the California Geographer

Volume XXIV
1984

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CALIFORNIA GEOGRAPHICAL SOCIETY

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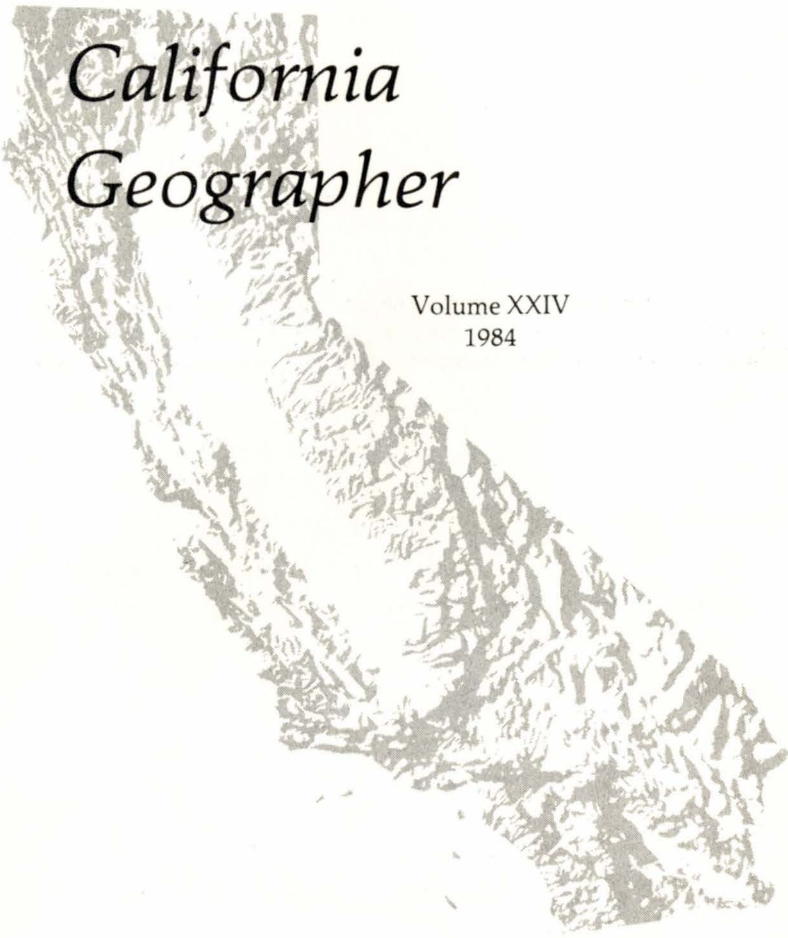

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CALIFORNIA GEOGRAPHICAL SOCIETY
Volume XXIV, 1984

PRESERVING DIVERSITY: THE IMPORTANCE OF STREET-LEVEL DOORS

*Larry R. Ford**

Historically, city centers have been characterized by tremendous functional and socio-economic diversity. Until recently, much of this diversity was openly displayed at street level: to experience the street was to experience the city. The visibility of urban life and activity played a large part in creating the image of the city as an exciting, opportunity-filled place, an image that persisted well into this century and perhaps into the 1950's. In the past few decades, however, the acceptance of the glass-box skyscraper, the fortress hotel, the enclosed shopping mall, and the massive convention center has led to the internalization of activity and city streets which are all but devoid of life. The cityscape at street level tells us nothing—the pedestrian in the city experiences little more than block after block of blank, glassy walls and empty plazas.

Even some of our most-praised urban beautification schemes, including efforts to create fountain-filled plazas and malls, have served only to make the city invisible and undiscoverable by encouraging lot assembly and, therefore, the elimination of small, marginal buildings. Urban designer Allan Jacobs depicted the impact of all this in a recent article entitled: "They're Locking the Doors to Downtown."[1] The city, once the very symbol of diversity, has become a series of enclosed for-

Dr. Ford is Professor of Geography at California State University, San Diego.

tresses, open only to a relatively narrow clientele for a relatively short time period and suitable for only a relatively narrow range of activities. Yet, subjectively anyway, people seem to feel that good cities are those with lots of people on the streets, and the majority of planning reports and design proposals for downtowns claim to encourage such activity.

Admittedly, some of the diminished street-level activity is simply a result of the changing nature and scale of urban activities—banks are now more important than lively food markets. To call for the return of the cobblers and peddlers of yesteryear would be wildly unrealistic; yet many of the more appropriate and reasonable activities of the city have had no choice but to decamp. The problem lies in the nature of the built environment. The urban landscape must be viewed as a container for the activities of the city. The buildings and the spaces that make up the urban fabric provide a set of parameters for location decisions which greatly complicate the study of spatial arrangement and change. The city is not a two-dimensional plane upon which activities move according to spatial forces only, but rather it is a set of architectural spaces which may or may not be appropriate for a given function. Most small, street-level activities cannot afford to build their own space; instead, they must rely on the existence of street-level doors in order to stay downtown. Those doors are rapidly disappearing. (Figure 1.)

Downtown San Diego is typical of most American downtowns. Over the past few decades, a dozen or so office towers have been built while fewer and fewer people go downtown to browse or shop. Using the Polk Street Directory for 1927 (the first year activities were listed by address in San Diego), 1950, and 1979 (the last year before massive urban renewal destroyed much of the study area), I have mapped changes in the street-level diversity of the 45-block core of downtown San Diego.

In 1927, the study area contained 1,494 street-level activities of a wide variety of types ranging from "general second hand

Figure 1.   Skyscrapers in a park (San Diego)

stores" to "farm equipment." There was something for everyone: 17 print shops, 20 grocery stores, 15 candy and confectioneries, 10 musical instrument shops, 35 tailors, 114 cafes, 45 barbers, and 16 auto repair shops. In 1950, there were still 1,238 street-level activities; and while the number of tailors and cigar stores had diminished, card stores and liquor stores were booming. New activities were constantly moving in to take the places of old-fashioned and dying activities. The building stock changed little from 1927 to 1950. Three or four new office buildings were built, but few old buildings were torn down unless they were to be replaced by other structures.

By 1979, the scene had changed drastically. Street-level activities had dwindled to 660, and of those, 45 were auto parks. Mapping these activities showed them to be concentrated on only two streets rather than spread evenly throughout the core. Indeed, the one downtown area with many street-level activities was lower Fifth Avenue, a skid row in the process of becoming an historic district where the building stock remained relatively unchanged. Most downtown blocks contained only one or two street-level activities.

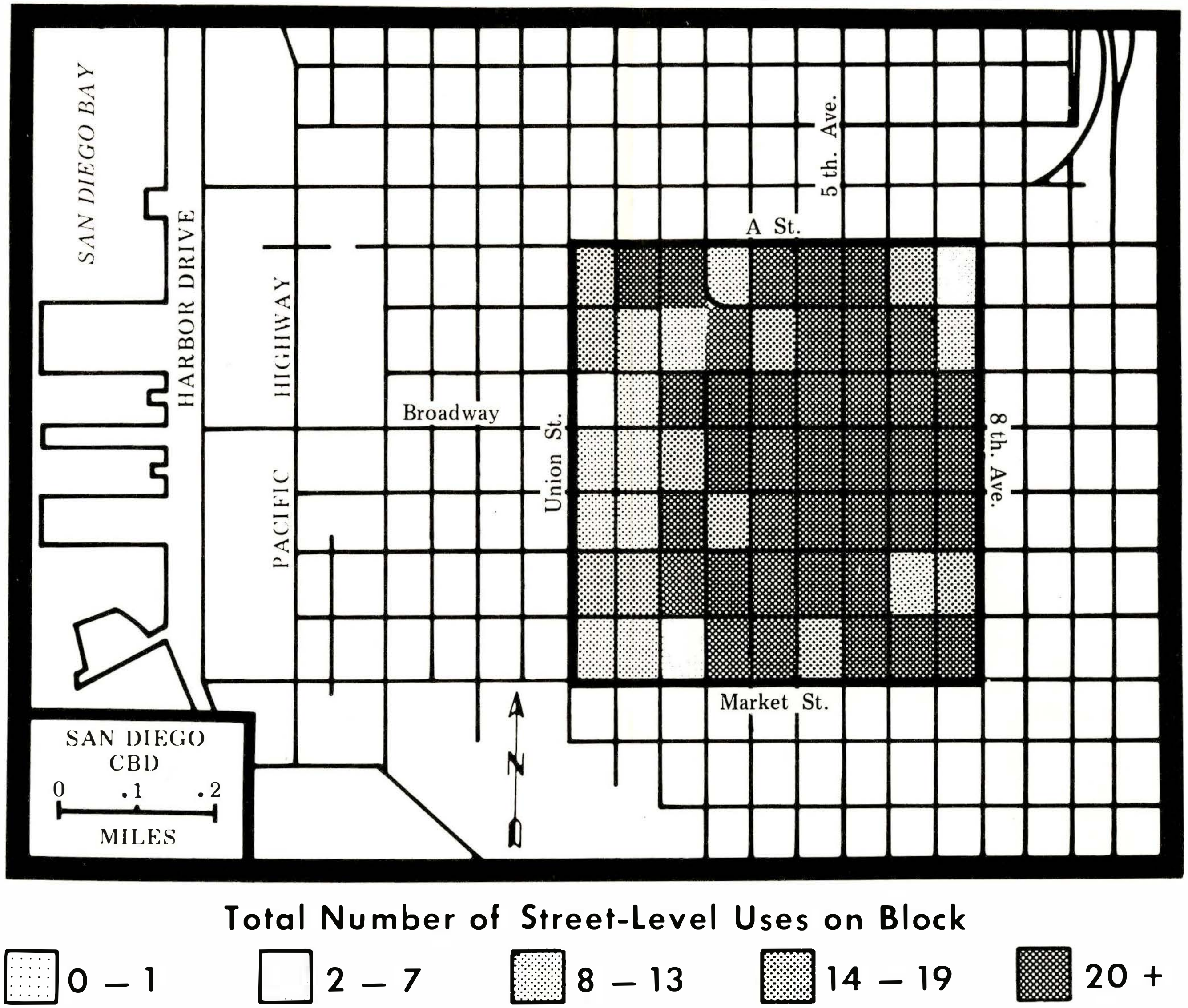
In spite of the increasing prospect of urban renewal during the 1970's, the number of vacancies remained surprisingly

Table 1

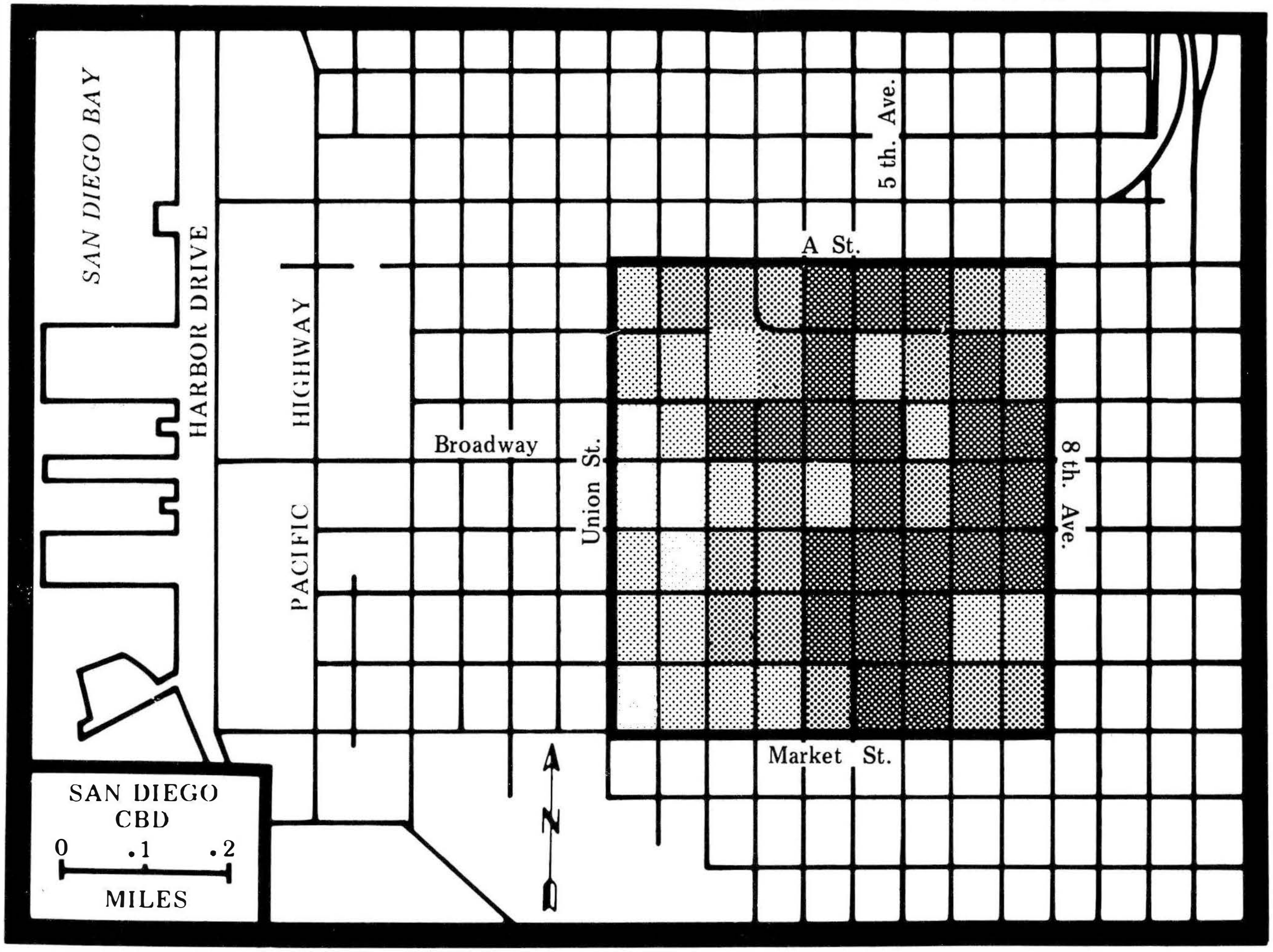
Number and Type of Street-Level Activities, 1927-1979

	1927	1950	1979
Residential/Hotel	242	117	43
Manufacturing/Warehouse	59	40	22
Transportation/Parking	56	61	94
Retail/Wholesale	594	637	265
Services	487	322	181
Cultural/Entertainment	36	36	31
Office Buildings	20	25	24
Vacant	126	89	107

SAN DIEGO
DOWNTOWN DIVERSITY: 1927



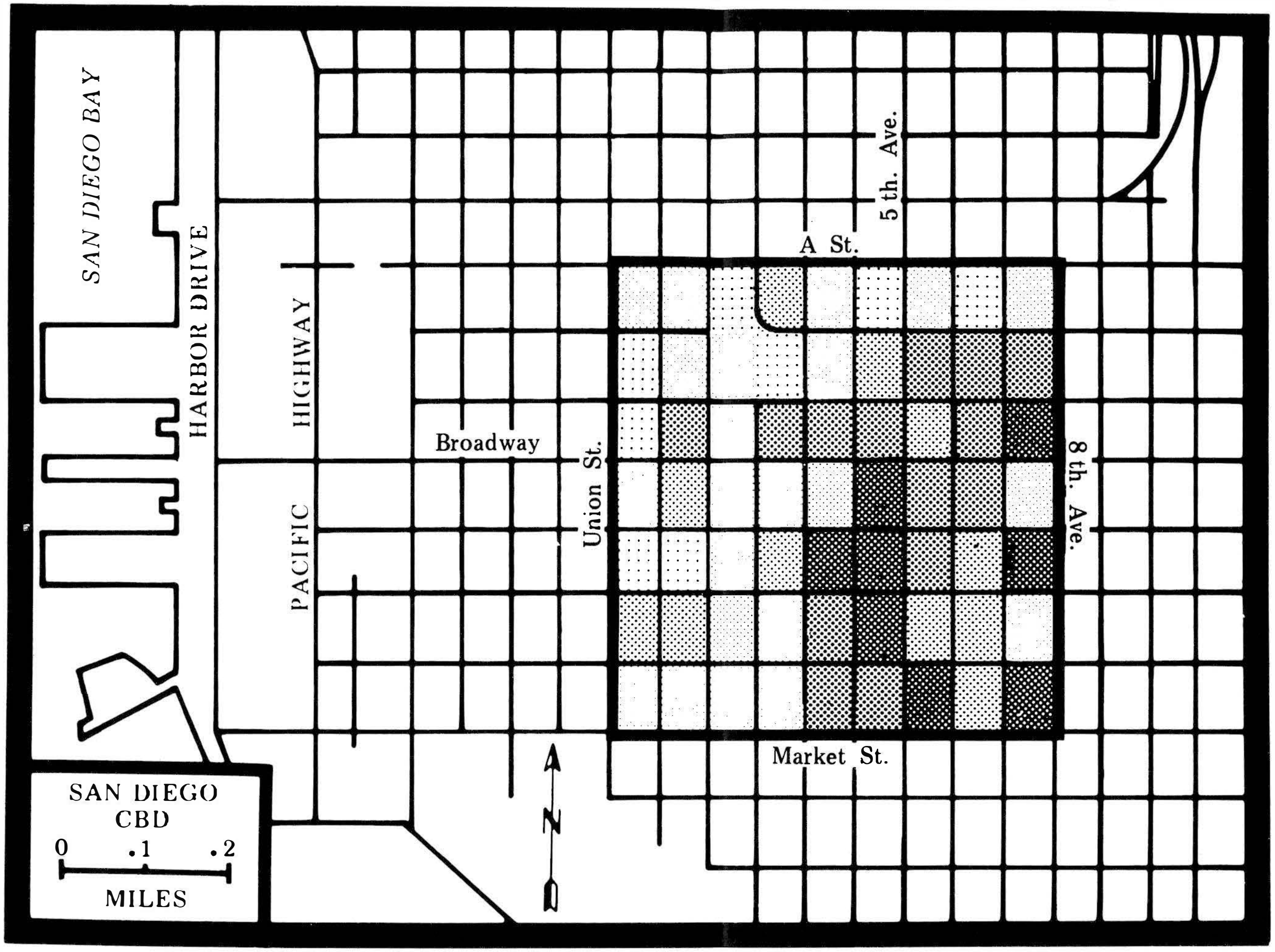
SAN DIEGO
DOWNTOWN DIVERSITY: 1950



Total Number of Street-Level Uses on Block

0 – 1 | 2 – 7 | 8 – 13 | 14 – 19 | 20 +

SAN DIEGO
DOWNTOWN DIVERSITY: 1979



Total Number of Street-Level Uses on Block

0 – 1 | 2 – 7 | 8 – 13 | 14 – 19 | 20 +

stable. The core of downtown San Diego was not characterized by a large number of vacant store fronts. Field investigation revealed that where street-level doors existed, there was street-level activity; the problem was that there were very few doors. Many blocks consisted of one or two large office buildings with one or two doors, each of which usually led to an empty lobby with a bank of elevators. By 1979, the downtown area was becoming devoid of nooks and crannies, that is the kinds of spaces that can incubate and nurture a variety of urban activities. In addition, the paucity of such spaces drove up the rents for the better ones still in existence and further diminished the variety of street-level activities.

