The California Geographer

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Migrants between California and Other States

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Abstract

Using the U.S. Census Bureau's County-to-County Migration File and Public Use Microdata Sample File, we investigated California's interstate migrants between 1995 and 2000. After mapping and discussing the spatial patterns of migrants' origin and destination counties, we calculated percentages of college graduates and detailed industries of employment for Non-Hispanic White, Latino, Black, and Asian migrants. To examine migrants' social and economic fit at their destinations, we compared them to longer-term residents of both California and other leading destinations. In all cases inmigrants to California had higher percentages of college graduates than did their ethnic group in origin states, and in nearly all cases inmigrants raised the percentage of college graduates of their ethnic group in California. Migrants from California worked in destination-state industries at similar or slightly lower rates than non-migrant residents, but migrants to California were better represented in higher-status industries than longer-resident Californians.

Introduction

PEOPLE WHO MOVE into and out of a state can change its population characteristics. However, the role of migration in a state's changing population and economic characteristics is not usually known because most population and economic research measures only the net change in characteristics of the entire population from one census to the next. In contrast, our research investigated directly the characteristics of people who move within the United States, often referred to as internal or domestic migrants to distinguish them from international migrants. We looked specifically at the largest migration flows that connect California with other states and their counties.

Whereas most migration research has treated all migrants as a single group or divided them into certain age groups, our research specifically probes for possible differences among migrants in the four most commonly used ethnic categories: Non-Hispanic Whites, Latinos, Blacks, and Asians.

Also, because we studied only migrants moving within the U.S., we refer to our subjects as "inmigrants" and "outmigrants," following common demographic practice. This should clearly differentiate them from people migrating between countries, usually called "immigrants" or "emigrants" depending on whether they were moving into or out of a specified country.

California has long been a popular destination for migrants from other states. It had very high rates of net inmigration from other states during the 1930s and 1950s, and net inmigration continued at lower rates during the 1960s, 1970s, and 1980s (Long 1988, 78–82; U.S. Census Bureau 1995). In the 1980s California was apparently losing some of its appeal for Americans, including many who had lived in the state for a long time, and in the 1990s California had net domestic outmigration for the first time since migration was measured over a five-year period at the end of decades. Between 1995 and 2000, 1.4 million people migrated from other states to California, whereas 2.2 million left California for other states (U.S. Census Bureau 2003e). Despite this general net outmigration, California remained a magnet for the young, single, and college educated, whose rate of net migration into the state was exceeded only by six other states (U.S. Census Bureau 2003f).

Migrants from other countries have also liked California. With increasing immigration to the United States over the past forty years, the state has become the primary state of residence for immigrants and now is the leading state in percent foreign-born (26 percent). From 1995 to 2000, a total of 1.4 million people moved to California from abroad, equivalent to the numbers arriving from other states (U.S. Census Bureau 2003e).

In general, the last half of the '90s—the years of our analysis—was a period of growing employment and prosperity in California. These years contrasted with the first half of the decade when Los Angeles County suffered a severe recession due to employment losses in defense industries compounded by riot and a major earthquake. In 2001 the "dot-com bust," focused on Silicon Valley and the San Francisco Bay Area, hit the state hard but occurred too late to have any effect on Census 2000 and the migration flows we measured.

Why did the state experience net out-migration during the prosperous late '90s? This question has not been satisfactorily answered. In earlier decades, Americans have indicated that some aspect of employment was their most important reason for moving between states (Long 1988, 235). Similarly, during the late '90s, annual Current Population Surveys showed that work-related reasons still accounted for a third of the expressed primary reasons for people moving between counties, with family-related and housing-related reasons also of major importance (U.S. Census Bureau 2001, 4). Because the Current Population Survey analyzes only the single most important expressed motivation for migration between counties, it misses secondary motivations that could be important as well as possibly different motivations of interstate migrants, who move longer distances, and possibly different motivations such as the desire for lower home prices on the part of people in high-growth metropolitan areas such as those in California.

For many of us who live in densely populated southern California, the large net outmigration suggests a reaction to negative aspects of the state's prosperity, such as its growing congestion and high housing prices. Some people who left California may have also been reacting to the growing numbers of Latinos, Asians, or other immigrants, observing cultural and economic changes in their local areas. Research using 1985–1990 data attempted indirectly to determine outmigrant motivations. One nationwide study found that patterns of net internal migration of the U.S.-born for metropolitan areas were more a function of the size of the local labor force than of foreign-born net migration (Wright, Ellis, and Reibel 1997). This seemed to indicate that employment concerns rather than anti-immigrant attitudes lay behind migration decisions of the U.S.-born. However, in another analysis of state-level outmigrant flows in which individual migrant characteristics were controlled, non-Hispanic White men were found to have left California between 1985 and 1990 at almost twice the rate of foreign-born men with similar characteristics (Kritz and Gurak 2001, 141–142). This finding, unexpected and the opposite of the situation in almost every other state, seemed to suggest that many White men moved out of California more in reaction to the immigrants than to the economy. Thus, these contradictory research findings from the earlier decade shed little light on the motivations of California's outmigrants.

In contrast, analysis of Census 2000 data suggests that much migration into and out of California was prompted by a labor surplus among less-educated Californians but continued employment demand for college graduates (Frey and Liaw 2005, 226–227). Net outmigration rates were highest for people who were not high school graduates, but graduates of four-year colleges did show a small net inmigration. This large net outmigration of less-educated Californians characterized both Whites and Latinos and was perhaps exacerbated by their observation that many other Californians were doing much better economically, a reflection of the state's increasing income inequality (Reed 1999). That trend of a growing income gap, much more evident in California than in other states, resulted from both economic restructuring and the increasing supply of less-educated immigrants working at low wages. Nevertheless, a problem with all these explanations is that they did not treat high home prices, congestion, or environmental problems as possible factors in outmigrant decisions.

Although many readers may imagine that geographers and social scientists could understand something as apparently simple as the reasons why people migrate within the United States, this introduction has demonstrated clear weaknesses in the Current Population Survey data on migrant motivations and the difficulties in determining migrant motivations from aggregate data analysis. Our study, however, is very different. In it we used U.S. Census data in ways in which the data are particularly strong—to describe flow patterns and selected migrant characteristics in more detail than has been done before.

Research Questions and Methodology

This research has two goals. First, we wanted to determine the county origins of people who moved to California from other states between 1995 and 2000 and the county destinations of Californians who moved to other states during this period. Understanding these patterns can illuminate the impact of Californians on other places and the people connections between other places and California. Second, we wanted to see how migrants into and out of California differed from non-migrants in key characteristics related to the economy. For this purpose we measured two variables: the percentage of adults ages 25 and older with bachelor's degrees, and the detailed industry of employment for people age 16 and older. Those variables were selected because we wished to know how migrants fit into the economies of California and the various destination states. Our questions echo to some extent those of other scholars who asked, "What are the socioeconomic characteristics of the native inmigrants to Los Angeles (and New York) and how do they mesh with immigrants and residents of the city in the region's labor market" (Wright, Ellis, and Reibel 1997, 252).

We did not examine older migrants specifically because in another analysis we found that in the largest retirement migrations into or out of California between 1995 and 2000—Whites moving to Nevada and Arizona—Whites ages 60 to 80 constituted only 13 and 14 percent of the migrants (U.S. Census Bureau 2003g).

Migrants were identified by means of the Census 2000 question that asked a 16-percent sample of the U.S. population where they lived five years earlier. Special state-to-state and county-to-county migration tables from the Census Bureau made it possible to determine migrant origins and destinations (U.S. Census Bureau 2003a, 2003e). After examining migration patterns with these data, we used the 5-percent Public-Use Microdata Sample (PUMS) file to measure the educational attainment and industry of employment variables (U.S. Census Bureau 2003g). Our research is one of several projects that have used these or similar sources to investigate aspects of migration, in some cases especially for California (Frey 2002, 2005; Frey and Liaw 2005; U.S. Census Bureau 2003b–d, f; Johnson 2000; California Department of Finance 2007).

Whites (Non-Hispanic), Blacks, Asians, and Latinos (or Hispanics) may differ substantially in their perceptions of the desirability of various state destinations and in the social networks that direct people toward specific employment opportunities (Hardwick 2003). Although analyses of migration flows have traditionally not distinguished various ethnic groups, recent research on interstate migration indicates that groups do differ substantially in their migration patterns (Frey and Liaw 2005). For this reason our analyses cover each of these four leading ethnic groups. If the groups weren't analyzed separately, the state destinations and characteristics of Whites would dominate and obscure distinctive features of the other three groups. This is because Non-Hispanic Whites constituted 59 percent of all domestic migrants leaving California and 69 percent of all domestic migrants to the state from 1995 to 2000 (U.S. Census Bureau 2003e).

In addition, it seemed possible that the characteristics of migrants leaving California could differ according to their state of destination. Likewise, the characteristics of migrants to California might vary by their state of origin. To explore this possibility, we analyzed characteristics by leading states of origin and destination rather than for all domestic migrants to and from the state, as most other research has done.

Although the data are several years out of date, the spatial patterns and characteristics of migrants tend to change slowly. The basic continuity of migrant flow sizes during the 2000–2004 period compared to 1995–2000 was demonstrated for major metropolitan areas by Frey (2005, 9). Similarly, maps of county net migrations based on Internal Revenue Service data on address changes between 2004 and 2005 show a pattern very much like those of our maps (Smith and Poindexter 2007). All this means that our findings should be applicable in large part to migrants during the present decade.

The Larger Demographic Context

The context of this study is indicated in a table showing the role of net domestic outmigration as a component of demographic change for each group from 1995 to 2000 (Table 1). An advantage of examining migration flows with Census 2000 data, as opposed to annual intercensal estimates, is that internal migration was measured directly rather than estimated as a residual when natural increase is subtracted from estimated total population change. Although international migration flows could only be estimated because of insufficient data, we are reasonably confident of the other figures because they are based on U.S. census data, the state's records of births and deaths, and its estimates of annual total population change.

All four groups showed net domestic outmigration during the last half of the 1990s. Group differences in relative sizes of in- and out-domestic flows are evident. Latino migrants leaving California outnumbered three to one those moving in from other states, but most non-Latinos were probably unaware of this net domestic outmigration of Latinos because it seemed hidden behind the larger net immigration from abroad, particularly Mexico. Immigration from Mexico to California would have been greater if news of the increase in housing prices in relation to wages hadn't reached Mexico, resulting in immigrants choosing to move to less-populous localities, particularly in the South and Midwest, where they hoped to be better off (Light 2006, 129–157). The other groups were more balanced in that their domestic inmigrations were at least 60 percent of outmigration. Although we recall the media's emphasis during the '90s on people who were leaving California, we should realize that over a million Whites moved in from other states—a flow that was 70 percent of the outmigration.

Many people seem to attribute Latino population growth to immigration because of the publicity concerning immigrants, but the evidence makes clear that the larger source of Latino growth was natural increase. Of the total Latino increase of 1.7 million, two-thirds was due to the excess of Latino births over Latino deaths. This fact should caution researchers that data on immigrants may miss the larger part of Latino population growth. On the other hand, the declining White population resulted from the large net outmigrations, both domestic and international, that were hardly offset at all by natural increase.

Table 1. Components of Population Change for California, 1995–2000 (in 000s)

		Domestic Migration			International Migration	
	Natural Increase	Inmigrants to CA	Outmigrants from CA	Net to CA (+/-)	Net to CA (+/-)	Total Pop. Change 1995–2000
Whites	81	1,004	1,303	-299	-216	-434
Latinos	1,123	160	506	-346	899	1,676
Blacks	92	99	162	-63	102	131
Asians	218	127	152	-24	540	734

Source for domestic migration: U.S. Census Bureau 2003c or 2003e. Numbers exclude persons under five years of age. Source for natural increase and population change: California Department of Finance 2005. We estimated net international migration as the residual from the other, better-known components of population change. White, Black, and Asian numbers do not include members of those groups who are also Latino or Hispanic. Census migration figures for Whites, Blacks, and Asians include only people reporting a single race in Census 2000.

Migrant Origins and Destinations

County-level patterns. Although most of our analysis occurred at the state level, we believe that county-level maps can be especially illuminating as to both specific places and types of places that are important migrant origins and destinations within other states. Accordingly, we first map destinations of recent migrants from California to emphasize those counties in which migrants from California had larger proportions in local populations (Figure 1). The importance of nearby states as destinations is evident, but even clearer is the migrants' preference for counties adjacent to California.

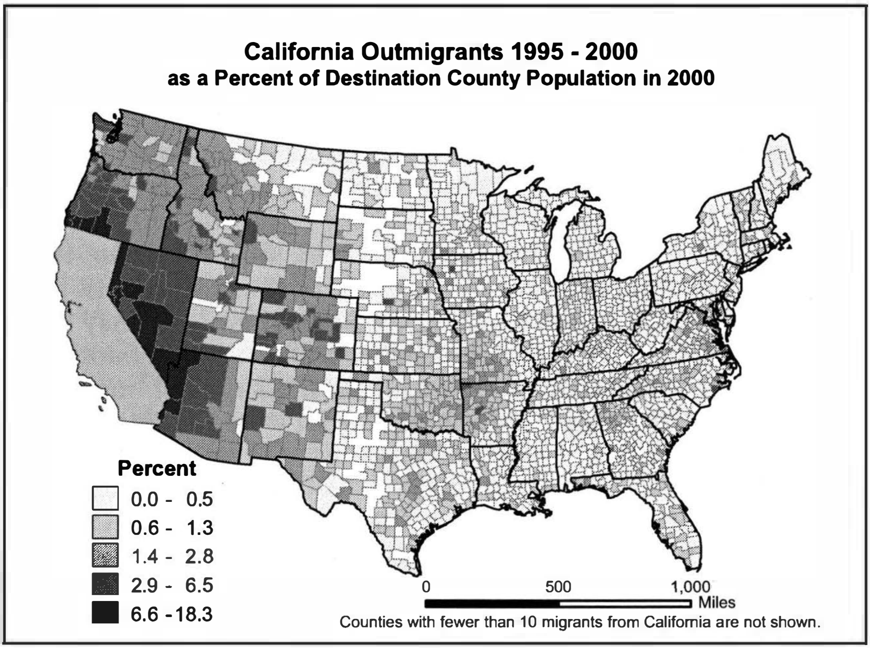

Figure 1.—California outmigrants 1995–2000, as a percent of destination county population in 2000. (Data source: U.S. Census Bureau 2003a)

Because most of these flows into counties close to California have been occurring for two or three decades or longer, Californians have probably played the major role in populating these counties.

Although this map suggests that migrants have been attempting to minimize the distance they must move to live in another state, we believe their motivation is less to reduce the migration distance than to access certain amenities that happen to be found in counties nearest to California.

To illustrate, Arizona's Mohave County contains the fast-growing towns of Lake Havasu, Kingman, and Bullhead City, the latter located right across the Colorado River from the casinos in Laughlin, Nevada. In Nevada, California migrants have had a large demographic impact on small desert towns as well as the large cities of Las Vegas and Reno. Those who moved to Oregon were particularly evident in southern Oregon, in places like Grants Pass, Medford, and Klamath Falls. Of course, some people went farther afield, often to less-populous counties with scenic amenities such as the Tetons in northwest Wyoming and the western side of the Rockies in Colorado.

To complement Figure 1, we also show destinations by the absolute numbers of migrants (Figure 2). The map indicates the names of some of the main cities within the clusters of counties that comprise metropolitan areas, but unlabeled clusters of outmigrant destinations also represent metropolitan areas. Figure 2 is important because too much attention to the pattern of Figure 1 could mistakenly convey the impression that migrants from California settled primarily outside metropolitan areas.

Migrants who moved to California represented the largest proportions of the origin counties in the same locations to which outmigrants were drawn—the counties adjacent to California (Figure 3). The fact that Figure 3 is almost a mirror image of Figure 1 illustrates the widely observed generalization that rates of inmigration and outmigration tend to be positively correlated (Long 1988, 75; Morrison and Wheeler 1978). This is surprising to many people, perhaps because most of us tend to think in terms of net migration and do not realize the large movements into and out of places that sometimes result in little net migration. We suspect that many of the people who left the western part of Arizona, for example, had arrived there from California a few years earlier. The impor-

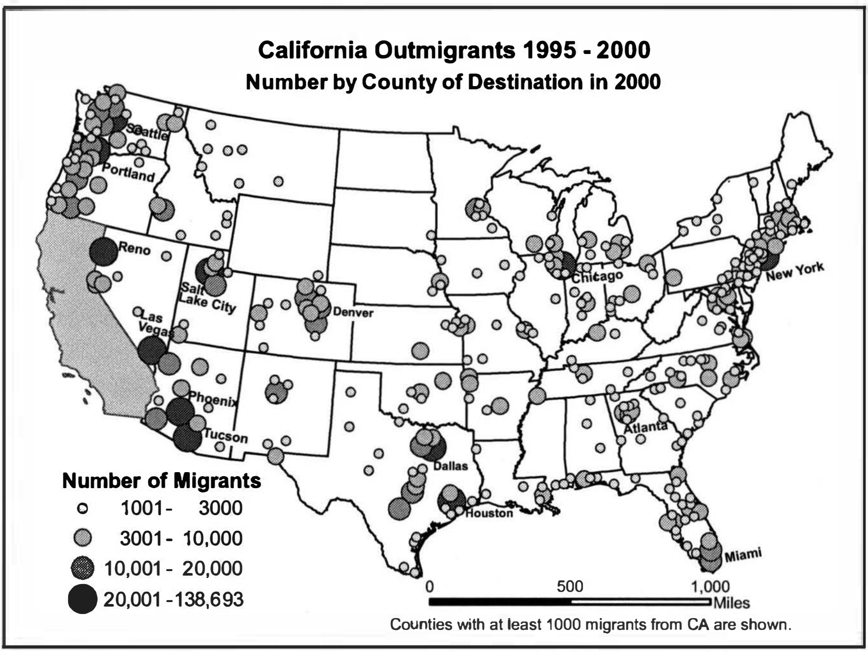

Figure 2.—California outmigrants 1995–2000, number by county of destination in 2000. (Data source: U.S. Census Bureau 2003a)

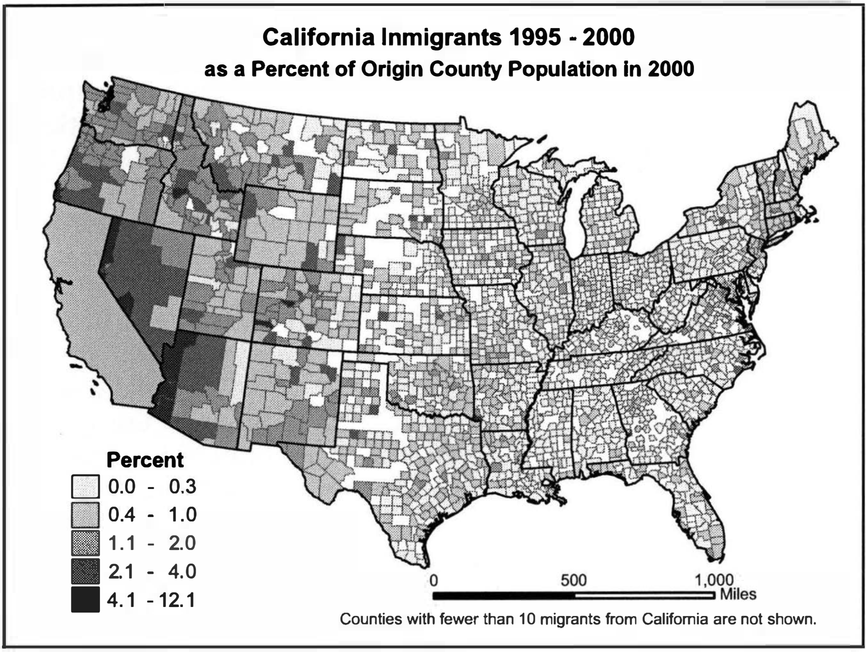

Figure 3.—California inmigrants 1995–2000, as a percent of origin county population in 2000. (Data source: U.S. Census Bureau 2003a)

tance of metropolitan sources for migrants to California is evident (Figure 4), with a pattern that is similar to that of outmigrant destinations (Figure 2). However, the difference between the two maps is clear in the final map, which shows the direction and size of net migration (Figure 5).

