and drainage system, and platted a new town, known as Manzanar. Although the town of Manzanar failed to develop as planned, considerable demand existed for the small tracts surrounding it, most of which were marketed in Southern California. The general plan of the Owens Valley Improvement Company was to expand the valley's apple production,

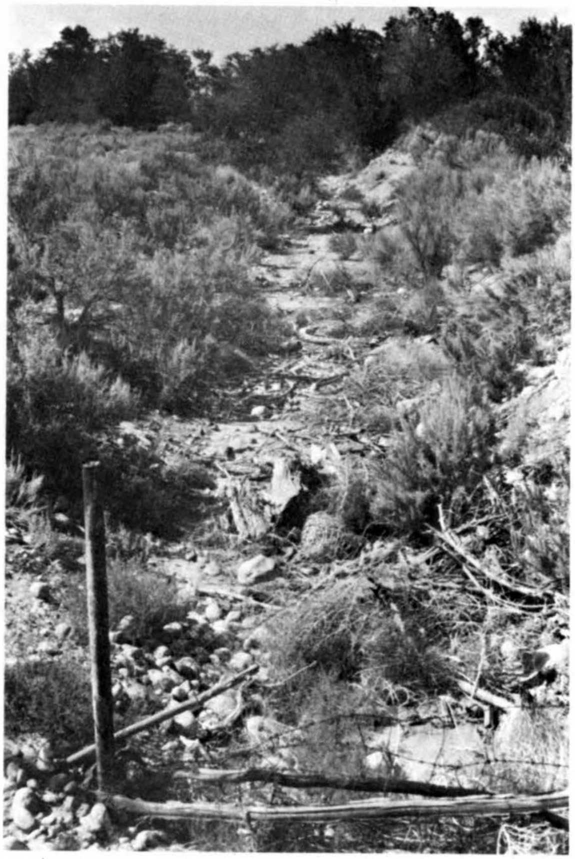

Figure 9. Dry channel of Owens River Canal. One of the more successful cooperative ditches in the valley, Owens River Canal served lands to the west and southwest of Bishop

and the firm therefore offered to plant apple trees and care for them for absentee land owners, or to sell the trees directly to new residents (Anon. 1911). Much of the increase in the valley's fruit production in the 1920s was related to the Manzanar development (Figure 10).

The *Inyo Register*, published in Bishop, also recommended alternatives to stockraising, and dairying was proposed as a feasible option (Anon. 1892). The systematic development of Owens Valley's dairy industry had begun in the Bishop region in 1892 when the Inyo Creamery was incorporated and a plant constructed at Bishop (Chalfant 1933). In 1898 Owens Valley's first silo (and reportedly the first in the trans-

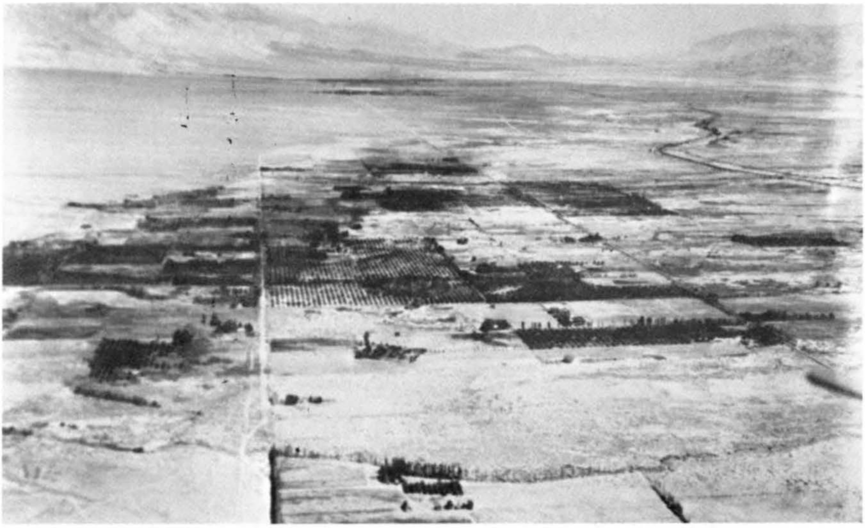

Figure 10. Fruit ranches at Manzanar in 1931. Following the abandonment of Manzanar, the subdivision was used as an internment camp for Japanese-Americans during World War II. Source: Spence Photo Collection, University of California, Los Angeles

Figure 11. Remains of Roberts' silo in Round Valley, the first silo to be built in Owens Valley. Constructed in 1898 of light tufa rock, it stood twenty-two feet high and held 230 tons of silage

Figure 12. Abandoned concrete silos located southeast of Bishop. Many silos, although unused today, are still seen in the Bishop-Round Valley region where dairy farming was once prominent

Mississippi West) was constructed in Round Valley (Figure 11). It was "the first experiment with ensilage in the entire region, from which dairymen in the north section of the valley were anxious to learn results" observed the *Inyo Register* (Anon. 1898). Dairying would subsequently become one of the leading enterprises in the Bishop-Round Valley region, and its advance was reflected in the numerous concrete silos which began to appear on Owens Valley's horizon. The *Inyo Independent* reported that approximately a dozen silos were erected in the valley between 1914 and 1916, and "many more were in the course of construction" (Anon. 1916). By 1922 over 100 silos were distributed across the valley floor, most located in the north end of the valley (Anon. 1922). Today, the majority of extant silos are abandoned, standing forlorn against the mountain backdrop (Figure 12).

Alfalfa, beef cattle, fruit and dairy production were the chief agricultural enterprises in Owens Valley when Los Angeles embarked on its final acquisition program, and the evolving rural livelihood patterns in the valley were abruptly terminated. Each activity was a small-scale endeavor compared to other agricultural districts in the state, primarily because of the valley's relatively short growing season and its habitual isolation from the more settled regions of California. Yet much of the historic ambiance of Owens Valley evolved out of its farming and ranching activities, and the valley's abandoned rural landscapes serve as reminders of the hardships associated with settling this remote, arid region.

Conclusion

Owens Valley's abandoned landscapes enable us to recount the region's settlement history, but they also demonstrate how the shift of water away from farming can have significant implications for those who are tied to agriculture and related activities. Fortunately, nearly all western states today have some agency with discretionary authority to oversee proposed water transfers and, in contrast to the past, those contemplating water exchanges now face an array of legal, logistical, and financial hurdles (Udall 1987).

Nevertheless, water reallocations in the West will inevitably increase in importance and the abandoned landscapes of Owens Valley should also stand as reminders of what could happen to small communities elsewhere in the region as rural-to-urban water transfers become more common. Since much of the economic vitality of the West derives from its farming and ranching base, a sound and functional transfer process is critical to the region's future; otherwise, large cities will ultimately squeeze the water and life out of small communities, as happened to Owens Valley (Babbit 1988). But numerous options are available for sharing some of the larger water supplies used for agriculture with growing municipalities without creating hardships for farmers or rural communities (Lamm 1986). With adequate safeguards in place, there need be no more Owens Valleys, and the ambiance and lifestyle of western rural areas can be preserved in tandem with the ongoing urbanization of the region.

Acknowledgements

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SUBURBAN LANDSCAPES OF THE EAST BAY

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Rapid urbanization has led to an ever increasing proportion of our population living in cities and surrounding suburbs. With this increase, the actual and perceived quality of intensely humanized urban and suburban landscapes grows in importance. As humans we long for a habitat, a landscape, in which we can develop our full potential (Tuan 1979). How well do suburban landscapes currently meet our needs?

Commonly, the term to "'landscape' means to 'prettify'" (Lewis 1979). Although landscapes are usually thought of in visual terms, they are, in fact, "what we live in, move through and experience with all our senses — sight, sound, touch, smell, and taste" (Kennedy 1989). We have an interactive relationship with landscapes and with vegetation as the predominant natural element in suburban landscapes. In many cases trees may be seen as being a symbol of nature, of the web of life — a condensation of the natural environment. The same might be said of other forms of vegetation. In our relationship with landscapes, emotions as well as practical considerations are involved (Kennedy 1989). Hence, Shroeder (1986) points out the need for research which will help illuminate the emotional attachment people feel for places and associated features such as vegetation. Emotional attachment to place and vegetation is directly related to quality of life and may help us understand why people choose to live or remain in certain places. It could also help us find ways to improve the satisfaction of a city's inhabitants with the city and neighborhood environment (Bartenstein 1981).

Landscapes in the broader sense, are a mixture of humans and nature (Meinig 1979). They are our autobiography, our philosophies and history given tangible form (Meinig 1979; Lewis 1979). Geographers such as Jackson, Relph, Meinig, and Tuan recognize the importance of social

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factors in creating humane, aesthetically pleasing landscapes (Kennedy et al. 1988). And, according to Meinig (1979), "If we want to change the landscape in important ways we shall have to change the ideas that have created and sustained what we see." First, however, we must learn to see the landscape and to try and understand what it is we are seeing.

