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MACROCALIFORNIA AND THE URBAN GRADIENT

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Buridan's ass is a classic example of the dilemma of indecision. In a story originating with Aristotle, but usually attributed to the late medieval French philosopher Jean Buridan, a donkey once found himself located between two bales of hay lying at identical distances to his right and to his left. Unable to decide between the equally attractive bales, the unfortunate animal starved to death.[1] In other situations like this there is a more prudent course of action. In the absence of prior information leading a person to prefer one alternative over another, the rationally justified procedure is random choice.

Indifference Lines

In geography, the problem of choice without preference finds expression in the indifference line. Such lines are used to measure the spatial reach of cities and to identify boundaries between competing market areas. When individuals plan shopping trips they often must decide between alternate destinations. If, after considering such things as time and effort, they find that they have no particular preference between two different cities, then their location between the two cities stradles what is called an indifference line. In such cases it is usually said that they have feelings of indifference toward both cities.

Indifference lines are often defined as the midpoint between two places. Buridan's ass was located on just such a line. If human beings acted like Buridan's ass we might expect to find starved bodies lying at irregular intervals along each of these indifference lines. However, people are not usually this indecisive and along each line random choices are made. Huff has considered

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such lines and sees them as 50% probability lines.[2] Right on the indifference line half the people are likely to choose one city and half will choose the other. Farther away, the probability that people will cross over the line for a trip to a market center on the other side decreases. Indifference lines have also been called lines of equilibrium, where the gravitational forces of one city are balanced by the gravitational forces of surrounding cities. Even though a given city's influence actually extends beyond these lines, into the territory of adjacent cities as it were, its influence is greatest within the lines.[3]

Larger places are often seen as having greater attraction. However, attractiveness is an elusive quality and characteristics other than size are often part of it. Where two places are of unequal attractive power the indifference line between them will be curved away from the place with the higher level of attraction.[4] In the special instance where two places are of equal attractiveness, the line between them will be straight.[5]

Indifference lines have many uses in geography and several new ones will be explored here. The first such use involves the various levels of influence California exerts outside the state and how far this influence might extend. The second involves the connections and paths of influence that exist between California cities and other cities beyond California.

Indifference Lines and Economic Functions

Market area boundaries can be drawn between competing firms, between competing cities, and even between competing states. California is usually defined by its political border. Another definition involves indifference lines and the hypothetical areas of influence they separate. Individuals, ideas, and artifacts are both attracted to and emitted from the cities of California along various well-known channels of movement. California's attractive and emissive qualities are strongest within the state's area of influence and weakest beyond it. This area of influence and its many levels of intensity can be identified by the multiple lines of indifference that separate California cities from cities farther east.

As has been established in studies of threshold, range, and economic hinterlands, higher order functions are increasingly concentrated in successively larger central places, and a greater variety of goods and services can be found in larger central places than in smaller ones.[6] Size and function

are thus positively related. If higher order functions with higher thresholds tend to be located in larger central places, then it follows that there are some functions whose thresholds are so high that they can only be met in the largest central places. There are also some functions whose thresholds are so high that their minimum ranges extend beyond individual places and include the entire nation. Such functions survive (or survive best) in a system's largest central place. In the United States most, though not all, of these highest order functions can be found in New York, the highest order central place in the country. They include such things as the diamond market, Wall Street, specialized retail facilities, rare services, and much of the nation's best talent in law, medicine, advertising, corporate management, and the arts. At the highest functional level, then, New York's hinterland stretches across the entire nation. Individuals wishing access to these highest, or first, order functions must either travel to or communicate with New York. They may also have things shipped or transmitted to them from New York.

If all economic and cultural functions in the United States were listed in rank order from highest to lowest threshold, it could be shown that all or most functions exist in the nation's primate city and that only a few of the lowest order functions exist in the nation's smallest cities. At the lower end of the scale many such lists can be found in the literature.[7] Immediately below these first order functions exising only in the primate city are the second order functions existing in both the primate city and the second largest city. Individuals wishing access to these second order functions must travel to either the primate city or the second largest city. If we assume that the attractiveness of both the largest and the second largest city is the same with respect to second order functions, then the indifference line between the two cities will be straight and will lie halfway between them.[8]

Macrocalifornia and Microcalifornia

Figure 1 shows the indifference line separating New York from Los Angeles, the nation's second largest metropolitan area. Since the 1975 population of the Los Angeles Standard Consolidated Statistical Area (SCSA) was well over 10,000,000 this can be called the 10M indifference line. Individuals wishing access to goods and servcies existing only in urban areas of 10,000,000 and above must look for them either in New York or Los Angeles. Take, for

example, the case of Dallas, which in Figure 1 is located just to the west of the New York-Los Angeles, indifference line. Residents of Dallas who wish access to second order (10M) goods and servcies (those available only in New York and Los Angeles, but not in Dallas) must seek them in one of these two larger centers. Because Los Angeles is closer (in physical distance, though not in other kinds of distance) there is a higher probability that they will be sought or obtained in Los Angeles instead of New York. Therefore, at least for second order (10M) goods and services, Dallas and other places west of the New-York-Los Angeles indifference line are within the orbit of what might be called Macrocalifornia.