The pattern of net migration from California to other parts of the West reflects in large part a long-term flow in which many individuals and families that arrived in California decades ago decided later to leave for other states. On the other hand, most counties with net migration to California were older manufacturing centers, no longer as prosperous as they once were. In addition to places that are named, there was net migration to California from Boston, Baltimore, Pittsburgh, Rochester, Detroit, St. Louis, Cincinnati, and similar places. Perhaps residents of these areas, with their harsher winters, found the California climate particularly attractive, but it seems to us more likely that the status of the economy in these different counties compared to California was probably more important in explaining the larger net inmigration flows to California. During the late '90s, the net flows out of greater New York City and Chicago were particularly large, and later in this report we document the

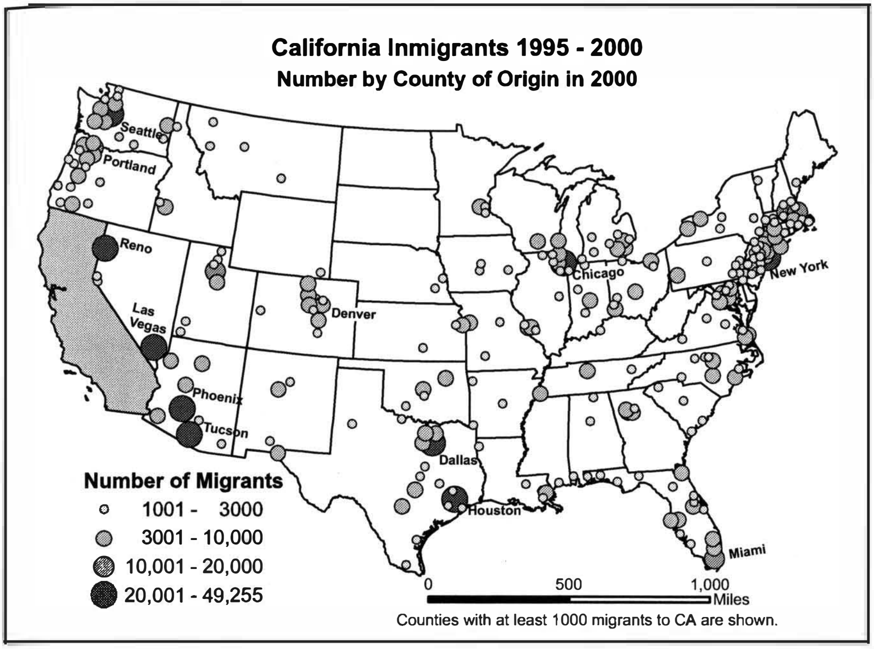

Figure 4.—California inmigrants 1995–2000, number by county of origin in 2000. (Data source: U.S. Census Bureau 2003a)

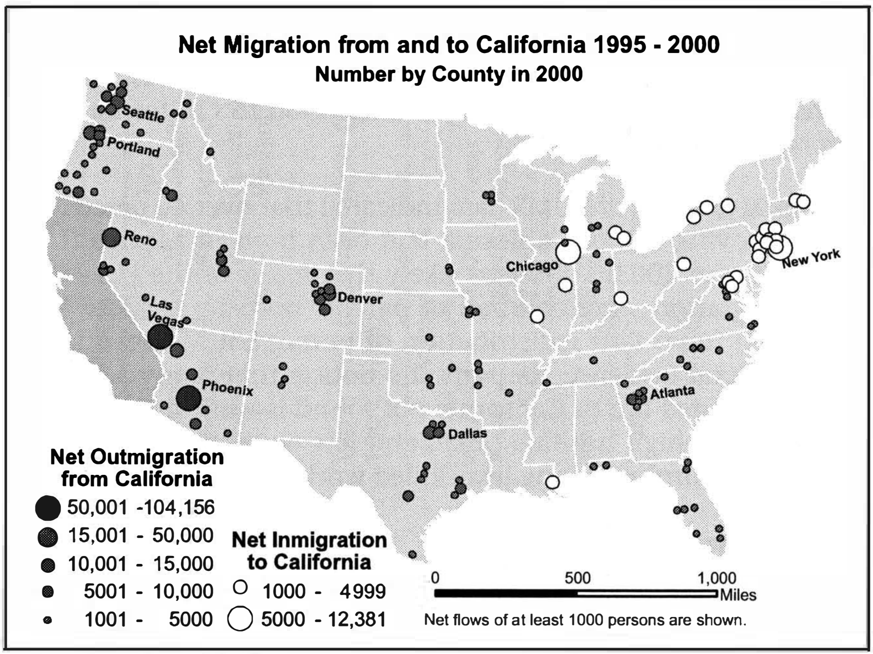

Figure 5.—Net migration from and to California 1995–2000, number by county in 2000. (Data source: U.S. Census Bureau 2003a)

exceptionally high percentage of college graduates among White and Asian migrants to California from New York and Illinois.

State-level patterns. For each ethnic group, the five leading origin and destination states accounted for between 30 and 47 percent of all migrants from and to California. A few states were leading origins or destinations for all groups (Tables 2A and 2B). For those departing California, Nevada was among the top three destinations and Texas among the top five, but among migrants to California, only Texas was a leading state of origin for all groups. New York, Illinois, and Washington were leading origin states for three of the groups.

There were significant ethnic group variations in origin and destination states. For example, Whites and Latinos found Arizona particularly attractive, but for Blacks, Georgia and Florida were more important destinations. Oregon was an important destination only for Whites, a continuation of the pattern of the 1970s, when Californians moving to Oregon and Washington represented two of the five largest state-to-state flows in the country (Long 1988, 108). Many of the leading states of origin are also on the list of leading destination states, a result consistent with previous research (Long 1988, 75) as well as our finding from maps that the numbers of inmigrants and outmigrants at the county level correlate positively. Although net migration from California characterized all groups, for Asians the total in- and outflows did not differ greatly (Table 1). Thus, it is not surprising that Asians showed net inmigration to California from both New York and Hawaii.

Additional analysis of PUMS data indicated that over 40 percent of Latinos moving out of California had been born in Mexico (U.S. Census Bureau 2003g). It seems likely that many of the U.S.-born in this migration were children of parents born in Mexico. This suggests an important redistribution of immigrant Mexican families. Anecdotal evidence supports the notion that many Mexican immigrants tried life in California but found it wanting, probably because of the high housing prices and low wages resulting partly from a labor surplus among less-skilled workers.

Educational Attainment

The level and quality of a person's education are strong influences on his or her employment and income. Accordingly, we measured the educational attainment of migrants compared to non-migrants. Today, the most widely used census indicator of educational attain-

Table 2A. Leading State Destinations and Numbers of Migrants from California, 1995–2000

Whites		Latinos		Blacks		Asians	
Arizona	109,232	Texas	62,802	Texas	17,590	Nevada	12,890
Nevada	105,130	Nevada	60,543	Georgia	14,060	Texas	12,386
Washington	102,089	Arizona	59,670	Nevada	13,704	Washington	12,141
Oregon	98,102	Colorado	29,898	Florida	8,371	New York	8,559
Texas	85,287	Washington	26,611	Virginia	8,051	Minnesota	6,994

Table 2B. Leading State Origins and Numbers of Migrants to California, 1995–2000

Whites		Latinos		Blacks		Asians	
Washington	68,620	Texas	25,826	Texas	9,181	New York	13,714
Texas	66,095	Arizona	17,083	New York	6,743	Texas	11,207
New York	62,372	Washington	11,021	Illinois	5,913	Hawaii	10,545
Oregon	53,362	Florida	10,003	Louisiana	5,529	Illinois	8,635
Illinois	49,071	Nevada	9,641	Georgia	5,254	Washington	7,184

Source: U.S. Census Bureau 2003

ment is the percent of all adults (age 25 and older) who are college graduates. The small net inmigration of college graduates and the large net outmigration of those with less education suggest that Americans with higher levels of education were generally finding opportunities in California while those with lower levels of formal education were leaving, presumably in response to the lower wages of California than they expected to find in other states (Frey and Liaw 2005, 226).

Our analysis of educational attainment compared in- and outmigrants with both California and the leading origin and destination states. Several patterns were clearly demonstrated. We first examined migrants who left California (Table 3A). Migrants in all four ethnic groups who moved to Nevada were less educated than members of the same group who remained in California. To illustrate, 33.5 percent of White adults in California and 15.7 percent of Black Californian adults were college graduates, but only 21.3 percent of White migrants to Nevada and 11.5 percent of Black migrants to Nevada had bachelor's degrees. In contrast, the Asian migration to New York was highly selective of the more educated, with two-thirds of Asian adult migrants having at least a BA degree. Minnesota was just the opposite. Additional analysis of the PUMS file indicates that most Asian migrants to Minnesota were ethnic Hmong, who have generally had low educational attainment since their initial arrival as refugees from Laos and Thailand.

California outmigrants in all groups except Latinos had higher levels of education than did residents of destination states. Thus, migrating Californians tend to improve the educational attainment of the states to which they move. For instance, Blacks who migrated from California were much better educated than either those who remained in California or those who were already living in those southern states. Such migrants may well have been able to take some of the better employment positions in the South. In the same way, White migrants to Texas, Washington, and Oregon improved the educational level of those states.

Movers to California shared the same tendency to be more educated than residents of the states they came from, and this selectivity was found for all groups in all leading states (Table 3B). Many of the migrations were highly selective, more so than with the outmigrants. To illustrate, Whites from New York and Illinois represented about twice the percentage of college graduates of those remaining behind,

Table 3A. Education of Californians, Outmigrants, and Residents of Destination States

Group	Percent College Grads of CA Non-migrant Residents	Percent College Graduates of Migrants from California and Destination State Residents				
Whites	33.5	Nevada	Texas	Arizona	Washington	Oregon
California outmigrants		21.3	37.4	27.8	37.4	29.2
Residents of destination state		19.0	31.2	27.2	27.6	23.0
Latinos	7.9	Nevada	Texas	Arizona	Washington	Colorado
California outmigrants		3.4	8.4	6.9	6.9	9.3
Residents of destination state		6.0	9.5	8.3	8.7	10.2
Blacks	15.7	Nevada	Texas	Georgia	Florida	Virginia
California outmigrants		11.5	18.7	24.3	27.5	27.3
Residents of destination state		10.2	14.3	14.6	10.8	13.9
Asians	42.3	Nevada	Texas	New York	Washington	Minnesota
California outmigrants		25.6	46.5	66.4	48.6	30.7
Residents of destination state		23.5	45.8	41.3	34.3	30.1

Note: In Tables 3 and 4, the percentages describing Californians in 2000 include only these people living in California in both 1995 and 2000, and the percentages describing residents of other states in 2000 includes only those who were resident in both 1995 and 2000.

Table 3B. Education of Migrants to California and Residents of Origin States

Group	Percent College Grads of CA Non-migrant Residents	Percent College Graduates of Migrants to California and Residents of Origin States				
Whites	33.5	Texas	New York	Washington	Oregon	Illinois
California inmigrants		51.3	66.6	37.8	35.1	62.6
Residents of origin state		31.2	34.4	27.6	23.7	23.7
Latinos	7.9	Texas	Arizona	Washington	Florida	Nevada
California inmigrants		16.6	14.9	11.8	24.9	6.7
Residents of origin state		9.5	8.3	8.7	17.3	6.0
Blacks	15.7	Texas	New York	Georgia	Louisiana	Illinois
California inmigrants		24.2	40.3	35.8	24.2	21.3
Residents of origin state		14.3	15.5	14.6	10.5	14.4
Asians	42.3	Texas	New York	Washington	Hawaii	Illinois
California inmigrants		62.8	68.9	52.6	40.4	77.3
Residents of origin state		45.8	41.3	34.2	25.4	56.8

as did Blacks from New York, Georgia, and Louisiana. In contrast to the low educational attainment of Latino outmigrants from California, Latinos moving to California were better educated than those remaining in their origin states. Moreover, in all cases except Latinos moving from Nevada and Asians moving from Hawaii, the inmigrants from each of the leading states represented an improvement of the educational attainment of Californians.

These findings document the fact that migrants tend to be selective of the better educated in each group, regardless of the direction of migration—a finding observed nationally in earlier decades (Long 1988, 43). Latinos leaving California were the only exception. Although the numbers of people moving into California were smaller than those leaving the state, the educational selectivity among inmigrants was often particularly strong. For multiethnic California, the college graduates in each ethnic group are the people we should be retaining in the state and recruiting from elsewhere.

Industry of Employment

To what extent do the employment characteristics of migrants from California mirror those of the total work force in the destination states? Industry seemed an appropriate measure of employment structure, permitting us to see, for example, whether newcomers are more likely to work in the restaurant business or less likely to work in construction jobs than long-time residents. The destination states differ in their industrial composition, but for people moving to California, we provide a list of the state's leading industries as a context for understanding the industries in which migrants worked. Californians who resided in the state in both 1995 and 2000 were most likely to work in the following four industries, listed in descending order by numbers employed: (1) construction; (2) restaurants and other food services; (3) schools, elementary and secondary; and (4) hospitals. The next leading industries, also listed in descending order, did not differ greatly in total employment: (5) colleges, including junior colleges and universities; (6) grocery stores; (7) real estate; (8) justice, public order, and safety activities; (9) department stores; and (10) electronic components and products manufacturing. Because of the complexity of the data, we present only the leading industries for the three largest destination and origin states for each group.

Migrants who left California were represented in various industries in slightly lower proportions than the residents of the destination

Table 4A. Percent of Employed Persons in Leading Industries: Migrants from California and Residents of Destination States

White Employment

Nevada			Arizona			Washington		
Industry	Mig.	Resid.	Industry	Mig.	Resid.	Industry	Mig.	Resid.
Construction	9.4	9.7	Construction	7.3	8.0	Construction	6.0	8.2
Other recreat.	8.0	10.0	Restaurant	5.2	5.7	Restaurant	4.3	5.8
Travel. accom.	5.4	6.7	School	3.7	5.1	U.S. Navy	3.4	<1.1
Restaurant	4.1	4.9	Hospital	2.8	3.1	School	3.4	4.5
Retail grocery	2.9	2.3	Other recreat.	2.7	1.6	Hospital	3.2	2.7

Latino Employment

Nevada			Texas			Arizona		
Industry	Mig.	Resid.	Industry	Mig.	Resid.	Industry	Mig.	Resid.
Construction	16.3	16.8	Construction	14.9	12.5	Construction	11.6	12.9
Travel. accom.	13.0	13.3	Restaurant	10.1	9.1	Restaurant	10.1	8.8
Other recreat.	12.6	13.9	Retail grocery	2.5	2.7	Travel. accom.	3.3	2.6
Restaurant	8.8	9.4	Dept. store	2.1	2.6	School	2.5	3.7
Dept. store	2.6	<1.5	School	2.1	4.8	Bldg. services	2.4	2.2

Continued

Table 4A continued. Percent of Employed Persons in Leading Industries: Migrants from California and Residents of Destination States

Black Employment

Nevada			Texas			Georgia		
Industry	Mig.	Resid.	Industry	Mig.	Resid.	Industry	Mig.	Resid.
Travel. accom.	10.1	14.2	Restaurant	7.4	7.0	Restaurant	5.2	8.0
Other recreat.	8.2	13.6	Army	3.8	<1.5	Hospital	3.4	3.9
Construction	4.3	5.6	Justice/Safety	3.6	2.3	Retail grocery	3.3	2.6
Restaurant	4.1	5.0	Hospital	3.5	5.3	Insurance	3.0	<1.5
Empl. services	3.9	1.8	School	2.8	5.2	Construction	2.8	5.3

Asian Employment

Nevada			Texas			Washington		
Industry	Mig.	Resid.	Industry	Mig.	Resid.	Industry	Mig.	Resid.
Other recreat.	15.3	25.5	Restaurant	5.0	7.8	Restaurant	6.7	9.4
Travel. accom.	13.3	24.3	Hospital	4.9	6.4	College/univ.	5.6	4.0
Restaurant	6.7	7.3	College/univ.	4.8	3.9	Hospital	4.0	3.4
Hospital	5.1	3.4	Electr. manuf.	3.4	4.1	Navy	3.2	<1.2
Construction	2.0	<1.6	Nail salon	3.3	2.5	Electr. manuf.	2.9	2.2

Notes: The PUMS data provides employment figures for these detailed industry categories, which differ somewhat from those in the Summary Files of census data. The following are more complete descriptions where abbreviated labels may not be clear. "School" refers to elementary and secondary schools. "Other recreation" includes gambling casinos and amusement parks. "Travel. accom." refers to employment in motels and hotels; "Electr. manuf." refers to electronic component and product manufacturing. "Artists, sports" includes independent artists and people in the performing arts and spectator sports. "Computer systs." refers to computer systems design. "Recreation" refers to other amusement, gambling, and recreational industries than bowling centers. In Table 4B "Resid" refers to California residents.

states (Table 4A). This is expected because it is a reflection of the difficulties of adjusting to work in a new place. This suggests that migrants from California are not at a major disadvantage in becoming employed in key industries in their destination states. In a few cases, however, migrants were working in certain industries at a much lower rate than all residents. The disparity is greatest among Black and Asian migrants to Nevada in the traveler accommodation and other recreation (gaming) industries, perhaps because people who had lived longer in Nevada already had many of these jobs as well as the wider social networks that would enable them to obtain employment more easily in those industries.

Key exceptions to the general pattern of lower representation in industries by migrants compared to the longer-resident population are migrants in the armed forces. This is illustrated by Black migrants in the Army who moved to Texas, and Asian migrants to Washington who were in the Navy. Similarly, Asians migrants were employed in colleges and universities at a higher rate than all Asians. Such exceptions may relate to characteristically high rates of migration among military personnel and the nationwide labor markets for university professors and administrators.

Nevertheless, the fact that California migrants were found in industries in not very different proportions from the residents of the destination states suggests that migrants do not end up working in certain industries that older residents have avoided. This point is illustrated in the case of Latinos in the animal slaughter industry of Colorado. The 330 California migrants working in that industry and the 2,690 state residents so employed each constituted 1.7 percent of their employed Latino populations (U.S. Census Bureau 2003g). In that case, being a migrant from California seems to have had no effect in propensity to be employed in that difficult industry.