Some politicians and business people viewed the decline in street-level activity as a positive thing, since by the late 1960's and early 1970's the downtown area was becoming oversupplied with adult bookstores, peep shows, and bars. It is unwise, however, to attempt to curtail such activities by eliminating the possibility for any street-level activity at all, both now and in the future. Once a one-door office tower is built, the possibility of a variety of street-level activities locating on the street is usually precluded forever (or for the life of the building). There is simply no room at the inn for a variety of activities which must find a small amount of space with a sufficient amount of foot traffic in order to survive. (Figure 2.)

As a result of changes in the building stock, many American downtowns have simply become boring. Walking downtown provides the pedestrian with little stimulation—just blank walls decorated with an occasional planter. When walking downtown becomes a dreary experience, people refuse to do it. The distance from point A to point B seems greater when there is nothing to do and little to see along the way. (Figure 3.)

Some Suggestions for Changing Things

Highly visible functional diversity is what gives downtowns a unique character and sense of place. This is what makes downtown different from a suburban shopping mall. Policies for encouraging rather than discouraging such variety are

Figure 2. Street-level doors are going fast. Area to be "renewed" (San Diego).

Figure 3. Fortess convention center (Louisville)

needed. While it is unrealistic to expect that modern cities will ever approach the lively diversity of earlier cities, policy changes can be initiated that will help to maintain at least a minimum of street-level activity. The first, and perhaps the most obvious, policy change would be to discourage the construction of large, fortress-style buildings having a minimum number of street-level doors. In the past, most cities have encouraged not only lot assembly for large buildings by awarding zoning bonuses but also have encouraged lot assembly for plazas and open space. The result is often a Le Corbusier city of "skyscrapers in a park." Small buildings providing a wide range of spaces and rents are torn down even when they are not located on space which is actually built upon. In the future, those constructing new buildings might be rewarded not for tearing down nearby older structures but rather for renovating them as symbiotic service buildings—cafes, clothing shops, printing establishments, etcetera. Open space would be encouraged only at key spots so as to reduce the trend toward plaza redundancy. Zoning bonuses for street-level commercial activities could also be awarded (especially for those facing outward rather than inward toward a private atrium). Development rights transfers might also be utilized so that air rights over smaller, adjacent buildings could be transferred to a new tower and thus provide the best of both worlds. (Figure 4.)

A second policy change would be aimed at broadening the concerns of historic preservation so as to consider function as well as form. In the past, a number of arguments have been used by advocates of preservation; but most of these arguments have been centered upon various aspects of architectural style and/or community history — built by a famous architect, unusually beautiful or picturesque, pleasant ambience, well-known and/or highly visible landmark, associated with some important personality or historical event, etcetera. Rarely has current function been considered. Indeed, it often is assumed that the function of an historic building will change after (and sometimes as a direct result of) designation.

Figure 4. Small buildings with lots of street-level activity act as "symbiotic" service buildings for the new towers (San Francisco).

Perhaps, if they provide space for a wide variety of street-level activities that would otherwise have to leave the area, buildings and even entire blocks of buildings should be designated as worthy of preservation efforts. Such buildings would provide small, inexpensive, street-oriented spaces exactly counter to the current trend. Criteria could include such things as number of street-level doors and flexibility for future conversion for a wide variety of uses. Sometimes, city authorities are anxious to get rid of such buildings since they may contain marginal or unsavory uses; but, as mentioned earlier, once such buildings are gone, they are gone forever. We cannot build new, small, inexpensive, marginal space downtown. Preservation designation could even be temporary, that is it might last as long as there is a demonstrated need for the kinds of activities which might feasibly contribute to the area. Undesirable activities, however, should not be eliminated through the elimination of buildings except as a last resort.

Such functional preservation zones might be especially appropriate for areas in and around large redevelopment projects that are likely to be devoid of activity for several years. (Figure 5.)

By considering existing function as well as architectural form as a criterion for preservation, and by spreading preservation efforts over a wider area of the downtown, it might be possible to mitigate the image of preservation as something which encourages a few, tightly-controlled, overly-cute, "quiche-and-spider plant" districts catering only to tourists. If preservation results in rents which are as high as those in new buildings, then the range of activities in historic districts will be comparably narrow (increasingly chain restaurants and exotic boutiques).

Third, cities could perpetuate and encourage the use of alleys as well as the backsides and service entrances of buildings for uses that are deemed inappropriate for the prestigious front

Figure 5. Preservationists might seek to save buildings suitable for a variety of street-level functions.

lobbies of new buildings. Cities are full of small, left-over spaces such as these; but they are often still used either for garbage cans or nothing. Downtown San Francisco has led the way in revitalizing such spaces with more than a dozen alleyways containing bookstores, restaurants, cardshops, and pubs. These spaces are often cozy and away from noisy, traffic-filled streets, thus providing the ambience of a pedestrian-scale city. Grady Clay has identified the existence of "venturis" in many cities—narrowly-channeled, intensive activity/information zones where important people know they will bump into other important people.[2] Well designed alleyways often provide the perfect spot for "venturis," especially when restaurant-lined alleys exist in back of a row of prestigious office buildings. These kinds of activity zones are what good cities are all about; yet, since there have been few articulate spokesmen on behalf of alleys, they are often accidentally destroyed in redevelopment projects. (Figure 6.)

A fourth proposal for increasing the number and variety of street-level activities is to ease restrictions on the creation of genuine street activities—flower stalls, street musicians, pretzel vendors, outdoor cafes, and the like. In some downtowns, the number of street-level doors has diminished to the point that the only space left for activity is the sidewalk. In other cases, a few remaining doors can be made to serve large areas by expanding sidewalk cafes around them. Some object to such cafes on the grounds that they make crowded sidewalks more crowded by taking up valuable public space. European cities, however, have demonstrated that such "obstacles" draw pedestrians rather than discourage them. In any event, few American downtowns need be concerned about such crowds. Pedestrian flow, and even the creation of "venturis," can be encouraged by locating sports arenas and cultural centers so as to be supported by door-rich, downtown districts. The symbiotic relationship which has developed between the Pioneer Square Historic District in Seattle and the nearby Kingdome sports arena is a case in point.

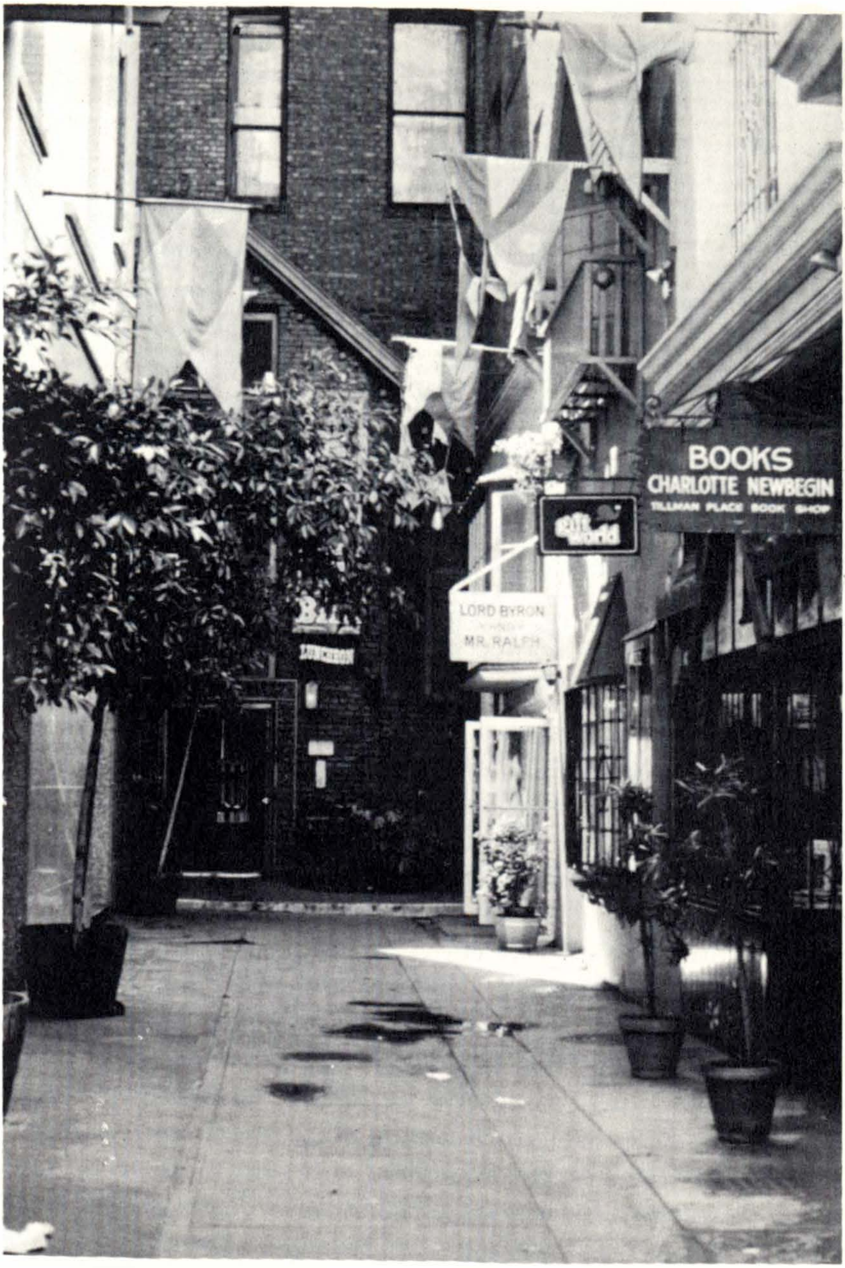


Figure 6. Alleys as "nooks and crannies" (San Francisco)

Figure 7. A lively Plaza is one which is surrounded by street-level commercial activity (Market Square, Pittsburgh).

A fifth, and final proposal for the maintenance of downtown activity has to do with the preservation of peripheral, large "industrial-era" buildings as incubators for new downtown activity. Most American downtowns are surrounded by old factory and warehouse structures that are no longer needed for their original uses. In tourist cities such as San Francisco, these buildings are often quickly converted to retail and service uses as in the case of Ghirardelli Square and The Cannery. More typically, however, demand for such intensive rehabilitation does not exist. Still, these buildings can serve a useful purpose by preserving large amounts of cheap, downtown space available for activities which need a place to get started. Some of these activities become successful and later move to a more central downtown location (assuming some doors exist), while others fade away. If such activities must get started in another part of the city, however, they rarely move downtown.

In San Diego, large industrial buildings have been and are being used for a variety of increasingly successful activities from a farmers' market to antique warehouses. Large buildings can provide the mass threshold needed to attract people to the location. Nearby smaller buildings later develop symbiotic uses (sandwich shops, etcetera) and contribute to the life of the area. The art galleries of New York's Soho District illustrate what can emerge from large amounts of downtown industrial space. Yet, even as in the case of alleys, large numbers of these industrial structures in cities all across the country have been eliminated as "eyesores."

Conclusion

Urban geography includes two equally important traditions—the study of landscape and urban morphology on the one hand, and the study of the spatial arrangement of urban phenomena on the other. Often, however, these traditions of place and space are inadequately integrated. Geographers should be concerned with the relationship between morphologic change and changes in the spatial arrangement of activity. The gradual and difficult nature of morphologic change in the city makes it increasingly important that we learn to monitor such change so as to better understand the relationship between spatial decisions and the nature of the built environment. In order to encourage not only variety but also flexibility in the urban landscape, change management policies should seek to provide as wide a range of opportunities as possible. Monitoring changes in the number of street-level doors in relation to changes in the number and variety of street-level activities provides an example of place/space integration. If the doors do not exist, the spatial decision options are limited.

NOTES

1. Allan Jacobs, "They're Locking the Doors to Downtown," *Urban Design International*, Vol. 1, No. 5 (1980), p. 25.
2. Grady Clay, *Close-up: How to Read the American City* (Chicago: University of Chicago Press), p. 53.

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1. Center City Development Corporation. *Urban Design Program: Centre City San Diego.* San Diego: Redevelopment Agency of the City of San Diego, 1981.
2. Costonis, John. *Space Adrift: Landmark Preservation and the Marketplace.* Urbana, Ill.: University of Illinois Press, 1974.
3. Ford, Larry. "Urban Preservation and the Geography of the City in The USA," *Progress in Human Geography,* Vol. 3, No. 2 (1979), pp. 211-238.
4. *San Diego City Directory.* El Monte, Calif.: R. L. Polk Company, 1927, 1950, 1979.

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LITTER IN CALIFORNIA: RESULTS OF THE 1980-1981 STATEWIDE LITTER SURVEY

Bruce Bechtol and Jerry Williams *

Introduction

Contrary to popular belief, geographers are interested in more than place names and global trivia. By training and inclination geographers study a wide range of subject matter, much of which relates to the human use of the earth as evidenced by distinctive cultural landscapes. Cultural landscapes have traditionally been a focal point for geographic inquiry. In our contemporary "throw-away" society, which is a by-product of industrialization, media-generated demand, and subsequent hedonistic mass-consumption, litter has become a conspicuous part of the cultural landscape. Given the spatial and temporal dimensions of litter, it is a logical subject for applied geographic research which can identify, measure, and offer recommendations relative to a specific environmental problem.

The State of California is concerned about the litter problem and what to do about it. Since the first step in finding possible solutions to any problem is information gathering, the State Legislature directed that a litter survey be initiated in California in 1980. Geographers were selected to investigate and report on the situation.[1]

**Dr. Bechtol and Dr. Williams are both Professors of Geography at California State University, Chico.*

The Problem

The California Litter Survey of 1980-1981 evolved as a carefully controlled, two-person research effort that resulted in the collection and analysis of litter items from 105 sites throughout the state. The objective of the survey was to acquire a comprehensive overview of the nature of the littering problem in California. Prior to actual initiation of the survey, staff members of the California State Solid Waste Management Board (SWMB), in conjunction with the Survey Team, designated general target areas for study and agreed that specific survey sites would be selected in the field. Sites had to be identifiable for future reference and geographically representative of the state in terms of: land use, road type, population density, socio-economic status, and environmental conditions.

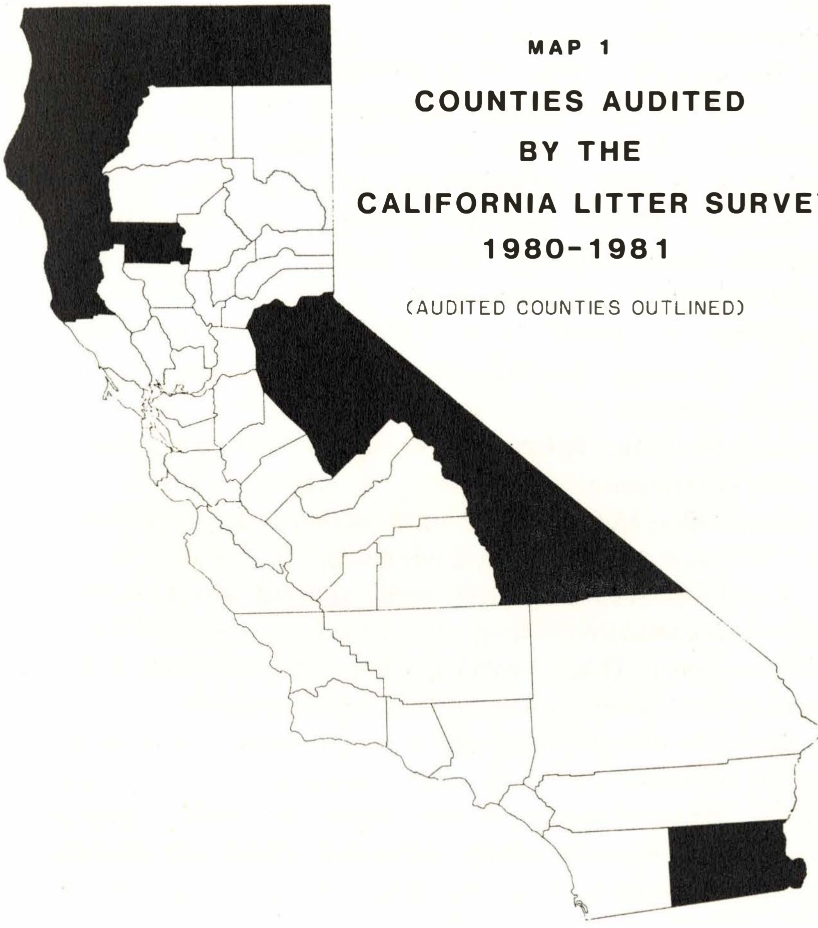
Locations to be sampled were selected in forty-two of the fifty-eight counties of California. These counties encompassed 97 percent of the state's population in 1980 (Map 1). After selecting and clearing all sites of accumulated litter, the survey effort was separated into two time phases. Of the 105 selected sites, fifty-two were surveyed on a bimonthly basis for fourteen months; that is, every two months litter was removed and audited, and the totals were then combined into consolidated bimonthly data. The remaining fifty-three locations served as control sites and were audited on an annual basis; that is, litter was allowed to accumulate for a full year before it was collected and analyzed. To facilitate comparison with previous studies conducted by the Survey Team, one-third of all sites were monitored for beverage containers only. The remaining sites were audited for all litter items larger than 1 sq. cm. in size (the size of a cigarette filter).[2]

During the survey period, every reasonable attempt was made *NOT* to influence local littering patterns. Previous research by the Survey Team established that littering activity is influenced by the perception that a place is clean, is being cleaned, or being watched. Also, there is a threshold level of interference beyond which the removal of litter from a particular

MAP 1

COUNTIES AUDITED
BY THE
CALIFORNIA LITTER SURVEY,
1980-1981

(AUDITED COUNTIES OUTLINED)



site becomes noticeable. Once this occurs, survey work influences "normal" littering behavior. Field testing established that minimum site perimeters of 30.5 m. x 30 m. were sufficiently large to provide a valid sample of the quantity and composition of litter on the individual sites. At the same time, the surveyed areas in their general settings did not appear to be changed in any way by the research effort.