To the east of this line second order goods and services are more readily obtainable in the closer city of New York and individuals are more likely to seek them there than in Los Angeles. This area can thus be called Extracalifornia, since it is here that the influence of California cities becomes minimal. Most of the cities in the nation do not share an indifference line with a California city. Some do, however, and when they are brought into the calculation their presence causes the boundary of Macrocalifornia to shift westward.

Just as there are second order functions available in the largest and the second largest central places in the nation, so also are there third order functions available in the largest, second largest, and third largest central places. In the United States the third largest central place is the Chicago SCSA (over 7,600,000 in 1975). Figure 1 shows the 7.6M indifference line, separating Los Angeles and Chicago, just to the west of the 10M indifference line separating Los Angeles and New York. Between these two lines the influence of California is low, although it is higher than in Extracalifornia. Second order goods and services (available only in the 10M cities of New York and Los Angeles) will be sought in Los Angeles, while third order goods and services (available only in the 7.6M cities of New York, Los Angeles, and Chicago) will be sought in Chicago, since Chicago is nearer. All other lower order goods and services desired by individuals located within this zone will be sought in beyond-California cities like Dallas, St. Louis, and Minneapolis.

As smaller and smaller urban areas are added to the map, the accompanying indifference lines mark off the boundaries between places where successively lower and lower order functions become available. The Dallas-Los Angeles indifference line marks off the boundary between this California city and the nearest non-California city where goods and services available only in places