As for those who moved to California, migrants were found in eight of the ten leading industries in the state; but real estate and justice, public order, and safety activities were not among the five leading industries for any ethnic group of inmigrants. However, those whose work required special talent or training were usually represented in slightly higher proportions than were California residents (Table 4B). This occurred for migrants from all groups employed in colleges and universities. It was also true for Whites from New York in the motion picture and financial investments industries, for Asians in the computer system design industry, and for Blacks who came to

Table 4B. Percent of Employed Persons in Leading Industries: Migrants from Leading Origin States and California Residents

White Employment

Washington			Texas			New York		
Industry	Mig.	Resid.	Industry	Mig.	Resid.	Industry	Mig.	Resid.
Construction	4.9	6.9	U.S. Marines	5.8	0.2	School	6.0	5.4
Restaurant	4.9	5.4	U.S. Navy	5.3	0.3	Restaurant	5.7	4.9
School	4.1	5.4	Restaurant	4.9	4.9	College/univ.	5.4	2.3
College/univ.	3.6	2.3	School	4.7	5.4	Motion picts.	5.3	1.2
U.S. Navy	2.5	0.3	Construction	4.6	6.9	Finan. invests.	4.7	1.1

Latino Employment

Texas			Arizona			Washington		
Industry	Mig.	Resid.	Industry	Mig.	Resid.	Industry	Mig.	Resid.
U.S. Marines	9.6	0.2	Construction	9.2	8.2	Construction	12.0	8.2
Restaurant	6.4	7.8	Restaurant	7.3	7.8	Restaurant	10.0	7.8
Construction	5.5	8.2	Crop product.	5.0	3.7	Crop product.	5.0	3.7
U.S. Navy	3.7	0.1	Dept. stores	3.7	1.8	Whlsl. grocery	2.8	1.7
Hospital	3.2	2.2	U.S. Marines	3.5	0.2	School	2.6	3.3

Continued

Table 4B continued. Percent of Employed Persons in Leading Industries: Migrants from Leading Origin States and California Residents

Black Employment

Texas			New York			Illinois		
Industry	Mig.	Resid.	Industry	Mig.	Resid.	Industry	Mig.	Resid.
U.S. Marines	5.3	0.2	Restaurant	4.7	3.8	Employ. svcs.	5.7	2.7
Restaurant	5.1	3.8	Artists, sports	4.3	0.9	Restaurant	5.3	3.8
U.S. Navy	4.0	0.5	Hospital	3.9	5.0	College/univ.	3.9	2.1
Hospital	3.6	5.0	School	3.2	5.2	U.S. Navy	3.8	0.5
Child day care	3.0	1.8	U.S. Navy	3.0	0.5	School	3.4	5.2

Asian Employment

New York			Texas			Hawaii		
Industry	Mig.	Resid.	Industry	Mig.	Resid.	Industry	Mig.	Resid.
Hospital	9.8	5.0	Electr. manuf.	8.7	5.0	Restaurant	6.2	5.9
Colleges/univ.	5.8	3.0	Computer systs.	6.3	5.0	Hospital	2.8	5.0
Computer systs.	4.7	2.4	College/univ.	5.0	3.0	U.S. Navy	2.7	0.3
Electr. manuf.	4.1	5.0	Hospital	4.8	5.0	Recreation	2.0	1.1
Restaurant	4.1	5.9	Restaurant	4.7	5.9	Travel. accom.	2.0	1.1

California and worked in the performing arts and entertainment industries.

Migrants to California were less well represented than longer-resident Californians in industries that were not particularly high in status, such as elementary and secondary schools and hospitals. The construction industry was similar. Although construction provided more employment than any other industry, the migrants who worked in construction were primarily White and Latino. Except for Latinos from Arizona and Washington, migrants of all groups were represented in that industry in lower proportions than longer-term California residents. This is a likely reflection of the role of social networks, including those based on ethnicity, as a key determinant of who gets what jobs.

Members of the Armed Forces were particularly well represented among migrants to California, a migration that most civilian Californians are little aware of. About ten percent of all Latino migrants from Texas and Asian migrants from Hawaii were either in the Marines or the Navy. Texas was an especially important sending state for Whites, Blacks, and Latinos who were serving in the Armed Forces in California. These migrations should remind us of the large and important Navy and Marine installations in the state.

Conclusion

This research explored spatial patterns and key characteristics of people who migrated between California and other states from 1995 to 2000. With respect to migration patterns, Texas and Nevada were major destinations for migrants of all ethnic groups. Only Texas was a leading state of origin for all groups, but for three of the four groups, New York and Washington were leading origin states.

County-level maps indicated clearly that migrants from California comprised the largest proportions of residents in counties adjacent to California. Because many of these migrations have been occurring for decades, the impact of Californians on those counties has been exceptionally large. At the same time, the counties adjacent to California had the highest percentages of residents who left to move to California. This illustrates the general finding that places with high rates of inmigration tend also to have high rates of outmigration. The greatest numbers of people leaving California moved to metropolitan areas, especially in the West, whereas metropolitan areas in the Northeast and Midwest were more important sources for people moving to California.

The detailed findings on migrant characteristics presented in Tables 3 and 4 tell us much about the migrants in the larger migration flows and their employment adaptations. We hope that the rich specificity of these tables helps make more real to Californians the roles of interstate migrants in the economies and societies of our state and other states.

Migrants from California raised the educational attainment of many destination states. This was particularly true for Asians moving to Washington and New York, for Blacks moving to Virginia and Florida, and for Whites moving to Washington, Oregon, and Texas. At the same time, migrants to California had consistently higher percentages of college graduates than did members of their same groups left behind. The educational selectivity of the flows into California of Blacks from New York and Georgia and Whites and Asians from New York and Illinois was particularly dramatic. Clearly, California gained from the arrival of these more-educated inmigrants although the influx was, of course, partly counterbalanced by the more-educated migrants who left California.

In general, migrants in both directions seemed to fit reasonably well into their new state's employment structure. Migrants from California distributed themselves in similar proportions to the population of the destination states, although in slightly lower proportions than the longer-resident population. This was presumably because newcomers are less familiar with work possibilities and less likely to have local contacts leading toward good jobs. Some migrants to California showed a similarly lower proportion in key industries, but migrants in higher-status industries (colleges and universities, motion pictures, and financial investments) were represented in greater proportions than longer-resident Californians. Members of the armed forces, particularly the Navy and the Marines, were highly represented among migrants to and from California.

There were important differences in migration patterns and characteristics between Whites, Latinos, Blacks, and Asians. These indicate that much is obscured when ethnic group differences are not taken into account. Examining migrant characteristics by specific leading states of origin and destination demonstrated some state differences, but these seemed not as significant as the ethnic group differences.

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Origin of the Arrowhead Landmark near San Bernardino, California

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Abstract

A seven-acre vegetational feature in the shape of a large arrowhead is visible from much of the San Bernardino Valley. There is a large number of legends that explain why the arrowhead exists, and a common theme of these legends is that the arrowhead is a natural landmark.

The concentrations of 32 soil elements from within and outside of the arrowhead landmark were examined. The chemical and field measurements indicate that there do not appear to be any substrate controls that can account for the arrowhead landmark, and suggest that it might be a human-made or human-modified feature.

A tentative conclusion of this work is that the arrowhead may be a human-made advertisement created sometime in the late 1850s or early 1860s, perhaps by the founder of the nearby hot springs resort.

Introduction

ON THE SAN BERNARDINO Mountain front, visible from much of the nearby valley, is a landmark in the shape of an arrowhead (Figure 1). The landmark is reported to be 1,375 feet (419 m) long, 449 feet (137 m) wide, and covering 7.5 acres (*Legends of the Arrowhead* 1913; Duke 1988, p. 3). The landmark is at an elevation of approximately 2,800 feet (853 m) a.s.l., and consists of "soft chaparral" (e.g., California buckwheat, white sage, black sage, laurel sumac), surrounded by "hard chaparral" (e.g., greasewood, chamise, manzanita). There is a widespread popular belief that the landmark is a natural feature. In the earliest known description, a newspaper reporter wrote:

> "In glancing from our valley toward the lofty coast range, the eye involuntarily rests on that very striking mark on the southern face of the mountain, which has the shape of an Indian arrowhead, or, as some prefer to call it, 'the ace of spades.' It appears to the distant

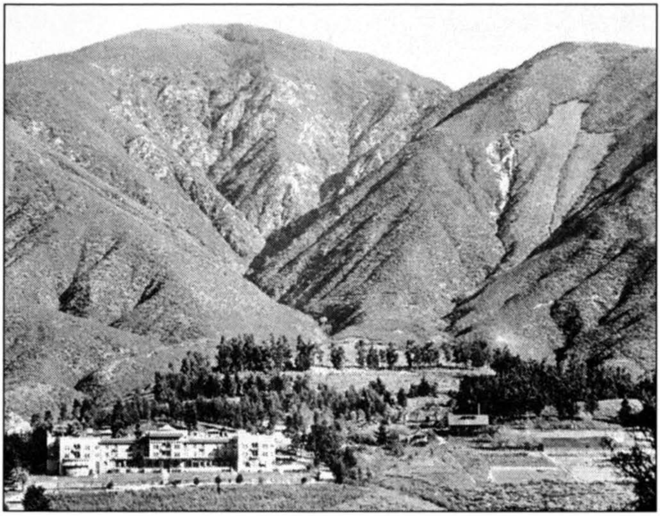

Figure 1.—Photograph of Arrowhead Springs in 1907. Courtesy of the Library of Congress.

> observer as if it were a 'wash' on the declivity, but on a nearer view it proves to be a section of the mountain composed of a soil differing from the adjoining slopes. It is a portion of the mountain formed of decomposed granite rock, the surface loosened by the action of the atmosphere, plentifully interspersed with boulders, and bearing a sparse growth of the low grayish shrub known as the sageplant, together with wild oats. The adjoining part of the mountain has a somewhat different soil, and bears a heavy growth of the dark green shrub commonly known as the greasewood. The arrowhead is a freak of nature, but it is as well defined as if laid out by rule and line" (*The Arrowhead* 1867, p. 3).

The arrowhead landmark has persisted despite numerous fires that have burnt across the area. Hotels at the nearby hot springs burnt down on March 20, 1885; July 4, 1895; and November 24, 1938; and eight outbuildings were lost on November 24, 1980. Fires that burnt the mountainside can be documented in 1916, 1922, 1938, 1943, 1953, 1958, 1970, 1975, 1980, 2001, 2003, and at least three fires occurred between 1863 and 1888. The area is slated to soon become the site of an expensive new development hosting 1,350 new homes, retail shops, a golf course, and corporate offices (City of San Bernardino 2005).

The purposes of this paper are threefold. The primary objective is to determine the first reliable evidence for the arrowhead's existence. A second objective is to examine the soils within and outside of the arrowhead to see if they differ in any significant and measurable ways that can account for the vegetation differences. Finally, the ultimate purpose of the paper is to figure out whether the arrowhead landmark is indeed a natural or human-made landmark, and if the latter, when it was constructed.

Historical Background

Regarding the origin of the arrowhead, Thompson (1976, p. 1) writes, "The story of Arrowhead Springs begins in 1857 with the arrival of David Noble Smith, builder of the first permanent building. Naturally the Arrowhead was well known prior to that time. Expeditions by Spanish soldiers passed through the valley below as early as 1772, and priests frequently visited the region following the establishment of a capilla, or temporary chapel, by Padre Dumetz in 1810."

Notably, the arrowhead was not mentioned by any 18th-century diarists that traveled in expeditions through the region. Moreover, Harley (1988) has thoroughly examined the evidence for the 1810 Dumetz expedition and has concluded that there is no reliable evidence for such an expedition, nor that a church structure was built in the region before 1819 (see also Belden, 1951). Critical to this paper is that there is no mention of the arrowhead landmark in any written records of the early Spanish inhabitants or the travelers in the region during the era of the Old Spanish Trail and the founding of Agua Mansa in the early 1840s.

Mormon colonization of the San Bernardino area followed in 1851. A stockade was constructed, and a thriving community of about 440 colonists grew in the valley about 10 km south-southwest of the landmark (Lyman 1996). Interestingly, no mention of the arrowhead landmark has yet been discovered in the diaries of the Mormon residents by the leading scholar of this era (Leo Lyman, personal communication 2000). This is noteworthy, especially because the Mormon diarists wrote wonderful descriptions of the surrounding environment.

The first scientific expedition to the area was the Williamson Survey in 1853, one of the expeditions conducted in preparation for a transcontinental railroad (Williamson 1853). The surrounding environment and hot springs immediately beneath the arrowhead landmark were described, and the temperatures of the various spring waters were measured (Williamson 1853, pp. 80–85), yet no mention of the arrowhead landmark was reported. It seems unlikely that a scientific expedition meant to describe the physical environment would miss such an important landmark on the mountainside directly above the hot springs they sampled.

Following a large, destructive earthquake on the nearby San Andreas fault in 1857 (McAfee 1992), the first evidence of an arrowhead landmark is a photograph reportedly made in 1864 (see Figure 2). The photograph shows the original infirmary building at the hot springs constructed by David Noble Smith and opened on April 14, 1864 (Thompson 1976, p. 5).

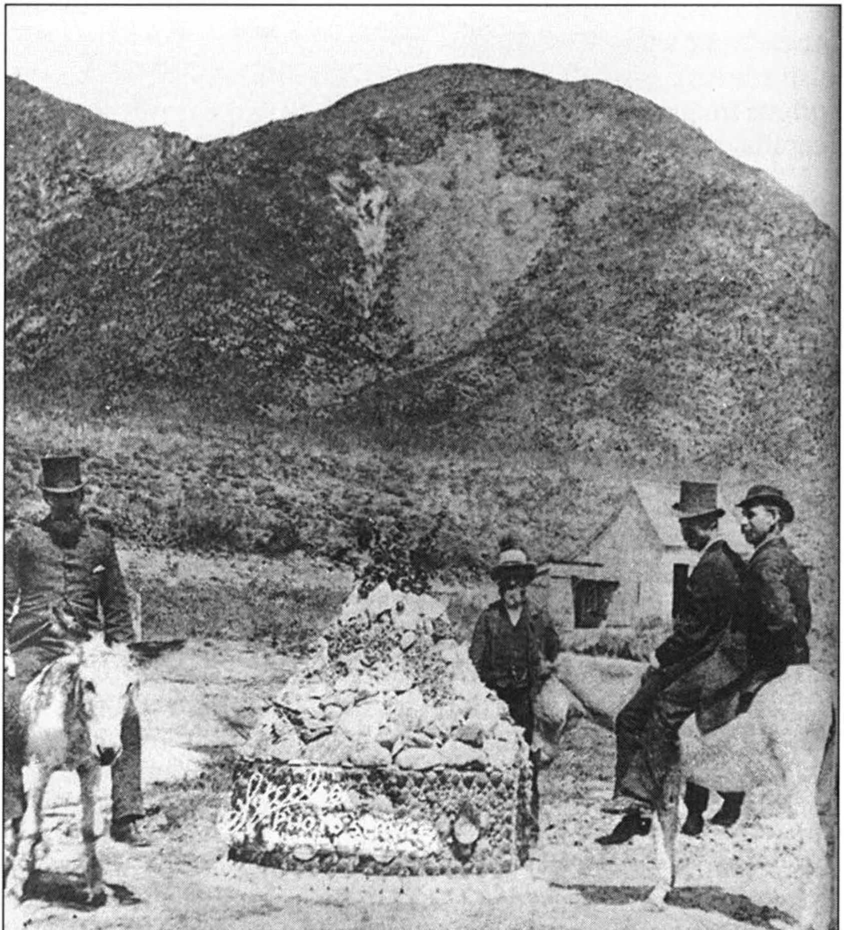

Figure 2.—Photograph of Arrowhead Springs reportedly made in 1864.

Thompson (1976, p. 3) accompanies a description of these events with:

> "While at his father's death bed, an apparition appeared before Smith—a saint he believed—and took him away to a far-off land. The spirit showed him a spot where a unique combination of climate and curative waters fused in such a manner as to perform miraculous cures for all lung diseases. The spot was marked by a gigantic arrowhead. Until he found this landmark, he said, he felt 'like a wanderer in search of a lost home.' Smith did wander around for a while, first to Texas and then to Illinois, where he met Thomas B. Elder, his future brother-in-law. In 1857, Smith and some of his friends from Illinois came to California, where later that same year he spotted the arrowhead."

If this is indeed accurate, then the arrowhead may have existed as early as 1857, but there is obvious reason to doubt the historical reliability of such a story.

Similarly, the earliest known newspaper description of the landmark in 1867 suggests that the landmark was an old feature by that time:

> "Several years ago, when prospecting was more common than now-a-days, some men were attracted by that mark, concluding that it had not been placed there for nothing, and that if a diligent prospect were made, something would be found in the locality which would well reward the search.... Years passed away, and the thought of these springs often presented itself to the mind of one of the discoverers, and after working to obtain means to enable him to make improvements, he returned to the springs and began, four of five years ago, the establishment now known as the 'Arrowhead hygienic infirmary'" (*The Arrowhead* 1867).

The arrowhead landmark appears in numerous photographs and reports after the late 1860s. It became a symbol of community pride and has been periodically maintained by the community since at least 1911. Thompson (1976, p. 25) reports that the Civilian Conservation Corps built about 200 check dams in the gullies within the arrowhead about 1940, and that the Boy Scouts helped renovate the site following the 1953 fire. He further notes that "state prison crews spent thousands of hours in manual labor" working to maintain the Arrowhead. To help define the arrowhead landmark, in 1953 four rows of *Cistus* (rock rose) plants were planted around the arrowhead (Duke 1988, p. 5; another source reports that this occurred in 1957). *Cistus* is native to the Levant and was believed to be fire resistant. Reseeding efforts were scheduled after the 1975 fire (Thompson 1976, p. 26).

Examination of the Local Substrate

Yetzer (1975, p. A6) reports, "As early as the 1920's, historian Lyman Rich took soil samples both inside and outside the landmark down to a depth of 12 inches. He sent the samples to the University of California at Berkeley and after several months of analysis the scientist concluded that there was no chemical content in the soil that could account for the difference in vegetation." Because this study was apparently not published, this paper presents the results of a new sampling of the soils both from within and outside of the arrowhead landmark using modern techniques.

On June 16, 1998, soils were sampled from 21 sites, 10 within the arrowhead and 11 outside of the arrowhead on all sides (see Figure 3). Following a texture analysis, the samples were sent to Chemex Labs, Inc. in Sparks, NV, for ICP-AES (Inductively Coupled Plasma with Atomic Emission Spectroscopy) multi-element analysis, the standard procedure employed by prospectors using exploration geochemistry (see www.alschemex.com for more details). The concentrations of 32 elements were examined for 15 of the 21 soil samples (see Table 1). The other six samples were examined using an ICP technique that can detect the concentrations of 39 elements in even greater detail (see Table 2).

The samples were then divided into two classes: one group from inside the arrowhead and one group from outside of it. Both a T-Test and a Wilcoxon statistical analysis were performed on the 15 samples shown in Table 1 to see if there are statistically significant differences in the means between each class for each of the 32 elements.

Using a 5 percent level to determine statistical significance, three elements (lanthanum, potassium, and scandium) occur in higher concentrations outside of the arrowhead, and two elements (lead and phosphorus) are significantly elevated within the arrowhead (see Table 3). Magnesium reaches the 5 percent significance level only in the Wilcoxon test, and is found at higher concentrations outside of the arrowhead.