Seeing and Understanding Suburban Landscapes

Suburban landscapes are similar to building styles. Various elements can be traced to certain location and eras. This is possible because our suburban landscapes are a compilation of different cultural biases we have gathered along our journey through time and space. These biases can be read in the suburban landscapes in the same way we read housing types. These modified suburban landscapes are not static "walled gardens" separating us from nature as McHarg (1966) claimed, but are instead reflections of our changing cultural interpretations of aesthetics and nature. They comprise features so common-place in our greater American landscape, that they act as symbols of our American home; they are our singular, giant, joint front yard.

The primary analysis of landscapes in this paper reflects the lead author's thirteen year involvement in the landscaping industry. During this time he has maintained, designed, installed, and upgraded many residential and commercial landscapes. The study area includes Contra Costa and Alameda County suburban areas in California's East San Francisco Bay region (Figure 1). Landscape architecture is "the art of arranging or modifying the features of a landscape, in an urban (or suburban) area . . . for aesthetic or practical purposes"(Random House Dictionary 1988). Landscape in this paper largely refers to that area of land designed by a landscape architecture, or designed in a similar fashion. It also refers, however, in the broader sense, to our habitat, our surroundings. In both instances landscape is anthropogenic; in the first it is primarily a planned environment, in the latter a reflection of our philosophies and ideas — conscious and otherwise.

In the East Bay, as in many other suburban communities throughout America, designed landscapes can be broken into three major categories: residential, commercial, and city-owned public land (although county, state, and federal land may also be present, they are not dealt with here). Many shared design elements, plantings, and other materials are found in all three landscape types. Each type, however, has its own characteristics and its own aesthetic qualities which serve a common purpose — that of beauty.

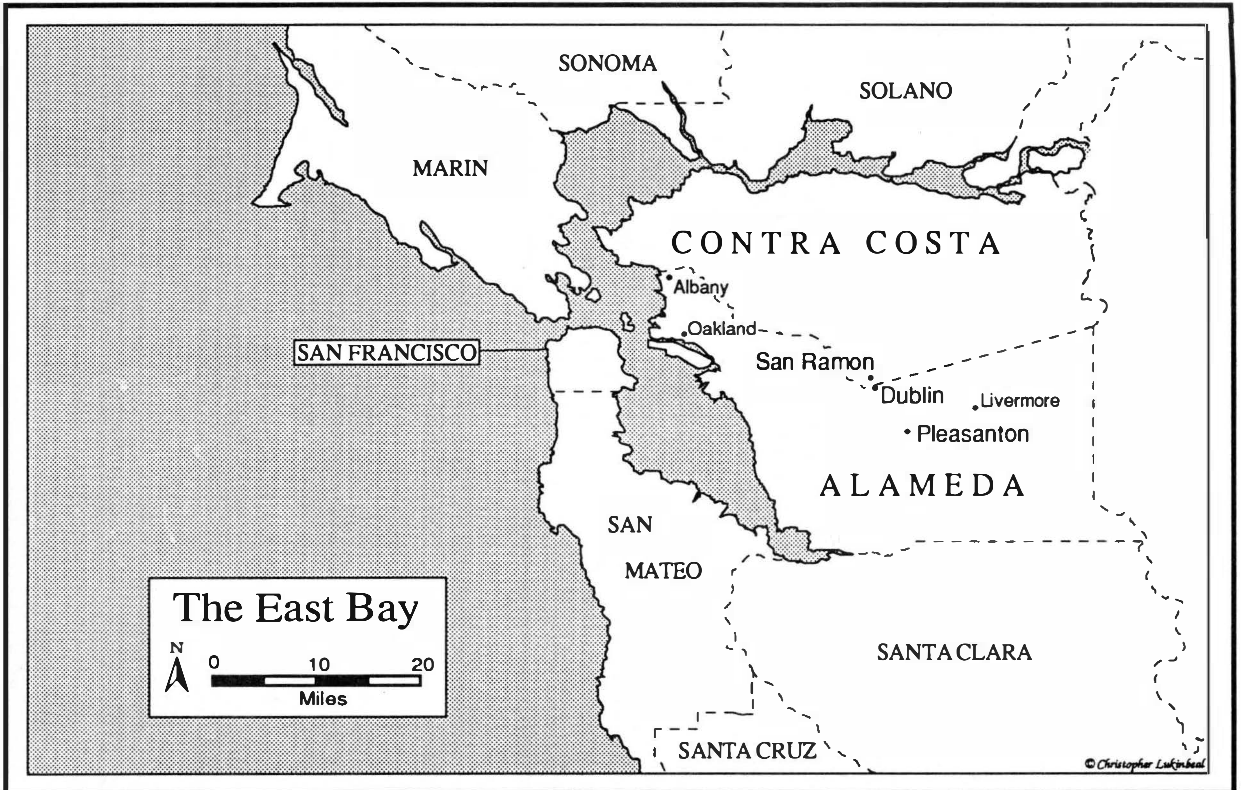

Figure 1. Location of towns in east bay study area

This paper presents an overview of three suburban landscape types in the East Bay. Recurring and unique elements found in each type are discussed. Views on suburban landscapes are reviewed. And, finally, we argue that these landscapes are much more than "walled gardens", not only are they integral parts of suburbia, but, as a whole comprise an American symbol.

Overview

Residential Landscapes. Residential landscaping combines uniquely personal space (the back yard) with communal aesthetics (the front yard). The Back yard can be viewed as a "setting for outdoor living", where the "form of the garden owes more to the house and family activities than to requirements of plants. The back yard is social rather than horticultural" (Grampp 1985). Back yards are usually enclosed areas, blocked off from the rest of the neighborhood by shrubbery and trees. They more truly represent "yards" as defined by Paul Groth (1990), a word that signifies enclosure. Back yards tend to reflect residents' personalities more than front yards. Back yards can be seen as extensions of the house — outdoor rooms (Grampp 1985). They provide private space for social gatherings, growing fruits and vegetables, or for work and storage (Kennedy 1989). In these contexts, back yards may become places to store old washers and used cars, or to keep pets. They may also be sanctuaries, rooms distinguished by their "esthetic environment", places of rest (Grampp 1985).

The communal aesthetics of front yards "are a national institution—essential to every home, like a Bible somewhere in the house." Front yards are public, places to be viewed by outsiders and by the community. They serve as a social "index of the taste and enterprise of the family who owns" or lives in this home. We subjectively rank a family's community pride and personal cleanliness by the quality of their front yards; "weeds and dead limbs are a disgrace, and the man who rakes and waters and clips after work is usually held to be a good citizen" (Jackson 1951, 3). The main purpose of front yards is seen as improving the appearance of the neighborhood (Kennedy 1989).

Front yards are not merely individual entities. Combined with streets, they comprise "the open, flowing, parklike spaces we now associate with upper-middle-class suburban life" (Groth 1990). This open space is sometimes protected by laws where cities restrict fence height. It is also protected by unwritten laws. Neighbors tend to frown upon residents that fence in their front yard and cut off a part of the open space from the rest of the community. When a fence was put up in the front yard of an Albany neighborhood many residents expressed dismay. "It cut into everyone's space" (Grampp 1988).

According to Jackson (1951), residential landscapes as a whole "provide a place for outdoor enjoyment and indicate social standing." The true purpose is "probably very simple: it exists to satisfy a love of beauty. Not every beauty, but beauty of a special, familiar kind; one that every American can recognize and enjoy, and even after a fashion recreate for himself".

Commercial Landscapes

Businesses, apartment complexes and condominiums are places of profit and loss. In commercial landscapes there are only front yards. Landscapes here are, aesthetically, oriented outward toward the community. These landscapes are maintained by professional landscapers and are typically carefully groomed environments were every detail is seen to. Personality is removed. They become symbols of J. B. Jackson's "establishment", of an orderly working environment. They reflect permanence and order. Tight geometric shrubs, straight lines, and clean edges are the norm. Commercial landscapes often appear to be pale copies of Classical gardens of old.

Like residential front yards, commercial landscapes can be used as social and economic indices. Companies' and apartments' social climate and economic standing are reflected in the quality and cleanliness of the landscapes. In general, the more money a company makes the more carefully groomed (or as it is called in the trade, "detailed") its landscape appears. There are exceptions, however, when corporations believe that an aesthetically pleasing landscape is a commodity they don't need, or when it is a low priority economically. Commercial landscapes, more than any, perpetuate Nohl's (1985) criticism that "nature is being destroyed by design".

City-owned, Public Landscapes

Areas throughout a city which are landscaped for aesthetic purposes and parks which are landscaped for activity purposes are important elements in a city's appearance. Public parks, predominantly large open lawns bordered by trees and occasionally shrubbery, make up the largest part of these landscapes. Their purpose is to provide an open common green where community activities can take place. This is the objective value of these areas but J. B. Jackson (1951) suggests that the "lawn with its vague but nonetheless real social connotations is precisely that landscape element which every American values the most. Unconsciously he identifies it with every group event in his life. . . ."

Landscapes designed primarily for aesthetic purposes exist along city streets. They include medians, areas around interchanges, intersections, and major arterials. City landscaping also includes areas around the library, city hall, and related buildings. The landscaping around city buildings is similar to that of commercial landscapes. There is no backyard. The purpose is communal aesthetics. City landscapes are, however, generally not as rigidly structured or "detailed" as commercial landscapes. Like commercial landscapes, the social and economic index also applies here. The more money a city has, the more "detailed" the landscape will be.

