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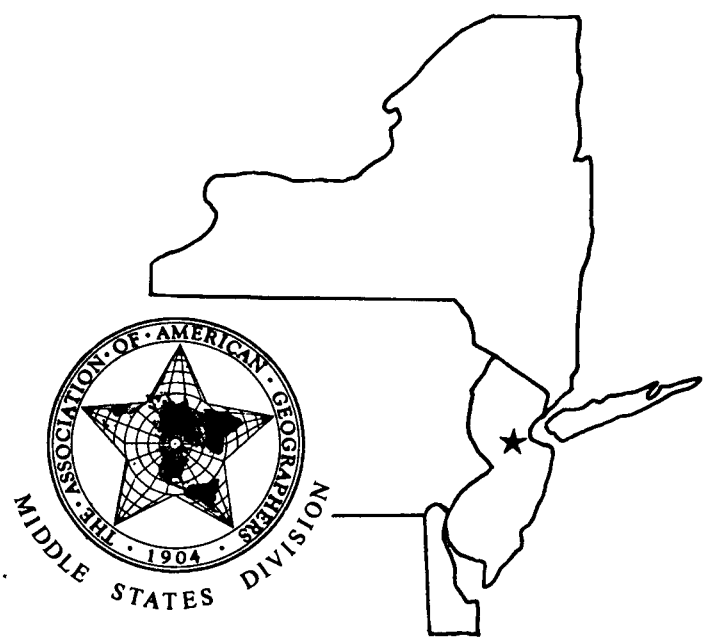

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PROCEEDINGS

OF THE

MIDDLE STATES DIVISION
ASSOCIATION OF AMERICAN GEOGRAPHERS

VOLUME XIII, 1979

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LAND TENURE, PHYSICAL ENVIRONMENT, AND POLITICAL CHANGE IN BARBUDA, WEST INDIES

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In 1961 Helmut Blume proposed that land tenure in the British Leeward Islands is directly related to land use, and land use ultimately determined by land form. He argued that tenure systems that favor large estates, small peasant holdings, or stock pasturage are a function of the physical environment.(1) Any Caribbeanist can immediately think of exceptions to such a generalization. In hilly Montserrat, for example, forty degree slopes that are now parceled into small holdings for cultivation and stock once held extensive sugar plantations on their upper reaches, and more recently, cotton fields to their lower reaches. Blume's observation, however, brings social organization--of which land tenure is a central aspect--and physical environment very close together in the Leewards. The connection is worth investigating. In this paper I try, not to present a case in favor of Blume's environmental determinism, but to credit Blume's observation for suggesting the following discussion of land tenure in Barbuda. I show that land tenure and physical environment are related, but also that recent political changes have begun to affect a tenure system that has been continuous since before emancipation.

The customary land tenure of Barbuda is unusual for the Caribbean. According to everyday belief and practice, all lands outside of Codrington, the single village, are held in common by all Barbudans. Any Barbudan by birth or parentage may use land for shifting cultivation, for free-ranging livestock, for hunting and gathering, and for timber. House sites alone are individually owned and, until 1976, could only be located within the village walls.

There is what anthropologists call a mythic charter for Barbudan customary tenure. The island is said to have been bequeathed by William Codrington, the last "owner." This bequest has never been verified in fact, and the Codringtons were not the owners of Barbuda at all. The British Crown leased Barbuda to the Codrington family from 1680 until 1870, when William Codrington surrendered the lease.

The Barbuda Ordinance of 1904 was an attempt to clarify land ownership. It refers to Barbudans as tenants of the Crown, and to Barbuda as Crown land.(2) Nevertheless, it is legitimate to question what constitutes "legal" ownership in any but an ethnocentric sense in a colonized land inhabited by the descendants of unwilling slaves. Certainly Barbudans consider the island their own. But even as colony and Crown land Barbuda was burdened by additional dependent status. During the 1920's, when it became clear that Barbuda would not be self-supporting through commercial agriculture, the Colonial Office arranged for subsidy from Antigua.(3) Barbuda was said to be a political part of Antigua, an Antiguan parish, but became, in effect, an unequal dependency. When Antigua became an associated state in 1969, the new constitution did not explicate the status of Barbuda, and it remains uncertain whether the ownership of Barbuda was transferred to Antigua at that time.(4) With full independence for Antigua in the near future, the question is vital. A separatist movement has developed in Barbuda since 1971, and a historical case for separation has been made.(5) The implication of these events for land tenure will be discussed below.

The belief that the inhabitants themselves own Barbuda long predates the death of William Codrington. The myth of the bequest is but a verbal affir-

mation of practices that existed before emancipation in 1834. A traveler's account of 1825, for example, gives an astonishing description of slave activities and prerogatives:

> ". . .a certain number of slaves...are called the Huntsmen; they wear a leathern cap, a belt round their shoulders with a long clasp knife stuck in it, and a rude kind of half-boots. They generally possess a horse each, a duck gun and dogs, and I believe, have little else to do except to maintain themselves and procure venison whenever it is wanted."(6)

This slave community had an unusual degree of autonomy, refused to leave the island, would not engage in field labor, and, after emancipation, regularly defeated schemes to develop commercial crops or livestock production.(7) Inhabitants continued to hunt, keep stock, cut timber, and engage in swidden cultivation wherever they liked. In 1860 and 1862, for example, the Codrington manager complained that the island was "eat up" with the people's livestock, and that cultivation plots were to be found "all over the island."(8) Rules against keeping sheep and opening gardens more than two miles from the village were simply ineffective.

These brief examples show clearly that customary land tenure is linked to customary land use, especially shifting cultivation and the keeping of livestock on open range. The connection is understandable, for shifting cultivation is difficult, if not impossible, for holders of small, permanent parcels, and stock numbers are more restricted by the need for fences and tethers than they are by open range. Having begun during slavery as swiddeners, hunters, and open range grazers, Barbudans successfully resisted changes in their productive economy by resisting incursions into their common rights to undivided lands. Their ideology of common ownership has long reinforced community integration, just as community integration in turn maintains a working system of common rights. But, returning to Blume, how may this situation be related to physical environment?

Barbuda is a dry coral island, so flat that the area known as Highlands is only 120 feet above sea level. Highlands is surrounded by a marginal plain averaging 7 feet above sea level. The island is the farthest east of the Leewards, and the northeast trades sweep over without interference. The soils are shallow and limited by factors such as stoniness, erosion, and salinity. The karstic Highlands area is pitted and hummocked, and dotted by tiny sinkholes and a few larger ones. Swiddeners plant between the hummocks, where a little deeper soil accumulates. The scarp between Highlands and the plain also collects some deeper soil and is therefore a favorite place for gardens. The marginal plain is subject to sheet erosion, and in years of rainfall, to mud and standing water. Plant communities range from almost bare, goat-devastated areas on the plain to some evergreen scrub forest in Highlands, where fencing schemes of the recent past gave some protection from grazing. It is a xerophytic vegetation, and mainly a product of subsistence activities. Nevertheless, cattle manage to find forage even in dry years, while goats and sheep survive quite well.

Barbuda is subject to droughts that may last up to twenty years. Annual rainfall averages below 35 inches during drought periods, and ranges between 35 and 40 inches during wet periods.(9) It is not surprising, then, that conventional plantation crops never succeeded in Barbuda. The Codringtons relied chiefly on export livestock in the eighteenth and early nineteenth centuries. They also profited from the salvage of ships that were wrecked on the reefs surrounding the flat, almost inaccessible island. Wrecking profits were especially high during the post-emancipation period.(10) The Codring-

ton interest in land use was therefore low, and post-emancipation Barbudans were left to their own productive economy. After 1870, sisal, cacao, coffee, and sorghum all failed, not only because of the physical environment, but also because of economic factors and the resistance of the Barbudan community.(11) Cotton has long been grown intermittently, but production cannot be sustained through drought periods.(12)

Thus the principal economic uses to which the slaves had put the island--grazing, hunting, shifting cultivation, and timber cutting--developed in physical conditions that discouraged plantations. After emancipation the same way of life continued, since there were no opportunities for wage labor. Continuous emigration has kept the population in balance with resources. Today, about half of Barbuda's 234 households receive some help from relatives living abroad.

Barbuda may now be facing change. Recent events suggest a paradox: that common land rights may be connected to political dependency, and that steps toward independence are accompanied by erosion of customary rules and the beginning of land alienation. What follows are a few of the suggestive events that have taken place since the secessionist movement began in 1971 and since Barbuda achieved its first self-governing council in 1977.