One of the requirements for the California Litter Survey of 1980-1981 was to determine accurately the relative composition of the litter stream in the state, that is, to find out what precentage of litter was beverage containers, beverage related, metal, glass, plastic, Styrofoam,[3] paper or other items. Data collected on sixty-nine all-litter-count sites provided the basis for this determination. Individual litter items recovered and recorded were grouped together into the following categories:

1. Beverage Containers (steel, aluminum, glass, etcetera)
2. Beverage Related Items (caps, corks, pull-tabs, carriers)
3. Metal (auto related, nails, screws, wire, food and juice containers, foil, etcetera)
4. Glass (auto related, food and juice containers, etcetera)
5. Plastic (bags, bottles, cups, lids, tubs, utensils, straws, wrap, auto related, etcetera)
6. Styrofoam (cups, plates, tubs, wrap, packaging, etcetera)
7. Paper (bags, printed materials, boxes, cups, plates, tubs, wrap, containers, napkins/tissue, etcetera)
8. "Other" Items (tobacco, cloth, leather, rubber, wood, oil containers, air and oil filters, sports related, diapers, binding, etcetera)

Thirty-six sites were audited for beverage containers only. These locations were utilized to establish comparability with earlier surveys and demonstrate the value of using only one type of litter as a surrogate for all other litter forms. Moreover, after removing only beverage containers from a specific site, that locale continued to have the appearance of being littered. During the survey, "normal" littering behavior continued in those places where only beverage container litter was monitored.

On beverage-container-only sites, all steel, aluminum, glass, plastic, and bimetal containers that previously had contained soft drinks, beer, wine or liquor were collected, tabulated, and removed. In this case, broken glass containers were counted as whole containers if bottle necks could be recovered and identified. Soft drink and beer containers were itemized and tabulated by brand and container material. Wine and liquor were categorized generically, for example, bourbon, scotch, gin, rum, wine, mixed drinks, etcetera, and by type of container material.

In tabulating results, the Survey Team based its work on the total count method; that is, each separate piece of litter was counted as a single item. This method was utilized because in a litter clean-up each item has to be individually retrieved; for example, removal of one cigarette butt requires the same effort as picking up one large paper bag. Since the cost of litter removal is really based upon the **number** of things collected, it was determined that in this survey all litter down to and including items the size of a cigarette filter would be picked up and tabulated. While litter items as small as cigarette butts and broken glass frequently are not perceived as litter, both are hazardous (potentially causing either fire or cuts) and in concentrations are a litter problem. During the 1980-1981 California Litter Survey, 166,982 items were collected, tabulated, and properly consigned to solid waste disposal facilities.

Survey Results

The number of litter items collected, enumerated and analyzed from the 105 survey sites during the fourteen-month period was impressive in terms of both quantity and diversity.

Determination of the composition of the litter within identifiable categories was a major requirement for the study, but other useful information also emerged from the data. For example, sources of litter were found to be consistent and fairly limited; attrition of some forms of litter occurred over time due to differing, site-specific, environmental conditions; and, littering, a behavioral problem, appeared to be clearly cyclical with the change of seasons. Each of these observations warrants further attention.

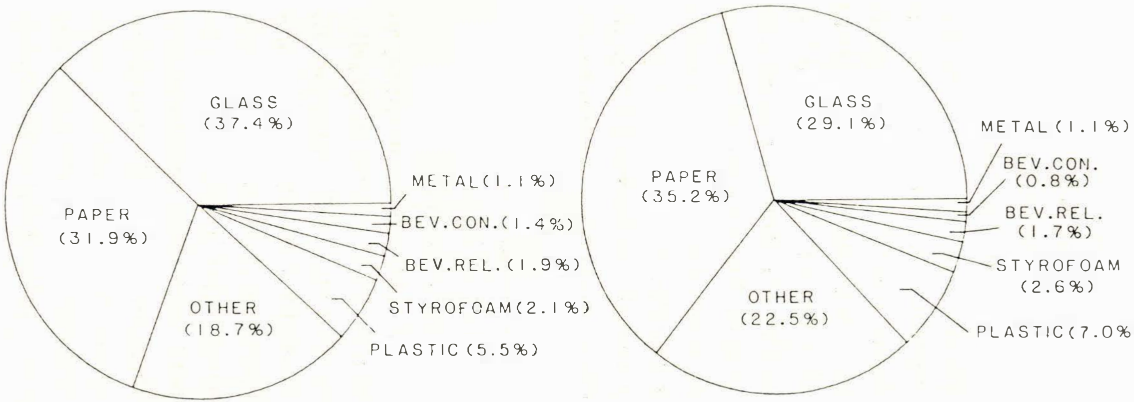
In terms of general composition, the litter recovered from the Annual all-item-count sites was predominantly glass (37.4 percent), paper (31.9 percent), "other" litter items (18.7 percent), and plastic (5.5 percent); the lowest relative percentages were tallied for Styrofoam, beverage related items, whole beverage containers, and metal in that rank order (Figure 1A). In the Consolidated Bimonthly Surveys paper gained in litter significance. On those sites, paper accounted for 35.2 percent of all litter; glass represented 29.1 percent; while "other," plastic, Styrofoam, and beverage related items retained their positions in the bimonthly composition ranking. Metal and beverage containers switched relative positions in the two surveys (Figure 1B).

Lower recorded percentages in plastic, Styrofoam, paper, and "other" litter items in the Annual Survey data illustrate an attrition rate for those categories of litter more subject to deterioration due to environmental conditions. Conversely, Bimonthly Surveys recover a relatively higher proportion of those items that are most susceptible to deterioration. For example, paper products are much more influenced by the weathering processes than beverage containers; so the longer a site is left littered, the more obvious beverage containers become. Consequently, increased relative percentages in accumulated beverage containers and glass evident in the Annual Survey data are definite indicators that when these items are not removed from the environment within a reasonable length of time their significance vis-a-vis other litter increases.

Figure 1

LITTER COMPOSITION

California Litter Survey, 1980-1981



A.
ANNUAL SITES

B.
CONSOLIDATED BIMONTHLY SITES

A more useful technique for analyzing litter composition was developed by identifying and combining litter products by their origins. For example, an initial assumption of the Survey Team was that recovered glass would be derived from a wide variety of sources. However, this was not the case. Field data disclosed that fully 96 percent of all broken glass recovered from the all-item-count survey sites was obviously broken beverage container material. This revised perception of the origin of glass litter dramatically underscored the significance of beverage products in the total litter stream. The next logical step was to lump the broken beverage container glass with the data for whole beverage containers and beverage related items. The resultant grouping encompassed all the packaging products put to use by the malt brewers, soft drink manufacturers, and the wine and distilled spirits industries. In short, the low relative percentage of whole beverage containers in the total litter data belied the beverage industries' real contribution to the overall litter problem. Some 39.2 percent of all litter in the Annual Survey and 30.4 percent in the Consolidated Bimonthly Surveys was traced directly to the beverage industry.

Other sources of litter also were identified from the total count data. Materials listed in the metal category, for example, were predominantly associated with the transportation industry and included such items as: nuts, bolts, screws, and other automotive parts. In the Annual Survey, fast foods packaging and convenience items, for example, gum, candy, and similar snacks, accounted for 94 percent of all plastic litter, 59 percent of all Styrofoam, and 32 percent of all paper. Together these categories represented 16.6 percent of the litter tabulated in the Annual Survey. In the Consolidated Bimonthly Surveys, those same products represented 20.5 percent of all litter recovered.

Tobacco products, cigarettes, and cigars dominated the ubiquitous "other" category, which included those items not noted elsewhere in the data. In the Annual Survey, tobacco litter accounted for 90 percent of the "other" category. With packaging included, tobacco products represented 18.8 percent of the litter that was allowed to accumulate on those sites for one full year. In the Consolidated Bimonthly Surveys, tobacco products comprised 94 percent of the "other" class and 21.2 percent of all litter recovered. Tobacco related litter, including packaging, matchbooks and the like, represented 24.3 percent of the total litter stream monitored on a bimonthly basis.

Miscellaneous paper, a subcategory, included those small paper items which were difficult to identify due to chopping by roadside maintenance equipment and deterioration because of weathering. Miscellaneous paper represented 17.3 percent of the annual accumulation and 15.5 percent of the bimonthly litter. Realistically, this litter probably was derived from beverage related packaging or wrapping associated with fast food and convenience items and should have been lumped in those groupings. However, due to their small size and attendant identification problems, miscellaneous paper was considered separately.

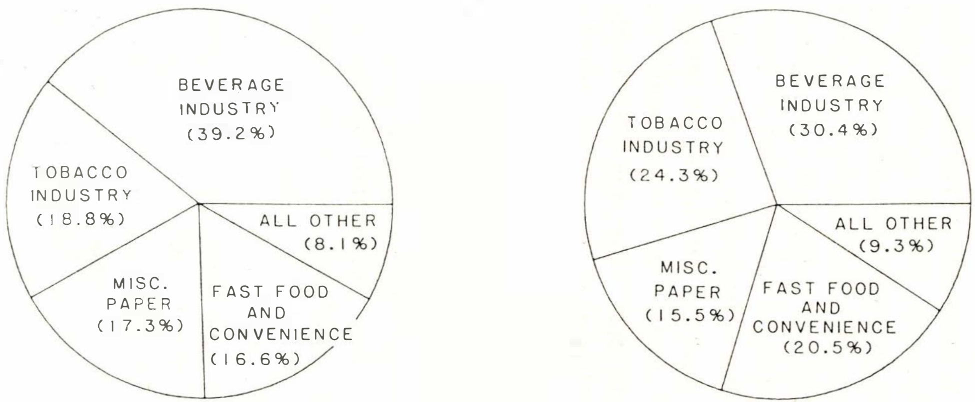
By logically grouping the data, major product categories or sources of litter were determined. Almost 92 percent of the litter audited on Annual all-item-count sites was identified with: the beverage industry (39.2 percent), the tobacco industry (18.8 percent), miscellaneous paper (17.3 percent), and fast food and convenience items (16.6 percent) (Figure 2A). Likewise, the same categories of data on the Bimonthly all-count sites represented over 90 percent of the total litter, that is, the beverage industry (30.4 percent), the tobacco industry (24.3 percent), fast food and convenience items (20.5 percent), and miscellaneous paper (15.5 percent) (Figure 2B). *All other* litter combined made up less than 10 percent of the total litter stream in *both* the Annual and Consolidated Bimonthly data.

Data collected on the thirty-six beverage-container-only sites provided further insights into the beverage products industries' contribution to the total litter stream. Notably, the relative percentages of beverage types in both the Annual and the Consolidated Bimonthly surveys are strikingly comparable. For example, beer containers constituted 78.6 percent of the Annual

Figure 2

LITTER SOURCES

California Litter Survey, 1980-1981



A. ANNUAL SITES

B. CONSOLIDATED BIMONTHLY SITES

and 76.9 percent of the Consolidated Bimonthly beverage container litter. The difference between the two relative percentages as a proportion of the total beverage container litter is only 1.7 percent and is statistically insignificant. Using the same format, soft drink containers comprised 14.4 (Annual) to 12.9 percent (Consolidated Bimonthly) of all beverage container litter, and wine and liquor containers made up 7.0 to 10.2 percent respectively (Figure 3AB).

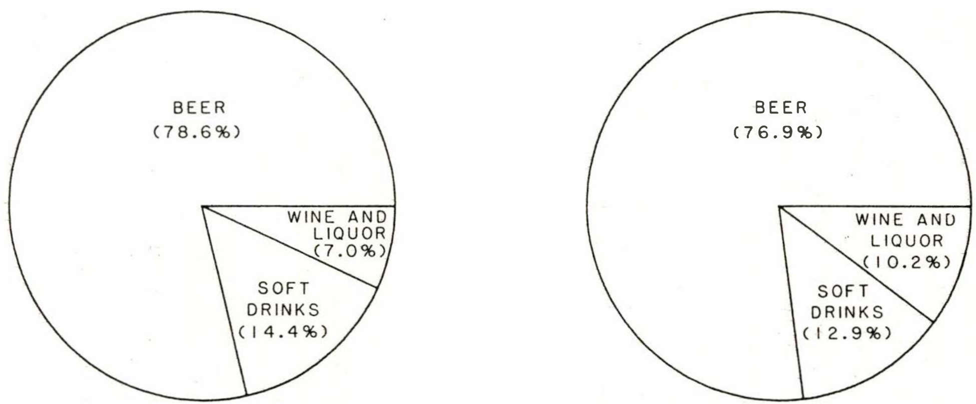
Analysis of the composition of beverage container litter by type of container material, that is, steel, aluminum, glass, plastic, and "other" (bimetal mixed alcoholic beverage containers) provided perspective on the nature of the packaging materials utilized by the beverage industry and the impact those materials have on the beverage container litter stream (Figure 4AB). Most notably, whether the data were derived from the Annual or Bimonthly surveys, glass containers constituted the highest proportion of all beverage container litter from that category of sites (83.5 to 78.4 percent). Aluminum containers, a recyclable product, represented 12.4 to 18.3 percent of the beverage container litter recovered from the same sites; steel containers ranged from 3.0 to 2.3 percent; plastic containers varied slightly from 0.5 to 0.4 percent; and "other" containers represented 0.6 percent in both surveys.

As has been noted, beer container litter accounted for over three-fourths of all beverage container litter recovered by either Annual or Bimonthly audits on the beverage-container-only sites (Figure 3AB). Only about 1 percent of all beer containers were steel, a reflection of the industry's rapid shift from steel containers to other types of packaging beginning in the 1970's. Recovered aluminum containers represented between 12.0 and 17.8 percent of the beer container litter, an illustration of the effectiveness of aluminum recycling since virtually all non-glass beer containers are aluminum. Glass dominated the beer container litter (87.0 to 81.3 percent) and further underscored the impact of aluminum recycling. The proportion of non-returnable glass beer container litter increases as more

Figure 3

BEVERAGE CONTAINER LITTER BY PRODUCT

California Litter Survey, 1980-1981



A.
ANNUAL SITES

B.
CONSOLIDATED BIMONTHLY SITES

and more aluminum is recycled. However, it is important to note that beer advertising, in general, tends to emphasize glass packaging; an actual increase in this component, therefore, would be expected.

Soft drinks accounted for between 12.9 and 14.4 percent of the total container litter recovered from the beverage-container-only sites (Figure 3AB). Steel containers made up 15.4 to 13.0 percent of the soft drink containers recovered. There was also a shift in packaging in the soft drink industry in the 1970's. Consequently, aluminum accounted for between 20.5 (Annual) and 36.2 (Bimonthly) percent of the soft drink container litter. The differences between the Annual and Bimonthly figures illustrate that the longer beverage container litter remains on a site, the greater the likelihood for aluminum gleaning. Aluminum recovery increases the significance of other types of containers in the litter stream. For example, between 60.8 and 47.9 percent of the soft drink container litter was glass; as expected, the highest percentage was recorded in the Annual data.

Plastic containers, a relatively new beverage packaging material in 1980, represented approximately 3 percent of the soft drink container litter. Plastic beverage container packaging poses new problems for litter abatement and solid waste management; however, the number of plastic containers recovered during 1980-1981 only hints at a future significance not yet assumed.

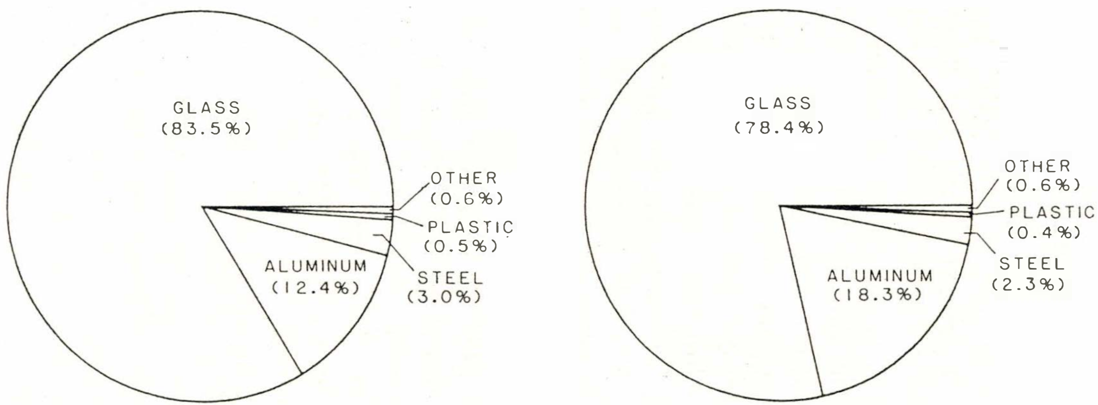
Wine and liquor container litter ranged from 7.0 to 10.2 percent of all container litter recovered from the beverage-container-only sites (Figure 3AB). Glass containers dominated this beverage category (90.7 to 94.0 percent); the only other type of container collected was bimetal (9.3 to 6.0 percent).

It is apparent that the longer any type of litter is left on a site, the more apt it is to be modified by human activity and/or environmental conditions. In analyzing the composition of litter from both Annual and Bimonthly sites, for example, it is clear that over time there is an attrition in some forms of litter,

Figure 4

BEVERAGE CONTAINER LITTER BY CONTAINER TYPE

California Litter Survey, 1980-1981



A.
ANNUAL SITES

B.
CONSOLIDATED BIMONTHLY SITES

CALIFORNIA GEOGRAPHICAL SOCIETY
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A CLUSTER ANALYSIS OF SOUTHERN CALIFORNIA DESERT CLIMATE DATA

*Gerald P. Hannes and Susan M. Hannes**

California's vast desert region has been of interest to many geographers. Generally, two or three subregions have been recognized within this area. These have been determined mainly on a physical basis, including such factors as landforms, climate, and vegetation. For example, Lantis, Steiner, and Karinen have divided this extensive area into the Trans-Sierra, the Mojave Desert, and the Colorado Desert.[1] Hartman has similarly identified the Basin and Range, the Mojave Desert, and the Colorado Desert provinces.[2]

Our study focuses on climatic similarities and differences within this area. Objectives of this paper are to cluster analyze climatic data from twenty-six stations in order to determine subregions and to describe the major elements and controls which possibly affect the various subdivisions.