Perhaps the most interesting aspect of the cities' landscapes is along its roadways. These areas can give the city an overall theme or personality. It is here that many suburban cities try to emphasize their differences from neighboring cities and to promote their city as an individual entity, thus enhancing its "sense of place". A good example of this can be seen in the comparison of the three neighboring cities of Pleasanton, Dublin and San Ramon. Street treatment in Pleasanton consists primary of lawns with Sycamore trees and shrubbery (Figure 2). In Dublin it is primarily brick patterns, Sycamore trees, with *Escallonia, Euryops, Agapanthus, Raphiolepis,* and *Xylosma* shrubs. San Ramon, recently finished landscaping much of its adjacent street property. Jim Estep (1992) of the public services division of the city explained that San Ramon made sure that their landscapes would be different than the other cities in the area. Estep explained that they wanted a look that would be unique. To obtain this they choose a "handful a plants" to create a theme, a communal character. Tree selection was essential. First they looked to see what other cities had used and avoided these species.

Elements in the Landscape

Regions are partially defined by repetition and elaboration on landscaping themes. Residents and landscape architects see things that they like in other landscapes and imitate them. Ideas spread through diffusion, yet cultural biases and neighborhood restrictions also play a role in what a landscape looks like. Many reoccurring elements can be traced through the cities of Pleasanton, Dublin, and San Ramon. We will focus the elements of time and growth management, climate and culture, and landscape as a selling feature. Other constraining factors that determine what landscapes look like include climatic and pedological factors,

Figure 2. Landscaping of streets, such as this one in Pleasanton, is intended to create a positive sense of place

nursery and supplier stocks, design characteristics, maintenance styles, plant and material selection, personal and communal preference, and economic considerations.

Time. Time has a significant effect on the appearance of landscapes. Landscape may reflect fashions and climatic conditions from the era in which it was designed. The city of Pleasanton with all of its green lawns was installed in in the early 1980's before drought became a factor. San Ramon's landscapes, on the other hand, was designed and installed during a period of continuing drought.

Growth Management. Time is also reflected by growth. How we interact with plant growth in our suburban environment can tell us a lot about ourselves. In suburbia the trend is to manage plant growth. Allowance for plant growth varies in each of the three areas. Growth is the most severely limited in commercial and residential front yards. Cities and residential backyards tend to have a greater growth allowance. Strict growth management can be related to a desire to keep an environment uniform and unchanged. In such environments change and age do not exist, human/nature interaction is thwarted, and "people have little opportunity for imaginative activities, and nature has little opportunity for unhindered growth" (Nohl 1985) (Figure 3).

Figure 3. Growth management of vegetation is most severely limited in commercial and residential front yards

This type of strict growth management is what we generally identify with landscape architecture. In our culture, landscape architecture has been identified with garden-making where we tend to perceive our ideal landscapes as arranged "in a simple geometry as a comprehensibly metaphysical symbol of a benign and orderly world" (McHarg 1966, 527). In such landscapes "no concept of community or association becloud the objective" (McHarg 1966, 527) and people become:

> . . . frustrated by the facilities that dictate our activities, and the spread of vegetation is thwarted by constant maintenance. The appropriation of open spaces by nature or by users is also made difficult because the design produced by the landscape architect is often regarded as a work of art and because implementing and maintaining the design is expensive. As a result of high maintenance costs, authorities often set up constraints to prevent the public from determining how they will use open spaces and to restrict the growth of plants (Nohl 1985, 39).

Less stringent growth management can provide a sense of continuity, promote human/nature interaction, and increase our esthetic enjoyment (Nohl 1985). Growth allows for a landscape to have a past, thus providing continuity. Continuity between past, present, and future, aids human/nature interactions and can promote community belonging. Esthetic enjoyment is increased when we "perceive not only colors, shapes, and smells — the perceptive level — but if the objects disclose the processes behind them, whether past, present, or future" (Nohl 1985, 37). With less emphasis placed on growth management, landscapes reflect a more natural state — a state that is not rigidly structured, a state were plants shape themselves (Figure 4).

Figure 4. Less stringent growth management allows this commercial residential landscape to reflect a more "natural" state

Cities and backyards tend to place less constraints on growth. Jim Estep explained that this is accomplished in cities not so much by design as by the scale at which the maintenance takes place. There is allowance for growth as the community grows. This can promote some assurance to inhabitants of permanence and belonging within a city, of a shared growth with the city. A resident might even fondly reminisce "I remember when that tree was only so high."

In the East Bay landscape maintenance makes up around forty percent of the waste going to landfills. With less stringent growth management this biomass waste could be limited. Cutting lawns less frequently and maintaining them at a taller cutting height the lawns requires less water. A move towards freer growth would require a change in cultural perceptions and in landscaping preferences. Currently many people tend to associate tight, formal hedges and short cut lawns with a clean, orderly, and desirable environment.

Climate and Culture

From an ecological perspective, a landscape is "a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout" (Forman and Gordon 1986). The three suburban landscape types form interacting ecosystems. Regional climate and the seasons play a large role in a landscapes appearance. Every spring flowering trees and shrubs such as *Prunus, Pyrus, Camellias,* and*Euryops* bloom. In summer, suburban areas in the East Bay are colored with annuals. During autumn Sycamores, Oaks, Birches, Alders and other deciduous trees drop their leaves. In the winter lawns turn brown and trees are pruned. Climate not only influences plant selection but it also affects the landscape in more direct ways. For example, in the winter of 1990-1991, the East Bay was subjected to extremely cold weather and heavy freezes. Many trees and shrubs were partially or completely killed. Effects from this freeze are still apparent in our landscapes today.

Climate and culture coexist in the lawn. The lawn carries social connotations and can be traced to its English origins. In England there is abundant water and grassy meadows occur naturally year round (Jackson 1951). In our Mediterranean climate, however, water is a valuable and limited resource and lawns are one of suburbia's largest water consumers. In this instance, our cultural preference seem to outweigh economic and climatic factors. Many people in the East Bay, however, are starting to question the value of a lawn. Home owners have to decide what to do when a beautiful green lawn turns into a water/money consuming commodity. In some instances, lawns are being replaced with gravel, or with bark and shrubbery (Figure 5).

Many new landscapes in all three areas reflect this more drought tolerant attitude. Still the lawn will not likely disappear because the preference for it is so deeply ingrained that it continues to be a major selling element for new home buyers (Bowman 1992; Lukinbeal 1992).

Landscape as Selling Feature

The final recurring element we wish to discuss is the way in which landscapes act as selling items. Not only lawns, but also well groomed yards are significant factors that are considered when people are buying

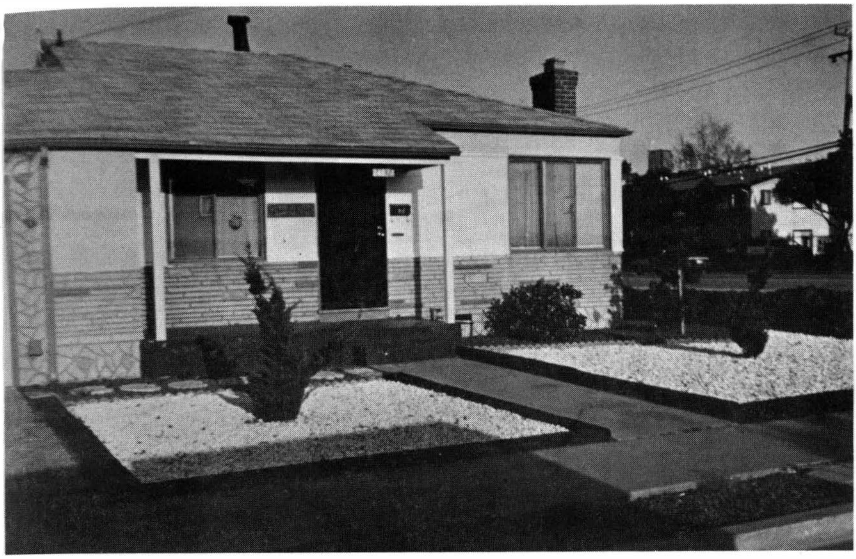

Figure 5. Rock, gravel, and bark are replacing lawns in many East Bay yards in an attempt to conserve water, money, and maintenance time

a home. Grampp (1985) interviewed one family who commented, "When I saw the heather in the front yard, I knew I wanted the house. I didn't even need to see the inside" .

In commercial landscapes, the ideal of selling plays an important role in the shape and appearance of a landscape. In large business parks, such as Hacienda Business Park in Pleasanton, and Airway Business Park in Livermore, landscaped areas exist prior to construction of the buildings. In this context, landscape is used to sell a company an image of what their corporation will look like behind beautiful green lawns. Corporate landscapes often reflects generic national preferences rather than regional differences.

Owners of expensive apartment complexes insist that it is the beauty of the grounds and greenness of their lawns that attract tenants to their site (Carney 1991). In such a context, a carefully manicured garden complex is seen as promoting the image of a respectable community in which people have a better standard of living than in overgrown, unkept complexes. Industries such as fast food outlets and gas stations also offer the potential customer a "wholesome and neat appearance" because "dyspeptic design does not promote sales" (Relph 1981).