The first plans for extending house site ownership to lands outside the old village walls began in 1973; by 1976 new houses had been built on deeded lands, and the village extended. In 1977, the Barbuda Light and Power Company managed to obtain a title deed to 90 acres of beach land.(13) In 1978, 134 acres were leased to Holmes Development.(14) Holmes had tried before 1971 to lease land for hotel development, but had not succeeded. The council claims that the Holmes deal was made in Antigua, bypassing the council, but in 1978 the council itself contracted rights to outsiders for a sandmining operation and heavy vehicle road.(15) The developers were permitted to choose their own sites, and chose to build the road through an ecologically delicate area of potential archaeological and historical value. The sand is mined from directly above Barbuda's only freshwater lens, the source of future water supply.(16)

If Barbuda achieves full independence from Antigua, economic pressures and national aspirations may require that the land tenure system give way to private ownership for development by outsiders, although common rights to interior lands for subsistence use may be preserved. The council has declared categorically that Barbuda will not take independence with Antigua in February, 1980.(17) Thus a significant social organizational change may affect the interaction of environment, land use, and land tenure that has endured since before emancipation.

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ENGLISH, IRISH AND AFRICAN INFLUENCES ON THE LANDSCAPE OF SEVENTEENTH CENTURY MONTSERRAT IN THE WEST INDIES

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The British colony of Montserrat in the Eastern Caribbean was never of primary economic importance to the mother country. The wealth she produced even during the height of colonial production lagged far behind that of her neighbors, Antigua, Nevis and St. Christopher. Yet the story to be told of her early settlement and development is most useful in understanding man's impact on the Caribbean environment. It was during the years from 1632 to 1680 that the character of British colonial occupance took shape. The three culture groups which have left their mark on Montserrat society--English, Irish and African--were introduced; and Montserrat's role in the British mercantile system was defined. It is the modification of the island landscape by the English, Irish, and Africans and the different ways they used the tropical environment that is the subject of this paper.

The society of early Montserrat was noticeably stratified. The English landowners formed the small upper class which served on the Council and Assembly and enforced the laws. Irish indentured servants and ex-servants made up the much larger laboring class. The African slaves, which by the early 1700's outnumbered the whites 5 to 1, were far fewer in number during the 1600's. By 1677 the population of Montserrat consisted of about 700 English, 2,000 Irish and 1,000 Blacks.

These three groups were not evenly distributed over the mountainous landscape. The English had plantations on the choicest land along the gradual slopes of the central and northern leeward coast and also in the saddle between the two major mountain ranges. By the 1670's these plantations, which had grown indigo, tobacco and cotton, were producing sugar with slave labor. Approximately 75 percent of the slaves in Montserrat were settled on these plantations; the others were owned in units of one to three slaves by a number of smallholders.

In contrast to the English, the Irish population was concentrated on very undesirable land on the southwest side of the island. This area, called St. Patricks, contained more than 40 percent of the island population who lived and cultivated on less than 10 percent of the island territory. This area has virtually no level land--steep rocky slopes are bisected by deep ravines--and even when the rest of the island receives a surfeit of rainfall, St. Patricks suffers chronic drought. Today the vegetation is sparse, scrubby and thorny and there is very little cultivation. But in the 1670's this same land was densely occupied and heavily cultivated by the Irish.

The favored cultivation techniques of both the English and Irish settlers were those they had seen or used at home, and their goal was to tame the Caribbean landscape into a facsimile of home.(1) Ligon lamented that in Barbados there were no smooth meadows to walk on and that, because one's view was "hem'd in with wood", no horizon was visible except that of the sea which quickly grew tedious.(2) Only when the land had a man-made look to it was the European eye satisfied. De Rochefort praised the terraced fields of St. Christopher--each planted with a crop of a different color, bordered with orchards and accented by plantation buildings.(3)

But this European preference for clean-cleared fields, planted with neat rows of one or two crops, was often stymied by the dense tropical forest. In the early years the forests of most islands descended right to the water's edge.(4) The trunks were hard to cut and difficult to move over uneven ground.

And so, more or less by default, some of the colonists wisely adopted the Indian practice of allowing large tree trunks to remain where they fell. The plot was burned over and a variety of Indian foods were planted between the charred trunks.(5) Though this method of cultivating on partially cleared plots was quite a sensible adaptation to the tropical environment, both conserving nutrients and inhibiting erosion, the practice was usually viewed as serious backsliding--evidence that the colonists were succumbing to the wanton ways of the natives. In spite of the success of this cultivation method, social pressure and personal preference meant that the goal of most cultivators was to tend several neatly laid out, completely cleared, rectangular fields of an acre or two, like those of the most admired farms in England.

Clearing the land was also important for political reasons. In cases of domestic or international territorial disputes, the clearing and settlement of land, with a sufficient labor force to keep it in cultivation, provided the soundest claim to ownership. After a short French occupation in the 1660's, several laws were passed to settle disputes among some of the major landowners. Fifteen planters were to have their ownership rights to more than 3,500 acres restored only if the acreage was cleared and settled within 12 months.(6) By 1670 all owners were required to clear their land annually or pay the very stiff fine of one thousand pounds of muscovado sugar.

The amount of land subjected to clearing by law is not certain, but a comparison of data from the colonial correspondence and the 1673 map of the island indicate that by just 50 years after first settlement, fully one third of the island territory was clean-cleared.(7) The consequences of such a drastic elimination of the natural vegetation in a tropical setting have been noted by others, but simply stated this modification resulted in increased sunlight at ground level, higher soil temperatures, increased rates of evapotranspiration, decreased available nutrients, and the transport of a great deal of soil downslope.

Though landuse by both the English planters and the Irish small plot cultivators was characterized by clean-clearing, the landscapes produced by these two groups were startlingly different. In the areas under plantation cultivation, the clearings occupied the broad gently sloping tops of volcanic fingers. These open spaces were surrounded by heavy woods. Here and there fencerows crossed the clearings. The great-house, worker's quarters, outbuildings and cattle, water or windmills were grouped into plantation yards resembling small settlements.

The parts of the island occupied by the Irish looked much different. In the steep dry section of the island to which they were relegated the Irish carved the landscape into hundreds of small rectangular plots which extended up as far as 1700 feet. Tiny houses and animal shelters dotted the landscape profusely. Here the Irish families grazed their animals and cultivated subsistence crops.

The primary way in which the slaves modified the landscape of Montserrat was in their capacity as laborers on the plantations. There they implemented the landuse policies of the upper class whites--clean-clearing the land into neat open fields. However, the possibility that the slaves may have modified the land in their capacity as subsistence cultivators should be noted. The evidence suggests that slaves were cultivating their own food plots already in the 1600's. First, there was a chronic lack of provisions, so the growing of local food-stuffs was encouraged by law.(8) Secondly, a law controlling predial larceny recognized that there were cases in which a slave could be legitimately in possession of and could sell garden produce.(9) Thirdly, there was an abundance of accessible well-watered land in the forests surrounding the plantations where most of the slaves lived. Fourthly, there was an

internal market system through which slaves could profitably dispose of surplus crops.(10) If slaves were cultivating in the 1600s, the attitudes and practices they brought with them as seasoned tropical cultivators in Africa, and the techniques and plants they adopted from the Amerindians, would have resulted in a far more subtle cultural landscape than that created by the whites. If the techniques of modern subsistence cultivators in Montserrat are indicative of slave techniques, the slaves probably employed shifting cultivation of the heavily wooded slopes surrounding the plantations. The fallow periods would have been long enough to allow forest regeneration. Complex inter-cropping and the use of mounds or ridges would have minimized erosion. In short the modifications by slaves may have been less conspicuous than those of the whites precisely because they were more in tune with the natural processes of the Montserrat tropical environment.

In summary, by the 1670's Montserrat was no longer in the limited world of the Caribbean, but had become a tiny part of the vast British mercantile system. The island was now occupied and cultivated by an alien population made up of English, Irish and Africans--each occupying a descending rung of the social ladder and each associated with a different economic activity: the English with overseeing plantation cultivation; the Irish with small plot cash and subsistence cultivation; and the Blacks with both plantation and subsistence cultivation. The character of colonial occupance had taken shape, and while tobacco, indigo and cotton were still being produced, sugar was grown on ever larger plantations and by 1680 was the dominant crop. As a British colony, Montserrat was busily contributing her wealth to a remote metropolitan country and her landscape was being modified to facilitate this contribution. At least two distinctive landscapes had been created by the white settlers. The third possible human landscpae--that created by the slaves in their capacity as provision cultivators--is much more difficult to document, in part, because it would have made a much less drastic and lasting change.