Data and Study Area

Twenty-six weather stations with a continuous record were selected from the *Climatological Data, Annual Summary* publications for a study period of seventeen years (from 1962 through 1978).[3] Figure 1 is a map of the locations of the twenty-six sites. The study area ranges from Death Valley in

**Dr. G. Hannes is Professor of Geography at California State University, Fullerton; Ms. S. Hannes is Instructor of Geography at Santa Ana College, Santa Ana, California.*

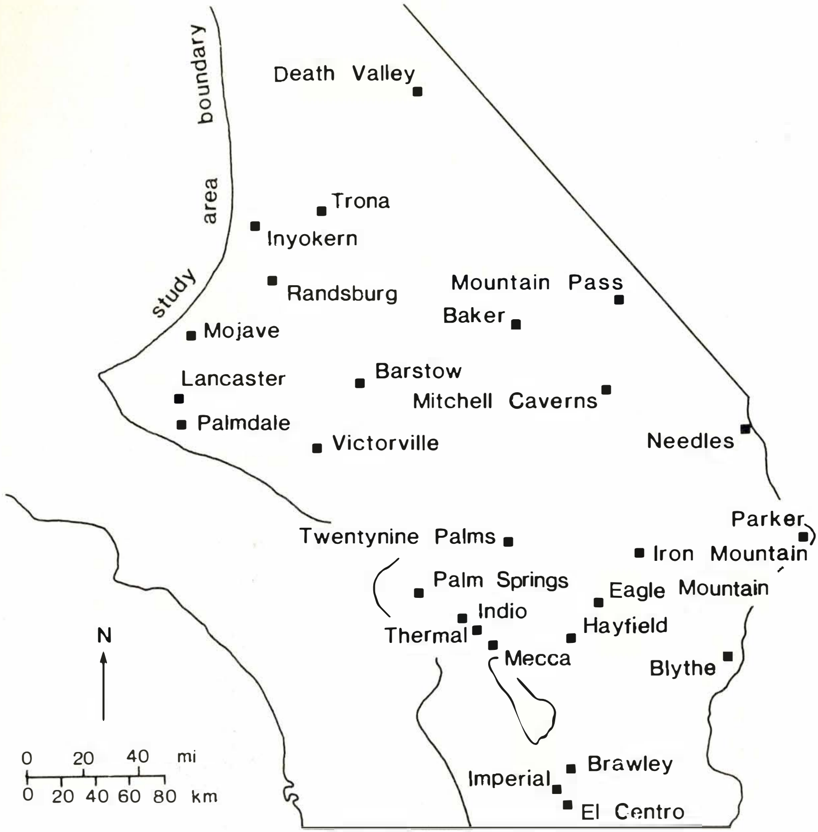

Figure 1. The Study Area

the north at approximately 36°30′N latitude south to the Mexican border; the southern Sierra Nevada, Garlock Fault, Tehachapi Mountains, Transverse Ranges, and Peninsular Ranges form the western boundary, and the Nevada state line and Colorado River border the east.

Nine climatic variables were subjected to cluster analysis. Six dealt with temperature: January average temperature, July average, annual average, extreme high temperature for the year, extreme low temperature, and number of days between the last frost of spring and the first frost of fall (if any). The extreme values and frost-free data are important in determining desert subregions. For example, winter frost is a prime limiting factor of many desert plants.[4]

Precipitation is definitely a major consideration in any study of the desert lands. Three of the nine climatic variables were: annual precipitation total, winter precipitation total, and summer total. In our report, winter was defined as January, February, and March; summer was July, August, and September. We do realize that December is an important winter month in terms of precipitation; however, we did not wish to combine data from two different calendar years. The summer convectional and hurricane-generated precipitation patterns are more typical of the southernmost part of the study area and, therefore, should contribute to the differentiation into subregions.

Data Analysis

The average value for each of the nine climatic variables was calculated for the seventeen-year period. The data for the twenty-six locations were then subjected to cluster analysis. Our computer program was modified from that of P. M. Mather of the University of Nottingham, England.[5] The purpose of cluster analysis is to select subsets of mutually similar data from the large set of all such data. A cluster is initially formed by the most similar pair; other clusters or groupings are formed based on similarity coefficients. Eventually, all the data will form one large group at a high similarity coefficient. Therefore, through cluster analysis, significant groupings can be obtained.

Results and Discussion

The results of cluster analysis are presented in the form of a linkage tree (Figure 2). The twenty-six stations form the vertical axis; the similarity coefficients are along the horizontal. The most similar locations pair off early at low similarity coefficients in the linkage tree. Note that all the stations belong to

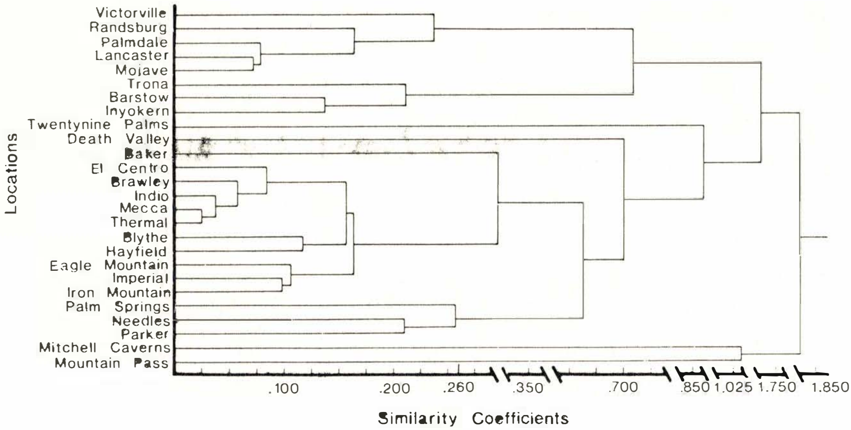

Figure 2. Desert Climates Linkage Trade

one large group at the highest similarity coefficient—a value of approximately 1,800.

Using a similarity coefficient value of approximately 0.260, four major groups occur: Group I: Victorville, Randsburg, Palmdale, Lancaster, and Mojave; Group II: Trona, Barstow, and Inyokern; Group III: El Centro, Brawley, Indio, Mecca, Thermal, Blythe, Hayfield, Eagle Mountain, Imperial, and Iron Mountain; and Group IV: Palm Springs, Needles, and Parker. Twentynine Palms, Death Valley, and Baker, as well as Mitchell Caverns and Mountain Pass, do not belong to any groups at the 0.260 level.

Figure 3 is a map of the general subregions. Although the boundaries are by no means concrete, this map organizes the findings of cluster analysis for visual display. Of the four major subregions previously described, two appear to be the northwestern Mojave Desert, one the more southern Colorado Desert, and one along the Colorado River with the inclusion of Palm Springs in this latter group. A fifth minor subregion consisting of Twentynine Palms, Baker, and Death Valley, appears to be more related to the Colorado Desert and Colorado River groupings, joining them on the linkage tree at the 0.875 level (Figure 2, Figure 3).

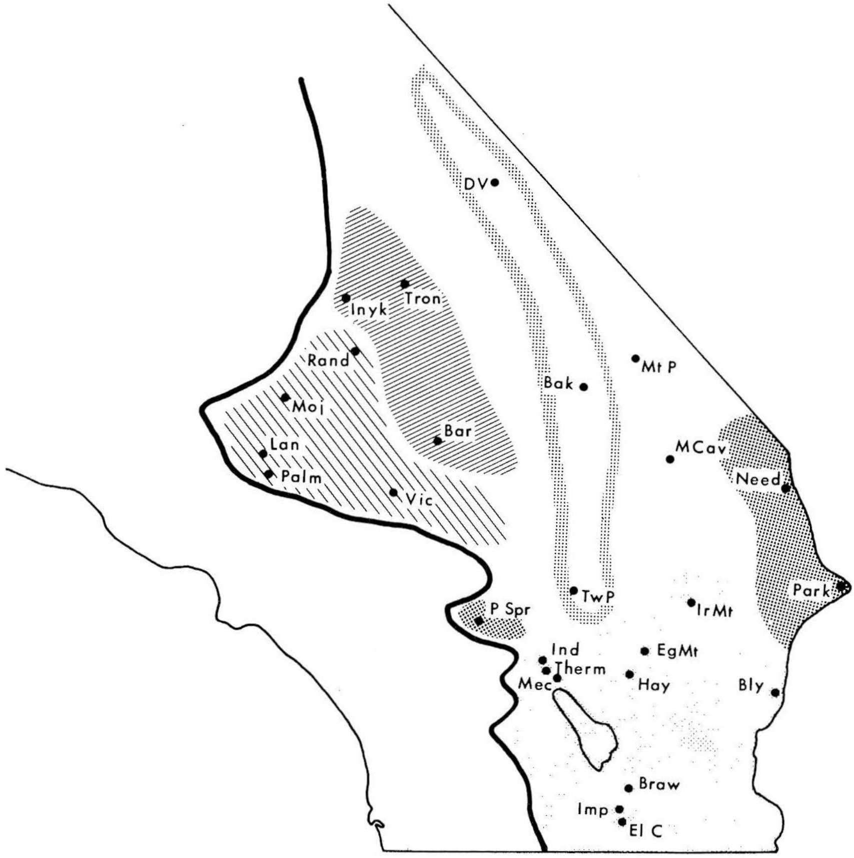

Figure 3. Major Climatic Groups

Table 1 presents additional data concerning the four major groups. Groups I and II are isolated from the larger Group III based upon latitude. The Mojave Desert (Groups I and II) is generally considered to have the higher latitudes; the Colorado Desert (Group III) includes the lower latitude locations. Parker and Needles of Group IV have relatively high latitudes as well; however, their climate is affected by virtue of location along the Colorado River. It is hard to define a sharp boundary between the Mojave and Colorado Deserts. Vegetational analyses have shown that tongues of Sonoran (Colorado

Table 1

Group	Location	Latitude	Elevation	Annual Prec.	W/S PPT	Frost-Free Days
	Victorville	34°32′N	2858 feet	5.34 inches	2.60	207 days
	Randsburg	35°22′	3570	5.70	4.21	232
I	Palmdale	34°35′	2596	6.74	5.00	222
	Lancaster	34°30′	2356	6.23	3.95	210
	Mojave	35°03′	2735	6.04	4.77	218
	Trona	35°47′	1695	4.22	2.25	250
II	Barstow	34°54′	2162	3.75	1.71	226
	Inyokern	35°39′	2440	4.48	2.51	208
	El Centro	32°46′	-30	2.33	0.91	314
	Brawley	32°57′	-100	3.13	0.76	300
	Indio	33°44′	11	3.28	1.10	305
	Mecca	33°34′	-180	2.71	0.85	297
III	Thermal	33°38′	-112	2.74	1.01	307
	Blythe	33°37′	268	3.74	0.85	287
	Hayfield	33°42′	1370	3.14	0.98	289
	Eagle Mountain	33°48′	973	2.92	0.67	362
	Imperial	32°51′	-64	2.59	0.89	340
	Iron Mountain	34°08′	922	3.08	0.96	348
	Palm Springs	33°49′	411	5.04	2.56	325
IV	Needles	34°46′	913	4.34	0.82	336
	Parker	34°17′	738	4.87	1.56	358

Desert) types of vegetation project northward into the Mojave, particularly along the Colorado River.[6]

Concerning elevation (Table 1), Groups I and II have values generally above 2,000 feet; those of Groups III and IV are basically below 1,000 feet, with several stations below sea level. Elevation is a significant control of temperature and precipitation.

The highest annual precipitation totals are found in Group I, and the lowest overall totals are in Group III (Table 1). A winter/summer precipitation ratio (W/S PPT) was also calculated for each site in Table 1. Values greater than 1.00 indicate a dominance of winter precipitation; those less than 1.00 signify more summer rainfall. The Colorado Desert Group III has most of its stations below 1.00, reflecting the effects of the Gulf of California and the Gulf of Mexico in the form of convectional summertime precipitation and spin-off from late summer hurricane activity. This is expected for these low latitude locations. On the other hand, the two Mojave Desert regions, Groups I and II, have the highest W/S PPT values. Most of their precipitation is frontal from the northwest.

The number of frost-free days (Table 1) is the greatest in Groups III and IV. Values over 300 are common. The smallest number, under 250 days, is typical of the two Mojave Desert groups. The more northern locations and the higher elevations are significant factors concerning temperature.

It is interesting to note that Mitchell Caverns and Mountain Pass did not link out until the end. These stations have the highest elevations of all—about twice as high as the Mojave Desert groups—at 4,730 and 4,330 feet, respectively. Elevation certainly would affect the precipitation totals (adiabatic effects, for example) as well as the temperature regimes (generally cooler in both the summer and the winter).

Summary

Cluster analysis can be a valuable tool for geographers in regionalization. In our study of nine climatic variables for twenty-six weather stations in the southern California desert, four subregions were defined at the 0.260 similarity coefficient level. With the exception of Palm Springs, which was more related to the Colorado River stations, each of the four groups contained locations in close geographical proximity. Basically, two of the groups belonged to the traditional Mojave Desert, and the other two were a part of the Colorado Desert. Climatic controls such as latitude and elevation as well as the elements of temperature and precipitation serve to explain why the subregions occurred.

ACKNOWLEDGEMENTS

We wish to thank Dr. Greg Olyphant, now of Indiana University, for adapting the cluster analysis program to the California State University, Fullerton (CSUF), computer system and Mr.Tom Wikle of the CSUF cartographic laboratory for photographing our diagrams.

NOTES

1. David W. Lantis, Rodney Steiner, and Arthur E. Karinen, *California: Land of Contrast* (Dubuque, Iowa: Kendall/Hunt, 1981).
2. David N. Hartman, *California and Man* (Santa Ana, California: Pierce Publishers, 1977).
3. U.S. Department of Commerce, NOAA, *Climatological Data, Annual Summary: California* (Asheville, North Carolina: National Climatic Data Center, 1962-1978).
4. For an excellent overview and superb bibliography on California desert vegetation, refer to Michael G. Barbour and Jack Major, eds., *Terrestrial Vegetation of California* (New York: John Wiley and Sons, 1977). Chapters of particular interest include: Jack Major, "California Climate in Relation to Vegetation," pp. 11-74; Frank C. Vasek and Michael G. Barbour, "Mojave Desert Scrub Vegetation," pp. 835-867; Jack H. Burk, "Sonoran Desert," pp. 869-889.
5. P. M. Mather, *Computational Methods of Multivariate Analysis in Physical Geography* (New York: John Wiley and Sons, 1976), pp. 309-419.
6. Barbour and Major, op. cit. (footnote 4).

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URBANIZATION AND THE CHANGING LOCATION OF AGGREGATE PRODUCTION

*Gary L. Peters and Richard Outwater**

In this article we are concerned with the mining of building materials, primarily with sand and gravel, but also with clay and volcanic cinder. Admittedly, mining activities are seldom considered "urban." Yet, despite their omission from most texts on urban geography, we feel the importance of our concern with mining activities, that is, with aggregate production in and near urban areas deserves attention for at least two reasons. First, though employment in the aggregate industry is relatively small in local areas, "it is significant, because aggregates and the products made from aggregates are an essential part of the construction industry, and the rest of the construction industry depends on aggregate production as its starting point."[1] For example, an average, single-family residence requires about 114 tons of aggregate for the house, driveway, and yard; and yet another 73 tons are required for construction of public facilities for that home.[2] Second, because aggregates are bulky and low in value per unit of weight, they must, in most instances, be produced in close proximity to the area in which they are being used. As urban growth expands outward, the production of aggregates often leads to conflicting land uses near the rural-urban fringe.

**Dr. Peters is Professor and Chairman of the Department of Geography at California State University, Long Beach; Dr. Outwater is Professor of Geography on the same campus.*

Our purpose, then, is twofold. First, by utilizing traditional models of urban land use we provide a means of explaining the changing location of aggregate production in and around urban centers. Second, we focus attention on possible future problems of expanding urban areas where land-use conflicts on the urban fringe and beyond may make the provision of aggregates more difficult.

Our approach employs basic models in urban geography as building blocks around which we generate a reasonable explanation of the locational pattern of aggregate production in an urban area. This essay not only demonstrates the utility of applying basic models to help understand urban spatial arrangements, but also explores a neglected topic of both economic and urban geography.

The geography of mining has been a somewhat neglected subfield of economic geography. In general, the geographic study of mining has been more descriptive than theoretical and has focused mainly on the production of major industrial materials, such as coal, iron ore, copper, aluminum and tin.[3] The environmental impacts of mining also have attracted the attention of some geographers.[4] However, the publication of several proposed models of mining location provides an encouraging sign of renewed interest.[5]

In searching for an explanation of the location of aggregate producers, the aforementioned studies, unfortunately, offer little guidance. The Russian studies, though interesting, offer no help toward explaining locational patterns in market economies. Indeed, only the work of Hay is of sufficient value to consider further in our context.

After lamenting the lack of a basic location theory for mining activities, Hay suggests that geographic variations in the costs of mining are a function of: (1) the nature and natural environment of mineral deposits and (2) the man-made and social environment of the mining operation itself. He argues that: "The geological and geographical characteristics of mining sites, their locations with respect to a market and the resultant transport costs together determine the joint aggregate supply curve of . . . mines to that market."[6]

Hay's model is instructive and provides a definite improvement over previous attempts to develop a theoretical model of mining location. Even so, it is not appropriate to our task. From it we could conclude that, because we are dealing with a low-value product that is very sensitive to variations in transportation costs, aggregate production will occur as close as possible to the market. However, numerous factors which tend to be especially sensitive in urban areas are not considered. Among these we would include the dispersed nature of the urban market for aggregate, competition from urban land uses, the role of zoning on the urban periphery, and a variety of environmental issues. Similarly, McCarty and Lindberg noted that:

> It is evident that for producers of some mineral products least cost locations will almost always occur at those deposits that are near markets. This situation may be anticipated wherever the products (1) occur almost everywhere in deposits that do not vary greatly in character, or (2) are heavy, bulky, or of low value per unit of weight. Sand and gravel usually are cited as good examples of commodities that have these characteristics.[7]

We do not reject the notion that aggregate production is a market-oriented activity, but we need to go beyond that generalization. We need to seek a model that explains not only where within an urban complex aggregate production is occurring, but also where it is likely to occur in the future. The best starting point, then, may be consideration of the bid-rent approach, ultimately coupled with constraints on aggregate production.

Well-known to both urban and economic geographers, the bid-rent model of land uses in and around urban areas seems attractive for our purposes, because it helps explain current land-use patterns and also offers clues to future land-use patterns associated with the expansion of urban areas. The classical presentation of the bid-rent approach, based on a monocentric city, was made by Alonso,[8] though many variations on the general theme have been orchestrated over the intervening years.