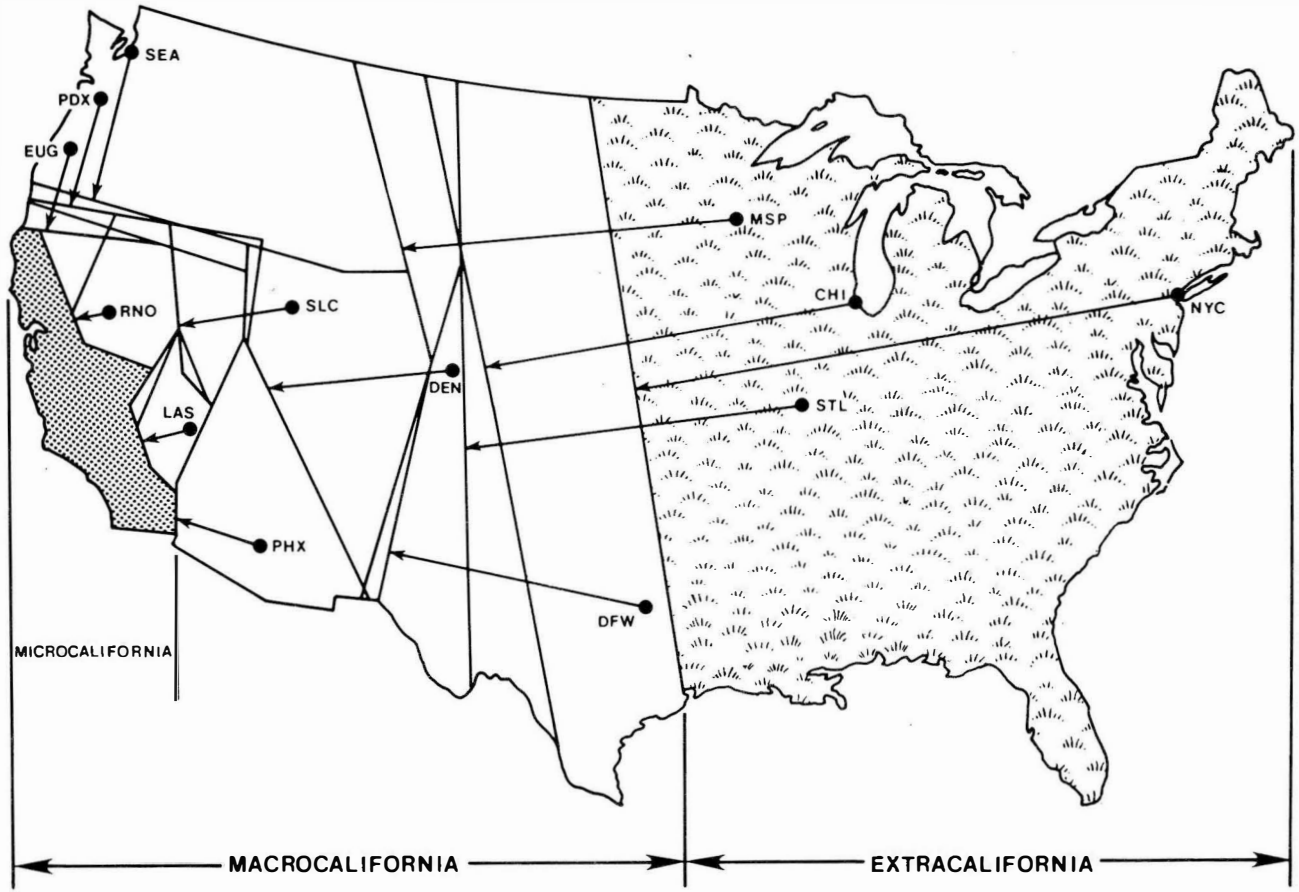

Figure 1. Macrocalifornia as Defined by Indifference Lines.

of at least 2,500,000 (the population of the Dallas-Ft. Worth SMSA in 1975) can be found. The Portland-San Francisco and the Phoenix-San Diego indifference line mark off the boundary between California cities and the nearest non-California city where things available in places of at least 1,000,000 can be found.

Eventually the indifference lines will identify a third region, Microcalifornia, by retreating west of the Sierras and south of the Siskiyous. When city sizes reach the level of approximately 100,000, all subsequent regions marked off by the indifference lines of smaller and smaller central places lie completely within California. At this point the influence of California and its central places becomes total. A listing of all the indifference lines used to delineate Macrocalifornia at its various levels of intensity appears in Figure 2. By themselves these lines are not particularly significant. However, they do lead directly to a new conception of how urban systems in the United States might be arranged.

		BEYOND STATE CITIES												
		NYC	CHI	STL	DFW	MSP	SEA	DEN	PDX	PHX	SLC	LAS	EUG	RNO
	LAX	X	X	X	X	X	X	X		X	X	X		
	SFO		X	X		X	X	X	X					
	SAN				X			X		X		X		
WITHIN	SAC							X	X	X	X		X	X
STATE	FRE										X	X		X
CITIES	BAK									X	X	X		
	SCK													X
	VIS											X		X
	CIC												X	X

Figure 2. Cities Sharing an Indifference Line with California Cities.

Christaller and the Indifference Line

Indifference lines also play a role in the Christaller System.[9] In Christaller's K=3 hierarchy lower order central places are located at indifference points between three larger centers and in the K=4 hierarchy they are located between two larger centers. In the K=7 hierarchy six lower order central places are located on one side of an indifference line separating three larger centers. In the K=3 system Christaller argues that since individuals

in lower order centers are equidistant from three higher order centers, they will gravitate with equal intensity toward all three larger centers for those higher order goods and services that are not available locally. At the same time, one of these higher order centers is larger than the other two and it is to this center that people will travel when they have a need for the highest order goods and services.

Surrounding each central place in the Christaller system there is a nested series of concentric hexagons that define that central place's field of influence.[10] Each one of these successively smaller hexagons is an indifference line. Each one also happens to coincide with the location of lower order central places. The outer hexagon defines the area within which people will travel for the highest order functions. The inner hexagon defines the area of travel for the lowest order functions.

In Figure 1 the New York-Los Angeles indifference line is the equivalent of a single outer hexagon in the Christaller system while the indifference lines delineating Microcalifornia are the equivalent of several inner hexagons. Every city in the United States is surrounded by these concentric zones of influence. However, unlike the Christaller pattern, they are not, nor are they ever likely to be, hexagonal or regular in nature. Instead, they form irregular wedges and polygons that share sides at many points in the hierarchy. A brief exercise with the Proximal Map elective in SYMAP, where cities are added one at a time (from largest through smallest) to a number of separate computer runs, will confirm this observation.

Displaying the results of such a procedure is difficult, however, and the complete picture of these nested and overlapping polygons is chaotic and virtually impossible to decipher. Fortunately, there is another way of looking at the patterns formed by indifference lines. This way is provided by the closely related nearest larger neighbor method, which follows directly from the spatial patterning of indifference lines.