Theoretically, potassium and phosphorus (and perhaps magnesium) are elements critical for plant growth, and the results suggest that substrate differences might play some role in the vegetation dif-

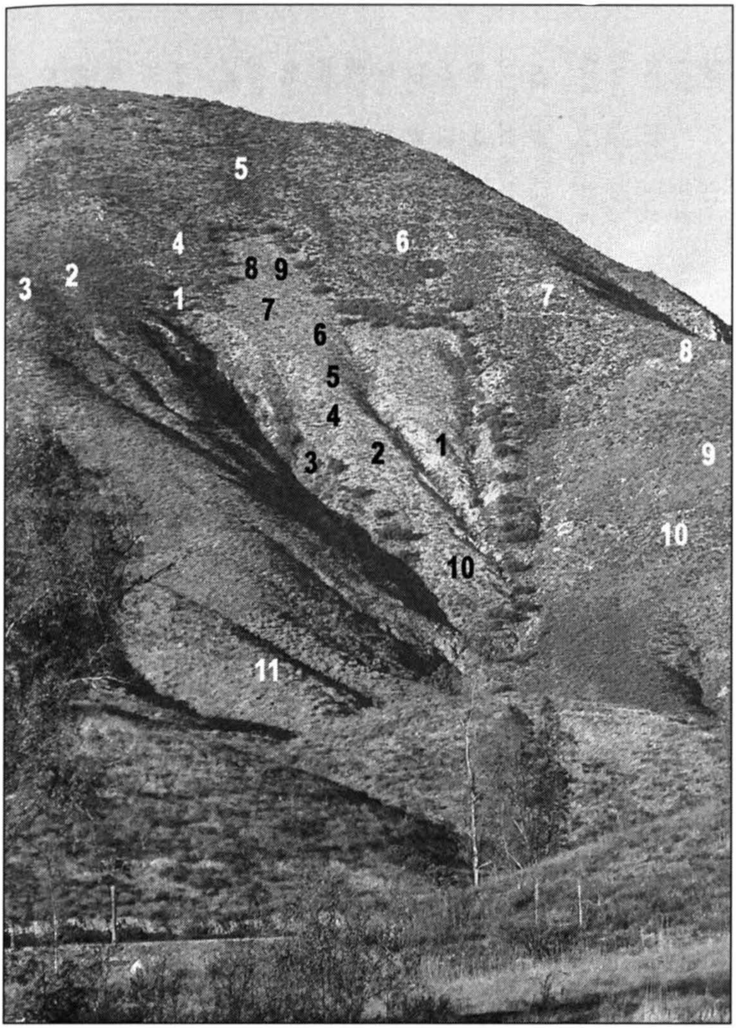

Figure 3.—The arrowhead landmark, March 2007. The sampling sites labeled in white were chosen so that runoff from the arrowhead could not contaminate them.

ferences between the arrowhead and its surroundings, despite the fact that the concentrations of the two elements trend in opposite directions.

The fact that both lead and phosphorus are elevated inside the arrowhead is unusual. I hypothesized that both might have been components of 1970s-era Phos-Chek, a commercial phosphate substance commonly dropped by planes to control fires. This belief

ID#	Al	As	Ba	Ca	Co	Cr	Cu	Fe	K	La	Mg	Mn	Ni	P	Pb	Sc	Sr	Ti	V	Zn
A1	3.46	4	50	0.46	9	17	18	3.95	0.45	30	0.82	465	10	1080	36	3	56	0.17	90	112
A3	2.89	2	50	0.42	10	16	22	3.97	0.59	30	0.89	530	9	1020	40	3	46	0.18	89	354
A4	3.57	6	50	0.61	10	15	16	3.45	0.50	40	0.93	535	11	1320	38	3	71	0.17	80	122
A5	3.55	6	50	0.47	9	17	16	3.59	0.48	40	0.88	520	10	1330	52	3	52	0.17	84	112
A7	3.14	6	60	0.61	9	17	16	3.47	0.50	40	0.88	570	10	1590	36	3	65	0.16	80	102
A8	3.07	6	60	0.70	9	14	15	2.92	0.54	30	0.94	545	10	1340	50	3	78	0.16	71	112
A9	2.98	8	50	0.63	9	18	17	3.60	0.50	30	0.88	515	12	1280	76	3	60	0.17	90	134
Avg	3.24	5.4	52.9	0.56	9.29	16.3	17.1	3.56	0.51	34.3	0.89	525.7	10.3	1280	46.9	3	61.1	0.17	83.4	149.7
StDev	0.26	1.8	4.5	0.10	0.45	1.3	2.2	0.33	0.04	5.0	0.04	29.9	0.9	173.8	13.4	0	10.3	0.01	6.5	83.9

ID#	Al	As	Ba	Ca	Co	Cr	Cu	Fe	K	La	Mg	Mn	Ni	P	Pb	Sc	Sr	Ti	V	Zn
B1	2.85	6	50	0.60	10	18	16	3.79	0.57	40	0.93	550	12	880	46	3	50	0.17	91	116
B2	3.63	8	40	0.25	9	9	11	2.47	0.59	70	1.03	415	6	80	10	3	60	0.17	54	88
B4	3.20	10	50	0.62	10	16	15	3.37	0.60	50	1.01	595	10	710	38	4	54	0.18	83	106
B6	3.28	6	40	0.37	10	13	17	3.29	0.76	60	1.08	540	7	340	10	4	37	0.19	79	92
B7	2.48	2	30	0.17	8	12	11	3.26	0.49	40	0.71	320	6	130	10	3	21	0.13	81	66
B9	3.69	6	70	0.76	17	21	12	3.81	0.83	70	1.66	675	11	800	14	6	66	0.22	112	116
B10	3.28	10	80	0.63	14	21	15	3.51	0.92	50	1.35	635	13	740	44	5	56	0.20	94	118
B11	3.02	12	90	1.05	17	51	23	3.61	0.87	40	1.78	495	25	1390	14	8	62	0.26	111	66
Avg	3.18	7.5	56.3	0.56	11.9	20.1	15	3.39	0.70	52.5	1.19	528.1	11.3	633.8	23.3	4.5	50.8	0.19	88.1	96.0
StDev	0.37	3.0	20.0	0.27	3.4	12.3	3.7	0.40	0.15	12.0	0.35	109.1	5.8	406.8	15.3	1.7	14.0	0.04	17.5	20.2

Table 1. Chemical analyses of the soil samples by ICP-AES. Samples beginning with an ID# A come from within the arrowhead, and samples beginning with a B are from outside of it. The Al, Ca, Fe, K, Mg, and Ti values are in percent. The others are in ppm. The values for Ag, Be, Bi, Cd, Ga, Hg, Mo, Na, Sb, Tl, U, and W are not shown because they were all below the detection limit, or the values for all samples were exactly the same.

ID#	Al	Ba	Ca	Co	Cr	Cu	Fe	K	La	Mg	Mn	Nb	Ni	P	Pb	Sr	Ti	V	Y	Zn
A2	9.59	440	2.44	10.8	19	15	4.61	1.81	50.5	1.07	705	36.6	9.8	900	36	428	0.64	123	41.4	282
A6	8.88	410	2.39	10.2	18	19	3.92	1.66	49.5	0.98	780	28.2	10.8	1360	41.5	425	0.54	99	32.7	108
A10	8.79	430	2.58	10.4	19	17	4.98	1.72	43.5	0.95	705	34.8	9.6	920	30.5	431	0.62	124	36.9	96
Avg	9.09	426.7	2.47	10.5	18.7	17	4.50	1.73	47.8	1.00	730	33.2	10.1	1060	36.0	428	0.60	115.3	37.0	162
StDev	0.36	12.5	0.08	0.3	0.5	1.6	0.44	0.06	3.1	0.05	35.4	3.6	0.5	212.3	4.5	2.5	0.04	11.6	3.6	85.0

ID#	Al	Ba	Ca	Co	Cr	Cu	Fe	K	La	Mg	Mn	Nb	Ni	P	Pb	Sr	Ti	V	Y	Zn
B3	10.2	480	1.79	10.4	13	23	3.66	2.10	83.0	0.94	670	22.2	8.2	430	24.5	358	0.47	81	26.6	106
B5	8.64	420	2.30	10.4	18	19	4.26	1.76	41.5	0.97	755	29.6	11	710	55	403	0.58	108	28.4	110
B8	8.86	470	1.92	10	16	43	3.77	2.01	78.0	0.9	760	29.4	10	900	46	352	0.54	85	28.5	126
Avg	9.23	456.7	2.0	10.3	15.7	28.3	3.90	1.96	67.5	0.94	728	27.1	9.7	680	41.8	371	0.53	91.3	27.8	114
St Dev	0.69	26.3	0.2	0.2	2.1	10.5	0.26	0.14	18.5	0.03	41.3	3.4	1.2	193	12.8	22.8	0.05	11.9	0.9	8.6

Table 2. Chemical analyses of the soil samples by ICP-MS, a technique that can analyze many additional elements, and sometimes in more detail. The three samples beginning with an ID# "A" come from within the arrowhead, and the three samples beginning with a "B" are from outside of it. The Al, Ca, Fe, K, Mg, and Ti values are in percent. The others are in ppm. The values for Ag, Be, Bi, Cd, Ce, Cs, Ga, Ge, In, Li, Mo, Na, Rb, Ta, Te, Th, Tl, W, and U are not shown because they were all below the detection limit, or there was little variability among the samples.

Table 3. Statistical results of a two-sample T-test and a Wilcoxon test. These results show the statistical significance of the difference in means between the two sample sets of 15 ICP-AES results from Table 1. Identical statistical tests were performed on the six ICP-MS results from Table 2, but with only three samples in each set, the statistical differences between the means are not a reliable measure of a meaningful difference.

Element	T-Test	Wilcoxon
Aluminum	.7521	1.0
Arsenic	.1558	.1594
Barium	.6888	.8545
Calcium	.9939	1.0
Chromium	.4590	.8613
Cobalt	.0831	.1128
Copper	.2337	.1422
Iron	.4057	.4634
Lanthanum	.0040‡	.0054‡
Lead	.0113†	.0477†
Magnesium	.0503	.0272‡
Manganese	.9588	.6126
Nickel	.6909	.9529
Phosphorus	.0030†	.0093†
Potassium	.0085‡	.0146‡
Scandium	.0442‡	.0190‡
Strontium	.1546	.2707
Titanium	.1724	.0936
Vanadium	.5440	.4511
Zinc	.1266	.0916

†significant at the 5% level, higher concentrations in the arrowhead

‡significant at the 5% level, lower concentrations in the arrowhead

was furthered by Thompson's (1976, p. 25) report that: "On August 12, 1975, fire once again burned the arrowhead. The mark was not completely destroyed this time, perhaps because of the efficient firefighters, who used bombers to drop chemicals on the burning hillside." Consequently, an effort was made to discover the chemical composition of Phos-Chek, a proprietary commercial substance. Eventually a chemist at the manufacturer responded: "There has never been a lead-containing component in any of the Phos-Chek wildland fire retardants.... In 1975, all wildland retardants contained a lead-free pigment grade iron oxide as a colorant" (Vandersall 2006). Thus, at this point the presence of elevated lead levels within the arrowhead landmark cannot be explained. Perhaps it could be due to some sort of adsorption process that occurred during the era of leaded fuel and was catalyzed by phosphorus, but this is pure speculation. Geologically, there are no obvious visible textural or lithologic differences between the substrate in the arrowhead and the surrounding hillside that can explain the elevated concentrations of lead inside the arrowhead.

The fact that potassium and perhaps magnesium levels are elevated outside of the arrowhead could be an important difference, but it could also be an artifact of the reseeding processes that occurred after fires in 1975, 1980, or some other time. In short, because the elements with significant variations are all elements that could be artifacts of human actions during a fire or its recovery, the soil geochemistry differences are inconclusive in determining that the substrate plays the primary role in the persistence of the arrowhead landmark. Undoubtedly, the concentrations of magnesium, phosphorus, and potassium were checked in the 1920s by the Lyman Rich study and not found to be significantly different, but could appear statistically significant today because of modern firefighting and/or reseeding techniques. The fact that only 5 of the 32 elements showed statistically significant differences suggests that there are not major differences between the substrate inside and outside of the arrowhead landmark.

Discussion

L. Burr Belden has written that Arrowhead Springs may have the distinction of "having had more untruths written about it and recorded as fact than any other place [in California] with the possible exception of Death Valley" (cited in Thompson 1976, p. 11). There is no doubt that a large number of myths and legends have arisen about the arrowhead, perhaps because it was the object of an early public relations campaign (e.g., *Legends of the Arrowhead* 1913). Buie (1967) reports:

> "Later the firm of Darby and Lyons, who had built a health resort at the hot springs below the arrowhead, were credited with authorship of many of the legends, including the most widely accepted one that Indians for miles around came to the hot springs and were guided by the arrowhead, pointing to the health-giving waters. As late as 1906, San Bernardino conducted a community celebration, 'The Festival of the Arrowhead,' which was to have commemorated the coming of the Indians to the springs. The story was pure legend." (Buie 1967)

Thompson (1976, p. 11) reports that the advertising campaigns of the 1880s that spread the myths "helped the spa achieve more widespread fame than any other in the state." For example, Dr. H. C. Royer, a promotional businessman, once wrote, "On the face of the mountain is the figure of an arrowhead...which may justly be considered one of the wonders of the world" (Yetzer 1975, p. A6).

After discussing the many legends, Thompson (1976, p. 12) goes on to dismiss a manmade origin of the arrowhead. He writes:

> "Some of these myths were reputedly told to the white settlers by the Indians, giving the Indian account of how the mark of an arrowhead came to be on the mountain. But this is unlikely, since neither race noticed the resemblance of the mark to an arrowhead—the settlers called it 'The Ace of Spades.' The honor of first calling it an arrowhead goes to David Noble Smith. One story even suggests the Indians built the arrowhead to point to the healing waters below, and incredible as that story may seem, many people today believe it. In view of the fact that the arrowhead is more than a quarter of a mile long, 450 feet wide, comprising some seven and one-half acres in area, and tilted at an angle of 45 degrees on the mountainside, the improbability of the Indian labor theory is apparent.
>
> One writer called the myths 'grotesque fiction' and tried to debunk them, apparently to no avail. Why people hesitate to see the landmark as an accident of nature is hard to understand. Throughout the area are patches of light vegetation surrounded by darker patches. The land movements which created the mountains left the area dotted with soils of different types. Wild sage and other plants of a silvery hue seem to do better in loose soils, thus forming a contrast to the darker vegetation found in heavier soils. It is not unusual to expect that among the countless thousands of these patches one could be found resembling a formation known to man. Perhaps what makes the arrowhead so remarkable is that it points directly toward the hot springs at its base." (Thompson (1976, p. 12)

Despite these arguments, several lines of evidence point to the manmade origin of the arrowhead landmark. First, there is no written or photographic record of the arrowhead until 1864, coincident with the opening of the infirmary at the hot springs below it, and to which it points. It could have existed a few years before 1864, but it is difficult to believe that the Williamson survey did not report its existence in 1853 when they thoroughly described the area, including the nearby road in Waterman Canyon used to haul lumber from the mountains.

The arrowhead landmark was likely constructed with the assistance of local natives, thus providing some basis for the later legends that it had an Indian origin. It is possible that they may have modified a rare triangular landslide scar, such as one that recently developed northwest of Devore, California, into an arrowhead feature (see

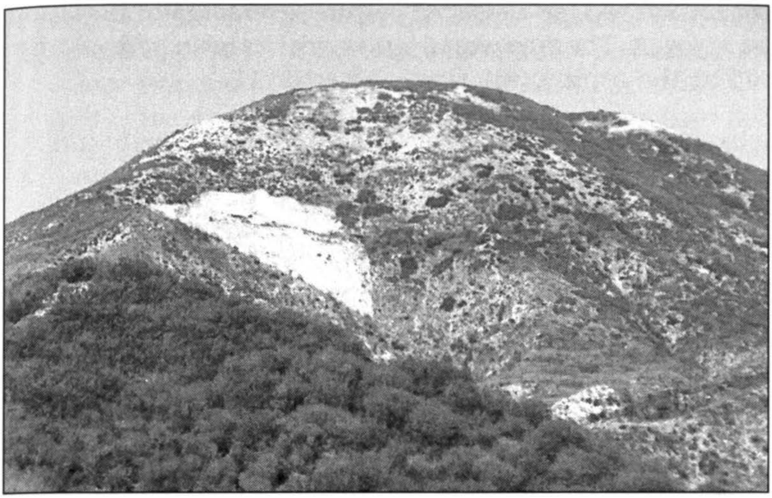

Figure 4.—Oblique view of a recent landslide scar northwest of Devore, CA. This feature has formed since the major fires of 2003, and probably could be modified into an arrowhead landmark if someone wanted to do it. November 2007 photo.

Figure 4). An obvious explanation for the landmark's origin is that it advertised the hot springs and infirmary at its base.

Because there are no significant differences in soil chemistry, slope, or texture between the arrowhead and surrounding areas, there are no obvious differences in substrate that can explain the persistence of the soft and hard chaparral areas after numerous fires. Humans have undoubtedly aided the process with annual community preservation efforts that can be documented from 1911 onward.

Imported "fire-resistant" vegetation and an extensive network of metal check dams and other projects to reduce erosion have helped to maintain the vegetation difference. Interestingly, now that the annual community projects have apparently ended, it appears a substantial portion of the landmark's left side is becoming difficult to differentiate from the background area.

Conclusions

The arrowhead landmark is a local cultural icon and appears in the names and logos of innumerable local organizations. There is a large number of legends that explain why it exists. A common theme of these legends is that the arrowhead is a natural landmark. The widespread public acceptance of its natural origin has been enhanced because the arrowhead has persisted despite several major fires that have burnt across it. The arrowhead landmark has been periodically maintained by the community since at least 1911.

The soft-chaparral vegetation inside the arrowhead clearly differs from the hard chaparral surrounding it. To examine the possible causes of this difference, 21 soil samples were collected from inside and around the arrowhead. The concentrations of 32 elements for 15 samples were examined statistically. Only phosphorus and lead levels are elevated in the arrowhead, and it has lower levels of potassium, lanthanum, and scandium compared to the surrounding areas. The chemical and field measurements strongly suggest that there is no difference in the substrate that can explain the arrowhead's persistence. Consequently, a manmade origin must be considered.

The earliest photographic record of the arrowhead is from 1864. No mention of the landmark has yet been found in the railroad survey or Mormon narratives written during the 1850s, although it is discussed in at least one newspaper column in 1867. A tentative conclusion of this work is that the arrowhead may be a human-made advertisement created sometime in the late 1850s or early 1860s, perhaps by the founder of the hot springs resort.

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Fire Risk in San Diego County, California: A Weighted Bayesian Model Approach

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Abstract

Fire risk models are widely utilized to mitigate wildfire hazards, but models are often based on expert opinions of less understood fire-ignition and spread processes. In this study, we used an empirically derived weights-of-evidence model to assess what factors produce fire ignitions east of San Diego, California. We created and validated a dynamic model of fire-ignition risk based on land characteristics and existing fire-ignition history data, and predicted ignition risk for a future urbanization scenario. We then combined our empirical ignition-risk model with a fuzzy fire behavior-risk model developed by wildfire experts to create a hybrid model of overall fire risk. We found that roads influence fire ignitions and that future growth will increase risk in new rural development areas. We conclude that empirically derived risk models and hybrid models offer an alternative method to assess current and future fire risk based on management actions.