Viewpoints

Anti-suburban sentiment. Suburban landscapes often are viewed with distaste. "It is a thoroughly accepted academic practice to condemn suburban landscapes and suburban living" (Relph 1981). Even though these are the landscapes that many of us are raised in and live in, it is hard for us to understand and appreciate their beauty. We long instead for virgin wilderness, for a time gone by, a place out of our past where scenic wonders offer beauty to our eyes and romance to our hearts. These are the "sacred" landscapes that stands in opposition to the "profane" domesticated landscape (Erickson 1977).

Suburban landscapes are forced to compete aesthetically with these non-humanized landscapes and with landscapes containing natural wonders such as National Parks. According to Salter (1983), "we tend to evaluate the landscape around us through the eyes of our other non-urban self. The dichotomy between where we want to be and what we want to see has led to a peculiar blindness in our landscape appreciation".

Conron (1973) points out that "landscape means, quite simply, the land's shape as it is seen from a particular and defined perspective" where perception —

> ...applies not only to the physical outlook but also to a psychic outlook, we come to see that landscape includes both a physical and an ideal shape. . . The visible image, of a personal or cultural point of view-an ideal design of hopes, needs, values, and ideas which both shapes and takes shape in landscape (xvii).

It is in the suburban landscape that the dominant, middle class American culture express itself. It is here that both the beauty and ugliness of a significant part of our culture takes shape in the land. In "America and in no other culture has the spatial construct of landscape been ... indispensable, for we seem to see ourselves as a people living in space more than in time, in an environment more than in a history" (Conron 1973). Thus, much in our landscape represents timelessness and lacks continuity.

To understand and enjoy the suburban landscape, one must perceive it for what it is — a domesticated landscape. It is *not* a natural landscape. Zube (1982) explains that —

> ...those who experience the wilderness on a continuing basis in their day to day activities sensed that savage and aesthetic qualities coexisted within the same landscapes. They recognized beauty but were also confronted with the realities of a landscape that was simultaneously harsh and dangerous.

We, however, living day to day amidst suburban landscapes, fail to recognize their beauty because "a personal preference proves immiscible with a societal preference" (Everden 1985). Our societal preference is lost somewhere in the romance of a vast, wonderful, and dangerous wilderness. As long as we view human activity as "despoilation" and "pristine nature as perfection" (Meinig 1979), the more difficult it will be to come to terms with and to appreciate the humanized landscapes we have created. The suburban environment has its own special and unique beauty. Beauty can be found in a personalized yard, the structure and color of a Japanese maple. Our senses can be enriched by the smell of fresh cut lawn or the pungency of sesame seeds that radiates from the leaves of *Podocarpus.*

A Relationship with the Land

Relph argues that the quality missing from suburban landscapes is personal commitment — because the manner in which these landscapes are planned and developed systematically denies it. To him these "excessively humanized" landscapes are "dehumanizing" because the only changes one may make are "trivial ones". He claims that "the small freedom of an individual to be involved in making or to be responsible for a fragment of the landscape has been denied"(Relph 1981).

We believe Relph underestimates personal involvement in suburban landscapes. People move to suburbia in order to own or rent a house with a plot of land. By having a yard one either becomes responsible or chooses not to be responsible for that landscape. People who choose the former begin an interaction with the land. Residents may design their own yards, select plant species, and complete the work themselves. Even if residents choose to hire a landscaper, however, they are being responsible for their land and have an influence on it. This influence reflects their expectations of what they think *their* landscape should look like. In either case, it is these so-called "trivial" aspects — the choices, thought, and involvement — that provide a sense of commitment to the land and give the landscape personality. Whether through attentiveness or apathy, our perceptions and choices shape the suburban landscape around us.

Suburban landscapes can promote a sense of belonging to the area through their common characteristics and, for the long term resident, through their growth. Cities in the East Bay attempt to promote a sense of unity and "sense of place" through their landscape design. Furthermore, attachment to a suburban place can be shaped over time as designed landscapes grow into their desired form. Attachment is especially likely to develop when residents design their own landscape or plant trees and shrubs. Plants are like domesticated animals, dependant on man for their survival, and are "man's cohorts, sharing his domestication" (McHarg 1966). Home owners, tenants, and office personal often develop attachment for certain aspects of a landscape. This attachment develops through interaction with the landscape. Indirect interaction with the landscape occurs when a person expresses an idea about an aspect of the landscape to the landscaper who then makes their idea — their perception — a reality. Although some aspects of suburbia may act to "dehumanize" the environment, landscapes provide an arena in which personality, cultural bias, commitment, and belonging can be seen. As Jackson (1951) points out,

> As one travels west . . . you begin to mark the contrast between the yard and its surroundings. It occurs to you that the yard is sometimes a very artificial thing, the product of much work and thought and care. Whoever tends them so well... must think them very important .

Suburban Landscape as Symbol

Ian McHarg (1966) argues that suburban landscapes are walled gardens and that, as such, they play an important symbolic role in our society:

> ...the walled garden [is] separated from nature, a symbol of beneficence, islands of delight, tranquillity, introspection... Not only is this a selected nature, decorative and benign, but the order of its array is, unlike the complexity of nature, reduced to a simple and comprehensible geometry. This is then a selected nature, simply ordered to create a symbolic reassurance of a benign and orderly world, an island within the world and separate from it. . . the garden symbolizes domesticated nature, the wild is beyond.

Nature is, however, a part of the anthropogenic landscape — a key element that blends itself into the "walled garden". Suburbia is not enclosed and separate from the natural world. It is affected by natural processes, by weather and time, and by encroachment of native and exotic species. McHarg is correct, however, that this is a "selected nature". Nohl suggests that we have selected pieces from the "totality of nature" in such a way that these suburban landscapes present us "with subjectively based 'graphic' images" of nature that show a "harmonious unity of the cosmos", thus "making them relevant" for us (McHarg 1985).

Suburban landscapes are portraits of both local and national culture. They also, however, reflect personal decisions. When viewing a landscape one should consider three aspects: the designer's original intent, adjustments made to the design by previous owners or by the city, and the current inhabitant's perspective on the landscape. One perspective may be to ignore the landscape. This, in itself, tells us something about their attitude towards the landscape. Landscapes are constantly changing. As Relph (1981) points out, they are multi-layered, rooted in cultural history, and reflect both the technology and philosophical outlook of the present.

Suburban landscapes are our cultural interpretations of an idealized landscape. Yet with time and each generation, the values associated with these landscapes change to accommodate a new generation's values. As Jackson (1951) pointed out over forty years ago, and as is true of suburban landscapes in the East Bay today:

> A new human landscape is beginning to emerge... It is even now being created by the same combinations of forces that created the old one: economic necessity, technological evolution, changes in social outlook and in our outlook on nature. Like the landscape of the present, this new one will in time produce its own symbols and its own beauty.

Conclusion

Suburban landscapes can be interpreted symbolically. As symbols they are a combination — a synthesis — of nature and culture; they affect our perceptions and provide contrasting elements to compare with more natural places. These landscapes are truly American. Representing our interface with the lands' surface, they are one interpretation of the relationship between culture and nature. They, therefore, symbolically represent a continuing struggle within ourselves. As our civilization has evolved we have alienated ourselves from nature, thus creating a great longing for nature. The more civilized our culture becomes the greater our apparent need for natural beauty. Through suburban landscapes we attempt to find a new union with nature. According to Nohl (1985), if less emphasis placed on growth management and abatement, a freer, more natural "interplay between human use and the forces of nature" might exist.

Suburban landscapes are ideal American symbols of our cultural adaptation and our blending with nature. Rooted in the past, these landscapes reflect an areas taste, economy, and individuality. Culturally, most of us long to dabble with the earth and change it in some way. Our desire to have an effect on our surroundings appears to be stronger than our desire to be "one" with our surroundings. We want to see ourselves in the landscape, give our mortality continuity through our interactions with the earth. Culturally and individually this is reflected in the suburban landscape, in every pruned tree and shrub, in every stylized yard, and in every personalized domesticated plant. Through less stringent growth controls on vegetation and greater sensitivity to local climate and native vegetation, suburban landscapes can provide us access back to nature.

People generally seek comfort, whether it be physical comfort or emotional comfort. In doing so they often modify their surroundings or choose to live in a landscape in which they feel at home. The suburbs are "home" to an ever increasing number of people. Questions arise regarding exactly what constitues a humane, liveable landscape? How can we better create a sense of place and nurture people's sense of belonging? How can we take a non-expressive landscape and make it more responsive to our needs? The challenges are broad and include a need to find solutions which take into account people's emotional, intellectual, and spiritual needs as well as their physical ones. But first, in order to do this we must actually "see" and understand the suburban landscapes we have created.