The Nearest Larger Neighbor Method

Note in Figure 1 that Dallas lies to the west of the New York-Los Angeles indifference line. This means that for goods and services available only in urban areas of 10,000,000 or larger, people in Dallas will find their nearest source in Los Angeles. Note also that Dallas is to the east of the Chicago-Los Angeles indifference line. This means that for goods and services

available only in urban areas of 7,600,000 or larger, people in Dallas will find their nearest source in Chicago, There are no other cities that are larger than Dallas and nearer to Dallas than Chicago.[11] Chicago is therefore Dallas' nearest larger neighbor. Anything not available in Dallas must be sought first in Chicago (assuming that the choice to do without is not made). If the desired good or service is not available in Chicago, people in Dallas will seek it in their second nearest larger neighbor, Los Angeles. If it is not available in Los Angeles, it must be sought in New York, the highest order central place in the nation and Dallas' third nearest larger neighbor. If it is not available in New York, it doesn't exist.

A hierarchy of nearest and subsequent nearest larger neighbors can now be envisioned for every city in the nation. Just as Dallas is part of a hierarchy that includes New York, Los Angeles, and Chicago, so also is every other city part of a similar hierarchy. If things are not available locally, they must be sought in a nearest larger neighbor. The lines connecting a city with its primary, secondary and subsequent nearest larger neighbor are called nearest larger neighbor axes. Macrocalifornia can now be defined by a hierarchy of nearest larger neighbor axes. Every city west of the New York-Los Angeles indifference line has Los Angeles on one of its nearest larger neighbor axes. West of the Sierras, in Microcalifornia, all axes save the highest one extending to New York are located within the state. Beyond Macrocalifornia there is Extracalifornia, where nearest larger neighbor axes extending into California are absent.

The Urban Gradient

Figure 3 shows the primary nearest larger neighbor hierarchy in California and the eleven western states, as derived from county and metropolitan populations in the 1970 census. Since this hierarchy focuses primarily on cities it can be called the urban gradient. All cities located in counties with populations greater than 50,000 are shown on this map. Hollow circles indicate places between 50,000 and 100,000. Circles with dots indicate places between 100,000 and 500,000. Solid circles indicate places above 500,000. The county seat, or the largest central place in each county, is connected by a line with its nearest larger neighbor. Places within 10% of each other in population are considered to be the same size. This urban gradient, or capillary system, identifies all the nearest places where higher order goods and services are

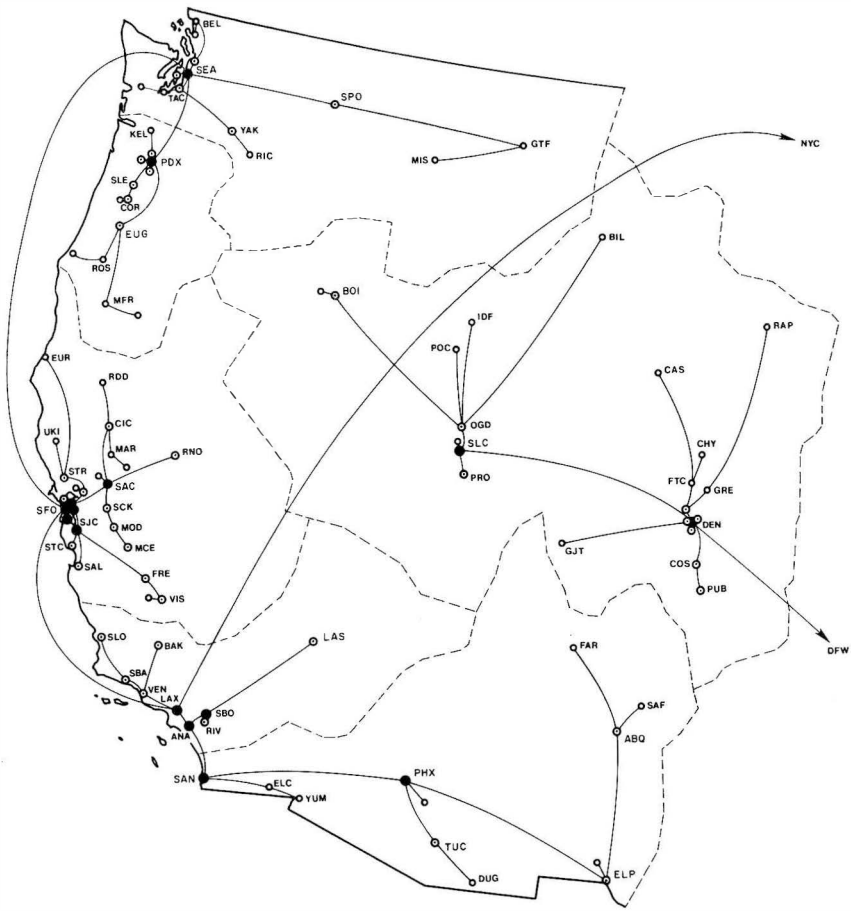

Figure 3. 1M Cantons in the Pacific Coast-Rocky Mountain Region.