The central theme, of course, is that in an urban area only a limited amount of land is available for any given activity. Accordingly, land will be offered for various uses as a result of competitive bidding for sites by various land-using activities. Because accessibility to the urban area is considered essential, bid-rents are highest for the most central sites, those nearest the center in the monocentric model. Thus, land uses will be allocated for various sites according to the activities that offer the highest bid-rents for those sites. Functions unable to pay high rents will be pushed toward the urban periphery. For each major land-use category we can imagine a bid-rent curve that declines from a peak at the most central location to zero at

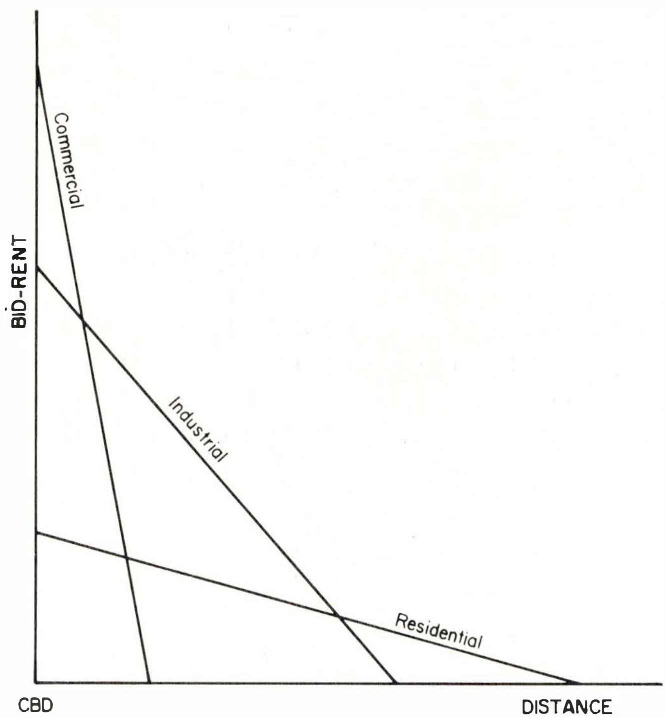

Figure 1.

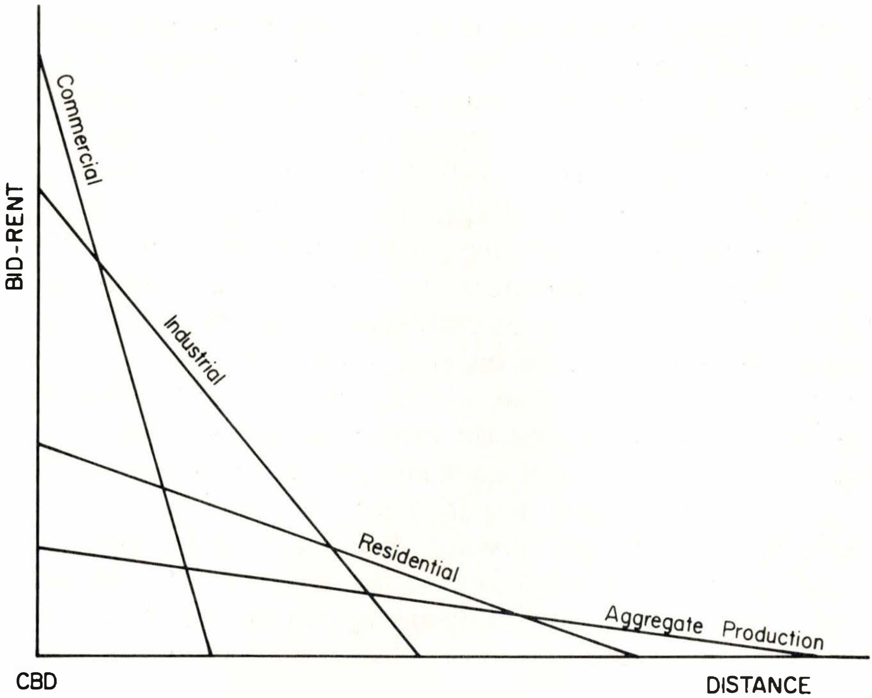

Figure 2.

some distance outward from the center, that distance depending, among other things, on the importance of accessibility (Figure 1). Of course, the bid-rent curve provides only a starting point, not a complete explanation of urban land uses.

Now, what does all this tell us about the location of aggregate producers in the urban milieu? First, it is apparent that aggregate producers will not be able to bid high rents for central locations; so we might imagine a bid-rent curve with a rather low gradient (Figure 2). All else being equal, we could argue that in the simple static model aggregate producers would locate in a concentric zone surrounding a similar zone of residential land-use, whereas commercial activities would dominate the central business district (CBD) and would be separated from the zone of residential land-use by an industrial zone.

Still looking at our simplified bid-rent model we can introduce some more realistic constraints. For example, as with all mining activities, it is essential that aggregate of a usable grade be available at sites within the production zone determined by bid-rent curves. Realistically, the zone is unlikely to be a homogenous source of aggregate; rather, production sites are likely to appear in clusters within the bid-rent production zone (Figure 3). Furthermore, local zoning ordinances may reinforce the clustering of individual producers around aggregate deposits within the bid-rent production zone.

The model is, of course, a static one; yet by introducing urban growth we can use the model to suggest what would happen to the location of aggregate producers over time. Obviously, urban growth would affect bid-rent curves, most likely by pushing them outward. Assuming that bid-rent relationships are maintained among the gradients for different land-use curves, we should find aggregate producers being outbidded by other land uses in established production zones and being forced to seek newer sites in more distant zones. Though he was speaking of manufacturing, the following remark by Barlowe is also appropriate to our case:

> Factory owners sometimes find that their properties have higher market and rental values for other uses than for their current uses. In these cases, it may be good business, if the operators' moving and supersession costs are not great, to sell or rent their properties and move their industries to new sites where they can benefit from lower land costs.[9]

Rising prices and land-use conflicts become more likely as suitable sites become scarcer around the expanding urban periphery. Hence, the very urban growth that generates the need for aggregates also complicates attempts to supply them. Thus, a dynamic model must also include a consideration of the environmental pressures generated by new urban residents in areas immediately adjacent to aggregate production districts.

As the metropolitan area expands, new suburban growth begins to surround aggregate production sites. This, in turn,

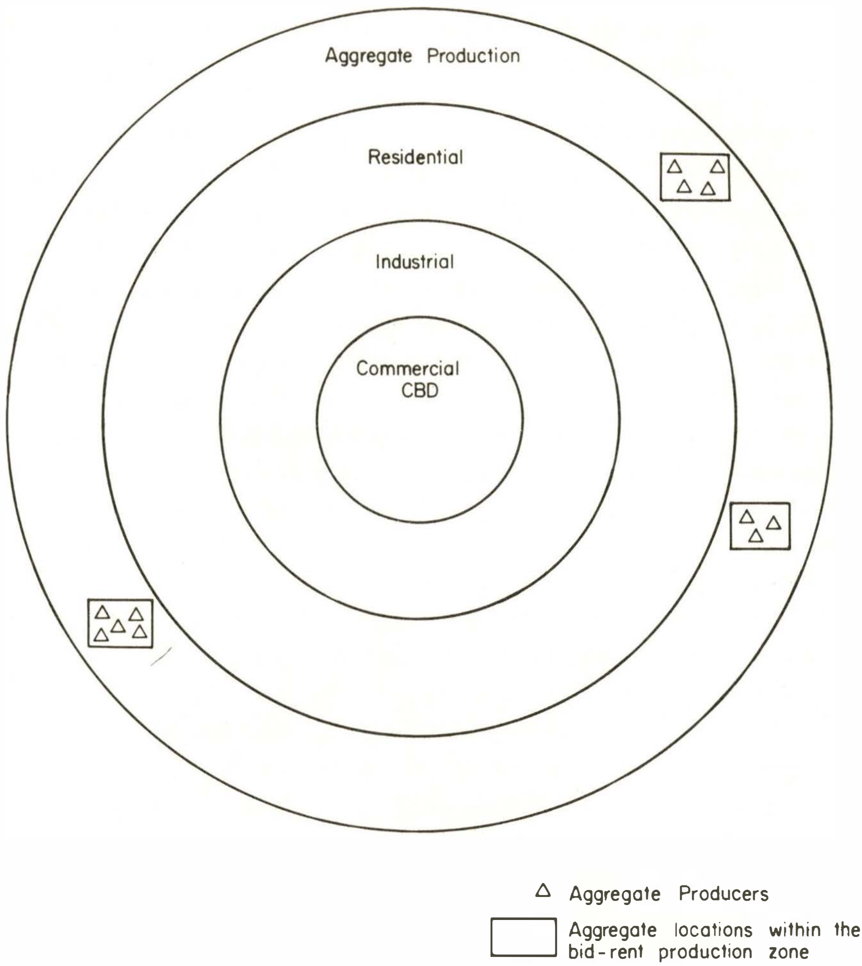

Figure 3.

provides a population base for applying social and political pressure to local government for restricting and further regulating aggregate production. Unlike the situation with airports and some other environmentally damaging land uses, there are few, if any, directly perceived benefits from aggregate production. Where land-value pressures alone have not been successful in driving out aggregate producers, social and political pressures often have.

Aggregate Production in Los Angeles: An Example

In order to view the location of aggregate producers in a major metropolitan complex that is definitely expanding, we turn, now, from the simple bid-rent model to the Los Angeles urban area. Figure 4 shows the location of aggregate producers as of 1975, at which time seventy-one companies were active in the industry.

First, note that production sites are scattered within the various zones. No aggregate production sites are located within the innermost zone, that is, within ten miles of the Los Angeles CBD; and only two sites, Irwindale and Sun Valley, are located

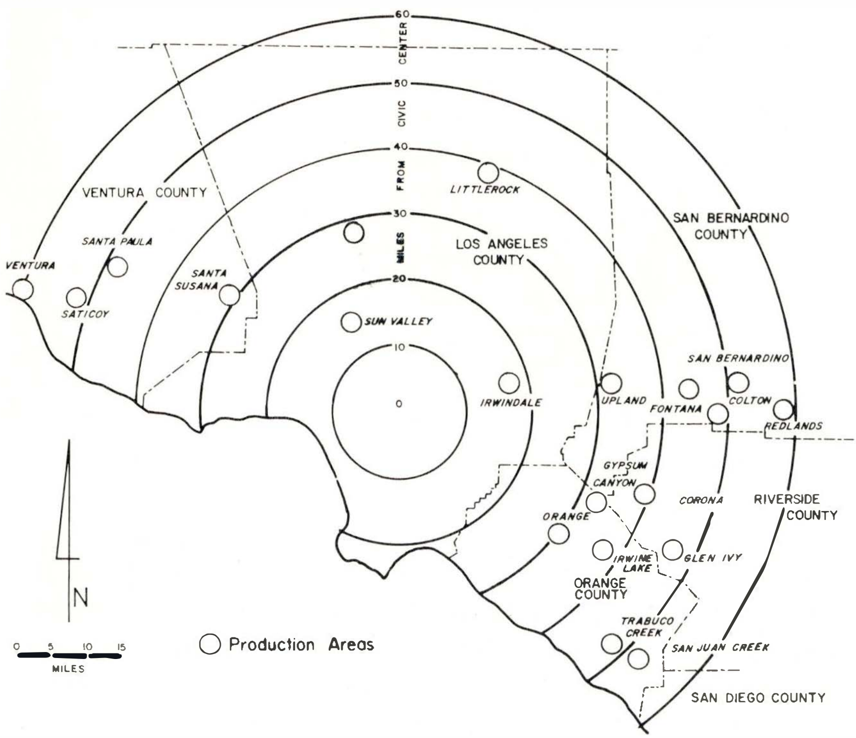

Figure 4. Aggregate Production Sites in the Los Angeles Urban Area

in the second zone, which extends ten to twenty miles from the CBD. Most of the aggregate production sites are located thirty miles or more from the CBD, mainly in Orange, Riverside, and San Bernardino counties, all of which are now undergoing rapid urbanization.

Considering the evolution of the Los Angeles metropolitan area, the location of aggregate producers fits well with our expectations. There are few surprises. Persistence of the close-in Sun Valley and Irwindale production sites is the only noticeable anomaly; few production sites can be found in Los Angeles County.

Furthermore, where aggregate sites occur they are characterized by clusters of pits and companies. For example, in the Temescal Wash production district eight different pits are operated by seven different companies (Figure 5). At this location only 169,160 tons of aggregate were produced in 1960, compared with a 1975 production figure of 1,980,173 tons, indicating production increases in such peripheral sites as production declines closer in. An example of the latter is the Tujunga fan production district, which reached a peak annual production of 6,772,488 tons in 1963 and by 1975 had dropped to an annual production of 4,324,988 tons. We stated earlier that as the urban area expands rising land values and competition for land use would force producers to relinquish close-in production sites and seek locations further away from the city center. An excellent example of this process occurs in Upland, where an aggregate production site is being reclaimed and converted to light manufacturing.

Impact of Land-Use Controls Beyond the Urban Fringe

So far we have suggested that a bid-rent model, with expanding bid-rent curves in response to urban growth, could help us understand changes in the location of aggregate producers over time. What we end up with is a prediction of new sites continuously opening up on the urban fringe as sites are closed down nearer the CBD. At first glance it appears this process

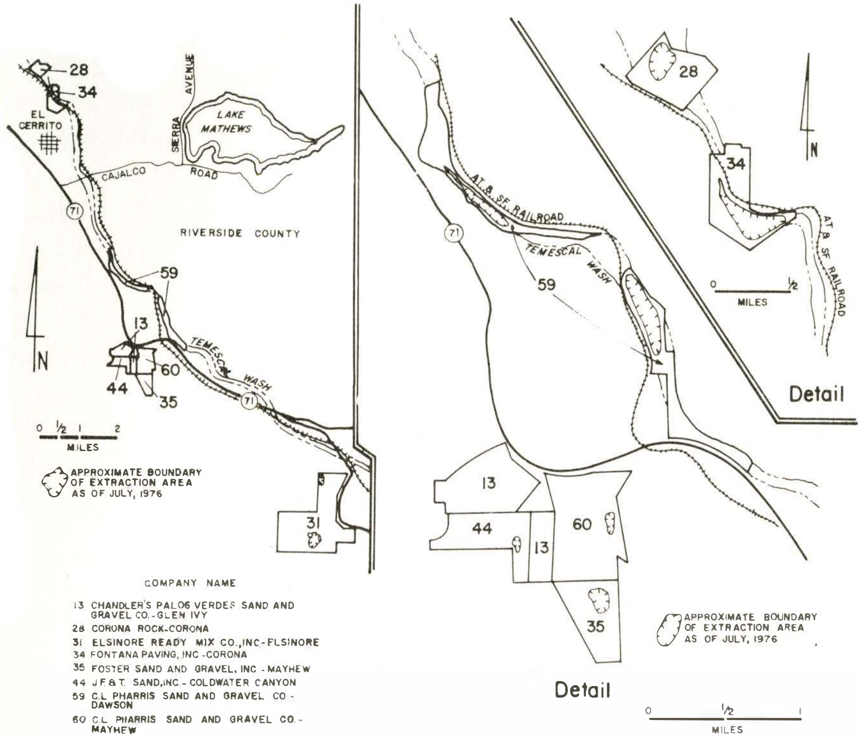

Figure 5.

could go on indefinitely. That, however, is deceptive, because it assumes not only that rural land uses continuously will give way in the face of competitive rents from urban land uses, but also that few, if any, controls exist to impede the opening of new aggregate production sites on the urban fringe. Neither of these assumptions is safe, because many rural areas are adopting measures to stem the impact of ever-expanding urbanization.

Recreational and agricultural land uses, for example, may be protected from conversion to urban areas. State and federal statutes may require either the establishment of agricultural preserves or the creation of strict, land-use plans for public lands, such as those for National Parks and for areas managed by the Bureau of Land Management. What occurs, then, is that aggregate producers find themselves caught, as the adage goes, "between a rock and a hard place."

Additionally, urban sprawl creates both a demand for aggregate and an increase in the bid-rent for current production sites. Hence, as building materials become scarcer and more expensive they will begin to impact housing costs, already driven up markedly since 1970. In turn the entire housing cycle and construction industry could be impacted. Even without further urban growth, replacement construction and in-filling would sustain a demand for aggregate at some reasonable level, whereas supplies may become inelastic and gradually even diminish.

Consider an example. We have indicated the expansion of aggregate production around the Los Angeles metropolitan fringe, and anyone familiar with this region might note the seemingly endless supply of rock, sand, and gravel that stretches across the desert and ask how aggregate supplies could ever run short. Indeed, some mining occurs there. Limestone, for example, is quarried for cement; and volcanic cinder is mined for use as a lightweight aggregate for concrete blocks, which are produced within the metropolitan region.

Conservationists and ecologists, however, are increasingly vocal about the need to protect fragile desert environments from the ravages of urbanism and industrialism. Current trends portend a marked change in the future use of California desert environments. The Bureau of Land Management has completed the California Desert Conservation Plan, which designates some desert lands for a variety of specific uses and also sets aside other tracts that are simply not to be used for any economic purpose. Elsewhere, too, rural areas are coming under governmental control, thus leading to some of the aggregate supply problems noted earlier.

Resolving Conflicts Beyond the Urban Fringe

What we now have is an early warning about a seemingly innocuous industry and its attempt to provide essential building materials to expanding urban areas. In the not too distant future, metropolitan areas must consider options which can resolve conflicts between rural and urban land uses on and beyond the current urban fringe.

One option is to adopt a no-growth policy, though as we previously pointed out even no-growth does not end the demand for building materials within the urban complex. Another possibility is to count on obtaining variances in rural land-use controls. However, reliance upon this alternative is risky, depending ultimately on whether state or federal governments are more enticed by environmentalists and their plans for preserving natural environments or by advocates of urban sprawl, who contend that the city, with its people and jobs, is entitled to take what it needs from the natural environment. A third option, one that is far less risky, is to use urban zoning to set aside lands that are reserved for aggregate production. At the same time steps should be taken to sustain aggregate production on current sites for as long as possible. Existing legislation in California encourages local governments to provide for the continued use of aggregate production sites in the face of urban growth pressures. The California Surface Mining and Reclamation Act of 1975, for example, requires the state geologist to classify and delimit aggregate resources in thirty-three urban areas in California and to make this information available to local planners. The law requires that this information be utilized by local governments when developing their planning elements and zoning ordinances. A comprehensive approach to dealing with the need to provide for continued production of aggregate at the edge of metropolitan areas could represent the beginning of a governmental process that would establish a few long-term aggregate mining districts which could survive the increased land values and public pressures of expanding metropolitan areas. Such an approach would have the added benefit of reserving land for conversion to recreation or other uses at a future date, when aggregate production areas are eventually depleted. Solid waste disposal and recreation lakes are two of the most common secondary uses.