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ETHNICITY IN THE SCHOOL: A CASE STUDY OF LOS ANGELES UNIFIED SCHOOL DISTRICT

C. Cindy Fan

In population studies ethnicity is generally considered an ascribed variable. Like gender, it is usually regarded as a stable and real characteristic of individuals that can account for some variations within the larger society. It is therefore distinct from achieved variables such as income, occupation, and marital status, which may change and are considered less stable. On the other hand, ethnicity can also be understood as an invention. Sollors (1989) argued that ethnicity is like nationalism, which can be invented, reinforced, and reinvented. For example, just as the Chinese laundryman comes from a country with no laundries, the Koreans in Los Angeles are almost immediately associated with hard working grocery store owners.

In Los Angeles ethnicity is an especially heated issue. It is quite clear that racial conflicts and urban discontent provided the backdrop for the 1992 riots and the episodes arising from the Rodney King incident. The tension between ethnic groups seems to be strong and prevalent. This is apparently an artifact of a unique metropolitan setting, with an increasingly multi-ethnic composition and simultaneously a high degree of segregation..

Segregation implies that a large proportion of the population have, willingly or unwillingly, restricted their activity space so that they do not have any significant degree of exposure to, and interaction with, members of other ethnic groups. The notion that ethnicity is an invention would be most effectively played out in an environment with a high degree of segregation. The school is one such environment. Unlike adults, who have considerable control over their activities, school children have very little say about which schools they attend, and what ethnic groups they will interact with in schools. But years of exposure or

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lack of exposure to members of other ethnic groups will tend to have potential and perhaps perpetual effects on school children's interpretation of ethnicity.

The literature on school segregation has tended to emphasize the impact of school desegregation policy on residential segregation (Clark 1988a; 1988b; Morrill 1989). The school, however, is where children spend much of their time and energy, and is an important source of information about their ethnicity and about own and other ethnic groups. Based upon the presupposition that the school environment is a key factor for the invention of ethnicity, this research focuses on ethnic composition and exposure in schools. Using Los Angeles Unified School District (LAUSD) as a case study, two separate and related questions are asked: (1) What is the current level of exposure of students to fellow students and staff of different ethnic backgrounds, and how does that compare with the level of exposure in the residential environment? and (2) What are the policy implications of changing ethnic composition in schools, from the point of view of school administrators? The first question highlights the school environment as an important determinant of the presence, absence, and degree of interaction between different ethnic groups. It involves analyses of the current degree of ethnic exposure in schools and in census tracts. The second question puts ethnic interaction into a practical context, by relating problem areas in schools to policy recommendation. Answers to this question are based upon a questionnaire survey of school administrators. The following sections address these two questions.

Ethnic Composition and Exposure

Data. Two sets of data are used in the analysis of ethnic composition and exposure. The first data set concerns the school environment and was compiled based on the *Ethnic Survey Report Fall 1990* published by LAUSD (1990b). In this research the ethnic categories have been combined and renamed as follows:

Ethnic Survey Report	This Research
American Indian/Alaska Native	Native
Asian, Filipino, Pacific Islander	Asian
Black, not Hispanic	Black
Hispanic	Hispanic
White, not Hispanic	White

The Asian, Filipino and Pacific Islander categories are combined to form an Asian category. Native Americans constitute less than one per cent of the students and staff in the district, hence in this research the analysis is confined to the Asian (A), Black (B), Hispanic (H) and White (W) populations. The *Ethnic Survey Report* contains the number of students and staff broken down by ethnicity for each of the more than 600 schools in the district. The analysis in this research includes the 490 elementary and junior high schools in LAUSD, but excludes the senior high schools and schools of choice.

Senior high schools and schools of choice were omitted from the analysis for two reasons. First schools of choice include many magnet schools, which are special learning centers focusing on a particular subject specialty, such as computer science, performing arts, or using a special teaching approach, such as alternative, gifted, or fundamental. Criteria for student selection depend on the type of school, and may range from the ethnic composition of resident schools to the student's current classroom achievement and scores. Because there are specific criteria for enrollment in these schools, and because enrollment in schools of choice (31,268) accounted for a relatively small percentage (5.04%) of the district enrollment (620,447), they were omitted from the study. Second, in order to conduct a questionnaire survey its design and administration have to be approved by LAUSD, which strongly discourages sending out more than 100 questionnaires. To generate a sample that is more representative (larger in size) of the population, I decided to include only elementary and junior high schools.

School staff are categorized as certified staff and classified staff. Certified staff include teachers and teachers who have become administrators. Classified staff are other administrators and staff in schools, including, for example, clerical staff.

The second set of data involves ethnic composition in census tracts to represent the residential environment. One can either study all of Los Angeles County, or only those census tracts in which LAUSD schools are located. Both approaches were explored and the patterns revealed are very similar. Conceptually, studying the entire county is more desirable, because student residence is not restricted by the boundaries of LAUSD, and many students commute. Therefore this research reports findings based on the entire county. Total population and population in the four ethnic categories (A, B, H, WA) for each of the 1,652 census tracts were extracted form the 1990 census PL94-171 tape.

Ethnic Composition. According to the 1990 census, the "minority" populations of Asian, Black, and Hispanic constitute almost sixty per cent of the population in Los Angeles County. Figure 1 shows that among the minority populations, Asians have increased from 6.1 per cent in 1980 to 10.3 per cent in 1990; the Hispanic populationhas grown from 27.0 per cent to 37.9 per cent; while Blacks have declined from 12.7 per cent to 10.6 per cent.

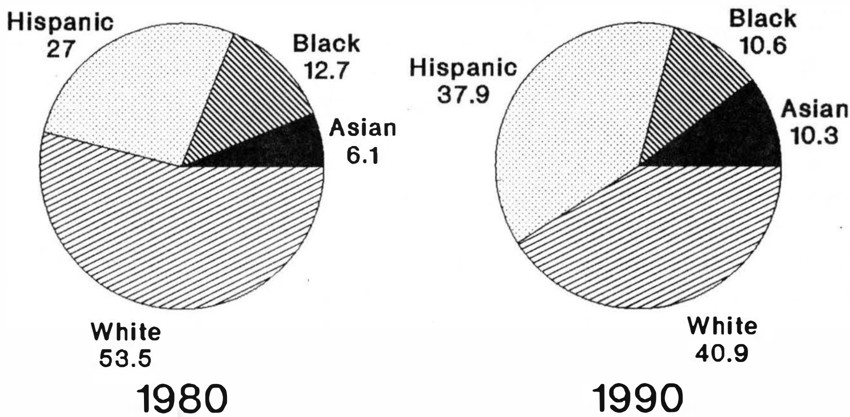

Figure 1. Ethnic Composition in Los Angeles County

The growth in Asian and Hispanic populations is also reflected in school enrollment. Figure 2 shows that in LAUSD, the percentage of Asian students increased from 3.9 per cent in 1966 to 7.6 per cent in 1990; the percentage of Hispanic students steadily increased from 18.6 per cent in 1966 to 63.3 per cent in 1990. On the other hand, both White and Black proportions have declined, from 56.1 per cent to 13.6 per cent and from 21.4 per cent to 15.2 per cent respectively.

The ethnic composition of school staff is considerably different from the student population. Figure 2 shows that White staff remains the largest ethnic group, followed by Hispanic, Black, and Asian staff. A closer look at the breakdown reveals drastic differences between the certified and classified personnel. Figure 3 shows that among the certified staff, 60.7 per cent are White and only 12.3 per cent are Hispanic. On the other hand, 50.1 per cent of the classified staff are Hispanic, followed by 22.8 per cent Black, 20.2 per cent White and 6.4 per cent Asian. Because teachers are certified staff, students in the district are more likely to have White teachers than teachers of other ethnic groups; and parents are more likely to meet White teachers and administrators in schools.

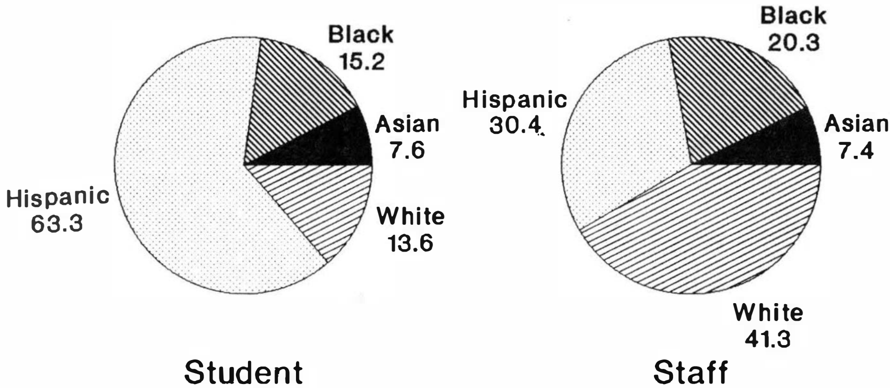

Figure 2. Ethnic Composition of Students and Staff in LAUSD, 1990

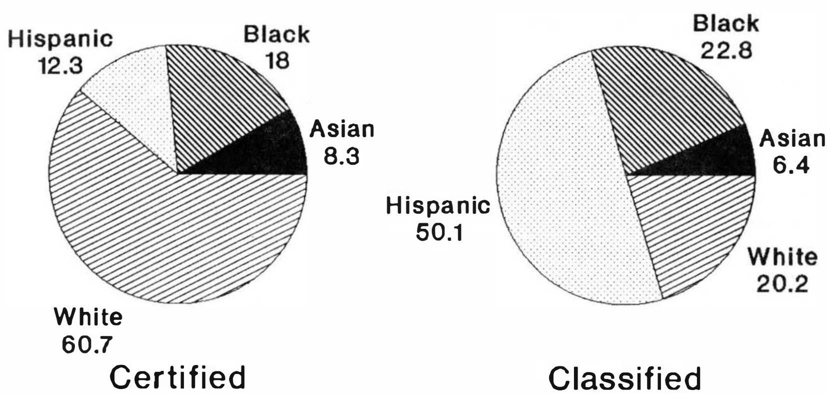

Figure 3. Ethnic Composition of Staff in LAUSD, 1990

Measuring Ethnic Exposure and Segregation. Two of the indexes that have been widely used to measure segregation are the dissimilarity index and the exposure index. They are often used to evaluate residential segregation in a two-group situation typically Whites and Blacks or Whites and non-Whites. In Los Angeles a two group approach is inadequate. This paper extends the concept and methodology of the indexes to highlight the multi-ethnic character of the study area.