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DIFFERENTIAL PLACE PERCEPTION: THE COLLEGE TOWN

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Over the past two decades geographers and environmental psychologists have studied intently how people react to their everyday environment. One research stream has focused upon the cognitive images held by people of these environments. Analysis of these images of place has generated a number of fundamental generalizations.

First, the image of a place is a simplification, the product of a process of selection which clarifies the place's structure by reference to a few key elements. Second, every individual has a distinctive image of a given place. This is not only because each experiences place from his own unique moments of space-time. In addition, each "brings a variety of cognitive activities to bear--expectancies, attitudes, even symbolic elaboration and transformation of the world of reality--which come to mediate and modulate the impact of the environment."(1) Third, variation in image properties across individuals is patterned. A host of variables has been used to explain a variety of image properties.(2)

Of course the perceptual relevance of particular personal attributes may be expected to vary not only with the image property under study but also with the community context in which a study is set. Particular contexts bring people together in ways that heighten the perceptual relevance of membership in particular social groups and may even create distinctive, perceptually relevant, social groupings.

One such context is the small college town which juxtaposes two populations which frequently differ along more dimensions than merely age and length of residence. Few such communities totally escape the mode of factionalism connoted by the phrase "town and gown." Within such a community the town-gown distinction might be expected to provide a fruitful framework within which to probe differential place perception. The two groups are typically in the community for different purposes and use it differently. Thus we may expect their perception of that community as a living environment to differ as well.

The present study examines selected facets of town-gown perceptual variability observed in Hamilton, New York. Hamilton represents, in many ways, an ideal setting for such an inquiry. Two distinctions between students and villagers may have particular perceptual relevance. First, an insignificant fraction of the student population is drawn from the local community. The students are primarily from metropolitan backgrounds and are accustomed to the availability of a broad range of cultural and recreational opportunities which Hamilton cannot possibly duplicate, even though the presence of Colgate University enriches the opportunities available locally. Secondly, the students are drawn from families who can afford the high cost of private higher education today. But the Appalachian Plateau portion of upstate New York is not an affluent area. Only a minority of local families could afford to send their children to Colgate, should they wish to, and this is both known and felt.

In addition, Colgate is not only located at the village edge but overlooks it from a hillside setting. This site contributes to a visual domination by the University. Colgate, the only large employer, dominates the community economically as well. Local merchants are dependent upon the student presence for their survival either directly or indirectly. The village must also adjust to the campus community's seasonal rhythm.

METHOD

Three basic devices were employed to elicit the cognitive images of Hamilton held by villagers and students. These were designed to allow assessment of structural, affective and evaluative image components. First, a sample of fifty villagers and fifty students was asked to answer the open-ended questions listed in Table 1.(3) Second, they were asked for a summary evaluation of how well they liked Hamilton, using a five point rating scale. Finally, those interviewed were requested to draw a map of Hamilton so that a visitor could find his way around the community and to label distinctive features of the village on the map.

None of the tasks drew explicit attention to town-gown factionalism, a circumstance which the interviewing process was also structured to avoid. Villagers were interviewed by an undergraduate student who grew up in the village. The samples were designed to be as discrete as possible. None of the students interviewed was raised in Hamilton. The sample of villagers excluded Colgate faculty and administrators.

FINDINGS

The maps drawn by each group displayed considerable within-group diversity. But since the focus here is upon variation between residents and students, the maps were first aggregated into two composite images, incorporating both the routes included as well as distinctive features labelled by at least one quarter of the respondents in that group (Figure 1).

The most striking differences concern the spatial extensiveness of the image and the complexity of the street network represented. The student image is a very partial one. Elements are totally concentrated either on and adjacent to the campus or within the retail-service cluster at the edge of the village green. The street network suggests a highly simplified "line" or "branch" style of representation. The overall image is strongly linear, strung out along Broad Street, the communication link between the campus and the village core. This principal axis is the only street which one quarter of the students identify by name.

In the villagers' image, Hamilton reasserts itself as a two dimensional entity. It even acquires a satellite, Lake Moraine, two miles to the northeast, on which many Hamilton residents own camps. Interestingly, the Colgate students who both swim there and use the Colgate boathouse do not consider it part of Hamilton. The sequential style of the villagers' representation is a more sophisticated, integrated network of streets. Finally, villagers represent a richer array of element types than students who select retail or service establishments almost exclusively.

Appraisive responses to the community were the subject of the first three questions on Table 1, which may be viewed as eliciting affective village meaning. Colgate students display weak emotional involvement with Hamilton. They perceive it as a small town in a rural setting with bars, supermarkets, and fast food services, which also happens to be the site of Colgate University and the Colgate Inn. Residents share the small town image but, to them, Hamilton is a particular village, <u>their</u> home, the site of <u>their</u> K through 12 school, populated with friendly <u>people</u>, some of whom are <u>their</u> friends. It has a distinctive climate, and between Lake Moraine and Colgate sports, offers varied recreational opportunities.

TABLE 1

APPRAISIVE IMAGE COMPONENTS OF VILLAGERS AND STUDENTS

QUESTION	VILLAGE RESIDENTS	COLGATE STUDENTS
1. Close your eyes and think about Hamilton. What do you see?	Small college town in a beautiful setting Snow Broad Street/shops Campus/Taylor Lake Lake Moraine	Small town College town Bars Colgate Inn Rural setting
2. Pretend you are moving away. What five things will you remember?	Hamilton Central School Colgate sports Friendly people/ particular friends Lake Moraine	Bars Colgate University Pizza Colgate Inn Rural atmosphere
3. What is important to you in Hamilton?	Friends That Hamilton stay small, quiet and friendly Hamilton Cinema Colgate sports My home	Bars Colgate Rural setting Supermarkets Recreational worth
4. What do you like about Hamilton?	Small size and quietness Enough things to do Beautiful setting Lake Moraine Colgate sports Friendliness of people	Friendliness of village residents Rural atmosphere Bars Small size Colgate Cleanliness
5. What do you dislike about Hamilton?	Colgate students Pizza Hut Colgate faculty members and their children Fraternity men Clash between Colgate and Hamilton	Small size Lack of social opportunities Lack of variety of services Inaccessibility Village police
6. What would you like to change in Hamilton?	Recent commercialism Attitudes of some Colgate students Nothing Weather Colgate/Hamilton gap	Add services Gap between Colgate students and villagers Clean it up Nothing