likely to be available. Only the primary axes appear on this map. Axes connecting each city with its second, third, fourth, or higher nearest larger neighbor are not shown.

The logic of the indifference line requires that on the average consumers patronize the closest centers offering the goods and services they need. Although agreement is not universal,[12] many investigators support this rule.[13] It is a rule, however, that should always be stated in the probabilistic terms favored by Huff and Pred.[14] If something cannot be found in Chico, for example, a likely and reasonable strategy is to look for it first in Sacramento, not in Redding or Susanville. If it cannot be found in Sacramento, it is reasonable to look for it next in San Francisco, not in Fresno. Such a strategy is logically sound and conforms to the Principle of Least Effort, an important though not fully appreciated concept.

In Figure 3 the dashed lines, called population divides, separate adjoining regions called nearest larger neighbor cantons. On this particular map, each population divide marks the boundary of a nearest larger neighbor canton associated with an urban area having a population of greater than 1,000,000. They can thus be called 1,000,000 (or 1M) cantons. Note that in the eleven western states there are six such 1M cantons focused on Denver, Seattle, Portland, San Francisco, Los Angeles, and San Diego. All of these cantons are separated from their neighbors by 1M population divides.

As one travels up the gradient, away from the population divide, the size of each central place gets larger and larger. Eventually all such travel terminates in New York. On the west coast, all such travel terminates in Los Angeles, the highest order central place in the west. In the Great Basin-Rocky Mountain region, all such travel terminates in Denver and its nearest larger neighbor, Dallas.

Cantons are named after their highest order central places. However, each canton can exist at many different scales. For example, at the highest level of abstraction the Los Angeles canton and its nearest larger neighbor gradient covers the entire Pacific Coast and engulfs four of the five smaller cantons referred to above. At this level it can be called (in 1970) the Los Angeles 10M canton since it is associated with a central place having a population of at least 10,000,000 and has a population divide separating it from another central place with a population of at least 10,000,000. It is bounded by the 10M Great Basin-Rocky Mountain population divide, which extends from eastern Montana and central Idaho, through central Nevada and southern Utah, to eastern New Mexico and the extreme tip of west Texas.

Since the highest order central place in this 10M canton is Los Angeles, it also represents another definition of Macrocalifornia. In Figure 1, Macrocalifornia was defined by a series of indifference lines. In Figure 3 it is defined by a series of population divides. The 10M Great Basin-Rocky Mountain population divide defines Macrocalifornia at the 10M level and the 1M population divides associated with the San Francisco, Los Angeles, and San Diego cantons define it at the 1M level. At a much lower level of abstraction the Los Angeles canton shrinks even more in size. If the population divides for all central places larger than 100,000 were drawn, the Los Angeles canton would become a .1M canton

The cantons of California will now be considered. Figure 4 shows the California urban gradient and the outer boundary of the three California cantons that emerge when the Los Anglees 10M canton is divided into .9M cantons, based on 1970 SMSA populations. Here, the Phoenix, Portland, and Seattle cantons have been calved off from the larger Los Angeles 10M canton leaving the Los Angeles, San Francisco, and San Diego .9M cantons. Although they are not shown in Figure 4, the population divides separating the urban gradients of these three California cities from each other are the same as those appearing in Figure 3. In Figure 4 only the outer population divide showing the maximum reach of the California nearest larger neighbor system has been drawn. This outer population divide separates the .9M cantons of California from the Portland, Denver, and Phoenix .9M cantons. It also defines Macrocalifornia at the .9M level.