A third approach used the entropy index. It is widely used in ecological studies for investigating species diversity, and has its origin in information theory (Pielou 1969; Shannon and Weaver 1949). In population studies the entropy index has been used to measure the extent of ethnic diversity when more than two ethnic groups are involved (Allen and Turner 1989; Turner and Allen 1990). However, the detailed relationships between pairs of ethnic groups are masked when one addresses a number of ethnic groups simultaneously. In the following I will report findings based on variants of the dissimilarity and exposure indexes, that are constructed specifically to deal with a multi-ethnic setting.

Dissimilarity index. The computation of the dissimilarity index (D) is based on the difference between the proportion of one ethnic group and the proportion of another ethnic group. For example, when only two ethnic groups of Blacks and Whites are concerned:

$$D = \frac{1}{2} \sum_{i=1}^{n} \left| \frac{bi}{B} - \frac{wi}{W} \right| \qquad (1)$$

where w_i = number of Whites in a subunit i;
b_i = number of Blacks in a subunit i;
W = number of Whites in study area;
B = number of Blacks in study area.

D measures to what extent population of an ethnic group is evenly distributed across some spatial units or subunits such as census tracts or schools. In this research the study area with respect to census tracts is Los Angeles County, and the study area with respect to schools is LAUSD. D also gives the minimum proportion of Blacks or Whites who would have to move from one subunit to another in order to obtain an even distribution of that ethnic group across all subunits (i.e. $b_i/B = w_i/W$ for all i). The theoretical range of D is from 0 (no segregation) to 1 (complete segregation). Suppose D is subtracted from 1:

$$S = 1 - D \qquad (2)$$

S is a "similarity index". It ranges from 0 to 1, 0 meaning complete segregation and 1 meaning no segregation. S is preferred to D for the purpose of this research, since greater (smaller) "similarity" between groups is associated with greater (smaller) interaction and exposure.

The four ethnic groups in this research generate six similarity pairs. Figure 4 shows that in both schools and tracts, the pair of highest similarity is Asian-White, followed by Asian-Hispanic and Black-Hispanic. Asian-Black and Black-White have the lowest levels of similarity. In all cases the similarity in schools is less than the similarity in tracts, suggesting that the exposure to people of other ethnic backgrounds is smaller in the school than in the residential environment.

Exposure index. The exposure index measures the degree of potential contact between members of different ethnic groups. Assuming a two-group situation:

$$E = 1 - P = 1 - \frac{\sum_{i=1}^{n} b_i w'_i}{BW'} \qquad (3)$$

where b_i =number of Blacks in a subunit i;
w'_i = proportion of Whites in a subunit i;
B =number of Blacks in study area;
W' = proportion of Whites in study area.

E in this case measures the degree of exposure of Blacks to Whites. The theoretical range of E is from 0 to 1: 0 indicates complete balance, when Blacks would encounter Whites at a rate equal to the city- or dis-

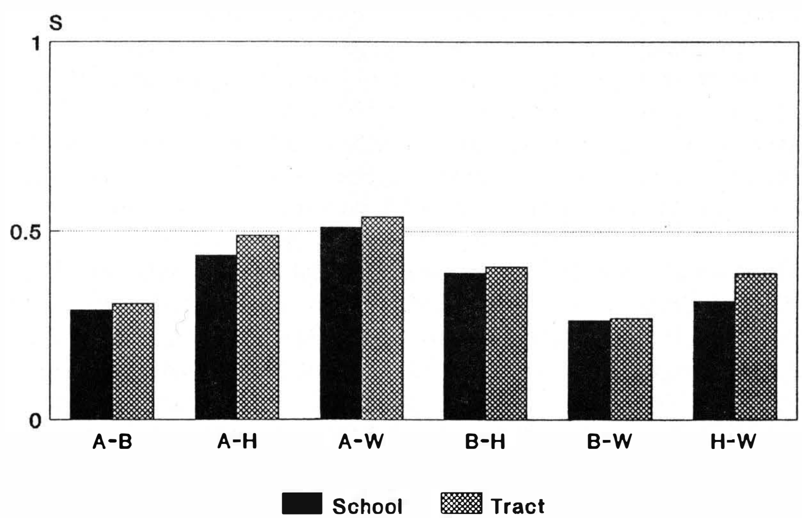

Figure 4. Similarity Indexes in Schools and in Tracts

trict-wide level; 1 indicates complete isolation, when Blacks would tend toward contact only with other Blacks.

The second term on the right, P, warrants some explanation. The denominator of P is the number of Blacks times the proportion of Whites in the study area, which is an indicator of the rate of Blacks' exposure to Whites as suggested by the number of Blacks and the proportion of Whites in the study area. The numerator is the sum of rates of exposure for all subunits. Maximum exposure of Blacks to Whites would occur when numerator = denominator, so that P = 1 and E = 0. If $b_i w'_i = 0$ for all i, either $b_i = 0$ or $w'_i = 0$; accordingly P = 0 and E = 1, which indicate complete isolation of Blacks from Whites.

It has been shown elsewhere that the theoretical range of P and E is 0 to 1 only if the population consists of two ethnic groups (Fan, in progress). In a multi-ethnic setting P may be greater than 1 and E may be less than 0. In the literature, however, there is a tendency to employ the formulation in (3) as well as the theoretical range of 0 to 1 regardless of the number of ethnic groups involved. To accommodate a larger range and to emphasize the concept of exposure, a more desirable measure is:

$$P^* = P - 1 = -E \qquad (4)$$

The interpretation is as follows: $P^* < 0$ indicates less than predicted level of exposure; and $P^* > 0$ indicates more than predicted level of exposure. The theoretical minimum of of P* is -1, which implies no exposure between the two groups involved. The positive value of P* evaluates the magnitude at which exposure is more than the predicted level. For example, $P^* = 2$ suggests that exposure is two times more than the city-wide or district-wide level. Some degree of segregation exists of P* for own ethnic group is positive and P*s for other ethnic groups are negative.

Figures 5 through 8 report the P* index, which evaluates the exposure of students to students and staff of different ethnic groups, and the ethnic exposure across census tracts in Los Angeles County. Figure 5 shows the exposure of Asians. P* is positive for Asian students, certified and classified staff, and Asians in tracts. It is particularly high for Asian students in schools, much more than for Asians in tracts, suggesting that the level of exposure of Asians to other Asians is greater in the school than in the residential environment. The difference in school and residential exposures suggests that on one hand, Asians have a rather diffused geographic distribution across census tracts; and on the other hand, there are certain schools of particularly large Asian student populations, resulting in high exposure as well as segregation.

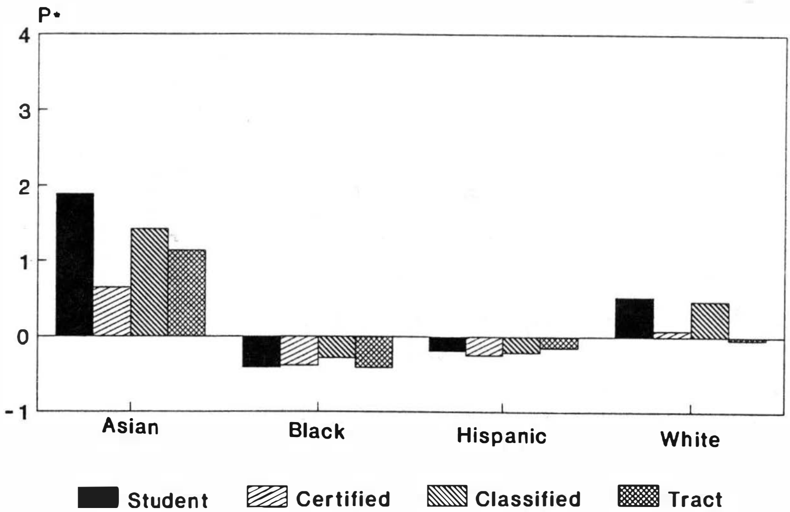

Figure 5. Exposure of Asians in Schools and in Tracts

P* is also positive for White students and staff, but slightly negative for Whites in tracts. This confirms the relatively high level of exposure of Asians to Whites in schools as suggested by the similarity index shown earlier. However, the exposure in tracts is less than predicted. That is, an Asian is more likely to encounter Whites in the school than in the residential environment. P*s for Blacks and Hispanics are negative in both schools and tracts, which is consistent with the similarity index results.