Introduction

THE DANGERS POSED by wildland fires, particularly in areas where the urban interfaces the rural, have led to numerous methodologies for mapping wildfire risk over the past two decades (Chuvieco 2003). Mapping wildfire risk requires not only an understanding of what factors contribute to the existence of a wildfire, but also a designation of the values actually at risk. Usually, this encompasses humans, human infrastructure, and human-valued ecosystems and ecosystem services. Given this human-oriented definition of risk, maps and mathematical models of fire risk fall primarily into two categories: the probability of an initial ignition; and, given that an ignition occurs, the potential for fire behavior conducive to fire spread. In both cases, Geographic Information Systems (GIS) and remotely sensed data have contributed significantly not only to spatially mapping fire risk, but also to understanding the relationships between contributing factors (such as the weather, vegetation composition and condition, and topography) and wildfire occurrence and behavior at variable spatiotemporal scales (Chuvieco 2003). These relationships are often difficult to quantify as inputs to the models used to produce fire risk maps and, given this lack of existing empirical knowledge about fire risk, there is considerable room to explore new approaches to mapping fire risk and modeling the factors that contribute to fire risk.

This study focuses on mapping the probability of current and future risk of wildfire ignition in one of the most fire-prone regions of the U.S.: San Diego County in southern California. Compared to the number of models developed for mapping risk of fire spread, models of fire-ignition risk have been fewer in number. This stems primarily from the difficulty of predicting atmospheric conditions conducive to lightning strikes, which start fires that eventually become the majority of large fires in the U.S. In urban southern California, however, fewer than five percent of wildfires are ignited by lightning, with most large wildfires ignited by human activities (Keeley, Fotheringham, and Morais 1999). Understanding how humans ignite fires in this region, then, is critical to fire management personnel who are responsible for mitigating this risk. Additionally, this understanding must be flexible enough to accommodate the changing human footprint on the landscape in the rapidly growing region.

Two types of models are generally developed for mapping wildfire-ignition risk. The deterministic, or "fuzzy," model relies on expert opinion to determine which factors contribute to the process being modeled, and then assigns a weight to each of those factors within the model. A static map, predicting a set of outcomes, is then produced. This is the most common type of model currently used to map wildfire risk, as weights can be adjusted to produce the outcome expected by model developers based on their knowledge and the intended use for the resulting map. For example, Radke (1995) created a GIS model of fire hazard in the East Bay Hills of California, with arbitrarily chosen inputs of vegetative fuels and structural fuels, which were differentially weighted based on expert opinions obtained in interviews of experienced fire experts. Burgan, Klaver, and Klaver (1998) used estimated fuel moisture in the linearly weighted National Fire Danger Rating System to produce a Fire Potential Index for the continental U.S.

The second method for mapping fire-ignition risk relies on statistical modeling to empirically derive relationships between causal factors and the resulting ignition of a wildfire. Since these models rely on a training data set of fire occurrences, they can be revised as additional training data is acquired, and, more importantly, can be validated using some portion of the training data not used for model creation. In wildfire-ignition risk, these models use previous fire occurrences as the data for training the model, and often assess potential for ignition based on either the availability of the surface fuel to burn (Hardy and Burgan 1998) or the development of atmospheric conditions conducive to dry lightning (Rorig et al. 2003). The most frequent critique of these models is that they are based on only limited data and don't necessarily represent local conditions, as there is no place for expert knowledge in pure empirical models (Martin et al. 2005). However, empirical models define relationships and describe a process when little is known pertaining to how causal factors produce an outcome. This is often the case with wildfire risk, as the contributing factors to wildfire ignitions are often poorly understood, and therefore difficult to predict.

Since both types of models offer both benefits and drawbacks, it is critical to understand the purpose of the model when choosing a type; in this case it is the mitigation of wildfire ignitions by fire management and public planners. Farris, Pezeshki, and Neuenschwander (1999) reviewed the inputs, decision-making process, and accuracy levels of both deterministic and empirical methods of modeling wildfire risk, and concluded that none of the models tested was "ideal" for fire management. They suggested that a hybrid model incorporating both expert knowledge and empirical, non-biased methods may provide the desired answers. The southern California region has been the focus of many wildfire risk studies (Yool et al. 1985; Chou et al. 1993; Keeley, Fotheringham, and Morais 1999), largely because it is densely populated and has experienced numerous catastrophic wildfires in the past century, including the 2003 Cedar Fire east of San Diego, the largest wildfire ever recorded in California at just over 113,000 ha (Keeley, Fotheringham, and Moritz 2004). Since previous studies in the region have been primarily deterministic, using expertly weighted models to produce static maps, this study produced an empirical model as an alternative approach for mapping wildfire-ignition risk (e.g., Dickson et al. 2006). The model was used to mask both current fire-ignition risk and future potential fire-ignition risk, based on a predicted urban growth scenario (Steinitz et al. 1997). The hybridization approach advocated by Farris, Pezeshki, and Neuenschwander (1999) was then used to combine the wildfire-ignition probability map with a deterministically produced map of wildfire-spread risk from the California Department of Forestry and Fire Protection (CDF) to create an overall wildfire risk map for the region.

The objectives of our study were to (1) determine the process by which recent wildfires have ignited in eastern San Diego County, California, by developing and validating an empirical model for fire-ignition risk; (2) apply the risk model to a future growth scenario to assess future fire-ignition risk; and (3) combine the weights-of-evidence model with a knowledge-driven fire-risk model to create a hybrid overall fire-risk model.

Study Area

In this study, we focus on the eastern part of San Diego County, primarily because it is the area that will likely see the most wildland-urban interface (WUI) expansion over the next few decades (Steinetz et al. 1997). A 378,720 ha portion of San Diego County, California, was chosen as the study area (Figure 1) based on the availability of the most accurate and extensive fire-ignition data to train the statistical model. The area lies to the east of the San Diego metropolitan area and contains the city of Ramona and portions of the Cleveland National Forest and Anza-Borrego Desert State Park. Mediterranean vegetation types dominate the region, with most of the study area covered in chamise (*Adenostoma* spp.), chaparral (*Ceanothus* spp.), and manzanita (*Arctostaphylos* spp.). At higher elevations, oak (*Quercus* spp.) forms a broadleaf deciduous forest adjacent to coniferous forest consisting of mountain mahogany (*Cercocarpus betuloides*), pine (*Pinus* spp.), and fir (both *Abies concolor* and *Pseudotsuga macrocarpa*) (Wells 2004). The mostly shrub vegetation is both fire-dependent and fire-prone: its waxy leaves burn easily and intensely, and it resprouts quickly after a fire. This makes the region prone to frequent fires and to less-frequent but highly catastrophic large fires driven by fall Santa Ana weather patterns (Keeley, Fotheringham, and Morais 1999; Keeley and Fotheringham 2001).

Methods and Data

To assess wildfire-ignition risk in the study area, we used a Bayesian weights-of-evidence model in a GIS environment. This was the same approach taken by Dickson et al. (2006) in their assessment of fire-ignition risk in Arizona. Arc Spatial Data Modeler (ArcSDM)

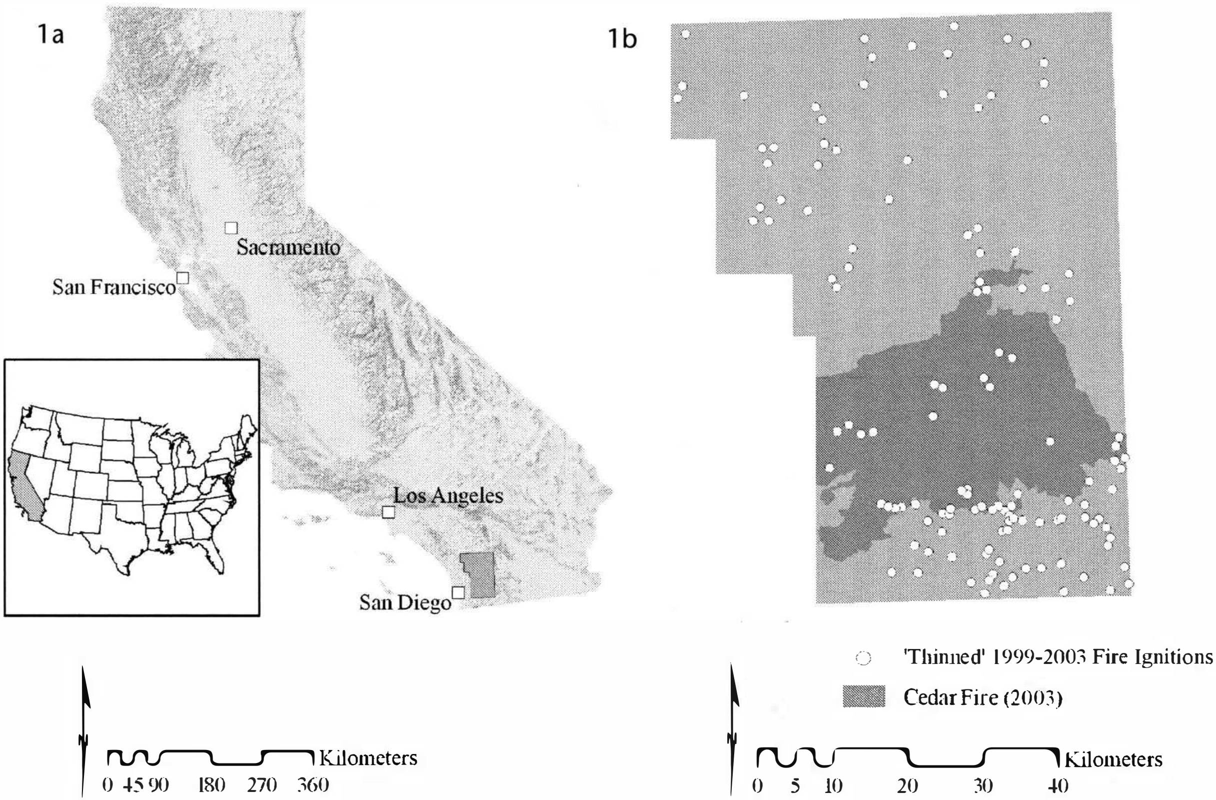


Figure 1a.—The project location in the southwestern corner of California, near the San Diego metropolitan area. Fire ignition data was obtained from the California Department of Forestry for this region. 1b.—The 378,720 ha study area used during weights calculation. The fire ignition distribution (n = 128) is for the period 1999–2003. 110,600 ha of the study area was impacted by the 2003 Cedar fire.

is an extension developed for ESRI ArcGIS software that calculates weights based on raster dataset inputs and vector (point) training data (Sawatzky et al. 2004). The ArcSDM weights-of-evidence tool has previously been used to predict fire ignitions (Dickson et al. 2006), and also for predicting mineral deposits (Bonham-Carter, Agterberg, and Wright 1988; Raines 1999), ecological habitats (Aspinall 1992; Mensing et al. 2000), and landslide potential (Lee and Choi 2004). Bayesian weights-of-evidence modeling calculates "weighted" positive and negative coefficients for the classes in evidential raster layers, based on the spatial correlation with the classes. Evidential layers are generalized into binary maps, according to favorable and unfavorable correlation, and are then combined using Bayesian modeling to calculate the posterior probability that a fire ignition will occur in a given cell within the study area.

Data

During pre-processing, several data sets (designated "evidential layers" for purposes of modeling) were spatially correlated to the fire-ignition history set, to determine what characteristics of the study area contribute to ignition of wildfires. Aspect, slope, vegetation, and fuel model layers showed no significant correlation to past fire-ignition points. Land use/land cover (LULC), land ownership, roads, and elevation showed significant correlation to the fire-ignition training points; subsequently, these four evidential layers were utilized as inputs to the fire-ignition risk model. The LULC and land ownership data were provided from the continuation of a previous project (Steinitz et al. 1997), and since they were initially derived from Landsat data analysis, the spatial resolution of the data was 30 m. The elevation data was derived from the national elevation dataset (also 30 m resolution), and the roads were rasterized from a TIGER line file available at the California Geospatial Data Clearinghouse.

The fire-ignition occurrence data was derived from a 12-year fire-ignition history published by CDF (http://frap.cdf.ca.gov/projects/fire_data/fire_perimeters/). Due to the rapidly changing land cover in the study area, training points were selected for the years 1999–2003, allowing us to assess the fire-ignition process and predict future ignition risk for a five-year period. The 390 initial fire-ignition history points where "thinned" to remove all but one point per 30m raster cell, leaving 363 points for "training" the model. A 50 percent subset of the "thinned" training points was selected using

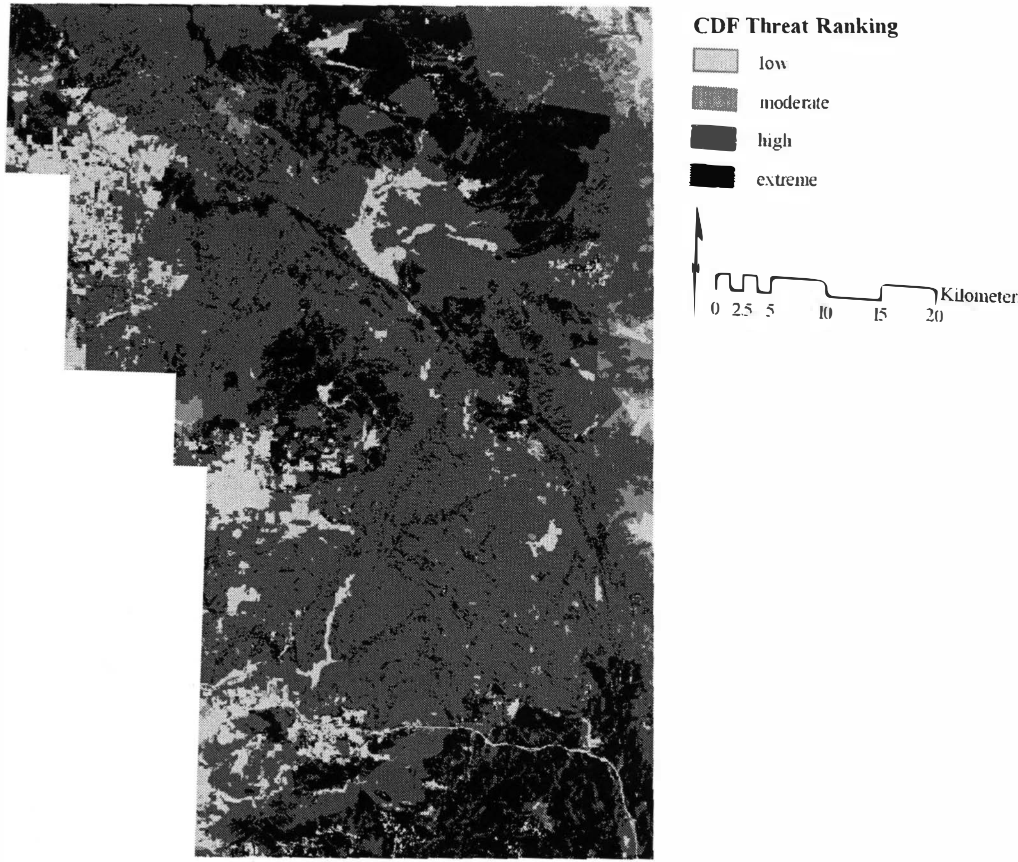
ArcSDM to randomly remove half of the set for validation, leaving 128 training points.

The future-growth scenario input layer was based on changes estimated in the LULC evidential layer from a study performed using regional growth models (Steinitz et al. 1997). The premise of the regional growth models was that one million new residents would move into San Diego County under one of four potential development scenarios: rural, low-density growth; or high-density growth in either coastal regions, the northern portion of the county, or around three new "urban centers." Previous work by the lead author test-modeled all four scenarios, and the "three urban centers" scenario showed the most significant change in wildfire-ignition risk. This scenario was selected for the final model run and is presented here as the future growth evidence layer. Farris, Pezeshki, and Neuenschwander (1999) noted the importance of hybrid models in capitalizing on both expert knowledge and statistically derived quantification of a process. With this in mind, we found a deterministic, fuzzy model of wildfire risk for comparison to the weights-of-evidence model (Figure 2). CDF derived this predictive Fire Threat model from a potential fire-behavior map (based primarily on vegetative fuels) and a fire-history assessment based on large fire perimeters, where the input layers were weighted according to the modeler's expert knowledge of fire (http://frap.cdf.ca.gov/data/frapgisdata/select.asp).

Calculation of Probability

The prior probability of a wildfire ignition was calculated as the total number of ignition points in the training data set over the area of the study region, essentially describing the potential for an ignition point to occur in any cell by chance. Correlations between evidence layer classes and training points were calculated in ArcSDM to determine which classes were associated with the fire-ignition training points. The difference between positive and negative correlations was calculated as the contrast value, which measures the "strength" of the association between training points and classes within evidence layers (Bonham-Carter 1994). The contrast was then used to generalize evidence layers into binary maps (Figure 3), where positive contrast denoted the classes "inside" the pattern (meaning those classes were significantly associated with wildfire ignitions), while negative or null contrast denoted the classes "outside" the pattern (not associated with wildfire ignitions). The four generalized evidential layers were then combined to calculate a response theme representing posterior probability of an ignition based on binary

Figure 2.—CDF knowledge-driven model of fire threat, based upon historic fire extents and vegetation classification (adapted from CDF). Higher values indicate greater threat from fire events.



weights of evidence. The weights-of-evidence modeling process assumes that the evidence layers within the model are conditionally independent (CI) with respect to the training points. To test for the assumption of CI, a CI ratio and Agterberg and Cheng test were calculated using ArcSDM (Bonham-Carter 1994; Agterberg and Cheng 2002). The accuracy for the posterior probability map was validated by tallying the percentage of validation points that fell within the range of posterior probabilities that exceeded the prior probability.

The future-growth simulation model was created by generalizing the future-growth evidence layer into a binary map using contrast values derived from the current LULC contrast values, and a posterior probability map was calculated. Percent change between the current and future posterior probability maps was calculated to assess changes in wildfire-ignition risk based on future urban growth.

Finally, a hybrid model was created to incorporate the empirically derived Bayesian model with the expert knowledge integrated into fuzzy models. First, we compared the CDF expert threat model to our model using a Kappa coefficient statistic to determine the extent of spatial difference between the two assessments. We then combined our two models by assigning each risk level a numerical value (low = 1, extreme = 4) and creating a new overall fire risk map where the cell value equals the sum of the two model values. The final risk of fire based on whether a cell has a probability of igniting (empirical model) and then burning (deterministic model) was broken into four categories based on the final sums.

Results

Fire-ignition process

Since empirical models are often distrusted by fire managers and can be difficult to validate with a relatively infrequent occurrence such as a wildfire ignition, it is less meaningful to report probabilities of ignition than to report on and discuss the process by which fires ignite in the study region. The posterior probability maps produced by the weights-of-evidence model were reclassified into "Low," "Moderate," "High," and "Extreme" risk of ignition (Figure 4), based on the natural breaks above and below the prior probability of an ignition. The positive and negative correlation weights calculated for each evidence layer indicate that proximity to roads (C = 1.288) was the best predictor of where fire ignitions do occur (Table 1).