Figure 4 differs from Figure 3 in that it shows end cities. End cities are the lowest order central places in any given canton and their locations are used to define the population divide. They are usually found in remote areas and are located nearer to population divides than are higher order centers. As one travels down the gradient, from larger to smaller cities, end cities are the ones found "at the end of the line." Also in Figure 4 the outer population divide has been drawn along the county boundaries separating the end cities of the San Francisco, Los Angeles, and San Diego urban gradients from the end cities of the Portland, Denver, and Phoenix urban gradients. In Figure 3 the population gradients have been drawn along indifference lines separating the various end cities. Note closely in both figures 3 and 4 the population divide between the Los Angeles and the San Francisco

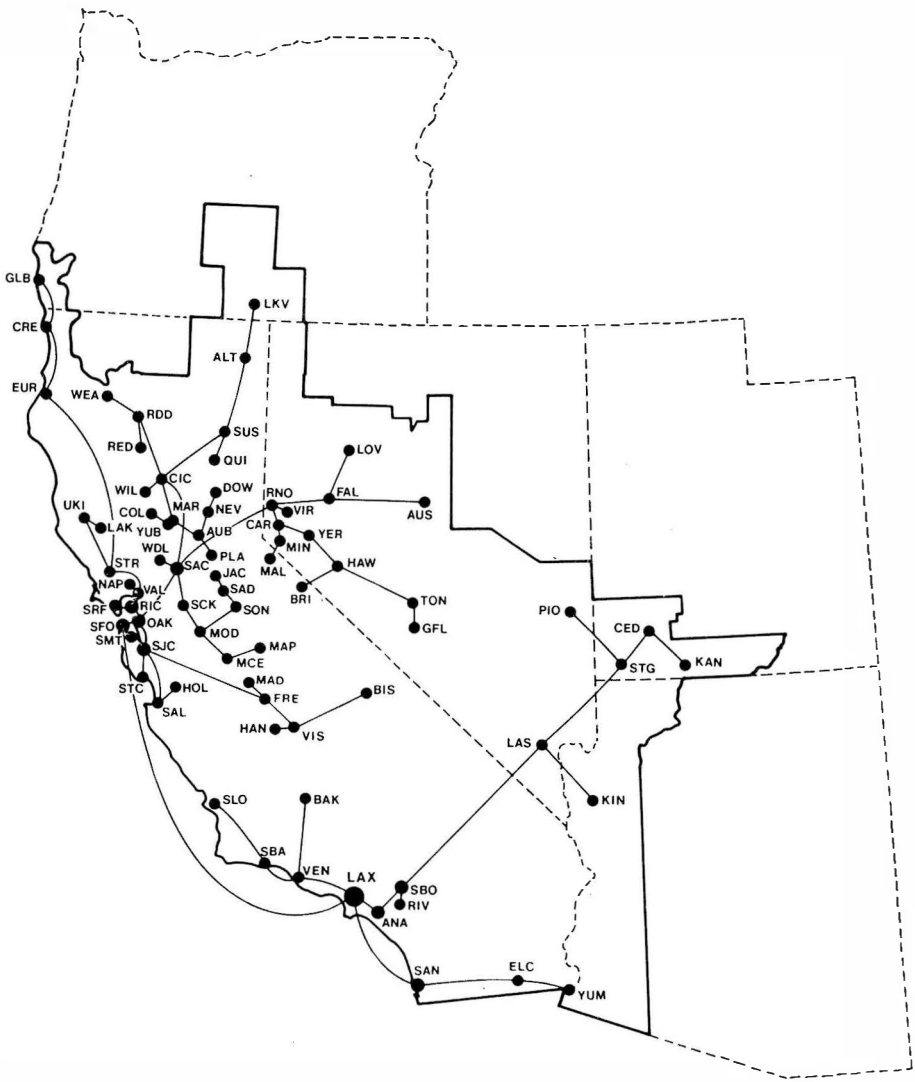

Figure 4. Macrocalifornia as Defined by .9M Cantons.

urban gradients matches the straightline, a traditional boundary between northern and southern California marked off by the northern borders of San Luis Obispo, Kern, and San Bernardino counties. Note also in both figures how clearly the San-San gap appears. This rural discontinuity in the San Francisco-San Diego megalopolis, which has been described recently in this journal coincides very nicely with both the straightline and the urban gradient.[15]

Empirical Test

What evidence is there that the nearest larger neighbor gradient, population divides, and Macrocalifornia indifference lines correspond to things in the real world? Are people within the San Francisco canton actually oriented toward that city for their higher order goods and services? To test such a hypothesis it would first be necessary to sift through mountains of data to determine the hinterland of each urban area in the nation, much as Ullman did for Mobile in 1943, Harris did for Salt Lake in 1939, and Borchert and Adams did for Minneapolis in 1963.[16] Fortunately something like this has already been done (quite independently) by Rand McNally in their Commercial Atlas and Marketing Guide, which contains a map showing fifty major trading areas in the United States.[17] Each of these regions focuses on a major center of specialized higher order activities like banking, wholesaling, advertising, and corporate decision-making. The boundaries of these major trading areas were drawn along county lines after a lengthy consideration of such factors as physiography, population, economic activities, highway facilities, newpaper circulation, railroad services, suburban transportation, and sales reports.