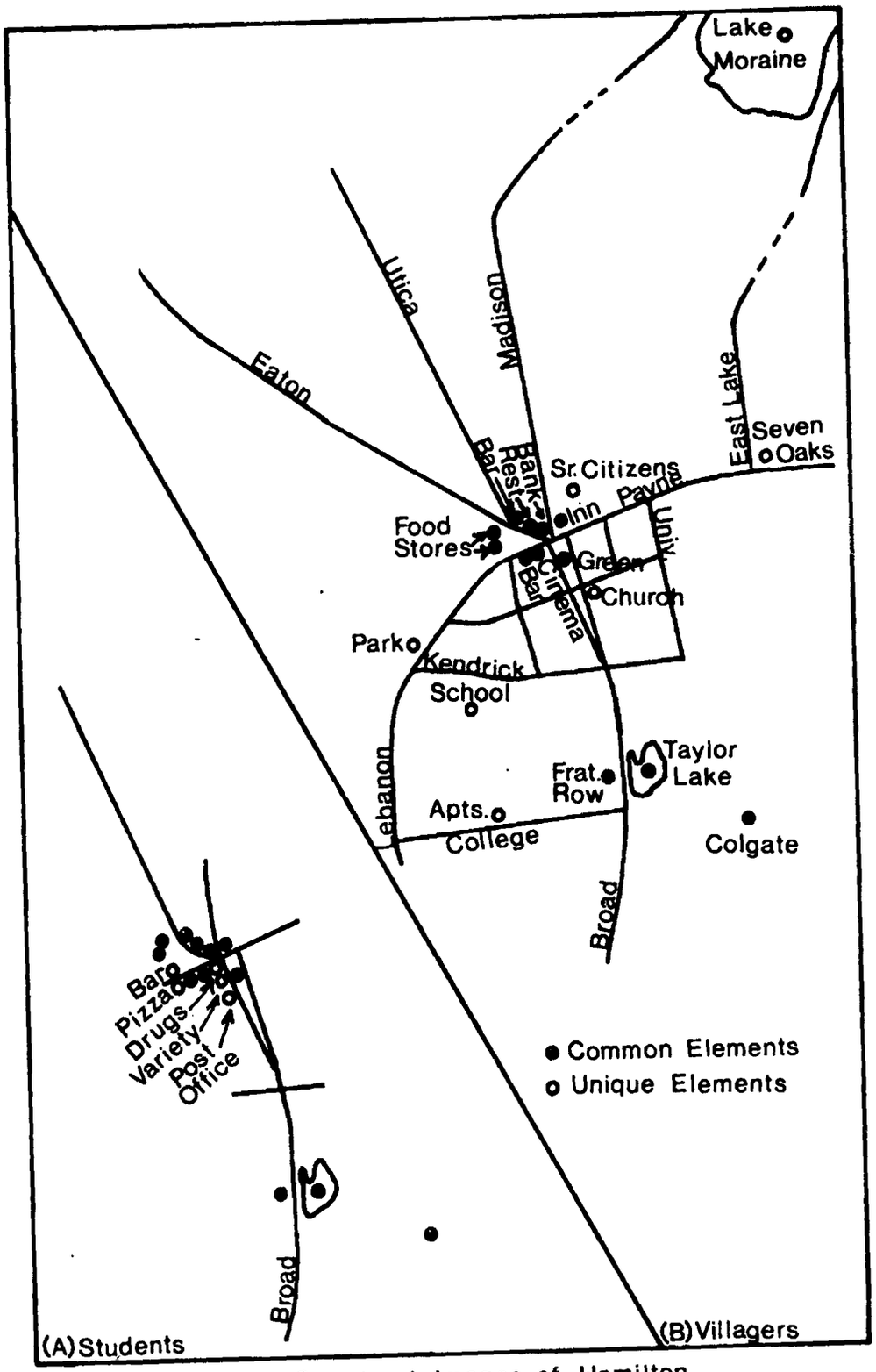

Figure 1. Composite Structural Images of Hamilton

The next three questions require more evaluative responses. Here the perceptions of villagers and students not only diverge but conflict. Town-gown factionalism surfaces indirectly over the issue of village services which students view as inadequate. The provision of additional services is their first priority for change. By contrast, to villagers, the community has already absorbed too many of the wrong kind of services, particularly fast food franchises.

Town-gown factionalism surfaces directly as well. Hostility toward the campus community permeates villagers' evaluations of what is wrong with Hamilton. It embraces not only students, particularly fraternity men, but faculty and their children as well. Students also perceive a gap but do not return the hostility. In fact, they are attracted by the friendliness of villagers. Perhaps the average villager's behavior simply does not reflect the hostility expressed here. Also, student contact is probably biased toward a subset of residents, particularly merchants, economically dependent upon the student market.

Finally the two groups' summary evaluations of the community as a living environment differ sharply. Villagers clearly like living in Hamilton. Forty-four percent "like it very much" and 82 percent express a positive evaluation. By contrast ambivalence represents the strongest response category for Colgate students (44 percent) and a minority of students (46 percent) express a positive evaluation.

DISCUSSION

The cognitive images of Hamilton held by villagers and students differ so strongly that the two groups appear to be experiencing the community from fundamentally different perspectives. How might those perspectives be conceptualized?

One possible approach is to apply a conceptualization of place identity elaborated by Relph. To Relph, "It is not just the identity <u>of</u> a place that is important, but also the identity that a person or group has <u>with</u> that place, in particular whether they are experiencing it as an insider or as an outsider."(4) There are several possible levels of intensity with which we may experience "insideness" or "outsideness." Four such levels appear relevant in the present context. These are: incidental outsideness; behavioral insideness; empathetic insideness; and, existential insideness.

On the whole, the students experience Hamilton from the first two levels. For many, Hamilton is merely the background for activities and quite incidental to those activities. Their responses suggest that if the University and the Inn were to be relocated to another small town with bars, pizza, supermarkets and a rural setting (hardly a unique combination of attributes), the difference would scarcely be noticed. The village is frequently evaluated with ambivalence because it is seldom really noticed. "Incidental outsideness" typically only applies to places in which we are visitors and towards which our intentions are limited and partial. But this is a fair description of the status of Colgate students in Hamilton.

Some students do attend deliberately to the appearance of the place (behavioral insideness). But few know and respect fully the symbols of this place (small, quiet and friendly) and this is the criterion of empathetic insideness. By contrast, with the possible exception of Colgate faculty and their families, village residents experience Hamilton from the level of existential insideness almost by definition. They are at home. It is <u>their</u> town. They know the place and its people. They are known and accepted there.

ACKNOWLEDGEMENTS

I would like to thank three undergraduate students, Karen McKay, Joan Bernhard, and Paul Markovits, who administered and analyzed the survey of villagers and students as part of a January project.

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THE GEOGRAPHY OF AMERICAN MARATHONS, 1979

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Whether for pusposes of weight control, general health, or exhilaration, millions of Americans are quite literally on the run. The running craze, which dates from the early 1970s, continues to attract converts and prove itself to be much more than just another ephemeral fad engulfing the American scene. For many runners the ultimate goal of their fitness program is completion of a marathon, which measures 26 miles and 385 yards. Increasingly there is ample opportunity to try, for the growing popularity of running has given rise to a virtual marathon boom in the United States. The present distribution of these running events is the subject of this paper.

Although there is already a substantial literature on the geography of sport, marathons have two unique properties that set them apart from what might be called "standard" athletic activities (such as football, baseball, basketball and soccer) and which make marathons of potentially special interest to recreational geographers. First, marathons do not require special facilities that can be financed only by municipalities, school districts, university athletic departments, or wealthy individuals. Second, marathons are organized by and for amateur athletes to meet the grassroot needs of the running public. In short, the marathon is an athletic event that can take place just about anywhere that there is safe firmament for the feet to land.

BACKGROUND

In 490 B.C. an outnumbered Greek army defeated an invading Persian force near the Grecian coastal village of Marathon. According to legend a soldier named Pheidippides was ordered to run to Athens and report the victory. Upon reaching the city he supposedly shouted "Rejoice! We conquer!" and then dropped dead. Out of his ignominious finish was born the marathon -- with some adjustments. No one knows exactly where Pheidippides began his run nor exactly where he ended, although the best guess is that he covered about 24 miles. Although subsequent races billed as marathons covered various long distances, 24 miles persisted as the official distance until the London Olympics of 1908. During that Olympiad, race officials supposedly moved the starting line to Windsor Castle so that the royal family could view the beginning of the run. The finish line was in front of the royal box at White City Stadium. The distance between those two points, 26 miles and 385 yards, became the official standard and remains so to this day.(1)

American marathons date from 1896, the year in which the modern Olympics were revived. The first race in this country began in Stamford, Connecticut and terminated at Manhattan's Columbus Circle, 35 miles away. Several months later a marathon was run in Boston. But whereas a second New York City marathon was not held for the next 62 years, the Boston marathon became an annual affair. In 1979 the Boston marathon was run for the 83rd consecutive year, making it far and away the oldest marathon in the United States. By contrast, the country's second oldest marathon, Yonkers, was run this year for the 43rd time.

PRESENT DISTRIBUTION

Data appear to be nonexistent on when and where American marathons were held between the turn of the century and the present. The best source is a list indicating the locations, dates, and the number of consecutive years in which present-day marathons have been held. Such information is published every year in the special marathon issue of Runner's World magazine and the

data presented here are all garnered from the latest of these special issues.(2) Two qualifications about this source should be kept in mind. First, the list of 255 U.S. marathons in Runner's World is not all-inclusive. There are probably (by the magazine's own estimation) several dozen additional marathons whose organizers, in an attempt to keep their races small and easy to manage, have chosen not to make themselves widely known. Second, Runner's World lists only marathons being run in a given year. Thus, a race that might have been annually until, say, last year would not be listed. This would likewise be the case for a race held occasionally but not in 1979.

Location and age characteristics of the 255 American marathons are shown in Figure 1. Locationally, marathons are staged in every state, though the state-by-state frequency of events and overall distribution is hardly uniform. California's 39 marathons are the greatest number held in any one state, and more than twice the total of the second ranked state, Texas, which plans 15 marathons in 1979. Rounding out the "top five" are Pennsylvania (14 marathons), New York (13), and Michigan (9). At the other extreme eight states (Wyoming, North Dakota, South Dakota, Mississippi, Kentucky, West Virginia, Rhode Island, and Vermont) are presently running only one marathon apiece. Nationally, the distribution of marathons suggests two generalized clusters. First, and dominated by the primacy of California, there is a West Coast cluster to which might be added Hawaii and Alaska. Second, there is the larger Eastern and Midwest cluster within which there is a notably greater marathon frequency north and west of an arc defined by the Mason-Dixon Line, the Ohio River, and the lower Mississippi River.