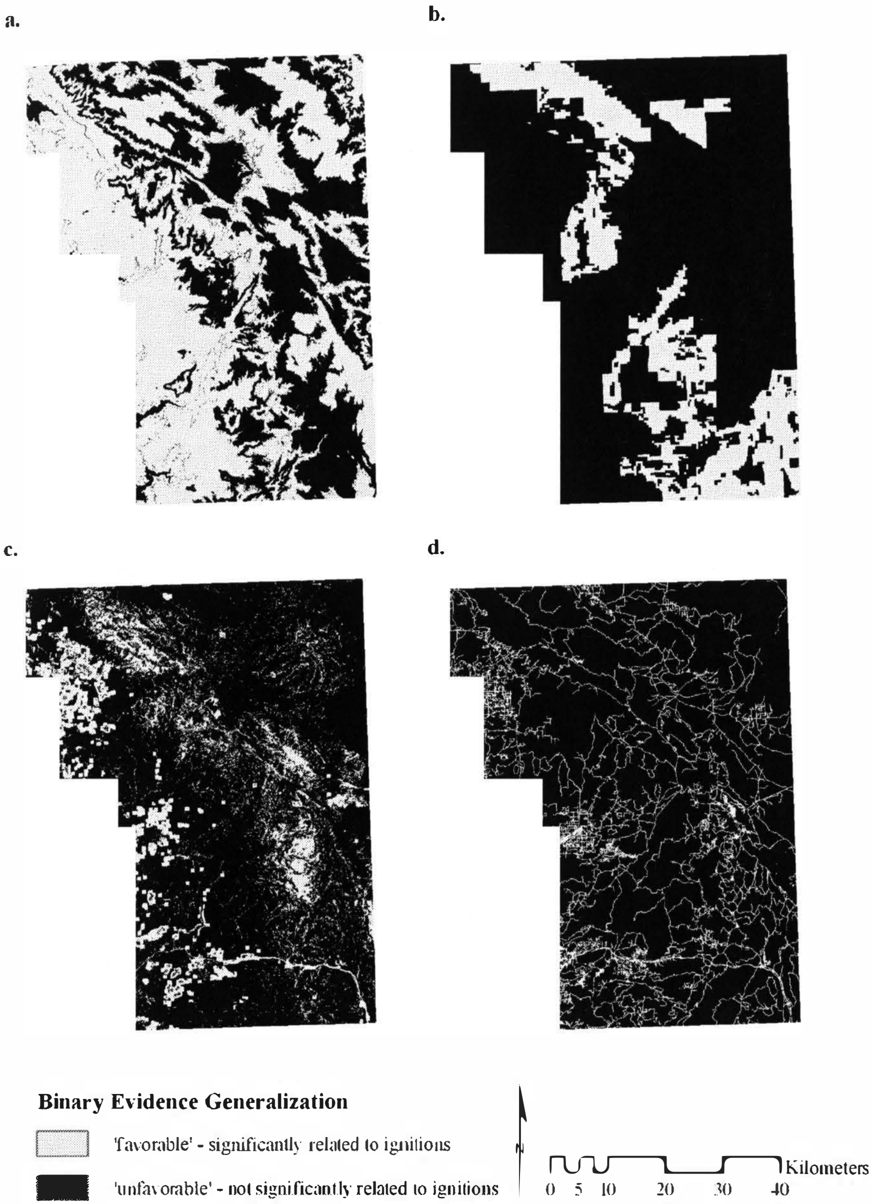


Figure 3.—Evidence layers generalized into "favorable" and "unfavorable" evidence, based upon maximized contrast values. a. Elevation, b. Ownership, c. Land Use Land Cover, d. Proximity to Roads. The binary patterns are then combined using Bayesian statistics to generate a posterior probability map, which indicates the unique combination of binary patterns and is the probability that a fire ignition will occur, given the presence of some favorable evidence.

Elevation was the worst predictor of fire-ignition occurrence (C = 0.069). In the validation assessment, 72 percent of the validation ignition points occurred in areas that were predicted at high or extreme ignition risk, the two classes where posterior probability values exceeded the prior probability.

Table 1. Weights, contrast, and confidence values for each evidential layer used in the weights-of-evidence model. The hypothesis of conditional independence can be accepted as expressed by a CI Ratio of 1.003 and an Agterberg & Cheng test of 48.3 percent. The contrast value indicates the strength of association between training points and evidence layers, with a high-contrast value indicating a strong predictive evidence layer. The confidence value is the StudC measure, which indicates the model's confidence that the contrast value is not zero. Confidence values ≥ 1.64 are operating at the 95 percent confidence interval ($a = 0.05$).

Training Points:	n = 128
Unit Area (Sq. m)	30
Prior Probability:	0.00003
Conditional Independence Ratio:	1.003
Agterberg & Cheng Test:	48.3%

Evidence	W^+	W^-	Contrast (C)	Confidence (StudC)
Proximity to Roads	1.0020	-0.2860	1.2882	6.9220
Land Use/Land Cover	0.4840	-0.1610	0.6442	3.3780
Ownership	0.41	-0.162	0.5718	3.0725
Elevation	0.0270	-0.0430	0.0690	0.3796

Future Growth Scenario Model

The percent change between the posterior probability maps for current fire-ignition risk and fire risk based on a future growth scenario indicated that 3 percent of the study area will see a decrease in fire-ignition risk, 87 percent will see no significant change in fire risk, and 10 percent will see an increase in fire-ignition risk (Figure 5). Development of high-density urban areas is associated with decreases in fire-ignition risk in this model, while development of

Figure 4.—Fire-ignition risk classified into four classes, based upon posterior probabilities for a fire ignition occurring given the presence of favorable evidence. Values classified as "High" or "Extreme" are most probabilistic for a fire ignition to occur. Values classified as "Low" or "Moderate" are less probabilistic for a fire ignition to occur.

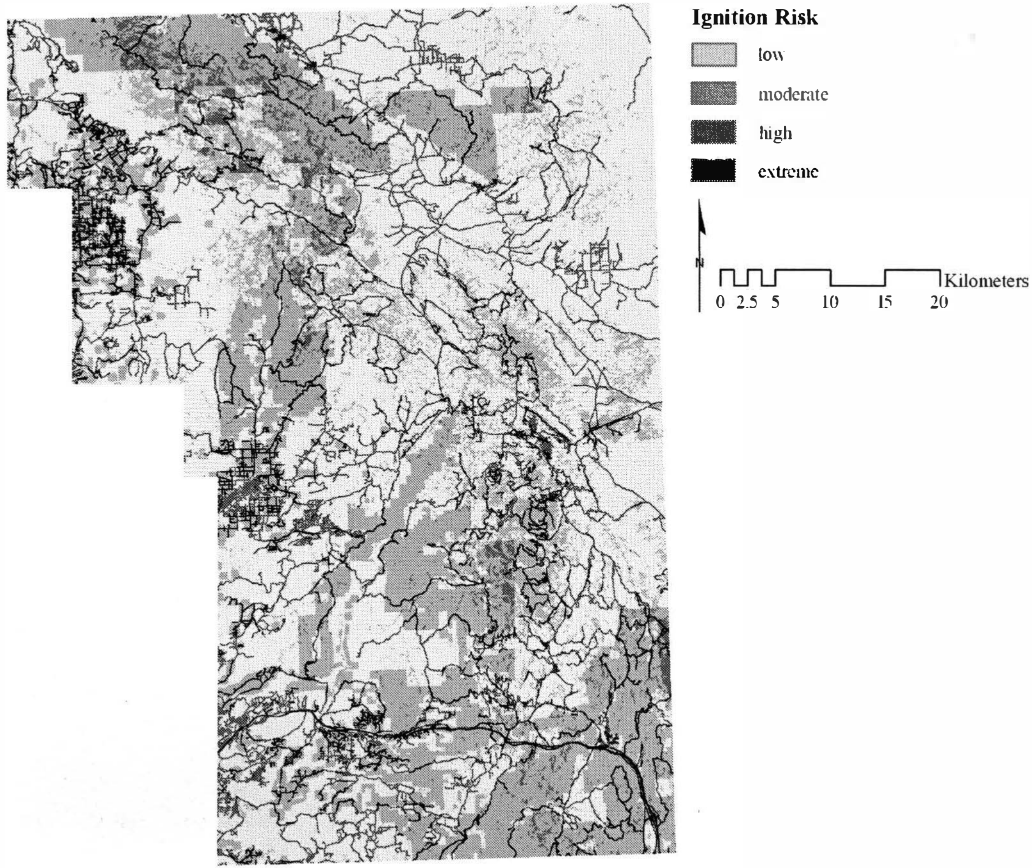
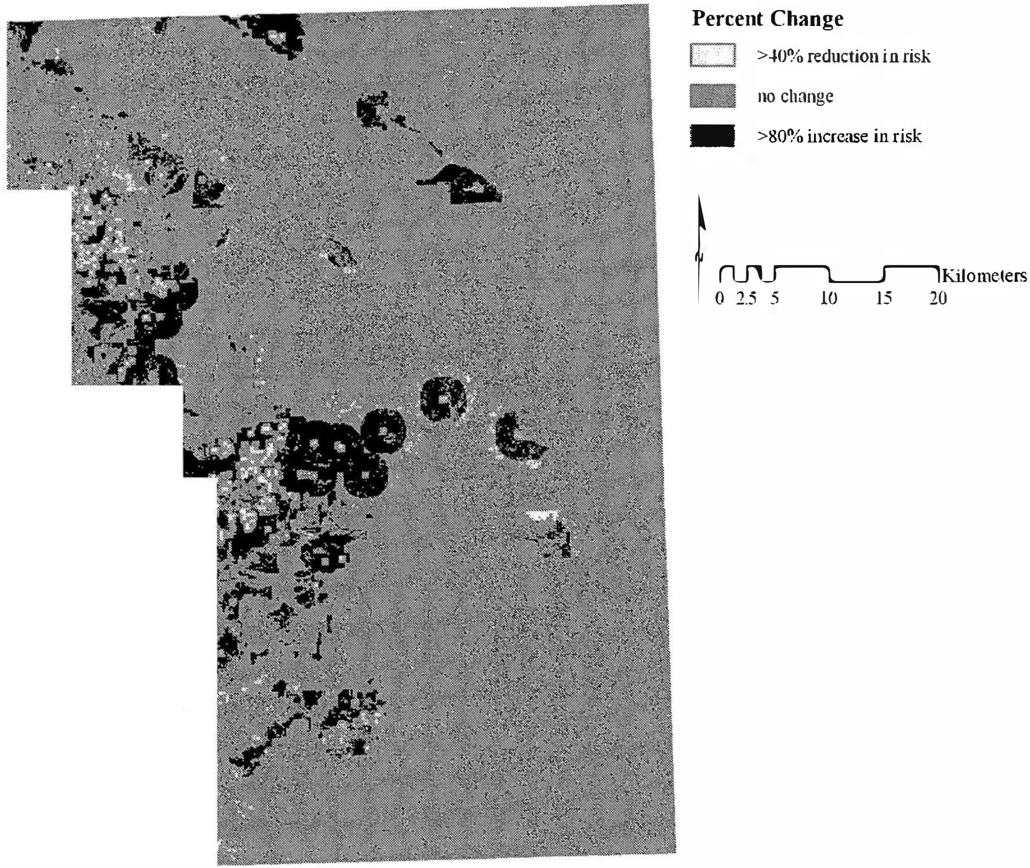


Figure 5.—Percent change in fire-ignition risk, based on a future growth scenario of 1 million new residents. Higher values indicate an increase in fire-ignition risk due to an expanding wildland urban interface. Lower values indicate a decrease in fire-ignition risk due to an increase in urbanization and unburnable areas.



rural residential areas (the WUI areas) is associated with increased probability of ignition.

Deterministic vs. Empirical Models

We found our two models to be significantly different (kappa = -0.029), which was to be expected given that CDF modeled fire threat was based primarily on potential fire behavior, while we modeled risk of ignition. Our hybrid approach, however, yielded a clearer picture of overall fire risk by taking into account both the likelihood of a fire ignition and the ability for the ignition to spread (Figure 6). For example, an area that was deemed high risk in the CDF threat model is not necessarily at high risk if there is no threat of an ignition occurring.

Discussion

Our objective in modeling fire-ignition risk with a Bayesian weights-of-evidence model was to statistically assess the process by which wildfire ignites in the study area, particularly given the high frequency of human-ignited fires. Other fire-risk models (particularly deterministic models) have utilized slope, aspect, and vegetation, three variables that determine fire behavior in the standard fire behavior models (Rothermel 1983). For the study area, however, we did not find significant correlations between these variables and fire ignitions. Instead, we found significant correlations between the fire ignitions and roads, land use/land cover, elevation, and land ownership. While we report on only 5 years of fire-ignition data, we found the same significant correlations between the evidential layers and 10 years of fire-ignition data. This indicates that for the study area, the biophysical factors have less influence in wildfire ignitions than human-environment characteristics (e.g., roads, land ownership, and land use). While the human-environment factors can be manipulated through regulation, education, construction, and other avenues, the biophysical elements are more difficult to control. For fire managers, understanding what human factors they need to focus on managing is critical to lowering the incidence of fire, and this model provides this focus through the weights produced.

To someone familiar with the area, simply looking at a map of fire-ignition density may reveal to the observer that fire ignitions in the area are primarily along major roads. The empirical model, however, defines quantitatively the strength of the correlation between roads and ignitions, and tells us how much stronger the roads correlation

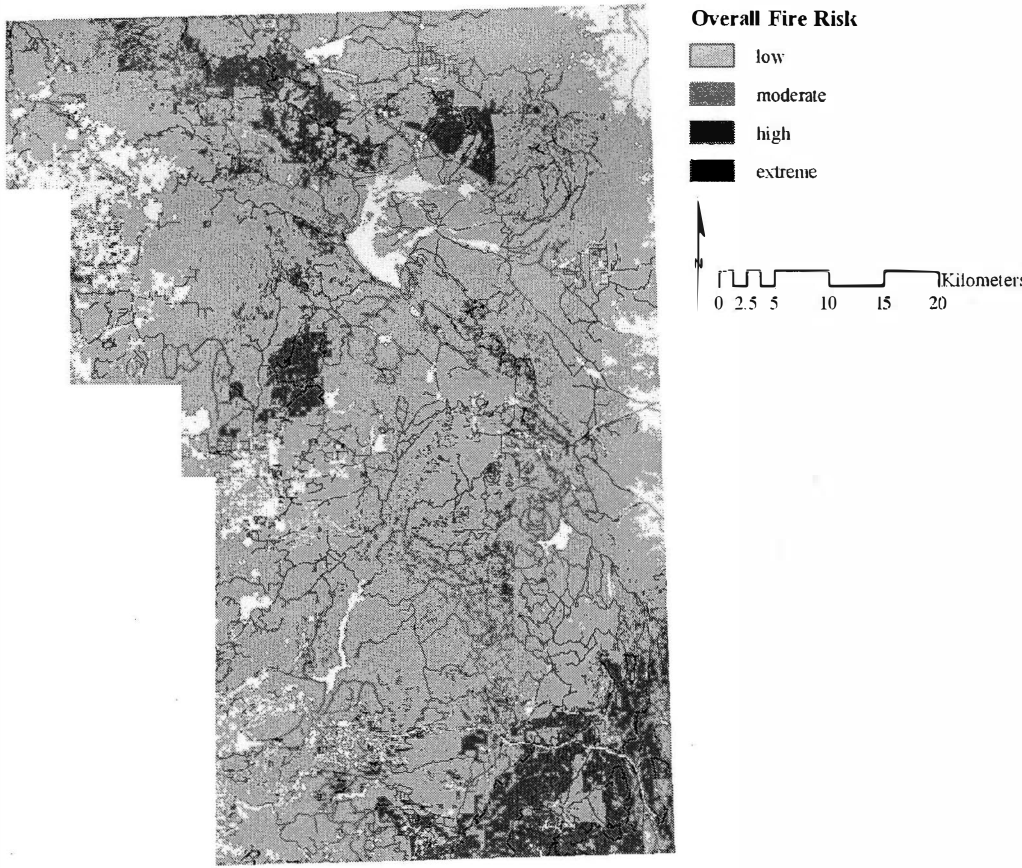


Figure 6.—Overall fire risk based on combining the expert CDF fire-threat model and the data-driven weights-of-evidence fire-ignition risk model. High values indicate areas that have a high probability of a fire ignition occurring and a high probability of a fire ignition spreading into a large fire. Low values indicate areas that have a low probability of a fire ignition occurring and a low probability of a fire ignition spreading into a large fire.

is than correlation to certain vegetation types, population densities, or elevations. Additionally, the posterior probabilities allow us to assess the percent changes in ignition risk associated with inevitable future development.

Beyond evaluating the risk for wildfire ignitions, the empirical model also allows us to assess the weaknesses of current methods for predicting wildfire hazard. Our training data set is one commonly used for fire research, but CDF still uses the somewhat-outdated method of locating ignitions in the exact center of a map section, making the dataset less accurate as a whole. We also questioned whether the reason so many ignitions occurred along roads was because GPS points or mile markers were taken at a fire truck sitting on the road somewhere near the actual fire.

Conclusion

Coupled with expert knowledge, weights-of-evidence and other empirical models can be an effective tool for fire-hazard management. Utilizing the weights-of-evidence tool within the Spatial Data Modeler extension for ArcGIS allows a user to create empirical models to evaluate and gain insight into processes that may not be fully understood, such as fire ignitions. For eastern San Diego County, the location of major roads was shown to be the primary determinant in fire-ignition occurrence. Limitations in weights-of-evidence models do occur and are dependent upon the data being used and the bias of the modeler. We were limited in our processing of these models by our training dataset obtained from the CDF.

Empirical models give us a way to assess future risk and help us to understand processes and mechanisms driving risk. They do not replace expert knowledge and deterministic models, and it would not be recommended to conduct modeling without insights from those individuals who understand the process best. Combining a fuzzy model with an empirical model in a hybrid fashion is an alternative way to infuse expert knowledge into the risk-modeling process. Overall, continued efforts to model the processes that produce fire risk in the first place can serve only to assist the fire-management community whose goal is to mitigate that risk.

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The Geographer's Viewpoint

Filling in the Blanks: Translating among Systematic Geographies

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Abstract

This article offers an approach to integrating systematic geographies by translating among them. First, a distinction is made between integration and synthesis, the former highlighting the relations among geographic subdisciplines, rather than an amalgamation of them. A matrix to be used in pursuit of this integration is then proposed and compared to other models of geographic integration and synthesis, namely region, place, landscape, and network. An in-depth discussion of the relational aspect of the model follows. The semiconductor is offered as a model of an individual relation between two subdisciplines. The concept of the parasite is then introduced as a metaphor for a wide range of human, biological, and physical actors that influence these relations. The article closes with a discussion of grammar that further expands the relational concept, particularly through the use of prepositions. Key concepts are adapted from the work of Michel Serres.

Integration

GEOGRAPHIC KNOWLEDGE as pursued via systematic investigation has never been more profound, but these subfields largely remain philosophically, methodologically, and institutionally separate, and in their isolation are limited in their power to explain geographical phenomena and processes in all of their complexity. The need to braid the subfields into a more interconnected form is currently well recognized (Cloke and Johnson 2005; Harrison et al. 2004; Gober 2004) and has been an ongoing debate within the discipline (see Freeman 1986; Goudie 1986; Graham 1986; Johnston 1986; and Taylor 1986 for one exchange). With both a growing need to understand the world in its complexity and the development of geographic information science, the call for geography to take an "integration turn" has never been clearer nor more answerable (Hoekstra 2005).

Systematic geographies that focus on culture or economics, on landforms or life-forms, are essential to the discipline and fascinating in their depth and detail, but they do not demonstrate the field's breadth and capacity for integration. The development of systematic investigation has moved the discipline from one primarily concerned with describing distinct geographic regions to one adept at theorizing distinct geographic processes. The idea of a distinct geographic process, however, is now recognized to be as problematic as the regional concept (Cloke and Johnson 2005). Economy, politics, society, and culture are perhaps more correctly understood as just aspects of human activity rather than as distinct activities in themselves. Buying a house, for example, has cultural, social, and political dimensions as well as economic ones. As for the natural environment, the lithosphere, hydrosphere, atmosphere, and biosphere may be more accurately characterized as interactive components of the physical world rather than independent processes (Wilkinson 2006). Additionally, all of these processes and interactions among them occur over time and are subject to technological intervention.