This Rand McNally system can be used as an empirical standard against which the nearest larger neighbor system can be judged. The agreement between the Rand McNally trade areas and the their corresponding nearest larger neighbor cantons is quite high. Of 408 counties in the eleven western states, 318 (78%) are placed within the hinterland of the same major city by both classification systems. When this pattern was compared with an even distribution, which might exist if there were only a chance relationship, a chi-square goodness of fit test indicated that the difference was significant at beyond the .001 level. Within California, 56 counties out of 58 (96%) were classified correctly by the nearest larger neighbor method, with only Modoc and Inyo counties being classified differently. In the case of Inyo county and

its largest city, Bishop, Rand McNally classified it as part of the Los Angeles trade area, while the nearest larger neighbor method placed it within the San Francisco canton. The disagreement can be attributed to the use of straight-line distances by the computer program used to generate the nearest larger neighbor axes appearing in Figures 3 and 4.[18] Within the larger area of the entire Macrocalifornia urban gradient shown in Figure 4, 69 counties out of 77 (89%) were classified correctly by the nearest larger neighbor method. There is strong evidence, then, that the nearest larger neighbor gradient and the indifference lines that define the retreating boundary of Macrocalifornia accurately describe something that exists in the urban landscape of California and its eastward extension.

Applications

There are several possible applications of the nearest larger neighbor method. The first is highly practical. The nearest larger neighbor gradient is a very efficient way of designing a marketing and wholesaling distribution network, where each smaller subsidiary location is oriented toward its nearest larger neighbor. Many such networks may in fact already be arranged in this chain of command fashion. Another application lies in transportation research. Are airline routes that follow the urban gradient more profitable than ones that connect hierarchically unrelated cities? The answer to this question might be interesting. The nearest larger neighbor gradient might also provide a more realistic criteria for delineating time zones. Perhaps the most significant application of the nearest larger neighbor method lies in historical research, where it has promising applications in central place theory. Such things as bank records, transportation schedules, shipping receipts, and newspaper subscriptions serve as the raw material against which theoretical central place geometries must ultimately be tested. However, as the investigator delves farther and farther into the past, information of this sort quickly disappears. This is a major problem faced by those who study the evolution of central place systems and it has even caused some scholars to advocate the abandonment of central place theory entirely.[19] If geographers really wish to describe and explain central place hierarchies, it will be necessary to observe how these urban systems have actually evolved through time. The nearest larger neighbor method, which owes part of its inspiration to the dilemma of Buridan's ass, provides a means for investigating their historical development.