Chronologically, the events are divided into four categories, less than 3 years old, 3 to 6 years old, 7 to 10 years old, and more than 10 years old. The ranges of the first three classes were chosen so as to provide a relatively similar number of observations in each age category. The fourth category (more than 10 years) was defined so as to reflect the significant decline one encounters when enumerating marathons that are more than a decade old. Indeed, only 30 of the 255 marathons (11.8% of the total) are more than 10 years old and only 4 marathons are more than 20 years old. Two of these four, Boston and Yonkers, already have been mentioned. The others are the Western Hemisphere Marathon, held in Culver City, California (in the Los Angeles area) for the past 31 years, and the Pike's Peak Marathon, held in Manitou Springs, Colorado for 24 consecutive years.

The 30 marathons in the oldest category have no particular regional orientation and, in conjunction with the other age groups, provide no substantive generalizations about the origin and diffusion of marathons in the United States. Three of the four oldest marathons, however, do coincide with major metropolitan areas (Boston, New York, and Los Angeles). Older marathons are also held in Detroit, Atlanta, and New Orleans. But the notion that marathons began as big city phenomena and have since filtered down the urban hierarchy is tenuous. Marathons in the younger age categories are all fairly uniformly proportioned between big, small, and intermediate-sized towns. And although some of the nation's oldest races are indeed held in large metropolitan centers, some of the oldest are also held in the likes of Gage, Oklahoma, Booneville, Arkansas, Falls City, Nebraska, and Monticello, Illinois. Large urban areas are certainly more apt to spawn marathons than are small towns -- a fact most visually evidenced by Greater Los Angeles (Fig. 1) which, by virtue of more than a dozen events, must be considered the marathon capital of the United States. Urban marathons are also more apt to attract larger fields. But again, marathoning is something more than a big town phenomenon. Save for the disproportionate number of runs in Hawaii, Alaska, and along the West Coast, one might say that the distribution of marathons, at best, broadly mimics general population distribution and thus, presumably, the general popularity of running.

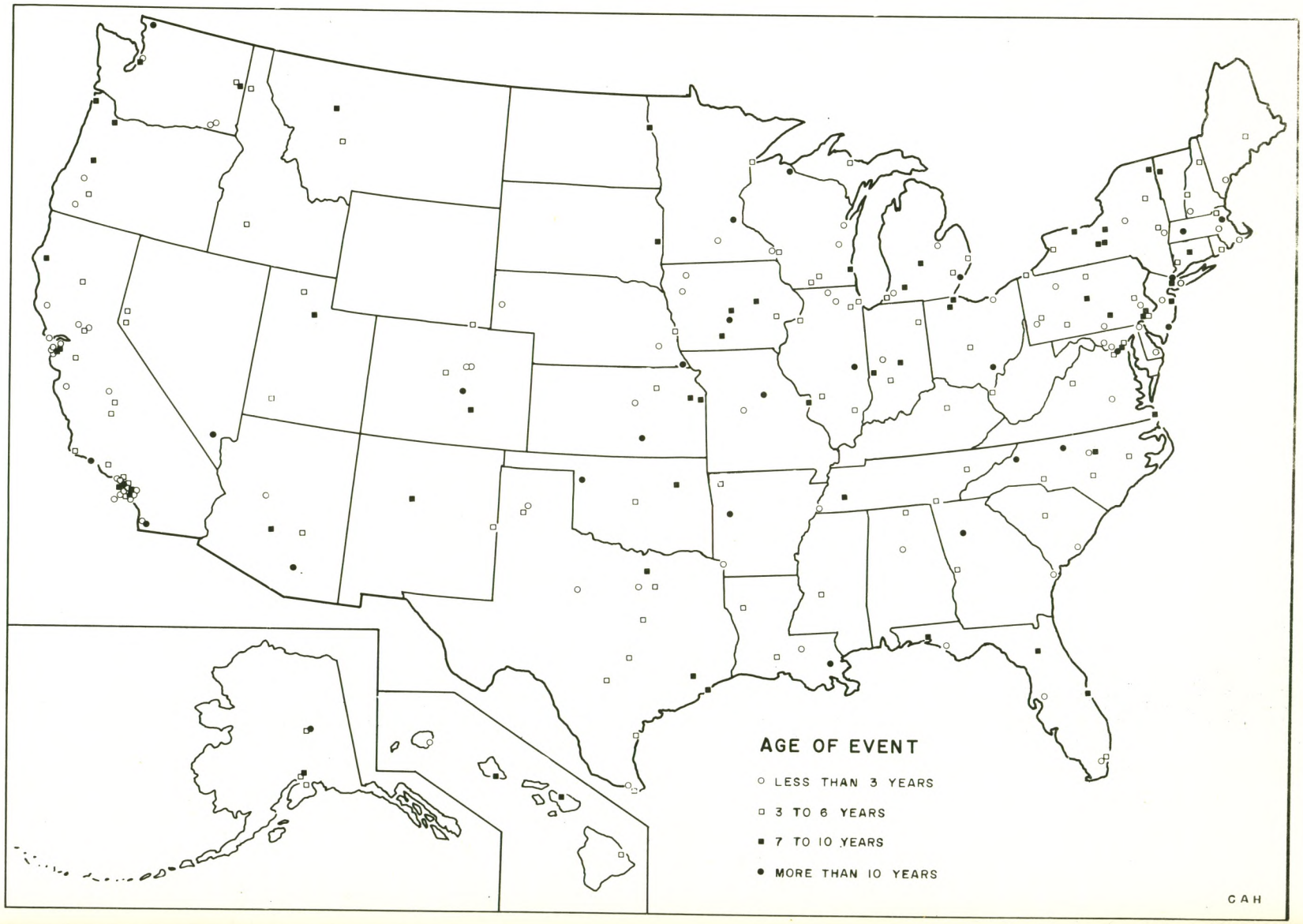

Figure 1. Distribution of Marathons, 1979. (Source: Runner's World, Feb., 1979)

Figure 1 also suggests two areas where marathons appear to be poorly represented: the Northern Rocky Mountain - High Plains area, and the Deep South. In the former, North Dakota, South Dakota, and Wyoming show one marathon apiece, while the additions of Nebraska, Montana, Idaho, Utah, and Nevada does little to bolster the number of marathons in that area. Perhaps this situation is to be expected, however, given the relatively low populations of the states in question.

In the Deep South the population is much larger, and the few marathons therein cannot be attributed to a lack of potential participants. Rather, the explanation is probably a function of climate. In a 26 mile run dehydration is a major physiological consideration. Thus, warm, humid, and/or sunny days, such as typify much of the South for much of the year, are a marathoner's nightmare. Conditions that constitute ideal marathon weather are beyond universal accord, although few marathoners would take great exception to a heavily overcast day, a temperature in the high 40s to the high 50s, and perhaps even a light drizzle. Climatic considerations tend to explain not only the general lack of marathons in the Deep South, but also the time of the year when marathons are staged. Basically, a spatio-temporal analysis of American marathons reveals that a disproportionate number of marathons tend to be held between November and February in areas stretching from the southeastern states westward through southern California -- precisely the time when that area reaches its coolest temperatures. During the summer months the states in the higher latitudes are disproportionately represented, particularly north central and northern Rocky Mountain locales. Although relatively cool days are the norm in those parts of the country, summertime hot spells are not uncommon. Accordingly, as added cool weather insurance, it is not unusual for marathons to begin around dawn. Finally, in intermediate latitudes as well as much of the northeast, marathons tend to be held in either the spring or the fall, temporal points on the calendar lying between undesirable temperature extremes. Starting times in this area fluctuate between roughly 10 AM and 1 PM with the earliest starts typifying races held closest to the summer months and the later starts typifying races held closest to the cold of winter. Again, the basic desire is always relatively cool weather.

SUMMARY

Although marathons have been run in the United States for more than 80 years, the vast majority of the country's 255 races are less than a decade old. While several of the earliest runs were held in large urban areas, subsequent growth exhibits little hierarchical diffusion. At best the distribution of marathons appears to mimic general population distribution, but with some exceptions. The West Coast, and California in particular, show a disproportionately large number of marathons as does much of the eastern half of the country excepting the Deep South. Relatively few marathons are run in the High Plains - Rocky Mountain area for reasons of low population density. The few marathons run in the Deep South are because of runner dehydration problems associated with the warm climate.