Geography has the capacity to contain these myriad functions and chart their mingling, by virtue of its variegated structure with space as its milieu. Within the discourse on nature-culture, it has begun to close the physical/human gap. Other epistemological gaps, such as that between culture and economy, need to be narrowed, however (Barnes 2005), while others should be made wider, such as that between culture and society (Gregson 1995). The practice of hyphenating these binaries into forms such as socio-cultural is more a surrender to the ambiguous or unknown relationship of the social to the cultural than it is a subtle expression of it. The intuition that produces these combinations is correct, but the hyphen needs to be both more informed and more informing, and wrought to fit the particular manifestations of the processes as they occur in specific periods and places (Serres 1995).

A common understanding of the creation of the European Union is that supranational integration is facilitated by each nation retaining its own distinct cultural and historical identity, secured in practices such as language, art, and tradition, and symbolized by sites and monuments. Once national identity is established and safeguarded, connections and concessions can then be made concerning contemporary economic, political, and social activities (Dinan 2004). This is hard to do because the processes are entangled, but it still seems possible to make useful and valid distinctions among them. Strong national cultures do complicate the process of building strong supranational cultures, however.

The project of integrating geography would benefit from similar distinctions being made among its subfields, because only then can the bridges between them be accurately and usefully modulated. For this reason, I prefer the word "integration" over "synthesis." An integration of geography calls for clear connections being made between distinct subfields to create an articulated epistemology, whereas synthesis implies a blurring of these distinctions to form an amalgamation. The discourse that problematizes the relationship between two ontological and epistemological spheres, nature and culture for example, is enlightening and useful, but perhaps the discussion of these binaries would be better served by cleaving and then explicitly reconnecting them (Puleo 2007).

An integrated approach differs from four synthesizing discourses in geography—region, place, landscape, and network—in its privileging of relations over phenomena or process. What follows is the briefest of commentaries on these four concepts, each of which has long embraced the task of synthesizing spatial data, to give just a slight indication of some past approaches.

The region was a central unit in a number of geographic projects including chorology, exploration and colonization, *terroir,* spatial science, and locational analysis. As such, it was always conceived as an object that was both partitional and aggregative. Regions were building blocks that could be divided or put together to make larger or smaller units (Gregory 2000). The synthesis of phenomena and processes within them was the mode of creating them, making the project one more of amalgamating an object (Hart 1982) rather than striking an informed and informing relation among processes. The various approaches to formulating and representing regions have been criticized for being incomplete, reductive, and biased, but the model persists because, as murky and riddled as they are on the ground, regions retain a firm grasp on the geographic imagination. We may not know exactly where Appalachia is, but we know without doubt that it exists and have at least some accurate ideas of what it is like, and describing it and other regions remains a valid and important project within the discipline (Gregory 2000).

A number of these difficulties found some resolution in the discourse on place in which subjective engagements with space (identity, attachment, meaning) were mated with more objective spatial understandings (Entrikin 1991), thereby pitching the concept somewhere between the two poles. Other approaches to the concept posited a three-part, multi-scalar model in which an intermediate realm of informal social interaction (locale) mediates the interaction between subjective engagement (sense of place) and geographical setting (location) (Agnew 1987).

Landscape interpretation underwent a similar expansion under the discipline's cultural turn. The standard approach of the 1950s developed by Carl Sauer relied upon the observation of surface artifacts to reconstruct histories of human impact. Innovative work on landscape conducted in the 1980s and '90s revised this method by considering the social, cultural, and political contexts of landscape representation as "a way of seeing" (Cosgrove 1984).

The network concept has been conceived as infrastructural, administrative, informational, and social linkages. It has been central to the globalization and supranational regionalization discourses, and yet the strands have been kept largely separate because of the philosophical, methodological, and institutional divides mentioned in the opening of this article. This separation is not without good reason, since a study of just one type of network is a daunting task in itself; the braiding of the various streams overwhelms most theoretical approaches. Nevertheless, some theoretical gains have been made in hybridizing products and activities such as the cultural and the economic (Barnes 2005; Cresswell 1996). Conceptual binaries such as culture-economy offer some promise as dynamic units that can be further combined to form a larger complex. To do this, some kind of fertile structure is needed, some kind of matrix.

Matrix

Matrix is a marvelous word that is a core concept in several academic disciplines: anatomy, biochemistry, botany, computer science, electronics, geomorphology, logic, mathematics, photography, and recording, to name most of them. Originally it denoted a female domesticated animal to be used for breeding. I use it to mean not a theoretical framework but a way of holding multiple geographical processes in relation to each other. It does not provide content, only shape. Therefore it is compatible with any theoretical perspective and ideally calls for the use of multiple theories to explain each relationship between a pair of functions such as culture and politics, economy and land, water and biosphere, and so on. As a means of spatially organizing data, spreadsheets are useful but may be too rigid and constraining in the early stages of an investigation. Their use dampers the observer's intuition, curiosity, and naïveté: faculties from which the most inventive and original insights spring (Serres 1995).

Brian Berry's seminal "geographical matrix" is one such spreadsheet that uses rows to log places and columns to note phenomena (Berry 1964). Once a matrix is complete, the area can be studied in two ways. Looking across a phenomenon row would indicate spatial variation; this could be mapped. Looking down a place column would reveal a spatial association; this could be synthesized. Each spread sheet would represent a particular slice of time, so that a series of such spread sheets could be used to capture temporal variation to imbue the spatial variation with historicity (Berry 1964). This method was a response to the overwhelming task of organizing the massive amount of detail that is gathered even in a single glance. The synthesizing process was left unspecified and, as with all spatial analytic methods, there was no accounting for subjectivity.

Spider diagrams are more flexible. The combination of circles, lines, and words is directional yet flexible. I start every investigation by using one, move later to spreadsheets, and then later still move to a word-processing program to type out a more-detailed outline. The geographical matrix is a more rigid kind of spider diagram that also has built in geographic prompts that facilitate a methodical approach. Without the prompts, it would be possible to overlook a particular process that may not be immediately or strongly evident. Data and other thoughts about the place or event under investigation is not limited to on-site observation but can be derived from any source. Much of its design is derived from Nevin Fenneman's concept of geography cited earlier (Fenneman 1919). By using the framework of matrix-spreadsheet-word processing program, the move from phenomena to observations to words is done gradually so that a clear focus is maintained on the relations among geographic functions. Bruno Latour describes the step-by-step practice of science in a similar way of transforming places into sentences and data sets, one which he describes as being characterized by doubts, difficulties, and compromises (Latour 1999).

The matrix proposed here contains 10 functions that represent common disciplinary subfields: economy, politics, society, culture, history, land, water, atmosphere, biosphere, and technology (Figure 1). Geographic phenomena and processes such as cities and agriculture are compounds of these functions. An investigator selects the functions needed to investigate a particular place or event and

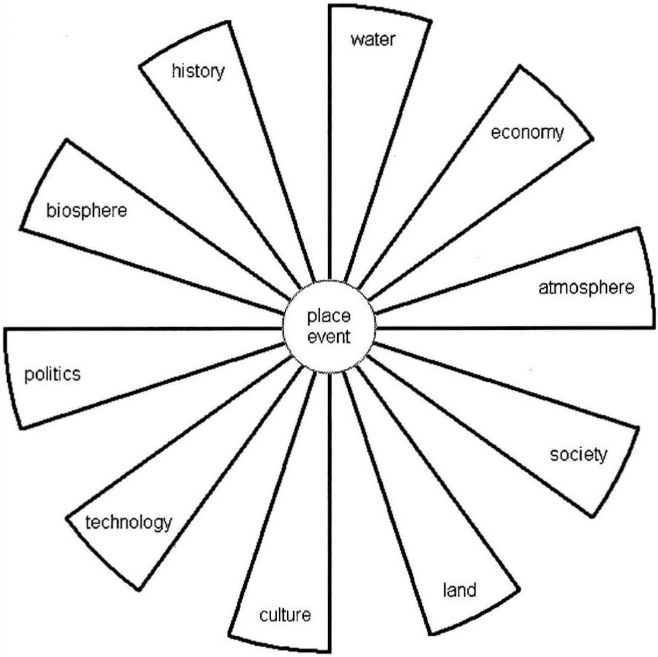

Figure 1.—A 10-function, integrating geographical matrix, for place/event investigation.

connects them in a way that leads to the best explanation of and story about the thing in question. A total of 45 functional pairs are possible: economy and water, economy and politics, and so on, eliminating the identical (economy and economy) and repeating (economy and politics, politics and economy) pairs. Not all of the components have to be used—only those that are relevant to the study. Function definitions are variable according to the philosophical, methodological, and theoretical formation and needs of the investigator.

It is not only the multiplicity of functions that allows for a fuller and more-accurate investigation, but also the multiplicity of ways that these different functions can be held in relationship to each other. The arrangement of the functional data in the circular format of the matrix allows for the random movements made by the observer in response to the complex demands of geographic integration (Serres 1995). A place or event does not unfold linearly; functions must be visited repeatedly and intermittently as one function responds to another.

The ordering of the functions is determined not only by the observed features of the place or event but also by the subjectivity of the observer. The sequence can be constructed chronologically, listing the function that had initial impact, followed by subsequent functional reactions and interventions. Or it can be designed hierarchically, with the strongest function listed first and weaker or dependent functions following. Sometimes, within the sequence, it is impossible, undesirable, or unjustifiable to fix an exact sequence of functions. This ambiguity is expressed in the non-hierarchical grouping of the functions in the sequence and in the analysis and discussion about it. These decisions rely at least partly upon the independent judgment of the observer.

Relations

Serres often expresses his integrative perspective using geographical metaphors. The crossing of disciplinary boundaries, if not their erasure, is at the core of his thinking. His fundamental stance is that the world is a chaos and that any discernible patterns are rare exceptions. Synthesis, whether mental or material, is fragile and fleeting, relative to the general noise and confusion of the world. He describes knowledge as randomly appearing islands in a vast and unknown sea or to flames that dance before his eyes. To connect these forms of knowledge, the investigator must move with swiftness, intuition, and freedom. He likens the process to Hermes flying from place to place, to an explorer making his way through the tortuous Northwest Passage, or to a fly buzzing in a seemingly crazy pattern but in truth responding to its own internal logic and the specific features of its environment (Serres 1995).

Relations are all-important for Serres. He evokes mathematics as a sublime model that works equally well when applied to human as well as physical interactions. Quite understandably, he finds geometry and topology to be particularly useful in the study of the relationships of human and physical spatial phenomena. They offer a space of relations without numbers, however. For Serres, numbers are just markers of relations, like a rugby ball that is passed from player to player, tracing the invisible connection among them. The relations make the game and move the players; the ball is just a token on the game board. It lets the observer keep track of the activities on the field. The adept player is the one who sees the connections forming ahead of him, understands how to make them, and then makes them successfully. As in rugby, the connections among players are oblique and difficult to follow, as they are by their very nature completed with feints and bluffs, and in an atmosphere of movement and chaos where signals are communicated with difficulty. This noise, however, is as much a part of the game as are the plays and players. The explication of these complex relations is the purpose of science and art, which he holds as identical ways of knowing that have been foolishly separated. The task of scholars is to put them back together (Serres 1995).

My own experience offers a simpler example. Beginning in the early 1990s and through to the early 2000s, I worked in property management and redevelopment in San Francisco. My understanding of how places are made, humanly and physically, is strongly influenced by what I observed while engaged in this work. Every project of making or remaking a place was a navigation or negotiation of multiple processes. Economic factors were important, but they were not always decisive and never did they act alone. Historical identity, political goals, cultural meaning, and social organization often had a say, and these various processes rarely combined in the same way twice. The same was true for physical processes. Fault lines, underground streams, microclimates, pigeons, and the technology that exists to deal with them, not to mention their intersections with human factors, all mattered in ways that were particular to every project. Sometimes a venture would fail, and it would always develop in unexpected and unintended ways. Each place was always a product of a particular arrangement of multiple processes, so using a single systematic approach or focusing on only one feature such as capital, identity, weather, or terrain could never yield a complete and accurate description and understanding of its development. These experiences have led me to value geography as the use of multiple systems to understand a particular place, rather than as the use of particular places, to understand a single system.

Semiconductors

If we accept this model of geography as one of subdisciplines that are characterized by varying ontologies and epistemologies that are related in some way, the next step is to understand the nature of these relations. One metaphor that Serres offers is that of the semiconductor (Serres 1995).

A semiconductor is a nonmetal solid material, commonly silicon, which has the capacity to act as either a conductor or as an insulator depending on its intrinsic or extrinsic condition. Two factors can change this condition: heat and impurity. In an intrinsic semiconductor, there is a narrow gap between the valence (insulating) and conductive bands in the material's crystal lattice. When the semiconductor is thermally excited, electrons gather enough energy to leap the gap between the valence and conductive bands and conduct either heat or electricity. In an extrinsic semiconductor, the conductive process is facilitated by the introduction of an impurity into the semiconductor material's crystal lattice. This impurity permanently narrows the gap between the bands and increases the semiconductor's conductivity. This process is called doping, and it allows the conductive capacity of semiconductor material to be changed permanently via an external means, or extrinsically. A semiconductor that has been overly doped to the point where it is almost always a conductor, even at room temperature, is called a degenerate (Yu and Cardona 2005). This use of human metaphors to describe an engineering concept shows how mixing across disciplines already exists.

As a metaphor for the relation between two geographical processes, the semiconductor has rich potential. Let us take as an example the relation between land and economy. If land is infertile, it cannot be used to grow crops that could support a population. One could say that the relation between land and economy is very much in its insulating mode, as there is no positive dynamic between the two systems. (Alternatively, you could say that the infertile land positively prohibited the raising of crops and was therefore in a conductive mode, but this would be an atypical human perspective.) Some factor would have to be introduced to change the relation from insulating to conductive; something would have to heat up or contaminate it somehow. Something or someone would have to act upon the relation to change its state. What could that be? Serres switches disciplines, moving from electrical engineering to biology to provide an answer: the parasite (Serres 1995).

Parasites

In French and other romance languages, a parasite has three forms: social, biological, and physical. The first two forms are the same as in English: the social parasite is someone who takes something for nothing; he invites himself to dinner and does not bring a bottle of wine. He thinks his own noisy company is payment enough. Similarly, a biological parasite invades its host's body. It derives nourishment from the host and gives nothing in return. Often it hurts the host (but does not kill it) or changes the way it functions, so that it derives the greatest possible flow of nourishment (Combes 2005). The third type of parasite is unknown in English; this is the physical kind: static, noise. If the static on a cell phone connection interrupts the conversation, it is a parasite. This meaning exists in English in the sense that a computer can become infected with a virus, or more colloquially and generally, there can be a "bug in the system." But in French, *le parasite* is all three: social, biological, and physical, and it attacks in three ways—by bankrupting, interrupting, or corrupting its host. This is "the logic of the parasite": analyze (take without giving), paralyze (stop the host from functioning), catalyze (cause the host to act differently) (Brown 2002).

But what does the parasite have to do with the semiconductor? The parasite, says Serres, is "nested on the relation (Serres 2007)." If the relationship is a semiconductor, it is sensitive to heat and contaminants: heat on and the electrons pass; heat off and they are kept isolated. Dope the material and the message passes along the wire. Parasites are thermal exciters and polluters. As biological infections, they cause fever. As talky guests at the dinner table, they warm the host with their charm. They are also catalysts, agents that facilitate a reaction. Parasites, in nature as in society, are clever, inventive, and dynamic. They find the gap and fill it. They make the connection.

Back to our fallow field: it is not dynamic, nothing grows in it and it does not support a population. Someone, a parasite, finds ore or oil there, which can now be traded for food. Or perhaps it is fallow because it is contaminated by hazardous waste. One kind of microbe might be able to metabolize that waste. Perhaps there is no water; the parasite builds an aqueduct. The parasite is the third element that causes the relation, and which is the relation, between land and economy that did not exist before. It is inventive. It sees opportunity where others see failure (Serres 2007).

Grammar

So far we have a mixed model of a relation—the semiconductor—and of an agent that causes this relation to turn on and off—the parasite. But we are probably correct in assuming that the relations among diverse subdisciplines will also be diverse. Just as parasites are adapted to specific organs in their hosts' bodies—the heart, the brain, the gills—so too are the relations among various subdisciplines and the parasites that create and influence them. To address this variability, Serres goes to another discipline: linguistics.

"Between" is an important word for Serres (1995), as is for Entrikin in his discussion of place, and more obliquely for Agnew and Cosgrove, who emphasize the role of mediation and imagination in geographic construction and perception in their conceptualizations of place and landscape. The part of speech that serves this mediating function in language is the preposition. Like parasites, they are highly specific to their environment. When used in a sentence, the prepositions "to," "at," and "for," for example, have different meanings, depending on the words and phrases that they mediate. And they radically change the relationship among subject, verb, and object. Did you speak to, at, or for him? Deceptively small, prepositions serve as vital, variable, definitive, and content-rich links among the parts of a sentence.

They would be similarly effective as links between two geographic subdisciplines, as well as between geographic binaries in a chronological or hierarchical explanation of a particular phenomenon or process. The preposition forms the relation that translates between single functions (culture-economy) as well as linked binaries (culture-society—land-economy). By informing the hyphen that links the single or paired functions, one constructs an outline that can then be turned into a narrative that is held together not by a mute hyphen, but by an informative preposition. There are approximately 150 prepositions in English, allowing for a rich and promising number of configurations of geographic phenomenon and process.

An Example: The Drought in Southeastern Australia

I end with a brief application of the approach I have just described. Under investigation is the drought in Australia's Murray-Darling Basin, as described in a brief newspaper article (Marks 2007). It is an event that is common to California and an increasing number of places in the world, due to increasing population and climate change.

Immediately apparent is that even a 1,139-word article produces a bewildering collection of observations that can be combined in an unlimited variety of ways. The sequence that an investigator adopts depends on the question asked, but even then the permutations of the data are unlimited because one reaction always leads to another until either the end of time or the collapse of space, neither of which seems imminent. But there is still much to be derived from the exercise, because the goal is not an exhaustive and definitive geographical history of the drought, which is impossible, but the successful linking of functions in their particular detail and within a given sequence.

For example, if we decide to order the functions as atmosphere-water-land-biogeography-economy-technology-history-politics-culture-society, we could offer the following explanation of the drought: Less rain led to a reduction in groundwater, which made the land less fertile. The resulting decrease in agricultural productivity has historically been mitigated by irrigation, but unprecedented conditions require new water-management policies. Australia's then-prime minister John Howard has offered only words of encouragement, however. Land, livelihoods, and hope are being lost and people are killing themselves because of it.

Space does not permit the construction of a more-complex model of linked binaries, but simply by making pairs within the sequence of single functions, one can easily construct a more-complex and accurate scenario.

The sequence begins with atmosphere and ends with society, but the argument being made is not deterministic, even given a linear sequence. The effects are contingent and depend upon the particular time and space characteristics of the drought. These contingencies would be more apparent in a model that would extend both linearly, preceding atmosphere and following society, and laterally with offshoots that intersected and informed the sequence, turning it from a one-dimensional line into a two-dimensional model.