Figure 6 shows the exposure levels for Whites. Again, like Asians, their exposure to Blacks and Hispanics in schools as well as in tracts is less than predicted, particularly in schools. The exposure of White students to other White students is very high, about two times more than the predicted level, and is higher than the residential level. So again, like Asians, White students are more likely to encounter other Whites in the school than in the residential environment. Their exposure to Asians in schools is also higher than predicted, although this in not true for tracts. Overall, it seems that Asians and Whites are more exposed to one another in schools than to other groups, and both ethnic groups tend to be more segregated in the school than in the residential environment.

The exposure levels for Blacks are reported in Figure 7. The very high P*s for other Blacks are quite striking. In particular, the exposure

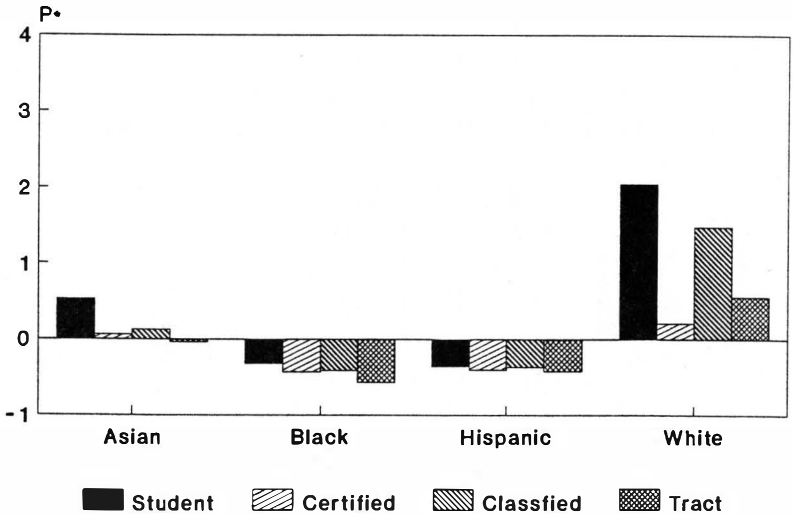

Figure 6. Exposure of Whites in Schools and in Tracts

to Blacks at the census tract level is extremely high—three times more than the predicted level. The exposure to Blacks in schools is somewhat less, but is still almost two times more than predicted. Also, the exposure to Black staff is strongly positive. On the other hand, P*s for all other ethnic groups are negative, in schools as well as in tracts. Noticeable is the very low exposure to Whites in tracts. It seems that, unlike Asians and Whites, segregation of Blacks, and thus isolation and lack of exposure to other ethnic groups, is stronger in the residential environment than in schools.

Figure 8 shows the exposure levels for Hispanics. Although P*s are positive for exposure to Hispanics and negative for exposure to all other ethnic groups, the deviations from the predicted levels tend to be small. Noticeable among them is the higher P* for exposure to Hispanics in tracts, and the lower P* for exposure to Whites in tracts. Like Blacks, residential segregation of Hispanics seems to be greater than school segregation, but the difference is small compared with Blacks.

The above figures yield some disturbing facts. First, both in the school and in the residential environment, Los Angeles is very segregated ed. This research does not involve comparative studies, but it is clear that the current level of segregation is substantial. A high level of segregation means limited exposure and personal interaction with members of other ethnic groups. The residential segregation of Blacks is par-

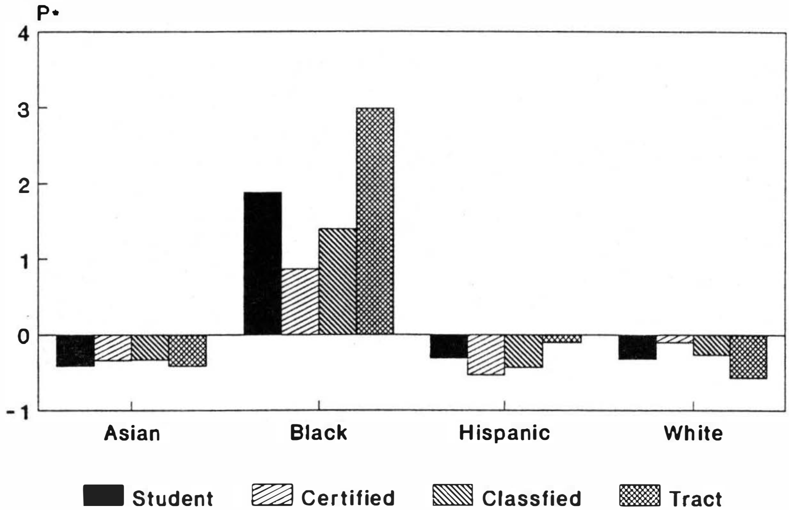

Figure 7. Exposure of Blacks in Schools and in Tracts

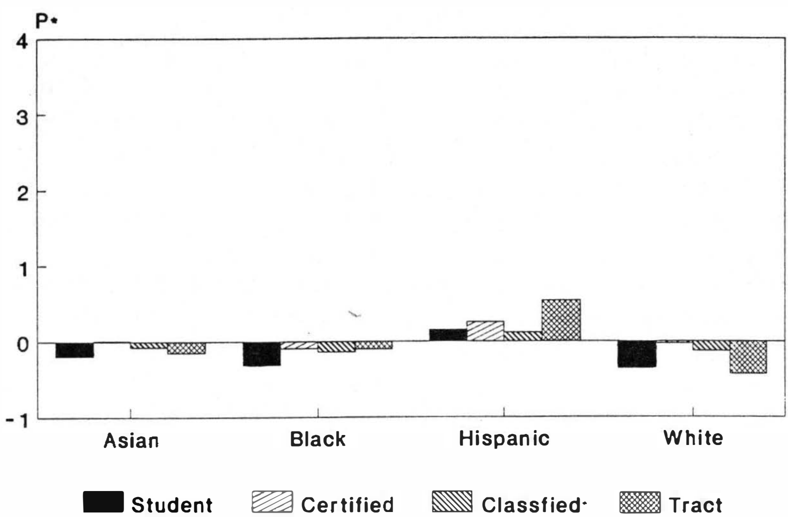

Figure 8. Exposure of Hispanics in Schools and in Tracts

ticularly alarming. Second, the deviation in exposure between schools and tracts is quite large. The case for Asians and Whites is particularly problematic. Their exposure to Blacks and to Hispanics is very low in schools. Their segregation in schools is more severe than residential segregatation, although the latter has received greater attention in the literature. For students who are at an age of intense learning and absorption of new facts and materials, their knowledge about other ethnic groups would have to come from other sources, typically the media, instead of in schools where they spend a good proportion of time and energy, and where they may have access to personal interaction. On the other hand, for Blacks and Hispanics, residential segregation is greater than school segregation. It is likely that desegregation policy and programs such as PWT (Permits With Transportation) (LAUSD 1990a) have greater impacts on Black and Hispanic students, so that they are more likely to encounter members of other ethnic groups in schools than in the residential environment.

Questionnaire Survey

The questionnaire surveyed school administrators for information about problems associated with changes in the students' ethnic composition, the school's response, and policy recommendations for better serving a rapidly changing school population.

The questionnaire was evaluated by LAUSD, and revised according to LAUSD's suggestions. It was sent to 127 schools in the fall of 1991. The sample, which represents about 1/4 of all elementary and junior high schools in the district, was generated by selecting randomly approximately 1/4 of elementary and junior high schools from each of the eight administrative regions of the district, to ensure a representative geographic coverage. I received 51 completed questionnaires, for a response rate of forty per cent. Most of the respondents are school principals.

The questions in the questionnaire can be collapsed into three separate headings: bilingual teachers, curriculum and textbooks, and interaction with parents. The results are summarized below.

Bilingual Teachers. There is a strong feeling among school administrators that bilingual teachers are very important, regardless of the respondents' ethnicity, the ethnic composition in the school and in the school's neighborhood, and the ethnic composition of school staff. On the other hand, in schools with predominantly White students, respondents indicate that *increasing* the number of bilingual teachers is not considered an important issue.

A majority of respondents from schools that are predominantly Hispanic recommend strongly that more resources be allocated to provide language train for non-English speaking students.

Curriculum and Textbooks. The general feeling about textbooks is that the emphasis on culture is inadequate. This is particularly the case for respondents from schools that are predominantly Hispanic, and less so for respondents from schools that are predominantly White. Respondents were also asked which subjects are most lacking of textbooks with culturally relevant materials. The most frequently mentioned subject is social studies, followed by science, literature and history. Other subjects that are mentioned include mathematics, art, physical education and music.

There are many comments and recommendations about curriculum and textbooks. They tend to concern three areas. First, there is a perceived need for books written in languages other than English, particularly Spanish. Second, respondents indicate that publishers have been responding to the needs of a diverse student composition, so that current textbooks are more culturally relevant than previous ones. Third, it is suggested that in addition to emphasis on culture, textbook materials should include contributions of women and minorities, and social responsibility.