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THE GEOGRAPHY OF CRIME AND CRIMINAL VICTIMIZATION: A TIME TO START THEORY BUILDING

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The early geographic and social ecological literature on the spatial manifestation of crime and criminal victimization had a profound effect upon later pedagogic studies as well as upon social control force utilization of spatially based crime data. Thus, the Chicago School of Sociology and geographic base file applications of spatially based crime data are familiar to most professional geographers and geography students interested in urban social problems.

Nonetheless, the work of new pioneers such as Keith Harries, Gerald Pyle, Phillip Phillips, and George Rengert, who have continued the work and methodology of Ernest W. Burgess, Clifford Shaw, Henry D. McKay, Robert E. Park, Frederick Thrasher, Clark Tibbitts, Roderick D. McKenzie, Nel Anderson, Louis Wirth, Henry Zorbaugh associated with The Chicago School, have yet to gain the aura of pedagogic respectibility accorded the mainstream urban geographers whose works frequently appear in the The Annals and Economic Geography. One might ask the reason for this neglect. Is the absence of crime related studies in prestigious geographic journals due to the dirth of quality research and scholarship exhibited by these contemporary scholars? I would contend that the only reasonable answer is "No," that in fact, one need but consult a copy of The Journal of Research in Crime and Delinquency, Criminology, Urban Affairs Quarterly, or The Journal of Environmental Systems or a half dozen other non-geographic journals, to know what urban geographers are doing in the realm of spatially based crime studies. Thus, there must be some explanation other than poor scholarship that explains the almost total absence of geographic interest in crime related studies, if frequency of publication in journals such as The Annals and Economic Geography can be utilized as an index. I believe a possible explanation for this phenomenon is the lack of theoretically based spatial analysis, if we exclude the orientation of social ecology.

Studies by contemporary geographers have in essence furthered our understanding of 1) the relationship of the area of criminal residence to the area of crime offense (a concept originated approximately fifty years ago by The Chicago School ecologists), and 2) the manifestation of adult crime and criminal victimization (an approach which has gone beyond the juvenile delinquency studies performed by early Chicago School ecologists). Work by Ronald Carter, Gerald Pyle, and Christopher Smith have also highlighted the applicability of "mental imagery" and "mental map" conceptualization to studies of citizen perception of crime, as well as studies of the criminal's choice of crime (or offense) target. Urban geographers have also applied the classic "Distance-Decay Function" and "Site-Situational" factors to descriptive explanations of crime perpetration and criminal victimization. Yet, this geography of crime to date has remained descriptive, and in the case of geographic base file applications by police departments, predictive. It has also been almost totally non-theoretical. In fact, there has been no real systematic attempt by geographers, including this author, to tie descriptive geographic crime analysis to either theory building or support of contemporary theoretical explanations of juvenile or adult crime perpetration and victimization. Thus, contemporary studies have not attempted to explain how descriptive spatial analysis may be utilized in support or refutation of such common theoretical explanations of crime and criminal victimization as Control Theory, Strain Theory, Anomie Theory, Differential Association and Differential Identification Theory, Labelling Theory, Culture Conflict Theory, and Radical (or Critical) Theory.

I would contend that the lack of theoretically based research has been due in part to two circumstances: 1) the fact that most of the contemporary geographic pioneers charting the parameters of the Geography of Crime and Violence have been trained as geographers, not criminologists (in fact, most are self taught criminologists) and 2) the absence of detailed micro- and macro-level spatial data from which geographers can draw for their analyses. Police and court officials vigorously hoard and protect crime data which details the spatial location of a criminal interaction, in part in an attempt to avoid prejudicing criminal cases before grand jury or court action, and partly as a reflection of police culture which views with suspicion the motives of society in general and social scientists in particular. This second point cannot be over-emphasized. Crime data, usually available to social scientists are filtered in regard to valuable temporal and locational factors, e.g. the Uniform Crime Reports(1) and The Source Book of Criminal Justice Statistics,(2) municipal police arrest, call, and suspect data. This filtering is necessitated by computer storage of the huge volume of cases, as well as various disclosure acts which protect the rights of the accused. This filtering process has also been necessitated by the naive or oft times blatantly irresponsible utilization of criminal justice data by muckraking sensationalists in the pursuit of a free but often biased press as well as by social scientists whose lack of social conscience often abrogates the rights of the accused, e.g. note social science studies of multiple homicides, forcible rapes, and so-called guerrilla or terrorists bands. One can note that tabloids such as the N.Y. Daily News, and New York Post tend to feature interracial criminal violence. They also feature accounts of multiple homicides. Nonetheless, various Federal Government reports indicate that interracial criminal violence and multiple homicides are the exception rather than the rule. Terrorism studies that utilize Counterforce Magazine,(3) various federal and state data sources, Freedom House(4) and Amnesty International(5) bear the obvious political biases of the primary data source. One should also note that content analysis of news media accounts often force social scientists to accept the conceptionalization of the activists as portrayed in the news media, such as a bomb thrower, an assassin, an assaulter and murderer, a nationalist, a terrorist, a guerrilla, or freedom fighter. And is it proper to utilize suspect data when the suspect has yet to have his day in court?

Yet the fact remains that geographic analysis and criminological investigation should, and must, be undertaken. Spatial analysis grounded in a theoretical base would further the comprehension of the processess and factors which appear to be criminogenic in form.

The question, therefore, remains, "How does one bring about this new relationship that is both criminological and spatial in form, yet also theoretically based?" First, the investigator must acknowledge that spatial analysis is essentially a methodology equally applicable to most, if not all, social science disciplines. Second, a series of research questions or hypotheses should be devised to test the power of explanation offered by one or more criminological theories. For example, one might wish to note whether Control Theory or Critical Theory (i.e. Economic Theory) more fully explains the abnormally high crime rate in El Barrio Nuevo in the South Bronx of New York City. Control Theorists would argue that crime-prone individuals are themselves 1) grounded in broken families or families that have lost their stablizing and socialization function, 2) associated into schools that are ineffective in teaching, training, and inculcating societal norms of proper behavior and morality, and 3) served by churches that no longer meet the physical and social needs of their constituents, much less their spiritual and moral needs. In brief, Control Theorists would argue that the delinquent or criminal is a deviant individual who is under-socialized. Conflict theorists would note that the delinquent or criminal need not be unaware of

societal norms or even improperly socialized into the dominant mores of the given society or of the specific community of which he or she is a member. For the Conflict Theorist by contrast, criminal acts are merely an expression of poverty. The geographer or social ecologist aware of the theoretical basis of these two theories would attempt to note the following: 1) whether or not low income individuals (or individuals who exhibit some other economic manifestation of poverty) are in fact more crime-prone than high income individuals; 2) whether the area of criminal residence and the area of crime commission coincide with the poverty characteristics allegedly associated with the suspect or arrestee; 3) whether or not suspects or arrestees come from dysfunctional homes, churches, and schools and whether or not the area of criminal residence and the area of crime commission coincide with the existence of the residences and life experiences of suspects or arrestees. Thus Conflict Theory would be in part supported (although not entirely validated) by spatial analysis that identifies the coexistence of persons who exhibit poverty characteristics with the areas of crime occurrence and criminal residence. Control Theory would receive support if there was a coincidence of crime occurrence, the area of criminal residence, and the personal social history of improperly socialized individuals serviced by dysfunctional homes, churches, and schools. The Conflict Theorist is in part making a statement in regard to the existence of a contraculture(6) or delinquent sub-culture(7) with a distinct spatial residential manifestation. He is not stressing non-existent or dysfunctional socialization. Rather, his is the argument of poverty and its consequent criminogenic sub-culture and subsequent socialization process, into which the suspect or arrestee has been socialized.

Such an approach is at best sketchy and incomplete. Nevertheless, it offers an alternative direction which may stimulate thought and debate about the geography of crime.

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PHOTOMAPS: QUESTIONS ABOUT CARTOGRAPHIC SYMBOL LEGIBILITY

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The ability to communicate multidimensional information clearly is essential to progress in understanding geographic relationships. Of the methods which are used by geographers, graphic techniques often are especially effective. Unlike written or spoken language which is imprecise and inefficient in its spatial effectiveness, graphic methods permit the preservation of locational relationships. In contrast to mathematical or statistical models, which may preserve the multidimensional character of a data set, graphic models usually are interpreted more easily because of their closer approximation of reality.