Particularly interesting is the fact that climate change is now occurring so quickly that it is easily perceptible within a single lifetime or even a few years; climate now changes over time in addition to changing over space. Such a development moves a discussion of any relationship between climate and society away from the environmental determinist and colonial discourses and toward an investigation of climatic and social changes as they occur within the same population and in the same place as they are mediated by other processes over a short period of time.

Does culture come before or after politics? Maybe culture exists around politics, and not only politics but also economy and society, as well as physical processes, seeping into the interstices, rooting in the cracks? Or might it be economy or politics, or a concatenation of processes that holds this position? Is geomorphology underneath it all? Is climate above everything? Does hydrology run through not only soil, but society and culture as well? Is water, which may become more precious than oil, simply in everything? Is it not already? We use prepositions to indicate relations. Any theory of relations must take serious note of them.

Closing Thoughts

Single-function geographies are excellent for making the theoretical tools that have raised the practice of geography up from mere description. Geographies of economy, politics, society, culture, and history, and those that focus on land, water, climate, life-forms, and technology, are sciences in themselves. But in addition to further deepening our understanding of these processes, it would be useful to start linking them back together again to accurately represent and interpret the complexity of a particular phenomenon or process.

Theories about human-environment interaction are very useful, but they can go only so far in describing and explaining particular situations. The constitutive processes of a place or event are specific, and any data reflects this particularity even though it may conform to a general type. A theoretical framework that is built in response to the needs of particular data, and which is a synthesis of multiple functions, will always be a more-nuanced and accurate representation of a phenomenon than one based on just one function, such as economics, culture, or climate alone.

The matrix provides a snapshot overview of the discipline's scope and method, or at least one conception of it. A discussion of the relation between each set of subdisciplines is described, interpreted, and integrated into a single geographical study. The result is an investigation that smoothes systematic data born of distinct epistemologies into a vernacular study that benefits from its wide embrace of related functions. Such a model enhances the narrative of geography as conceptually rich, uniquely integrative, and easily applicable. The integration of geography is an extremely complex but endlessly fascinating project, and one with a long tradition in the discipline. I intend this article as one very small contribution to the task.

Finally, I owe the inspiration of this idea to the brilliant work of Michel Serres, a true genius in the field of integrated study.

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Geographic Chronicles

2007 Conference Report: Anza-Borrego Desert State Park

Over the weekend of March 16–18, 2007, approximately 270 geographers from across the state and beyond gathered at the Palm Canyon Resort in Borrego Springs for the 61st Annual Conference of the California Geographical Society. It was a quintessential desert weekend, with hot, sunny days; warm, star-filled nights; and spectacular landscapes as far as the eye could see. By all accounts, the event was a huge success—and another precedent-setting conference for the CGS. The conference drew attendees from over 50 different colleges, universities, and other organizations, including two students from Fairbanks, Alaska!

On Friday, the conference kicked off with a diverse slate of field trips including an all-day hike to the historic Calcite Mine, an all-day tour of the Salton Sea and Imperial Valley Waterworks, an excursion into the Borrego Badlands, a historic tour of "Old Borego," and a late-afternoon hike into Borrego Palm Canyon, where a dozen Peninsular bighorn sheep made a rare appearance for the group. On Friday evening, 180 attendees enjoyed a relaxing barbecue, followed by an engaging conversation with Park Superintendent Mark Jorgensen. His stories, slides, and anecdotes from over 30 years of living and working in the Anza-Borrego Desert filled the amphitheater with laughter, camaraderie, and geographic inspiration for all.

Immediately following the Friday keynote, astronomer Brian Jennings dazzled a crowd of 50 participants with spectacular views of planets, moons, galaxies, star clusters, and nebulae through his many telescopes pointed into the vast desert night sky.

On Saturday, concurrent paper, poster, and map sessions kicked off the morning with diverse geographic topics spanning the human-physical continuum. The student competition saw another excellent field of graduate and undergraduate entries, and the Presidential Plenary speaker, Dydia DeLyser, enthralled a standing room-only crowd with her presentation on the geographical significance of Helen Hunt Jackson's 1884 novel, *Ramona*. Dydia brought to life the "Ramona" experience and its significance in shaping the southern California landscape and psyche. The towns, street names, businesses, and tourist destinations that bear the "Ramona" namesake will carry a whole new significance after Dydia's fascinating talk.

Saturday afternoon finished off with several workshops and a well-attended panel discussion on jobs in geography. Nearly 200 people attended the Saturday banquet dinner, where over $2,000 in scholarships and awards were given to both graduate and undergraduate students for their academic achievements and for excellent paper, poster, and map presentations. Certificates of appreciation were awarded to major sponsors (Cuyamaca College & Foundation, Anza-Borrego Desert State Park, and the Anza-Borrego Foundation & Institute), field trip leaders (Herschel Stern, Bruce Seivertson, Reena Deutsch, Joe Hopkins, Phil Brigandi, Phil Pryde, Don Barrie, and Christa Stutz), and the many people who helped behind the scenes to make this conference a reality.

Sunday rounded out the weekend with four additional field trips, including a birding and natural history walk, a tour of earthquake faults and hot springs, a return trip to San Diego via the Julian Gold and Wine Country, and a hike to the Maidenhair Falls oasis. I received many positive e-mails in the two weeks following the conference, with many remarks thanking me for another great

CGS experience. The real thanks goes out to all of the people who helped me over the many months of preparation leading up to the conference. In particular, I'd like to thank outgoing CGS President John Aubert and the entire CGS Board; Nancy Perry, my assistant and organizer extraordinaire; and all of you who shared in this memorable experience. I look forward to many more great CGS conferences in the years to come. See you next year in Chico!

Michael Wangler
2007 CGS Conference Coordinator

California Geographical Society Award Winners 2007

DAVID LANTIS SCHOLARSHIP AWARDS

GRADUATE AWARDS ($500):

Daniel Hermstad, San Francisco State University
Amy Marie McGrann, UC Davis

GEOSYSTEMS AWARD ($250)

Kathy Dicker, Humboldt State University
Shake Rattle n' Roll: Perceptions of Seismic Hazards on the Humboldt Sate University Campus; Are Students Prepared?

TOM MCKNIGHT PROFESSIONAL PAPER AWARDS

Undergraduate Papers

FIRST PLACE ($125):

Lorna Apper, UCLA
California Native Grass Cultivation, Restoration and Distribution in Los Angeles County

SECOND PLACE ($100):

Myles Shuler, USC
Effective Oil Cleanup

THIRD PLACE ($75):

Krista McCarty, USC
Factors Influencing the Distribution of the Pisonia Forest on Heron Island, Australia

Graduate Papers

FIRST PLACE ($125):

Zia Salim, CSU Fullerton
Impacts of Downtown Revitalization of the Homeless: Skid Row, Los Angeles

SECOND PLACE ($100):

Brian W. Dunbar, CSU Northridge
Occupational and Residential Trajectories of Zapotec Immigrants in Los Angeles

THIRD PLACE ($75):

Cameran Ashraf, CSU Fullerton
The Impact of Policy on Light Pollution: A Comparison of Palm Springs and Flagstaff

JOE BEATON PROFESSIONAL POSTER

FIRST PLACE ($125):

Rachel Yuriko Noelani Yukimura, USC
Comparing Human and Elephant Damage to Woody Vegetation in the Ololorashi-olulugui Group Ranch, Kenya

SECOND PLACE ($100):

Mario Landa, CSU Fullerton
South and Southeast Mexico: National Policy, Social Uprising and Deforestation

THIRD PLACE ($75):

Aaron Benavidez, Cosumnes River College
The Sun Never Sets on a Red Light District: Is Globalization Exacerbating the Sex Trade in Thailand and Abroad?

PROFESSIONAL PAPER CARTOGRAPHIC

FIRST PLACE ($125):

Simon Wright, CSU Long Beach
Japan's Tectonic Hazards

SECOND PLACE ($100):

Cesar Espinosa, CSU Long Beach
Strategic Mobility 21—An ArcIMS Advanced Logistics Project

THIRD PLACE ($75):

Gareth T. Erhart, Effie Kokrine Charter School (Fairbanks, AK)
Dog Mushing Routes in Fairbanks, Alaska

PROFESSIONAL COMPUTER DISPLAYED CARTOGRAPHIC

FIRST PLACE ($125):

Sylvana Cares, CSU Chico
Ernesto Che Cuevara's Tour Through South America

SECOND PLACE ($100):

Aaron R. Salles, Humboldt State University
Mapping Population in China

THIRD PLACE ($75):

Kristin Schoenborn, Cosumnes River College
Fires in Sequoia and Kings Canyon National Park

STUDENT TRAVEL AWARDS ($150)

Mario Landa, CSU Fullerton
Kristin Schoenborn, Cosumnes River College
Jamie D. Stern, USC
Simon Wright, CSU Long Beach

SPECIAL AWARDS

Outstanding Educator Award:
Chris Haynes, Humboldt State University

Distinguished Teaching Awards:
Pamela Stephenson, Cram Elementary School
Nicole Young, Beattie Middle School

Friend of Geography Award:
Marcia Fagan, Principal, Kimberly Elementary School

Distinguished Service Award:
Mike Murphy, Gettysburg Elementary School

Special Thanks to 2007 Awards Banquet Photographer:
Robert O'Keefe, CSU Northridge

Special Thanks to 2007 Conference Organizer:
Michael Wangler, Cuyamaca College

Book Review

Seeing Through Maps: Many Ways to See the World

Denis Wood, Ward L. Kaiser, and Bob Abramms. Seeing Through Maps: Many Ways to See the World. *Amherst, MA: ODT, Inc. 2nd Edition, 2006. 152 pp. +viii, illustrations, index. $24.95.*

Reviewed by Ralph K. Allen, Jr., Nine Mile Falls, WA.

In my current occupation as a healthcare administrator, it is readily apparent that employee diversity is becoming the norm not only in terms of language, custom, and territorial experience, but also in numerous instances where interpretation of directions can lead to significant "events" or "occurrences."

This observation regarding the healthcare environment is not so very foreign to educators and business concerns. In context, administrators of healthcare institutions, as well as in-class or business teachers/leaders, have few good tools with which to quickly educate the workforce on this often subtle world of perception. Typically we hire and/or train based upon generalizations we have derived over time, and we fail to gauge the variations of ability presented to us as individuals or as whole classes.

One of the many, many "Ah-hahs!" I recognized in reviewing this most entertaining and pertinent volume (*Seeing Through Maps: Many Ways to See the World*, by Denis Wood, Ward L. Kaiser, and Bob Abramms) was the book's wide-range of applicability. I found that the information and examples contained throughout the eight chapters could be applied to many situations, not singularly limited to the notion of map construction or interpretation. Clearly this is the basic intent of the book, but I suggest it has great value to the whole dynamic of geographic interpretation. It would make a terrific secondary read for courses in urban, cultural, historical, political, and economic geography or their special derivatives such as urban planning or the geography of war and peace.

Having a set of neutral "mapped" materials to introduce the nature of diversity makes the effort to demonstrate such concepts much easier through discussion of, for instance, the shapes of counties, countries, and continents rather than relying on language or skin color as major factors alone. Everyone has a personal perception of what a map is and what it might be used for. It becomes an excellent metaphor for considering the variations of human territorial expression and what might happen as a function of such perceptions.

As teachers, are we not truly trying to equip students with tools and techniques for dealing with the nonacademic life in which we are all participants? Engaging our students or workers in discussion of perception and diversity can lead to enrichment of all of us and give each of us new approaches from which, it is hoped, better and more constructive decisions can be made.

Wood, et. al present questions, probe perceptions, explore possibilities, describe nuances and changes over time, and project outcomes based upon the significance of the reasons for making maps in the first place. Chapter One explores the notion of "Multiple Myths of the Mappable World" and entreats the reader to understand that the quality of the map is a function of its (the map's) intent. Basic map-related definitions are laid out and crisp examples and illustrations provide pointed instruction.

In Chapter Two, "The Many Ways of Making Maps" clearly demonstrates that "The value of the map is the degree to which it serves its purpose" (p. 13). Introducing projections with illustrations derived from flattening orange peels to obtain representation of round objects on flat surfaces , the text leads logically into a discussion of the notions of true shape (conformal), true area (equivalence), and true distance (equidistance). A significant section of this chapter examines the uses and misuses of Mercator's projection and the historic significance of Mercator's navigational intent being misused for so many years as a basic teaching aid.

In diversity education one can use this analogy as a way to introduce the misuse of color or geographic origin as considerations of ability or perceived intelligence. Mercator's intent as a regional navigation aid certainly has been misused in placing wall maps in school rooms for generations—and giving students, then, the misguided impressions of size, shape, and relationships among and within countries so presented.

On pages 26 and 27, readers are confronted with two striking examples of world maps. Here the Hobo-Dyer cylindrical, equal-area projection is presented in a "typical" Africa-centered fashion on one page, while on the facing page, the same projection is centered on the Pacific Ocean, with the cardinal direction of South being on the top of the page.

Both maps contain the same information, but the perception and interpretation potential are genuinely different.

Chapter Three ("Unpacking Maps") introduces the reader to further aspects of projections and provides five questions to ask of any (world, typically) map projection to ascertain its usability or purpose. The five questions regard notions of continuity or interruptedness, shape, arrangement of continents, the graticule's properties of parallelism or curvature, and the angular properties of the parallels and meridians. Again, the healthy use of illustrations, properly placed in text, makes the book's points immediately understandable.

Chapter Four ("Three Popular Compromise Projections") focuses our attention on three different projections (the Van der Grinten, Robinson, and Winkel-Tripel) and the notion of shape preservation and presentation. Additionally, it mentions a host of other styles of maps and briefly describes attributes inherent to them. Uses of such maps are given and descriptions are accompanied by clear examples.

Chapter Five ("Pushing the Boundary of the Map") provides some extremes to the nominal notion of what a map is. Here we are shown Minard's map of Napoleon's Russian campaign as a graphic demonstrating temperature variation, route taken, and numbers of men lost during the campaign. We are also shown the world as reflected daylight, cloud cover interference, photographic-like images of the world, slave routes, cartograms, and other unique presentations—again, all to expand on the book's basic theme of instruction as to the nature and purpose of map creation and information presentation.

In Chapter Six ("The Power of Images"), the reader is guided through practical examples of image projection and interpretation using Christopher Columbus's voyages and perceptions of the world. This demonstrates how striking our impressions can be when we attempt to view the world in anything but our own mind's eye. Like Columbus, we have deep-rooted notions that at times heavily filter our ability to make good decisions or plans. We see this a great deal when we try to make generalizations about individual others based on our personal understanding of a foreign place.

Chapter Seven ("Seeing Through Maps") makes an analogy with our eyes: how we see things and interpret what we see. The authors make convincing points regarding the specific uses to which we put maps and why it is important to view (and study) each map from various perspectives in order to obtain the best results from the presented view. Again, like our analogy with diversity training, we need to be able to use people's resources with an understanding of why they do the things they do and how we can overcome or alter selected behaviors that we see and need or wish to change.

Chapter Eight ("Are Maps TALK Instead of Pictures?") wraps the text in a summary note that presents the authors' notions of maps as something more akin to talk rather than pictures. Their argument is that a map is really a proposition or statement about something. It has properties that make it picture-like, but not a picture. At the same time, a map can present an argument that could be stated or written rather than presented spatially as a map. They offer this as a way of encouraging more thought and design in both the presentation of mapped information and the interpretation of our earth on paper.

One of the beauties of this volume is that it provides not only the teacher/student but also the leader/participant (be it business, government, or nonprofit organization) with a dynamic way to deal with human resource development and diversity training.

Appendix A shows how the use of the Peter's projection characteristics can be used in leadership training at many different levels and for many different purposes. This is wonderful for those of us who have been educated as geographers but find ourselves in other occupations where our geographic backgrounds are not normally associated. Appendix B is a marvelous array of projection types and descriptions that will provide an easy but excellent graphic display for discussing map uses.

Overall, this book is, as Winnie the Pooh might say, a real "hunee" of a publication as either a primary text or a supplement. Highly readable and highly enjoyable.

INSTRUCTIONS TO CONTRIBUTORS

The California Geographical Society welcomes submissions in the following categories:

Geographic Scholarship—refereed articles that reflect the diverse interests of our membership and the range and depth of geography (all subfields, regions, and approaches). Maximum length: twenty pages, double-spaced.

Geographic Education—short articles on topics that stimulate geographic education at all levels, including innovative teaching techniques, classroom and field activities, educational initiatives, and special workshops.

Geographic Chronicles—includes chronicles of annual CGS meeting and presentation abstracts, reflective essays about the Society and its members, and items of general geographical interest including commentary on issues within the discipline, notices of grant or travel/study opportunities, and research notes.

Book Reviews—reviews of recently published books or atlases of particular interest to our members.

SUBMISSION GUIDELINES

Manuscripts: Manuscripts must conform to the guidelines published in recent issues of the *Annals of the Association of American Geographers.* (The *Annals* follows "Documentation Two" of the *Chicago Manual of Style.*) Pay special attention to formatting of references and citations, and use endnotes sparingly and only to explicate the text. Provide an abstract of 150 words or fewer. Place tables/charts within the body of the manuscript, but provide graphics separately as described below.

Graphics: All graphics—maps, photographs, drawings, graphs—must be clearly readable in black and white and cited within the text. For proper formatting of graphics and captions, follow *Annals* examples. For final submission, graphics must be in one of two digital formats: EPS (Encapsulated Postscript) for most illustrations, or TIFF (Tagged-Image File Format) for raster images. Resolution should be 300 dpi or better. Provide each graphic as a separate document, and in addition provide a list of captions.

Tables: Follow examples in the *Annals* for proper formatting. Place tables in appropriate location in the manuscript, not at the end.

Disclaimer: In your cover letter, provide a statement that your manuscript has not been published elsewhere, is not under review elsewhere, and will not be submitted to another publication while under consideration by *The California Geographer.* Articles that have been previously published or are being considered for publication elsewhere cannot be considered.

Peer Review: Manuscripts are subject to anonymous peer review, a process that takes approximately four to six weeks.

Submission: Please send by mail (or e-mail attachment) three double-spaced hard copies of the manuscript and figures to: Dolly Freidel, CG Editor, Department of Geography and Global Studies, Sonoma State University, Rohnert Park, CA 94928 (e-mail: freidel@sonoma.edu). E-mail attachments of manuscript and figures are preferred. Do not identify yourself as author anywhere in the manuscript except on a cover page. E-mail inquiries to Dolly Freidel at freidel@sonoma.edu.

The California Geographical Society

Founded in 1946 as the California Society of Teachers of Geography, the California Geographical Society (CGS) is the oldest statewide organization devoted to enhancing the understanding of geography. During the 1950s the organization became affiliated with the National Council for Geographic Education and changed its name to the California Council for Geographic Education. It acquired its present name during the 1980s as it sought, successfully, to become inclusive of all individuals interested in geography—academic and applied geographers, students, laypersons, and educators at every level. The CGS promotes interaction among its diverse members and holds an annual meeting in the spring at different venues around the state. Meetings include field trips and paper, poster, and map presentations, with cash awards for outstanding student presentations, and scholarships for graduate and undergraduate students. Teaching excellence and professional service are recognized with awards.

Members receive the Society's annual refereed journal, The California Geographer, as well as the periodic CGS Bulletin newsletter. Annual dues are $10 for students, $25 for regular members, and $20 for retired members. Applications for membership are available on the Society's Web site, http://www.csun.edu/~calgeosoc/.