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C G S
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THE PHYSIOGRAPHIC REGION IN PHYSICAL GEOGRAPHY AND GEOMORPHOLOGY: HISTORICAL APPRAISAL AND RE-EVALUATION

*Robert B. Howard**

Introduction

An examination of introductory physical geography texts reveals topical coverage exhibiting coherence and a clear sense of spatial pattern, particularly when it comes to climate, soils, vegetation, and hydrology. These interrelated topics establish the notion, necessary for beginning students, that the natural environment consists of a complex web of interdependencies. Unfortunately, when the atmosphere, hydrosphere, or biosphere are exchanged for the geosphere, these interrelations seem to disintegrate in confusion with a loss of spatial coherence. What has happened to the sense of the geosphere's cohesion and its interrelatedness with the rest of physical geography? More importantly, where is geomorphology's spatial aspect which is so necessary in an introductory course?

This paper attempts to draw attention to this inadequate spatial coverage in geomorphology, particularly at the macro-scale, and suggest physiographic regionalism as a partial solution. However, any re-introduction of the physiographic region needs to take as its basis the recent advances in the solid earth sciences, especially those in global tectonics.

* *Dr. Howard is Professor of Geomorphology and Physical Geography at California State University, Northridge.*

Some of the aforementioned confusion in dealing with the geosphere in general and geomorphology in particular is probably due to the two different scales at which geomorphology needs to be examined for even rudimentary understanding. At the macro-scale we are dealing with entire landscapes, those elements of topography that are structurally controlled and which depend primarily upon endogenic processes.* At the micro-scale, we deal principally with the detailed sculpting or etching of landscapes by exogenic processes whose magnitudes and frequencies are interrelated with climate and hydrology. These exogenic processes, interacting with earth materials (rocks and sediments), are responsible for producing the myriad individual erosional and depositional landforms which are etched into, or superimposed upon, the landscape's major structural elements. In addition to producing individual erosional features, these etching processes also enhance structure's influence on topography through exploitation of any structural weaknesses.

Historical Appraisal

In the development of what we now call geomorphology, the physiographic province was a very important and integral part. One of the earliest mentions of anything akin to a physiographic region in the United States was the early nineteenth-century recognition of the topographic uniqueness of the Ridge and Valley region.[1] The development of regional physiographic concepts occurred later in the same century. Recognition of intraregional topographic similarities leading to delimitation of physiographic provinces came during the period of westward expansion and western exploration in the years immediately following the Civil War. Physiographic

*Here structure is used in its broadest or geomorphic sense rather than in its more common and narrower geologic connotation. Used in the geomorphic sense, structure includes not only the attitude (dip and strike) of rocks (that is, geologic structure or structure *sensu stricto*) but also lithology and stratigraphy as well as any continuing tectonism or volcanism that will have an influence on surface morphology.

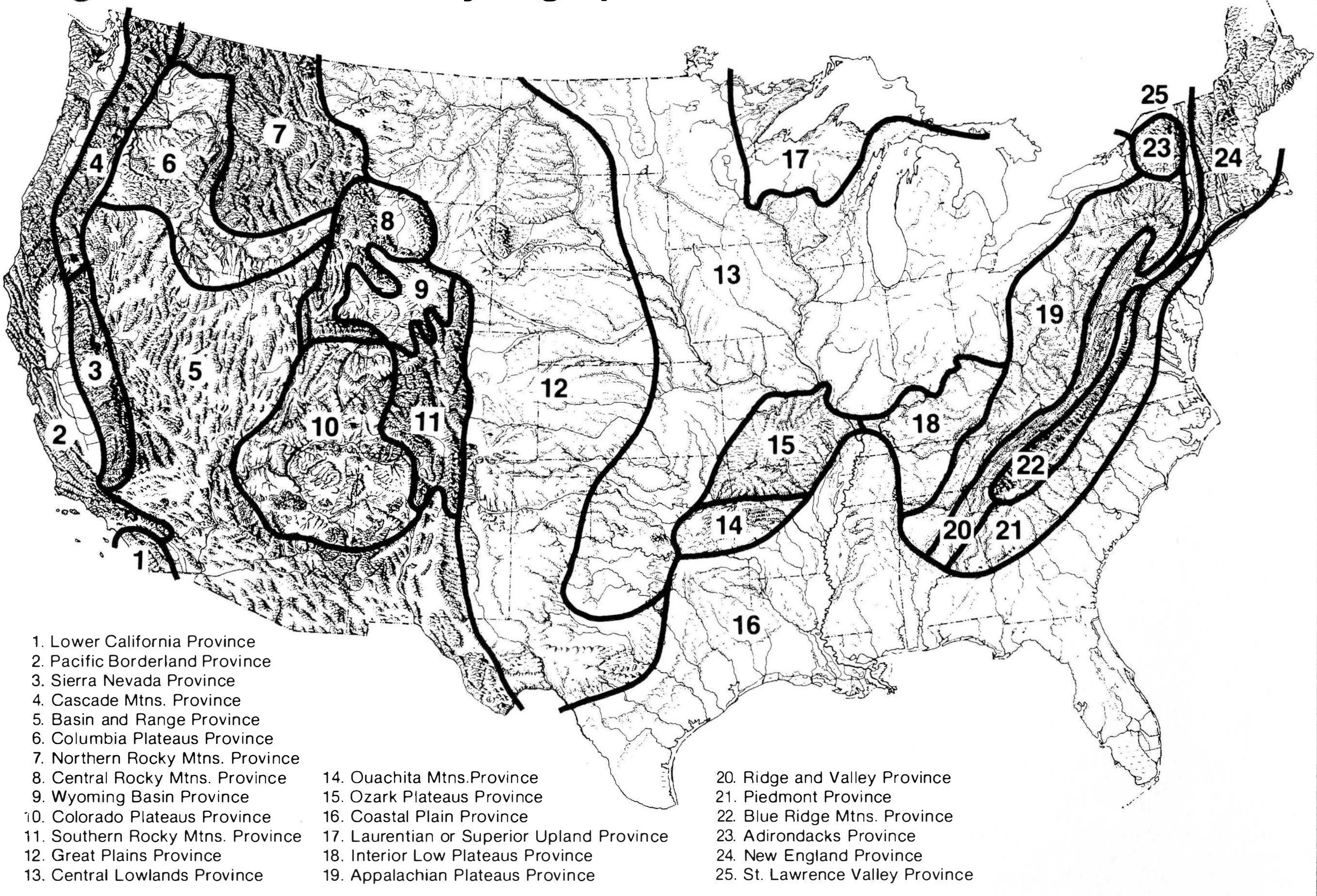
regions or provinces received the greatest geologic and geographic attention in the late nineteenth and early twentieth centuries.

An early scheme of nomenclature for the United States' physiographic provinces was that of Powell.[2] Subsequently, Powell's scheme was modified by Lobeck[3] and finally by Fenneman.[4] Fenneman's provincial boundaries and terminology are still recognized and employed by the U.S. Geological Survey (Figure 1). For geographers, the idea of physiographic regions was what made the study of physiography spatial or geographical. Without this spatial element it is doubtful that physiography would have continued to be included within what today is considered physical geography. Following this early period of prominence, however, the use of physiographic regions suffered a sharp decline.

The decline in the intellectual content of physiographic studies in the early twentieth century had many causes. Among these was the split between geography and geology as each field underwent separate development and specialization. Coupled with this was the demise of environmental determinism as a major rationale for physiographic studies together with the rise of human or cultural geography which displaced physical geography from its central role in the field. Finally, there was an unthinking mimicry involved in applying the Cycle of Erosion to landscapes. The Cycle of Erosion or cycle of Landmass Denudation, developed by Davis,[5] was an admirable first attempt at organizing into a meaningful format what was then known, or at least surmised, about the origin and development of the earth's landforms. It was designed as a pedagogical model; and herein lies its problem, since this teaching device was then used as a research model by Davis and his disciples. Uncritically they applied this simplistic cycle to their task of unravelling the denudational history of the world's landscapes. The basic assumption concerning the innate correctness of the cycle was never questioned; and reality was, therefore, made to fit the model rather than the reverse, as would be dictated in a real scientific field. To assume that all landscapes will evolve in a predictable and simplistic sequence of stages ignores reality. Davis himself had said on numerous occasions that a myriad of possible complications are possible within the cycle framework (for example, pattern of uplift). Curiously, neither Davis nor any of his students ever examined, even theoretically, these complications. It was this unscientific and formalistic simplicity passed off as scholarship that those outside the budding science of geomorphology saw and found decidedly wanting in scientific rigor.

Geomorphology's resurrection from its near demise began in the 1940's and 1950's, as a result of Strahler's development of morphometric studies based on the seminal work of Horton.[6] These studies included a strong areal element and clearly demonstrated the importance of spatial organization in the landscape. In fact, morphometric studies gave rise to the many ideas which eventually caused the collapse of the classical, or Davisian, school of geomorphology. Coupled with these morphometric studies the U.S. Geological Survey's Hydrologic Studies of Rivers, initiated in the 1950's, forever turned geomorphology's attention away from hypothetical studies of landscape evolution, based on deductions from unsubstantiated premises of the classical geomorphologists, and redirected it toward exogenic processes. The rationale for this change in scale and perspective was that if we are to understand landscape development we must first understand what occurs on the landscape's surface. For too many years postulates about an entire landscape system had been constructed without any attempt to study, understand, or even identify the system's constituent parts. However, in our recent fascination with the study of exogenic processes, we have tended to ignore that spatial element which can be a significant link in physical geography courses—the physiographic region. This is true not only at an advanced level in geomorphology, but also and especially at the introductory course level.

Fig. 1 Fenneman's Physiographic Provinces of the United States



I think geomorphology has maintained its place within the body of physical geography more by tradition and historical precedent than by any meaningful spatial rationale. As a geomorphologist and a geographer (but not a geographical geomorphologist), I have always had an interest in physiographic regions and have desired to see them incorporated in a meaningful and appropriate manner into the body of physical geography courses. After all, climatology has its climatic regions, and soils and vegetation are frequently discussed regionally. How, though, can geomorphology and geomorphic regions in particular be most effectively presented? Maps such as Murphy's,[7] while providing some spatial information for the initiated, offer little in the way of insights or integration for the beginner. Fenneman's maps, coupled with unrealistic and fanciful notions of peneplains, even though spatial or regional in intent, are justly viewed as historical curiosities, singularly unrewarding to the knowledgeable and particularly so to any beginning student.

Most physical geography texts maintain a schizophrenic treatment of geomorphology. Our geological roots are acknowledged in chapters dealing with the rudiments of mineralogy and petrology. Chapters on the dynamic and stratigraphic influences on topography are often the last in a book. Such is the usual geographic treatment of endogenic processes, but exogenic processes are generally covered in detail, often with a definite bias toward climatic geomorphology.*

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*I have no intention at this juncture of getting involved in arguments concerning climatic or climatogenetic geomorphology. Suffice it to say that the belief (which remains unsubstantiated) that there is a direct relationship between form and climate is simplistic, at best, given the multivariate character of nature and all the ramifications of the principle of equifinality. I think the emphasis by some physical geographers on climatic geomorphology derives from their desire for some type of geomorphic regionalism. Since geomorphology apparently has none, and climate does, then the combination of the two must result in an approach that can be looked upon as regional whether the combination is valid or not.

A desire for regionalism brings us back to the physiographic province or, in more modern parlance, the geomorphic region. What is needed is a regional approach which is shorn of classical geomorphic trappings. A search of the contemporary literature for some guidance on geomorphic regions leads to only two texts that deal with regional aspects of geomorphology, namely, Thornbury[8] and Hunt.[9] While Hunt is probably the more physiographic (*sensu stricto*), it is written without any insights which recent advances in global tectonics could provide. Thornbury on the other hand, although analyzing each physiographic/geomorphic region, does so primarily in the light of the voluminous and outdated literature in classical geomorphology. How then can the physiographic region be tied into the body of modern geomorphology and, by extension, provide a useful framework for beginning as well as advanced physical geography or geomorphology students?

Re-evaluation

A scientific revolution occurred in the solid earth sciences during the 1960's and early 1970's. This dramatic shift in perspective involved the rise and eventual acceptance of the plate tectonic paradigm as a basis for explanation of global patterns of tectonics and volcanism, among other phenomena. This same paradigm can, with imaginative application, provide a basis for re-evaluating the meaning and significance of our physiographic or geomorphic regions. The physiographic region is usually defined as a spatial analog based on geologic structural regions. While physiographic regions are recognized and delimited on the basis of surface morphology, gross surface morphology is in turn an expression of underlying structures. Geologic structure is the key to understanding physiographic regions because structural elements owe their existence to the three major stress regimes (compression, tension, and shear), which in turn are functions of plate motions and interactions occurring at plate boundaries. Where crustal consumption occurs, as in subduction zones, compression tends to be the dominant stress. Tension tends (though not exclusively) to occur where new crust is being generated, and shearing is found along those plate boundaries in which crustal conservation is favored.

In the tectonically active western United States, there is a growing and voluminous literature relating present plate motions directly to structural geology. From there it is an easy step to relate it directly to structural geomorphology. In the central United States, it is doubtful if much can be applied directly from plate tectonics except as pertains to the Mississippi embayment. This is not to say, however, that structural geomorphology has no application in this area. Structural elements are present, but because of the absence of tectonism and volcanism they are far more subtle than on either coast, being primarily associated with lithology and stratigraphy. In the eastern United States, there is a growing trend toward re-evaluation of regional geology in view of the plate tectonic paradigm, although here the re-evaluation applies to more ancient, and thus more problematical, pre-Pangaean plate motions. Some tentative but profitable beginnings have been made in this direction; and, though still a long way off, the implications for structural geologic and physiographic explanations are far reaching.

Imaginative application of the plate tectonic paradigm enables one to re-evaluate the various physiographic regions in more rewarding and meaningful historical terms. At the same time, a more complete spatial synthesis of structural geomorphic notions, coupled with our geologic/earth science roots, can be achieved. Ultimately, this re-evaluation and synthesis yields a meaningful regionalism in macro-geomorphology.

Examples of the possible re-evaluation of western physiographic regions or sections that might here be mentioned in very brief synopsis include the California Coast Ranges and Transverse Range Sections of the Pacific Borderland Province, the Cascade Range Province, the Sierra Nevada Province, and the Great Basin Section of the Basin and Range Province (Figure 2).

Prior to the complete subduction of the Farallon Plate and the East Pacific Rise off of what is presently coastal California, compression was the principle stress. This compressive stress regime resulted in a squeezing and an east-west shortening of the crust, producing the characteristic thrusts and folds found in the present Coast Ranges.* Once the East Pacific Rise was subducted, a process commencing some 30 million years (m.y.) ago, the apparent oblique subduction was replaced by strike-slip motion.[10] This strike-slip motion now concentrated along the San Andreas fault provides the final structural detail that is now being etched into relief by present exogenic processes.†

The east-west trend of the Transverse Range section in Southern California appears to be due to the opening of the Sea of Cortez, thus separating Baja California from mainland Mexico, some 4 to 5 m.y. ago. This opening resulted in a bend or

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*It should be mentioned that some of the present-day exogenic, geomorphic processes occurring in the California Coast Ranges section are affected by this pre-Miocene subduction. Compression in the "California trench" caused the sediments accumulating there to undergo blueschist (high-pressure, low-temperature) metamorphism, creating a melange known today as the Franciscan formation. This formation is characterized under present-day conditions by its high weatherability and its propensity for mass failure.

†Of course, it must be recognized that Pleistocene environmental changes also left a very important imprint on the landscapes of the United States. This point must be emphasized continuously, as it should be a leitmotif of both physical geography and geomorphology. No entire landscape can be in a steady-state condition. Since environments are dynamic, any change in one or more environmental parameters will necessitate changes in rates of a series of process activities. Changing types or rates of exogenic processes will mean that erosional and depositional forms must change as a response. Because all process rate changes have unique lag times, one process may be adjusted to new conditions while others are in varying stages of adjustment. All this means that any landscape will contain relict features, features whose formative processes no longer operate at original rates, if at all.

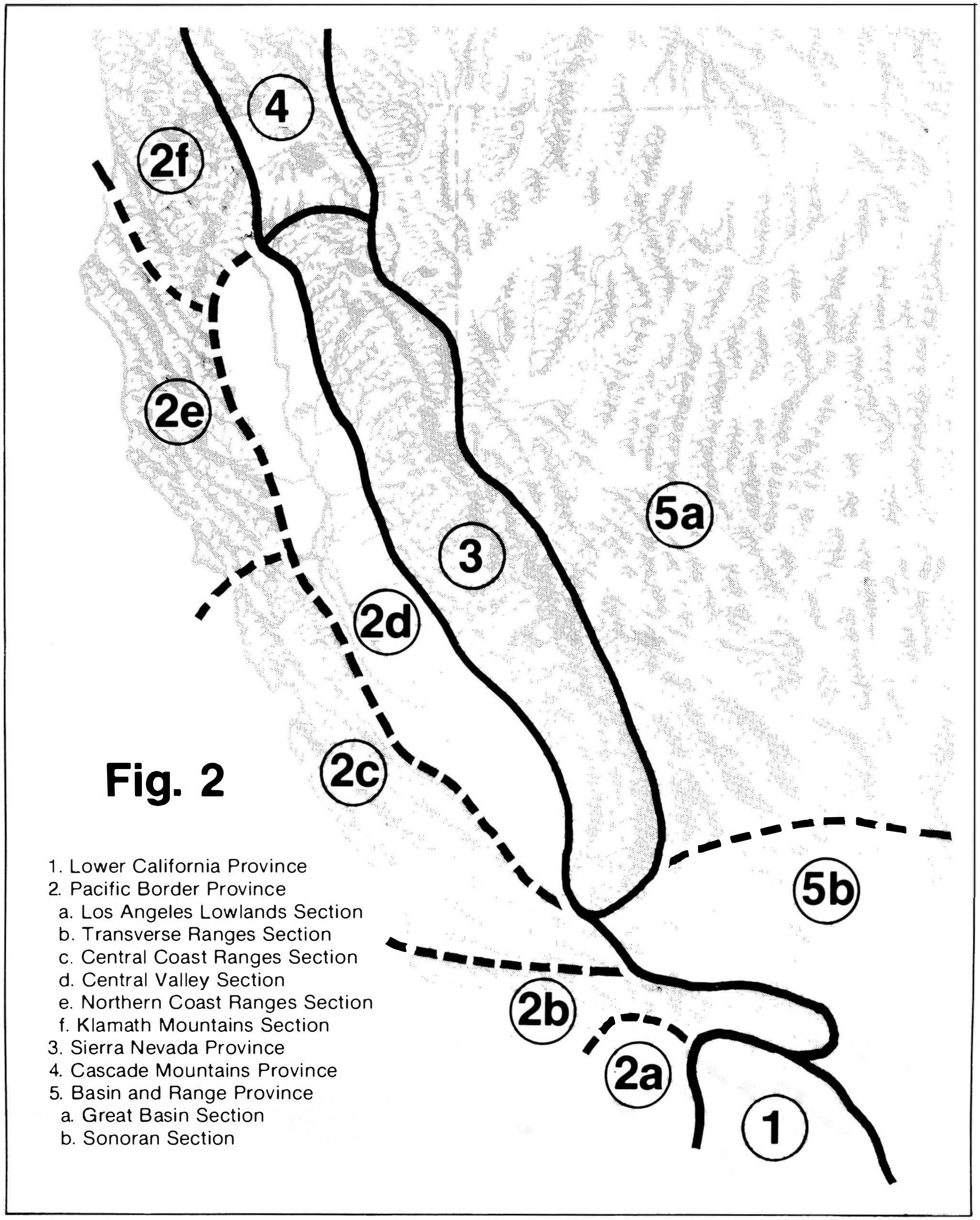


Fig. 2

1. Lower California Province
2. Pacific Border Province
   a. Los Angeles Lowlands Section
   b. Transverse Ranges Section
   c. Central Coast Ranges Section
   d. Central Valley Section
   e. Northern Coast Ranges Section
   f. Klamath Mountains Section
3. Sierra Nevada Province
4. Cascade Mountains Province
5. Basin and Range Province
   a. Great Basin Section
   b. Sonoran Section