ABQ Albuquerque, NM
ALT Alturas, CA
ANA Anaheim, CA
AUB Auburn, CA
AUS Austin, NV
BAK Bakersfirld, CA
BEL Bellingham, WA
BIS Bishop, CA
BOI Boise, ID
BRI Bridgeport, CA
CAR Carson City, NV
CAS Casper, WY
CED Cedar City, UT
CHI Chicago, IL
CHY Cheyenne, WY
CIC Chico, CA
COL Colusa, CA
COR Corvallis, OR
COS Colorado Springs, CO
CRE Crescent City, CA
DEN Denver, CO
DFW Dallas/Ft. Worth, TX
DOW Downieville, CA
DUG Douglas, AZ
ELC El Centro, CA
ELP El Paso, TX
EUG Eugene, OR
EUR Eureka, CA
FAL Fallon, NV
FAR Farmington, NM
FRE Fresno, CA
FTC Ft. Collins, CO
GFL Goldfield, NV
GJT Grand Junction, CO
GLB Gold Beach, OR
GRE Greeley, CO
GTF Great Falls, MT
HAN Hanford, CA
HAW Hawthorne, NV
HOL Hollister, CA
IDF Idaho Falls, ID
JAC Jackson, CA
KAN Kanab, UT
KEL Kelso/Longview, WA
KIN Kingman, AZ
LAK Lakeport, CA
LAS Las Vegas, NV
LAX Los Angeles, CA
LKV Lakeview, OR
MAD Madera, CA
MAL Markleeville, CA
MAP Mariposa, CA
MAR Marysville, CA
MCE Merced, CA
MFR Medford, OR
MIN Minden, NV
MIS Missoula, MT
MOD Modesto, CA
MSP Minneapolis/St. Paul, MN
NAP Napa, CA
NEV Nevada City, CA
NYC New York City, NY
OAK Oakland, CA
OGD Ogden, UT
PDX Portland, OR
PHX Phoenix, AZ
PIO Pioche, NV
PLA Placerville, CA
POC Pocatello, ID
PRO Provo, UT
PUB Pueblo, CO
QUI Quincy, CA
RAP Rapid City, SD
RIC Richland, WA
RIC Richmond, CA
RIV Riverside, CA
RNO Reno, NV
RED Red Bluff, CA
ROS Roseburg, OR
RDD Redding, CA
SAC Sacramento, CA
SAF Santa Fe, NM
SAL Salinas, CA
SBA Santa Barbara, CA
SBO San Bernardino, CA
SCK Stockton, CA
SEA Seattle, WA
SFO San Francisco, CA
SAD San Andreas, CA
SAN San Diego, CA
SJC San Jose, CA
SLC Salt Lake City, UT
SLE Salem, OR
SLO San Luis Obispo, CA
SMT San Mateo, CA
SON Sonora, CA
SPO Spokane, WA
SRF San Rafael, CA
STC Santa Cruz, CA
STG St. George, UT
STL St. Louis, MO
STR Santa Rosa, CA
SUS Susanville, CA
TAC Tacoma, WA
TON Tonopah, NV
TUC Tucson, AZ
UKI Ukiah, CA
VAL Vallejo, CA
VEN Ventura, CA
VIR Virginia City, NV
VIS Visalia, CA
WDL Woodland, CA
WEA Weaverville, CA
WIL Willows, CA
YAK Yakima, WA
YER Yerington, NV
YUB Yuba City, CA
YUM Yuma, AZ

Figure 5. Three Letter City Codes.

NOTES

1. For a detailed account of this problem see Nicholas Rescher, "Choice Without Preference: A Study of the Logic and of the History of the Problem of Buridan's Ass," Kant-Studien, Vol. 21 (1959/60), pp. 142-175.

2. David L. Huff, "A Probability Analysis of Shopping Center Trading Areas," Land Economics, Vol. 39 (1963), pp. 81-90.

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8. One justification for this appears in Raymond Gambini, A Computer Program for Calculating Lines of Equilibrium Between Multiple Centers of Attraction (Lawrence: University of Kansas Center for Regional Studies, (1966), p. 9.

9. Walter Christaller, Central Places in Southern Germany, trans. by Carlisle W. Baskin (Englewood Cliffs: Prentice-Hall, 1966, orig. 1933).

10. This is best illustrated in Harm J. de Blij, Human Geography: Culture, Society, and Space (New York: Wiley, 1977), p. 266.

11. Wattenberg, op. cit., pp. 926-932.

12. Eliot Hurst, op. cit., p. 207; R. G. Golledge, G. Rushton, and W. A. V. Clark, "Some Spatial Characteristics of Iowa's Dispersed Farm Population and Their Implications for the Grouping of Central Place Function." Economic Geography, Vol 42 (1966), p. 271.

13. Berry, op. cit., p. 10; William Bunge, "Theoretical Geography," Lund Studies in Geography, Series C, Number 1 (Lund: Gleerup, 1966), pp. 151, 159.

14. Huff, loc.cit.; Huff and Lutz, op. cit., p. 198; Allan R. Pred, "Behavior and Location: Foundations for a Geographic and Dymanic Location Theory," Lund Studies in Geography, Series B, Number 27 (Lund, Gleerup, 1967), p. 115.

15. Calvin Wilvert, "San Luis Obispo County: Heart of the San-San Gap," The California Geographer, Vol. 19 (1979), pp. 69-85.

16. Edward L. Ullman, "Mobile: Industrial Seaport and Trade Center," Ph.D. Dissertation, University of Chicago, 1943; Chauncy D. Harris, "Salt Lake City: A Regional Capital," Ph.D. Dissertation, University of Chicago, 1939; John R. Borchert and Russell B. Adams, Trade Centers and Tributary Areas (Minneapolis: University of Minnesota Press, 1963).

17 _____, Commercial Atlas and Marketing Guide (Chicago: Rand McNally, 1980), p. 64.

18. This computer program, called the Nearest Larger Neighbor Algorithm, is available from the author in either FORTRAN or BASIC.

19. John A. Dawson, The Marketing Environment (New York: St. Martin's Press, 1979, p. 190.