As graphic models conventional maps have limitations which result, in part, from the processes which are used in abstracting from reality to map form. Because maps must be scaled down representations, the degree of departure from a 1:1 relationship directly increases the extent to which a cartographer must limit the number and complexity of data categories and generalize those items which can be included. Even a complicated map, such as a U.S. Geological Survey (USGS) 1:24000 scale topographic sheet, is simplistic compared to the landscape which it represents. For example, vegetation types are generalized to a few categories: wooded, scrub, orchard and vineyard. The intricacies of land use/cover patterns are lost almost entirely in the selection, abstraction and simplification processes. At the same time, however, such maps may make real-world relationships more evident, either by showing phenomena which are not visible directly, such as political boundaries or place names, or by emphasizing some patterns through classification, simplification and grouping decisions, and through choices of symbols and their design.

In many instances, conventional map form is an adequate expression of geographic realities. However, such maps may be slow and costly to produce. In contrast, a photomap may be prepared at a lower cost, depending on the manipulation which is required for the aerial image and on the amount of supplemental information which must be added. Because of the rapidity with which photomaps may be made, there is a long history of their use for military purposes. Effective use is made of photomaps in rapidly changing areas, such as cities or resource exploitation sites, where the frequent revision of conventional line maps is not feasible. The idea of photomap is to combine the more life-like attributes of the photographic image with the minimum amount of abstract symbolization consistent with map user needs. The USGS has produced two orthophoto editions of parts of the United States: the cheaper black and white orthophotoquad with marginal detail and only four or five place names, and the full color orthophotomap on which contours, roads, buildings, boundaries and so on are symbolized as on a standard quadrangle edition. Ideally, the more realistic photomap should be an effective tool because the fine spatial detail is retained and either may be ignored or classified as necessary for a particular use.

As anyone who has dealt with photomaps will testify, the ideal in information accessibility is approached very rarely. One problem is that the interpretation of a photograph is not a simple or unambiguous task. Because the legibility of a feature depends on how well its spectral reflectance signature contrasts with that of its surroundings, objects which are distinguished by very different symbols on conventional maps may be illegible on an aerial photograph. In addition, serious questions may be raised as to how well cartographic detail can be combined with the photographic background.

Examples of maps on which inadequate contrast between symbols and their background or between categories or hierarchies of figures limits information legibility are all too common. On photomaps, one may encounter place names which require extended search time to locate and which, once found, are hard to read. Line following or point symbol counting tasks may be made difficult because of a lack of tonal contrast. Robinson, Sale and Morrison(1) note the overwhelming importance of sufficient contrast in map design, stating, "No element," including legibility and clarity, "is as important as contrast. Visual contrast is the basis of seeing..." Perhaps the inadequacy of contrast between map figures and a background image is encountered more commonly in conventional line mapping on a shaded relief background. The continuous tone image on which the map symbols are placed has been shown by DeLucia(2) to increase the amount of time required to extract nonterrain information from a USGS 1:250000 scale map.

An unanswered question is whether or not the continuous tone photographic image with its severe tonal variations and textural and pattern detail has a similar, statistically significant negative impact on the user's ability to read and interpret a map. A recent study by Smith,(3) using the USGS 1:24000 scale Pokes Point, Utah orthophotomap and standard edition, indicates that the increased graphic load on the orthophotomap does not hinder task completion time or accuracy. However, much of any effect which might be found depends on the complexity of the photo image, on whether the map is in color or black and white, on the design and placement of the point and line symbols and type and on the testing procedure which is employed. The general concern for effect still is valid. In order to settle some of the questions regarding the design of a broader evaluation program, a series of tests has been completed using the Eddy, Florida/Georgia 1:24000 scale topographic quadrangle. The goal of this research is to evaluate a wide range of photmap products in order to establish some general guidelines for cartographic information content design.

The Eddy quadrangle includes a sparsely populated section of the Okefenokee Swamp along the Georgia-Florida border. The landscape is a mixture of heavily forested swampland and low islands. Human occupance is limited to only a few sites, although the area is covered by a network of unimproved roads. A railroad and a secondary road cross the area. Although the dates of the maps are different (standard edition 1959, color orthophotomap 1971), cultural detail is essentially the same. Test questions were limited to unchanged portions of the map. These parts were isolated by masks. Test questions were prepared to include several basic map use tasks. The subjects were twenty graduate and senior level university students who were majoring in geography. They were instructed to work at a reasonable speed and not to give unsubstantiated answers to any questions. Both speed and accuracy of response were recorded. In general, the difference of means tests on response time support the hypothesis that the cartographic detail on the orthophotomap was less accessible to the reader. Some specific questions and responses are discussed below.

Several questions involved the 'locate' task, evaluating the user's ability to find type against either a flat tint on the standard edition or the variable background on the orthophotomap. All subjects were able to locate the names but response times varied widely. It took subjects 1.5 to 2.5 times as long to find the names on the orthophotomap. Inadequate contrast appears to be responsible for this. The cartographer lacks control over figure-background relationships within the photographic image.

In other cases, subjects were asked to interpret relief information. Again there was a statistically significant difference in favor of the standard edition. Several subjects noted the difficulties with the orthophotomap due to the brown lines merging with the dark, murky blue-green colors and

complex detail of the enhanced photographic image. Correctness of response was 2.5:1 in favor of the standard edition.

Other tasks involved counting point symbols (houses) in selected parts of the map. All answers were correct, but those who were using the standard edition took more than twice as long to answer as did those who were using the orthophotomap. This unexpected result apparently arose from the fact that the symbol sizes were different; squares on the orthophotomap were about four times as large as those on the standard edition. Thus, it is likely that the increased size promotes figure visibility and this effect should extend to lines and to type. However, the utility of this variable is limited because of space and aesthetic constraints.

A final task was to measure, visually, the percent of area in swamp and the length of all roads in a limited map area. Accuracy was much higher on the standard edition. For swamp area, the mean estimate differed from a precisely measured figure by only 3 percent. The mean answer based on the orthophoto image was more than 30 percent too low. The repetitive swamp symbol on the standard edition is less ambiguous than is the combined blue-green hue and plant texture on the photo image. It is important to remember that, although the photographic model is less abstract, its content is not necessarily available to all map users. A similar, although less dramatic, difference was noted for road length estimates.

The results of this preliminary investigation cannot be used to assert the superiority of any map type over another or of any particular method of symbolizing map content. It is likely that several techniques for improving symbol-image contrast will prove useful. For instance, spread-line negatives may be used to mask out part of the photo image, into which the cartographic symbols can be dropped. The symbol then is surrounded by the contrasting white background. Or, an outline symbol may be printed with a contrasting interior. Either method can be add greatly to information accessibility. The concept of photomapping, combining the best of two levels of data abstraction, has proven useful for many purposes. The improvement of photomap design deserves serious attention from cartographers.

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PIZZA PARLOR EXERCISE: A COMPUTER-BASED INSTRUCTION UNIT

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Over the last ten to twenty years spatial organization as a major geographic concept has been introduced into many undergraduate college courses. Such topics as spatial interaction, location-allocation, spatial decision-making, spatial diffusion, and location theory are commonly taught in these courses. In teaching these topics it is often both necessary and desirable to discuss their theoretical bases which are generally best expressed in quantitative terms. Many students either do not understand quantitative expressions or posses certain anxieties about them. Instructors thus are faced with the task of removing these barriers so that students can understand and appreciate the theoretical bases of spatial concepts. To meet this task the author has developed a computer-based exercise which allows students to examine various spatial concepts using a quantitative model. This exercise has been used in an urban geography course over the last five years.

Before developing the exercise, several objectives were formulated. First, the exercise needed to be constructed around a quantitative model to illustrate to students the significance of the theoretical-quantitative approach in studying spatial concepts. Second, the exercise had to be spatially dynamic so as to demonstrate the stimultaneous occurrences of phenomena within space. Third, the exercise had to be designed so as not to overburden students with mathematical calculations. Fourth, the map as geography's traditional and main research tool needed to be incorporated into the exercise to illustrate the spatial dimensions of the concepts being studied, and to show students the relationship between the map and spatial organization. Fifth, to simulate actual conditions a multi-variable approach was required but each variable had to be controlled independently so that students could manipulate one or two variables while holding the others constant. And last, a topic on which students had some knowledge and interest was needed in order for them to make intelligent decisions when working on the exercise. These objectives led to the formulation of an exercise on the spatial arrangement of pizza parlors based on a computer system utilizing Huff's retail gravitation model. This model, developed in the 1960s calculates the probability of consumers being drawn to a certain central place activity based on its centrality and location, in comparison with the centrality and the location of competing activities:

$$P_{ij} = \frac{A_j \,/\, T_{ij}^{a}}{\sum_{j=1}^{n} A_j \,/\, T_{ij}^{a}}$$

where P_{ij} = the probability of a consumer originating at point i being attracted to central place j,

A_j = the measure of centrality of central place j,

T_{ji} = distance separating i and j,

a = a parameter to reflect the sensitivity of various kinds of consumer trips to distance, and

n = number of central places.