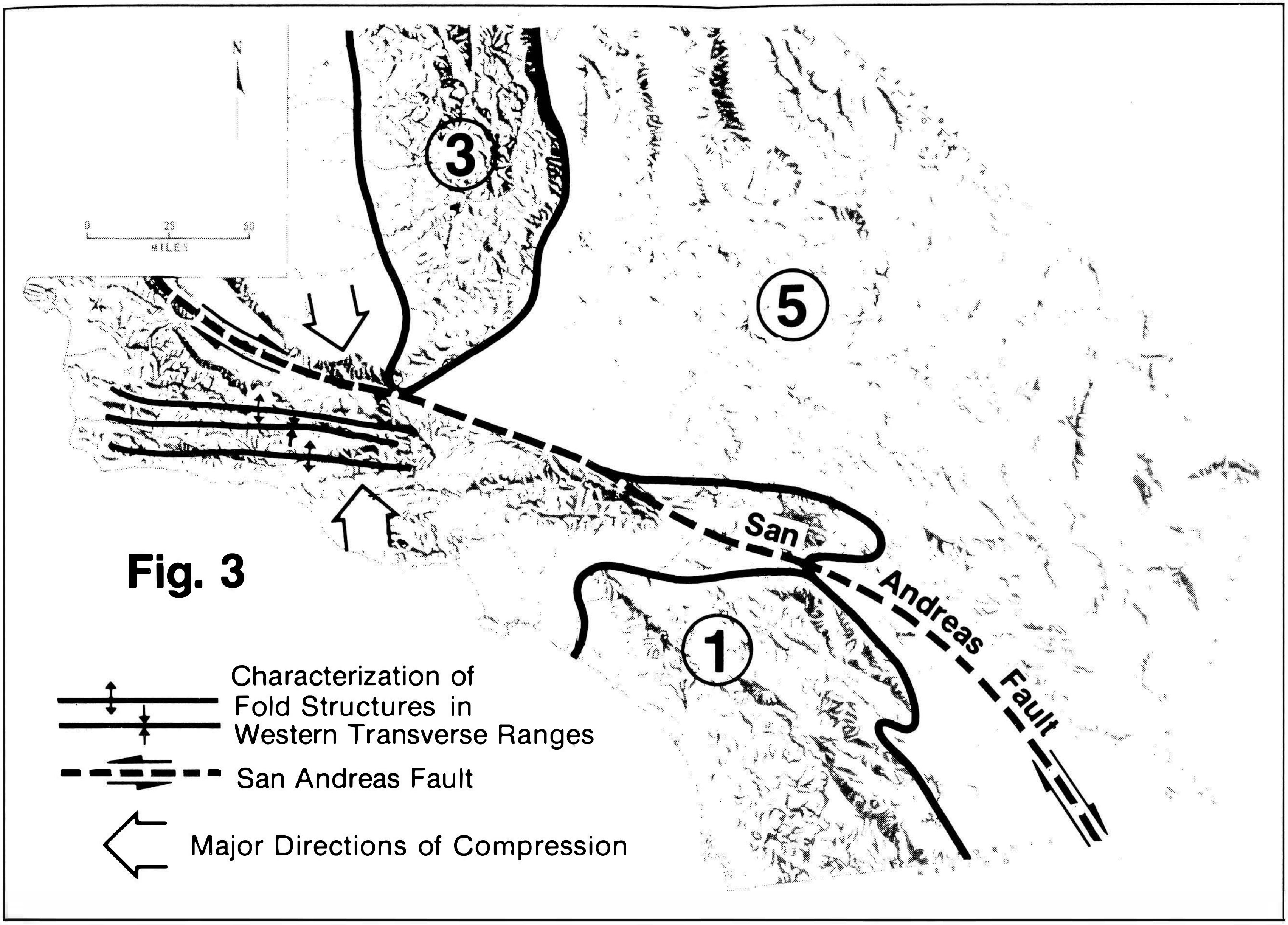
"dog-leg" in the San Andreas fault. Right-lateral strike-slip motion proceeds relatively unimpeded in a northwest-southeast direction to the north and to the south of the Transverse Range section. In the vicinity of the Transverse Ranges, however, compression is also occurring in addition to the shearing because of this bend in the fault (Figure 3). At the eastern end of the section this compression has resulted in the squeezing and upthrusting of massive basement crystalline rocks of the San Gabriel Mountains south of the San Andreas fault and the San Bernardino Mountains to the north. Both of these mountain masses, in addition to being separated from each other by the San Andreas strike-slip fault, are further bounded by thrust faults which serve to take up the necessary crustal shortening in this zone of both shearing and compression. In contrast to the crystalline rocks of the eastern portion of the section, the western Transverse Ranges have yielded to this crustal compression by developing massive folds in their Tertiary sedimentary rocks. The axes of these folds trend east-west, as would be expected from the north-south directed compression.

The Cascade Range of today has many elements in common with the Sierra Nevada of perhaps 40 or 50 m.y. ago. The subduction of the Juan de Fuca Plate (a segment of the Farallon Plate, most of which is now long since subducted) provides the "wet" oceanic crust which, when partially melted, provides the intermediate composition magmas that have erupted for the past several million years to form the majestic Cascade stratovolcanoes. This extremely dynamic link between plate tectonics, subduction, and volcanism is further exemplified by the eruptions at Mount St. Helens since May of 1980.

The Sierran block is, in many respects, genetically related to the Basin and Range Province, of which it forms the western boundary. It is given separate status as a physiographic province primarily because of its rather uniform lithology (principally granitic) and its sheer massiveness. Since it is genetically related to the Great Basin Section of the Basin and Range, its reasons for uplift are probably related to the extensional activity of the Great Basin.

The extensional tectonics in the Great Basin Section of the Basin and Range, which has continued for about 30 m.y., has had several explanations. Probably the most rewarding, and the one which offers the best explanation with the fewest problems, is related to the nature of shearing. It can be easily demonstrated that a shear stress regime will possess elements of both tension and compression. As a result, the right-lateral northwest to southeast shearing along the San Andreas fault in the lithologically heterogeneous crust of the western United States should yield an east-west extensional component. The topographic expressions of this extension—normal fault scarps, fault-line scarps, grabens, horsts, or tilted fault blocks—should trend north-south. A glance at a topographic map of the Great Basin reveals rather strikingly the north-south trend of the fault-block mountains and their intervening basins of internal drainage.

As these all too brief sketches indicate, the integration of plate tectonics, geologic structure and ultimately topography as the surficial expression of structure, is easily accomplished for any of the West's physiographic provinces. This is facilitated because of the recency of tectonic and volcanic activity. This is more difficult in the eastern United States because of the absence of recent endogenic activity. These difficulties can be ameliorated as more information is developed on the period of geologic time prior to the creation of Pangaea and the subsequent breakup of the supercontinent. For example, Pangaea's break up is probably responsible for the various Triassic-aged lowlands of the East Coast. Pre-Pangaean plate motions will eventually help to explain not only the Ridge and Valley Province's folds, but also the structure and topography of, say, the New England Province as we come to understand the nature of the Acadian or Caledonian orogeny in terms of collision between the Paleozoic American and European Plates.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San Andreas Fault
Characterization of Fold Structures in Western Transverse Ranges
San Andreas Fault
Major Directions of Compression
Fig. 3

Exogenic Activity

As noted above, all landscapes are historical documents whether viewed on macro- or micro-scale. This is due to the fact that no landscape can maintain steady-state over its entirety. The dynamic equilibrium that characterizes landscapes allows relict landforms to continue in existence until their processes of formation have adjusted to new conditions. Relict landforms are eventually effaced because they are no longer in equilibrium with existing processes.

What is needed is a way in which exogenic processes may be integrated into physiographic regions. In order to avoid the obscuring influences of climatic or climatogenetic geomorphology, the individual exogenic processes are best studied systematically. In the systematic approach, room is easily made for showing the interrelationships between the earth surface processes, the hydrologic cycle, and climatic patterns.* But once a rudimentary understanding of external processes is achieved by the introductory student, the influence of these processes on each physiographic region can be initiated. A benefit of this approach is that discussion of contemporary, as well as historical, activity inevitably emphasizes or reinforces the notion of environmental change.

Conclusions

It is particularly appropriate that any rebirth of regional geomorphology be made here in the West. After all, the stark physiographic differences across the United States were noted by the decidedly eastern physical geographers, geologists, or physiographers of the King, Hayden, Wheeler, and Powell surveys who worked in the West. Powell, Gilbert, Dutton, and even Davis wrote about these differences based largely on their western experiences, and Holmes illustrated them in his striking drawings for the works of Gilbert and Dutton.

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*Note here that while I tend to reject as simplistic the notion of climatic or climatogenetic geomorphology, I make no such rejection concerning the relationships between climate and process. The magnitude and frequency of virtually all exogenic processes tends to be atmospherically dependent.

I believe there is an environmental perceptual problem for eastern physical geographers and geomorphologists that prevents them from realizing the inherent value of the re-evaluated physiographic region. They live in a tectonically quiescent, humid environment where internal processes are a thing of the past. The humid climate forces them to emphasize not just running water (our most important exogenic agent even in the dry west) but chemical weathering, soil development, hillslope creep, and all those other natural humid processes which lead to a mantling of rocks and a rounding off of the landscape. As far as macro-geomorphology is concerned, these surficial props (particularly soils and vegetation) mask the geologic stage upon which all else depends. In the West our arid to semiarid climates act to inhibit vegetation as well as to reduce chemical weathering, soil development, and hillslope creep, thus generally leaving the rocks exposed so that their influence on topography becomes obvious. An elementary student shown a landscape photograph of, say, the Colorado Plateaus quickly appreciates the influence of sandstones, limestones, or shales on individual slope segments and thence their cumulative influence on the entire landscape. The immediate grasp of this simple relationship is far more problematical when shown a photograph of the Appalachian Plateaus. Although the structures are the same and the rocks are quite similar in age and lithology, the landscape has a vastly different appearance than that of the Colorado Plateaus. The frequency of tectonic and volcanic activity in the western United States also forces us to pay more attention to internal processes.

This plea for a return to the re-evaluated physiographic region serves two purposes. First, it introduces a nonartificial and more precise spatial unit into the geomorphology taught in physical geography. This can have the effect of eliminating the use of climatic regionalism as the spatial basis for geomorphology. It also offers a means whereby we can synthesize and integrate the research of the other earth sciences into physical geography in a coherent manner. Second, this re-evaluated physiographic region offers new insights and research opportunities in an atrophied aspect of geomorphology long overdue for renewed attention.

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EVALUATING THE SETTLEMENT OF THE LOS ANGELES REGION: A STUDENT PROJECT

*Richard Crooker**

Introduction

The fragmented, urban landscape of the Los Angeles region has a built-up area of 1,700 square miles. Only the New York metropolitan region has a greater area. Physiographically, the Los Angeles region encompasses the Coastal Plain and adjacent lowlands of Southern California (Figure 1). To the casual observer, the region's large area tends to disguise the importance of location-specific, environmental and cultural relationships which have influenced the timing and spread of settlement in the area. Any instructor who has addressed the historical settlement of the Los Angeles region knows the frustration inherent in trying to reduce the complexity of this urbanized landscape to a level of generalization that students can understand.

A review of some of the approaches used by scholars will help clarify this problem. Lantis, Steiner, and Karinen subdivide the Los Angeles region physiographically and sketch the history of settlement for each division.[1] Steiner emphasizes a topical approach by describing salient social, economic, and environmental factors that have led to the decentralization of urban functions and the rise of selected sub-regions.[2]

**Richard Crooker is Assistant Professor of Geography at Kutztown University.*

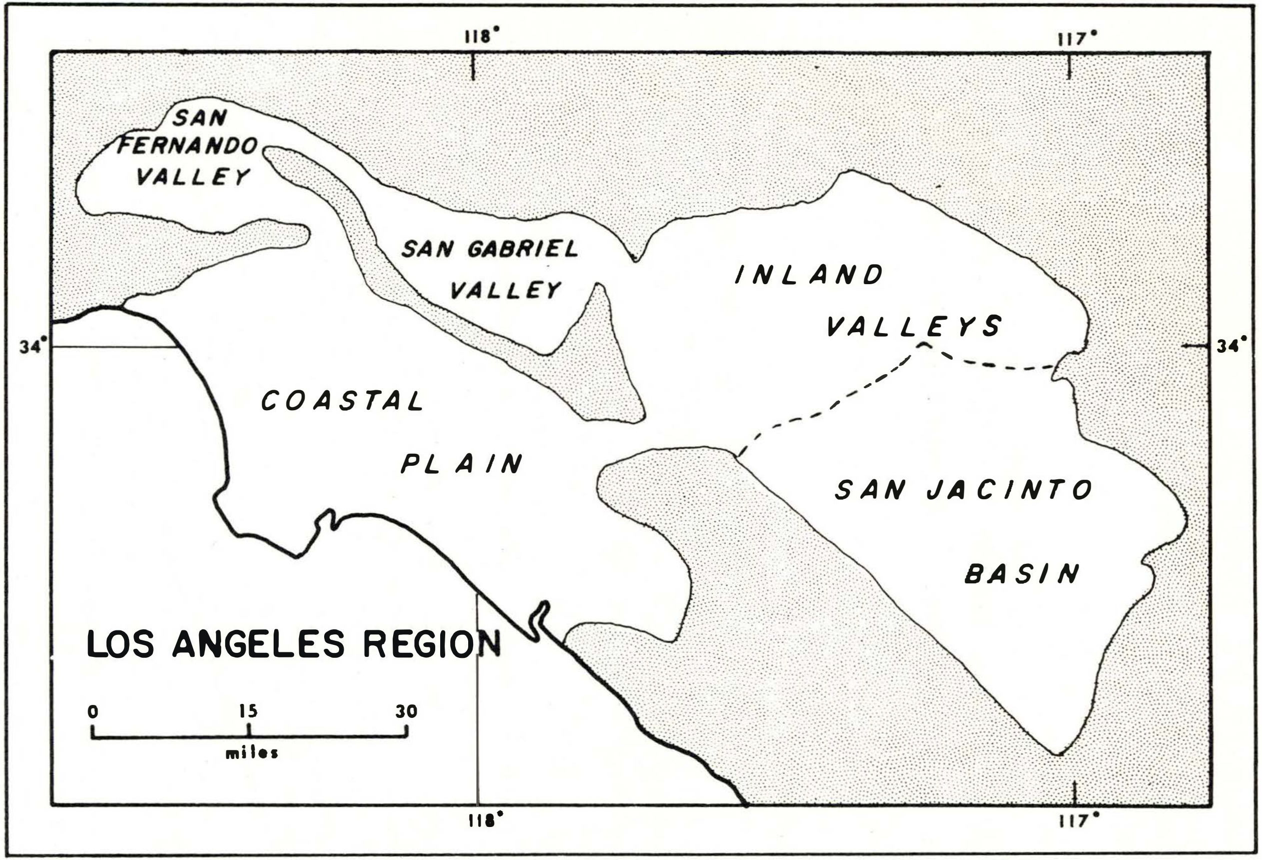

Figure 1. Map of the Los Angeles region (lowlands)

Aschmann[3] and Fogelson[4] also use topical approaches, and both focus on the importance of human perceptions and purposes in the evolution of the region's fragmented landscape. On the other hand, the historians Bigger and Kitchen[5] use a chronological approach in providing the background of city formation. Still others have dealt with the evolution of the architectural landscape. Banham, for example, provides a delightful treatment of this topic by subdividing the Los Angeles region into Surfurbia, Foothills, Plains of Id, and Autopia.[6]

Each of these approaches has made valuable contributions toward understanding how the Los Angeles metropolitan landscape developed.[7] Nevertheless, by themselves, they are inadequate pedagogical tools for use in teaching about areal settlement trends. The sub-regional approach often can frustrate students' efforts to cross-reference details about the timing of population growth and settlement for the entire region. On the other hand, topical and chronological approaches can be too narrow in scope, so that while some aspects that influence the timing and spread of settlement are adequately addressed, others are not chosen for examination.

Purpose

This paper focuses on the proposed use of a trend surface computer map as a heuristic device for the study of an evolving urban landscape. The specific purpose is to suggest how an instructor can use such a map to help students make generalizations and state hypotheses regarding locational relationships which may have shaped the timing and spread of settlement in the Los Angeles region.

Theoretical Considerations

Two assumptions serve as a basis for the following discussion. The first is based on the fact that city incorporation usually signifies that a community's population is growing at such a fast rate that its members have decided a city government is needed in order to formulate public policy and provide services. Therefore, it is assumed that the years in which cities are incorporated are good indicators of population growth; and, if the dates of incorporation are plotted on a map at their respective city locations, a time-dimension trend in settlement can be discerned. Figure 2 comprises such a map. It is based on all of the cities which were incorporated in the Los Angeles region between 1850 and 1940. The year 1850 was the date of the first city to be incorporated. The year 1940 was chosen as the arbitrary cutoff point for trend analysis. The communities and their incorporation dates are listed in Table 1.

The second assumption is that at the time a city is incorporated, its location may be regarded as the best means of satisfying the needs of the founding group. Therefore, in order to understand settlement trends, it is necessary to regard city locations in terms of original needs. In one case, for example, a very important need may have been a water supply for adjoining crop land, in another this may have been of less importance.

A final point of theoretical importance concerns the nature of Figure 2. Figure 2 is a trend surface map, and it is based on output generated by the SYMAP computer program. A trend surface map is a theoretical or *predicted* surface based on a least squares criterion. In this case, city locations are defined by X and Y coordinates, and the predicted dates of incorporation are defined by the Z coordinate. SYMAP reduces the sums of the squares to a minimum by using any one of several polynomial functions that delimit trend surfaces within a three-dimensional (X, Y, Z) coordinate space.