Interaction With Parents. Most respondents indicate that there are no significant difficulties in parent-teacher or parent-administrator interactions. Among those that indicate difficulties, the majority are from schools that are predominantly Hispanic. The reasons that are suggested, in order of importance, include language barriers, cultural barriers, parents not willing to interact, and lack of resources.

Some anecdotal evidence illustrates the range of perception among respondents in different school environments. One principal in a predominantly White school, which is located in a prestigious and predominantly White neighborhood, complains that minority parents rarely participate in school activities. An Asian principal, in a school that is predominantly Black, which is located in a neighborhood that is also predominantly Black, indicates that Black parents are not willing to interact because they want a Black administrator. These two cases depict ethnicity as a major factor in parents' role in school; they are also examples of how ethnicity is being constructed, how the image of certain ethnic groups is being formed, in the school environment.

The comments on parent participation highlight two areas that are of concern. First, language barriers are major obstacles to interaction. Some respondents indicate a need for hiring more bilingual staff, and some respondents comment that schools have been responsive to such need through programs such as language training for staff. Second, availability of the parents is another major issue. Some respondents suggest that the difficulty is related to apathy, poverty, and distance, especially for students who are transported long distances to school.

Recommendations that do not fall under the three headings above are less common, but nevertheless worth attention. Two respondents suggest counseling and self-esteem workshops for minority students, and more resources for extra-curricular activities. Others indicate a need for training programs for parents, including language, parental skills, and other social services.

In summary it seems that language is perceived as a major factor in teaching as well as interaction with students and parents. A number of problems seem to be more severe in schools that are dominated by minority students. It is quite clear that both schools and publishers have been responding to changes in the ethnic composition of students. Nevertheless, ethnicity continues to be an important underlying factor that contributes to defining the nature and magnitude of difficulties facing students, parents, teachers and administrators.

Conclusion

The findings in this research further underscore the severity of segregation in Los Angeles. In particular, the level of segregation in the schools is higher than residential segregation for Asians and Whites. For Blacks, both school segregation and residential segregation are high, and unlike Asians and Whites, they are more segregated in the residential environment than in the school. Although Hispanic students are not as segregated as the other ethnic groups, their sheer number in LAUSD schools seems to have contributed to greater awareness and concern on the part of administrators of difficulties in teaching and increasing parent participation.

To policy makers, the findings emphasize the importance of ethnicity in the school environment. Policy makers have at least two means to create an environment that is more conducive to interactions between different ethnic groups. Desegregation programs have been experimented with for many years and continue to be controversial. There is evidence that desegregation measures such as busing have no significant effects on residential segregation, and that school desegregation has led to White flight to private schools (Clark 1988; Morrill 1989). The second option involves more fundamental changes, along the lines of training teachers and administrators in languages, cultures and the concept of ethnicity. School administrators surveyed in this research also recommend efforts to diversify the ethnic composition of staff, and to train teachers for overcoming barriers associated with ethnicity.

Recent evidence indicates that the economic gap in the U.S. has tended to widen. Inasmuch as ethnicity is also intertwined with poverty as dividing lines in society, policy makers need to address seriously issues of inequality, and the distribution of, and access to, resources such as education, jobs, and transportation.

There are many questions which are not within the scope of this research but are indeed important issues related to ethnicity in schools. Among them are academic performance of different ethnic groups, ethnicity in private schools, and students' perception of their own and other ethnic groups. One limitation of this research is that only broad ethnic groups are studied. Future research should investigate breakdowns within these groups since they are very diverse in, for example, geographic origin, duration of stay, generation, and class.

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1992 Annual Meeting

California Polytechnic State University, San Luis Obispo, May 1-2

The California Geographical Society's 1992 meeting was hosted in fine style by the geographers at Cal Poly, San Luis Obispo, with a nice mix of social and scholarly activities. Field trips in the surrounding area on Friday were followed by a delicious "Cretaceous" Char-B-Q in Cuesta Park, featuring Brontosaurus steaks and other Don Floyd specialties. The opening address gave us an up-close look at southern Louisiana, as Lawrence Estaville, Jr. spoke to us on "Cajuns: Reality and Myth."

In addition to the paper sessions on Saturday, the program included a series of workshops, meetings, and a panel looking at "Women in Geography—Growth, Change, and Challenge." The evening was capped by the Annual Awards Banquet, held in Cal Poly's Vista Grande Cafe, where Dr. James Roberts (Managing Partner, Global Environmental Management Services in Sacramento) spoke about "Geographers Work in an International Perspective."

Awards were announced by CGS President David Helgren (San Jose State University). The Lantis Scholarships ($250) were awarded to **John Scott** (CSU, Chico) and **Samanthe L. Kadar** (CSU, Sonoma). Certificates of Appreciation were given to **Cal Wilvert** (Cal Poly, San Luis Obispo) and **Richard Hough** (San Francisco State University) for their services to the organization.

Awards of Merit for Distinguished Teaching in Geography went to **Robert Christopherson** (American River College); **Janice Jerabek** (Harvest Park Middle School, Pleasanton); **Carol Light** (Thompson Jr. High School, Bakersfield);**Marilyn Renger,** (Balboa Middle School, Ventura) **and Robert Williams** (Nord Elementary School, Nord). **Rod McKenzie** (USC) was awarded the Distinguished Service Award, and plaques for the Outstanding Educator Award were presented to the **California Geographical Alliance, North** and the **California Geographical Alliance, South,** for their efforts on behalf of geographic education.

The competition for the outstanding student paper in the graduate division resulted in a dead heat between **Michael Baublitz** (CSU, Hayward) and **Dann Fall** (CSU, Chico), and each was awarded a first prize of $100. Mr. Baublitz' paper discussed landuse issues in the Livermore wine district, while Mr. Fall looked at the military significance of the Volgograd region.

In the undergraduate division first prize, $100, was awarded to **Christopher Lukinbeal** (CSU, Hayward). Mr. Lukinbeal presented a profusely illustrated discussion of east bay suburban landscapes (see pages 77-93 of this issue). Second prize, $75, was awarded to **John Scott** (CSU, Chico), who examined the diffusion of cremation in the United States.

PRESENTATIONS

FABIAN ACOSTA and JOHN HIGGINS, California State University, Hayward, **A Geographer's View of the Hayward Fault**

MIKE ALLEN, HOLLY HERRING, JOHN ISON, DAN SCOLLON, and GEORGE WALLACE, California State University, San Francisco, **The Expanding Bay Area Commutershed: A Preliminary Assessment**

MICHAEL T. BAUBLITZ, California State University, Hayward, **The Ruby Hill Project: Land Use Litigation and Vineyard Estate Planning in Livermore Valley's Wine Country**

WILLIAM A. BOWEN, California State University, Northridge, **Mapping California with Computers**

GARY H. BULLOCK, California State University, Chico, **Mackinder's "Pivot" and "Heartland" Theories: A Post Soviet-Era Analysis**

JOHN E. CHAPPELL, JR. San Luis Obispo, **Theory of Borderland Contrasts, in Relation to the Colorado Delta Region**

STEPHEN CUNHA, Cosumnes River College, **Two Flags Over Moscow**

JAMES G. DUVALL III, Contra Costa College, **Landform Patterns and the Political Ecology of Hungary**

RICHARD ELLEFSEN, California State University, San Jose, **How Identifying Urban Building Types Can Be Used in Teaching Students to "Read" the Downtown Urban Landscape**

LAWRENCE E. ESTAVILLE, JR. California State University, Fresno, **Where is the West? A Classroom Activity in Geography**

DANN FALK, California State University, Chico, **The Military Geographic Significance of the Volgograd Region**

DOUGLAS HEFFINGTON, Cal Poly, San Luis Obispo, **El Cerrito, New Mexico: A Study in Economic Interlinkages**

MARCIA M. HOLSTROM, California State University, San Jose, **The Urban Terrain Zones of San Jose, California**

RICHARD F. HOUGH, California State University, San Francisco, **Prime Farmland Protection, the EPA, and the City of Modesto**

RICHARD HYSLOP, California State Polytechnic University, Pomona, **Hazards Planning 1992: Incoherence Incarnate**

JENNIFER KEESE, University of Arizona, **Cocoa Production in Bolivia**

JIM KEESE, University of Arizona, **Religion, Volunteerism, and Change in Cuba**

CHRISTOPHER LUKINBEAL, California State University, Hayward, **Suburban Landscapes in the East Bay**

RICHARD MACKINNON, Allen Hancock College, **Historical Geography of American Square Dancing**

CHRISTIANE MAINZER, Oxnard College, **A Community College Sponsored Geography Event: The Makings of a GEO Bowl**

THEODORE R. MCDOWELL, California State University, San Bernardino, **Analyses of Maximum Wind (Gust) Data for California State University, San Bernardino, 1976-1991**

DONALD MORGAN, California State University, Fresno, **The CSU Fresno Self-Guided Monterey Peninsula Field Trip**

CLEMENT PADICK, California State University, Los Angeles, **California Imagery in the NAPP (National Aerial Photography Program)**

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