The polynomial functions describe progressively more complex trend surfaces. The first-order polynomial function describing the trend surface is a linear equation in which the surface is a plane; the second-order polynomial function is a quadratic equation where the surface is a paraboloid; and the third-order polynomial function is a cubic equation, permitting two extreme points, a peak and a pit. SYMAP also maps

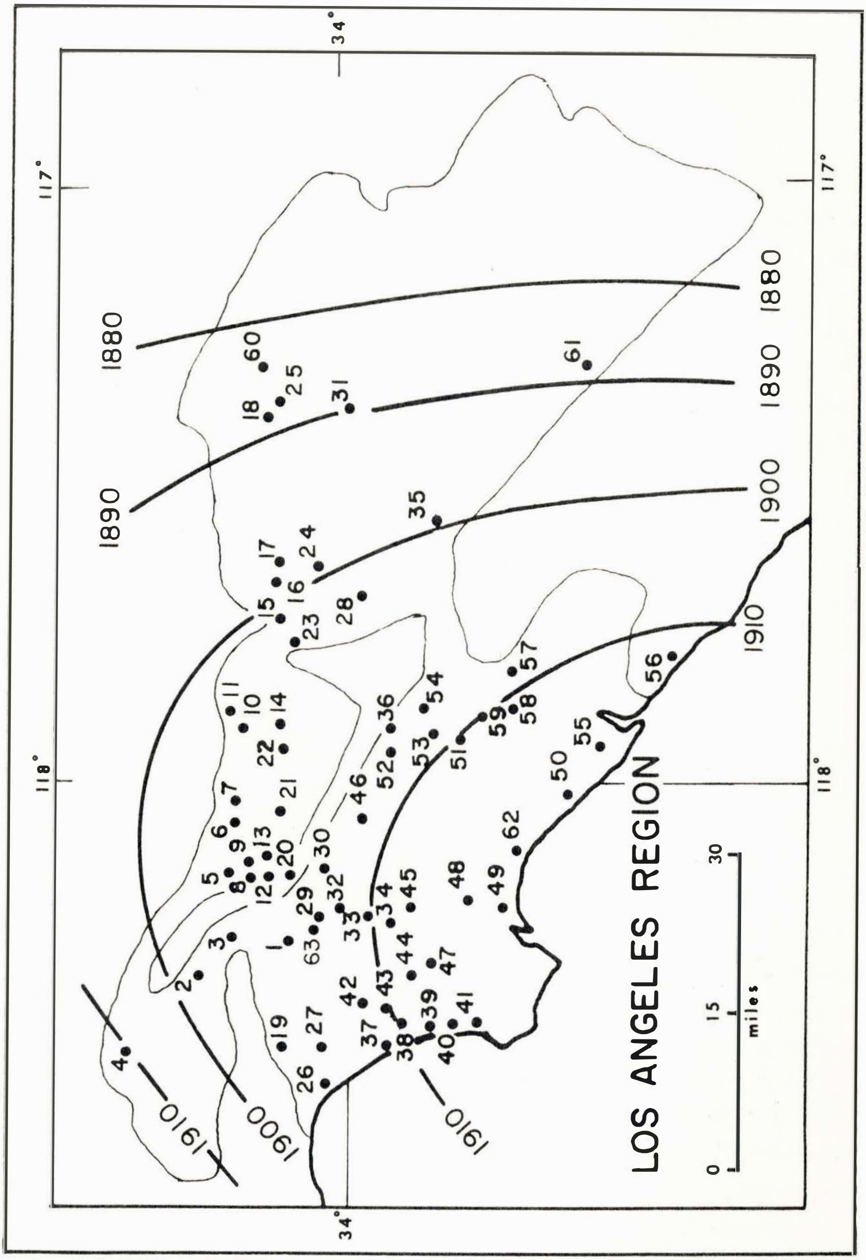

Figure 2. Trend surface map showing spread of settlement in the Los Angeles region (1850-1940). The numbers on the map correspond to the city names given in Table 1.

Table 1
City Names and Their Incorporation Dates

Map No.	Name	Date	Map No.	Name	Date
1	Los Angeles	1850	33	South Gate	1923
2	Burbank	1911	34	Lynwood	1921
3	Glendale	1906	35	Corona	1896
4	San Fernando	1911	36	Brea	1917
5	Pasadena	1886	37	El Segundo	1917
6	Arcadia	1903	38	Manhattan Beach	1912
7	Monrovia	1887	39	Hermosa Beach	1907
8	South Pasadena	1888	40	Redondo Beach	1892
9	San Marino	1913	41	Palos Verdes Est.	1939
10	Azusa	1898	42	Inglewood	1908
11	Glendora	1911	43	Hawthorne	1922
12	Alhambra	1903	44	Gardena	1930
13	San Gabriel	1913	45	Compton	1888
14	Covina	1901	46	Whittier	1898
15	La Verne	1906	47	Torrance	1921
16	Claremont	1907	48	Signal Hill	1924
17	Upland	1906	49	Long Beach	1897
18	Rialto	1911	50	Huntington Beach	1909
19	Beverly Hills	1914	51	Anaheim	1878
20	Monterey Park	1916	52	La Habra	1925
21	El Monte	1912	53	Fullerton	1904
22	West Covina	1923	54	Placentia	1926
23	Pomona	1888	55	Newport Beach	1906
24	Ontario	1891	56	Laguna Beach	1927
25	Colton	1887	57	Tustin	1927
26	Santa Monica	1886	58	Santa Ana	1886
27	Culver City	1917	59	Orange	1888
28	Chino	1910	60	San Bernardino	1869
29	Vernon	1905	61	Lake Elsinore	1888
30	Montebello	1920	62	Seal Beach	1915
31	Riverside	1883	63	Huntington Park	1906
32	Maywood	1924			

fourth-, fifth-, and sixth-order trend surfaces with additional points of inflection provided by more complex polynomial equations.[8]

The mathematical descriptions of the above trend surfaces constitute a statistical smoothing operation in which the sums of the squares are progressively reduced with higher-order surfaces. Hence, higher-order surfaces will be more accurate in their predictions and thereby reflect only local variations in Z-values. Conversely, lower-order trend surfaces are more generalized predictions; they are not complicated by local variations, and can thus be used in identifying trends over a larger area. Because Figure 2 is a low (second)-order trend surface, it is used as a basis for the student project described below.

Student Project

The student project proposed involves both an instructional and an activity phase.

Instructional Phase. The instructor must explain the purpose of the project as well as the utility and general nature of the trend surface map shown in Figure 2. In addition, the instructor must also clarify the importance of location factors in the early growth and incorporation of cities. In order to accomplish these tasks, the following scenario is recommended.

First, the instructor explains to the students that the objective of the geographic inquiry which they are about to pursue is two-fold: they will (a) learn about the importance of geographic location as a factor in the early growth and incorporation of cities, and (b) formulate hypotheses regarding the spread and timing of settlement in the Los Angeles region.[9]

The utility of Figure 2 is explained next. The instructor does this by pointing out that Figure 2 illustrates how settlement in the Los Angeles region spread from inland areas toward the coast over the nine decades between 1850 and 1940. The instructor continues by explaining some of the locational relationships within the region that may have influenced this settlement trend. For example, during the pre-1910 years this trend reflected the Los Angeles region's importance as a center for citrus production. Most of the cities that became incorporated were located inland from the Coastal Plain where soils, temperature regimes, and water supplies on the upper portions of alluvial fans were amenable to that type of agricultural activity. In contrast, during the 1910-1940 period most cities which incorporated were located along the southern part of the Coastal Plain, reflecting this area's expanding road and railroad networks, a local oil mining boom, and the growing commercial and industrial activity associated with improvement in the region's ocean trade.

Next, since the trend surface map is the primary basis on which students' hypotheses will be made, the instructor explains that the trend in settlement depicted in Figure 2 is rather general and that there are many exceptions to the trend. A common problem is that students incorrectly assume that cities located between given isochrones were actually incorporated during the time period the lines define; thus, their hypotheses prove to be untenable. The instructor avoids this problem by noting some examples of cities listed in Table 1 whose incorporation dates do not correspond with the settlement trend depicted on the map.

This is an auspicious time for the instructor to demonstrate further the utility of the trend surface map by beginning a discussion as to why certain cities were not incorporated according to the predicted trend. This may be done by asking a series of questions that are based on examination of Figure 2. For example, "Why were Los Angeles, Anaheim, and San Bernardino incorporated earlier than expected according to their locations on the trend surface map?", "Why were coastal cities such as Redondo Beach, Hermosa Beach, and Newport Beach incorporated before the predicted 1910-1940 period?", or "If both Pasadena and San Gabriel are located in the same geographic area (the San Gabriel Valley), why was Pasadena incorporated before the predicted 1900-1910 period and San

Gabriel after this period?" Discussion of possible answers to such questions will focus further attention on the roles that locational relationships have played in the evolving urban landscape of the region.

The instructor concludes this phase of the project by providing and discussing a list of cultural and environmental factors which can contribute to a city's location and population growth. Table 2 includes a list of such factors.

Activity Phase. There are four activities involved in this phase of the student project. The taxonomy of behavioral objectives developed by Bloom, *et al,*[10] is used in the following discussion to emphasize that these activities constitute a logical sequence toward higher levels of learning. The learning level objective for each activity is first defined; then a description is given as to how the objective is to be accomplished.

(1) *Knowledge.* Knowledge is defined as the remembering of previously learned material. By the end of the instructional phase, the students should know how to interpret the trend surface map. In order to make sure that this objective has been accomplished, the instructor gives the students a list of all the cities shown in Figure 2 and asks them to indicate whether or not each city was incorporated before, after, or according to the trend. Their answers can be checked quickly in class, and any misunderstandings about how to interpret the map can be rectified at this time.

(2) *Comprehension.* Comprehension is defined as the ability to grasp the meaning of material. The instructor assigns each student a city to research. Based on this research, the student identifies location factors, from a list such as the one included in Table 2, which contributed to the location and growth of the city prior to incorporation. In order to demonstrate that the student understands the roles of these location factors, he or she ranks each one according to its importance in determining the city's location and in influencing its early growth. (In order to avoid confusion about this activity, a simple subjective ranking is recommended, such as: A—Extremely Important;

Table 2
Tabulation Worksheet

Instructions. Rank the location factors as to their importance in the formation and growth of cities prior to their incorporation dates. Place one of the following letter symbols in each of the boxes in the chart:

A—Extremely Important
B—Highly Important
C—Important
D—Not Important

Location Factors	City Identification Number (See Table 1 for city name)				
Environmental Factors	2	6	7	34	46
1. Climate					
2. Water Supply					
3. Soils					
4. Topography					
5. Scenery					
6. Hot Springs					
7. Other					
Cultural, Economic, and Political Factors					
1. Religion					
2. Social Movement					
3. Language/Race					
4. Politics					
5. Land Ownership					
6. Resort/Recreation					
7. Railroad(s)					
8. Highway(s)					
9. Pack Trail(s)					
10. Sea Port					
11. Agricultural Processing					
12. Mining/Manufacturing					
13. Centrality*					
14. Other					

*The term *centrality* refers to the tendency for city growth because the city's retail and service functions benefit from its location with respect to other population centers.

B—Highly Important; C—Important; and, D—Not Important.) A short essay and/or oral report is assigned so that the student can explain his or her selection and ranking of location factors.

(3) *Analysis.* Analysis means separating the whole into its constituent parts with a view to its examination and interpretation. The student is first asked to refer to the trend surface map in order to determine if his or her city was settled according to the settlement trend. Based on this determination, the student must then re-examine each of the location factors of importance in the city's incorporation in order to explain why the city became incorporated in the year that it did.

(4) *Synthesis.* Synthesis refers to the ability to put parts together to form a new whole. The students must analyze a chart such as the one shown in Table 2, except that this chart will be filled in with all of the cities studied by the class, including all of the location factors and their ranking for each city. The students are asked to combine information from the chart and from what they have learned from previous activities so that they can draw inferences and formulate tentative hypotheses which answer the following questions:

(a) Why were certain cities incorporated earlier than the predicted trend?

(b) Why were certain cities incorporated according to the trend?

(c) Why were certain cities incorporated later than predicted?

Upon completion of the synthesis activity, the students will discuss with the instructor and the rest of the class why they believe that their hypotheses may or may not be valid.

Summary

This paper describes how a trend surface map can be used as an instructional and analytical tool to overcome difficulty in understanding complex locational relationships inherent in the development of the Los Angeles urban landscape. The trend surface map is used because it represents an average trend in settlement as it spread over the region.

The student project described above details how students are guided toward making deductions and formulating hypotheses about locational relationships which have influenced the timing of settlement in the Los Angeles region. In order to assure that this goal is attained, this project is structured according to behavioral objectives, each objective requiring a higher level of learning than previous ones.

The student project can serve as the basis for additional studies. Some examples include: (a) students can be assigned library research and field observation work in order to determine the validity of their hypotheses; (b) SYMAP can be used to generate a second-order residual map so that the degree to which urbanizing areas deviated from the settlement trend may be analyzed; and, (c) maps of other urban areas can be generated in order to make comparisons regarding the timing and spread of settlement in different regions of the country.

ACKNOWLEDGEMENTS

Thanks is due to my former student Steve Lech, currently a graduate student at the University of California at Riverside, for the generation of the trend surface map used in this paper. Professor Douglas Sherman of the University of Southern California Department of Geography was kind enough to read an earlier draft of this paper. I appreciate his insightful comments, but retain sole responsibility for any errors or omissions.

NOTES

1. David W. Lantis, et al., *California, Land of Contrast*, (Dubuque, Iowa: Kendall/Hunt Publishing Co., 3rd Ed., 1977), pp. 79-173.
2. Rodney Steiner, *Los Angeles, The Centrifugal City* (Dubuque Iowa: Kendall/Hunt Publishing Co., 1981).
3. Homer Aschmann, "Purpose in the Southern California Landscape," *Journal of Geography*, Vol. 66 (1967), pp. 311-317.

4. Robert M. Fogelson, *The Fragmented Metropolis—Los Angeles 1850-1930* (Cambridge, Mass: Harvard University Press, 1967).
5. For a background of city formation in Los Angeles County the reader should consult, Richard Bigger and J. Kitchen, *How the Cities Grew* (Los Angeles, Calif.: Haynes Foundation, 1952). A companion work, *Metropolitan Coast* (1958) treats Orange and San Diego counties.
6. Reyner Banham, *Los Angeles, the Architecture of Four Ecologies* (New York, New York: Penguin Press, Bantam, 1971).
7. A more extensive review of the geographical literature than the one presented in this paper is found in David W. Lantis, "Bicentennial Los Angeles: Comments on the Metropolis and Pertinent Literature," *The California Geographer*, Vol. XXI (1981), pp. 67-80.
8. *SYMAP User's Reference Manual* (Cambridge, Mass.: Laboratory of Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, 1979). Sources that discuss trend surface mapping in more detail than presented in this paper include: R. J. Chorley and P. Haggett, "Trend-Surface Mapping in Geographical Research," *Transactions and Papers of the Institute of British Geographers*, No. 37 (1965), pp. 47-67; John P. Cole and Cuchlaine A. M. King, *Quantitative Geography, Techniques and Theories in Geography* (New York, New York: John Wiley and Sons, Ltd., 1968), pp. 375-379; and, Mark S. Monmonier, *Computer Assisted Cartography, Principles and Prospects* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1982), pp. 52-55.
9. Students must understand the nature and purpose of the hypothesis before they can complete the synthesis phase of the project. Two recommended reading assignments are: L. Lloyd Haring and John F. Lounsbury, *Introduction to Scientific Geographic Research* (Dubuque, Iowa: Wm. C. Brown Company, 3rd Ed., 1983), pp. 11-22; and, Preston E. James, *All Possible Worlds: A History of Geographical Ideas* (New York, New York: The Odyssey Press, Bobbs-Merrill Company, Inc., 1972), pp. 471-474. A more advanced reading is, James L. Newman, "The Use of the Term 'Hypothesis' in Geography," *Annals, of the Association of American Geographers*, Vol. 63 (1973), pp. 22-27.
10. B. S. Bloom, ed., et al., *Taxonomy of Educational Objectives: Cognitive Domain* (New York, New York: David McKay Company, Inc., 1956).

ANNUAL MEETING, C.G.S
Anaheim, May 4-5, 1984

The initial annual meeting of the California Geographical Society (formerly the California Council for Geographic Education) was sponsored by the Cypress College Geography Department. The opening session at Anaheim's Conestoga Inn featured Jim Van Haun, Public Information Officer for the Municipal Water District of Orange County, who delivered an address entitled: "Water and Our Future." Awards presentations were handled by Joseph Leeper (CSU, Humboldt); and Peter C. C. Warren, a technical staff member of Rockwell Corporation's Space Transportation and Systems Group, concluded the luncheon-banquet by speaking on the topic: "Navstar (Global Position System)."

PRESENTATIONS

Thomas D. Best, Covina Travel Center, **Nostal Geography Again.**

Karen Collins, San Diego State University, **Consideration of the Medfly.**

Richard A. Eigenheer, Sacramento City Schools, **Geographic Skills for Tourism Industry Employees.**

Lois Gershenson, San Francisco State University, **Geographical Aspects of Insect Trapping by the Department of Agriculture.**

Myron Gershenson, San Mateo College, **Ships in the Night: The Yale and the Harvard**, and **The Remembered Past.**

R. F. Hough, San Francisco State University, **The Dunkards of Modesto: Traditional Values in a Modern World.**

David Lantis, California State University, Chico, **Seven Realities of New England.**

Richard MacKinnon, Allan Hancock College, and Ladd Johnson, California State University, Chico, **Teaching World Place Locations.**

Clement Padick, California State University, Los Angeles, **Update on Satellite Imagery of California.**

Richard Raskoff, Los Angeles Valley College, **Five Years of Environmental Stress in Southern California.**

William Selby, Santa Monica College, **Characteristics and Impacts of Summer Thunderstorms and Downpours: White Mountains of California and Nevada.**

Carolyn Sheehan, San Diego State University, **The Distribution of Dioecism in Islands.**

Adolf Stone, California State University, Long Beach, **The Volkswagen: A Modern Phoenix.**

Mark Williams and Barbara Fredrich, San Diego State University, **Cocciodomycosis in the Borderlands: Problems in Spatial-Environmental Analysis.**

SPECIAL SESSION

Christopher Salter, University of California, Los Angeles, (Chairperson), **Updating the Geography Curriculum in the High School.**