BACKGROUND INFORMATION

In college towns pizza parlors generally attract many students and also employ student help. Consequently, students are likely to possess some knowledge and interest about pizza parlors in comparison with other central place activities. Most college communities have more than one pizza parlor resulting in competition between businesses for the market. In this exercise, a hypothetical college community exists with three pizza parlors. Some business people wish to add a fourth pizza parlor but are not sure where to locate it in order to maximize profit. Students are told to visualize this problem from the community planner's perspective. The planner wants to find a profitable location for the new parlor but does not wish to endanger the economic health of the other parlors. Therefore, students face the problem of trying to determine the best location for the new pizza parlor and at the same time to maintain the other parlors. To accomplish this task the students are to employ an expanded version of Huff's model, which has been computerized.

As background information the students receive two basic maps of the hypothetical community. The first is an isopleth map of the distribution of population density within the community (Figure 1). The community contains 11,750 people and the map gives some idea of the community's potential consumer surface. The second map shows the location of the three existing pizza parlors and the probability contours for consumer trading at the parlors (Figure 2). To create this map the theoretical probabilities of consumers trading at each pizza parlor from each printer cell location are calculated based on Huff's model and the highest probability value for each cell is displayed on the map. For any printer cell three probability values are computed, with a total value of 100 percent. The shaded contours allow students to determine what areas of the community are dominated by each parlor and what areas are subject to competition. Straight-line distance between the printer cells and the pizza parlors and a relatively simple measure of centrality - the cost of a glass of tap beer and a single piece of sausage pizza at a parlor - are used as data for Huff's model to produce this map.

The second map contains additional parameter data and income values. The row and column coordinates for each pizza parlor are listed along with the measure of centrality, the economic rent, the consumption, and the accessibility cost for each parlor. The centrality values based on a glass of beer and a piece of pizza are 75¢, 70¢, and 70¢ respectively for the three parlors. With Huff's model, the larger the centrality value, the greater the attractiveness of the central place; therefore, when cost values form the bases for centrality, as in this case, the reciprocals of the values are used. As commonly defined, economic rent is the cost to operate a pizza parlor at a location for a certain amount of time. Consumption represents the average amount spent by a consumer within a certain period. Based on the population distribution shown in Figure 1 each printer cell contains a certain portion of the total population. In this exercise each person is considered a consumer; therefore, the population associated with a printer cell also represents the number of consumers found at that cell. The number of consumers attracted to each pizza parlor from a particular printer cell is determined by the probability values calculated from Huff's model. Counts are maintained on the number of consumers drawn to each parlor and these counts are multiplied by the average amounts spent by a consumer in order to determine the gross income made by each parlor. The gross income figures are subtracted from the economic rent values to give the net income for each parlor.

EXERCISE

The exercise is designed to allow students to advance in stages, with each stage building on the previous stage and developing a more complex situa-

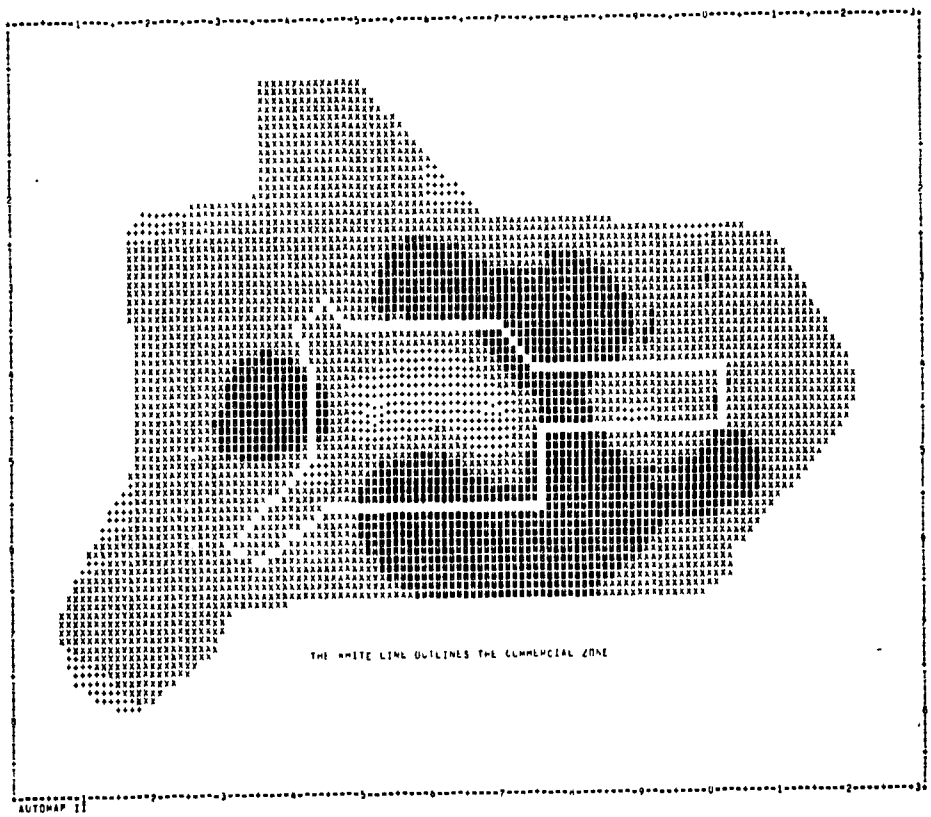
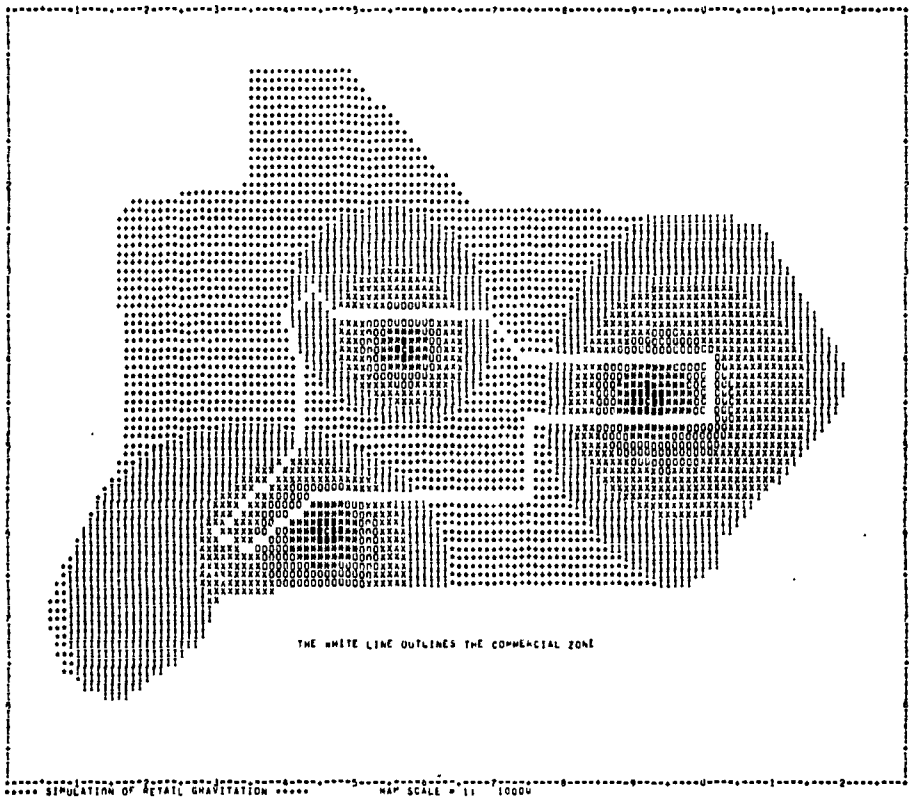
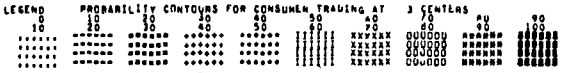


Figure 1. Dark areas represent high population densities and light areas low densities.





PIZZA LAND OR HEARTBURN ALLEY

STUDENT NAME

I N P U T P A R A M E T E R D A T A

		LOCATION COORDINATES DOWN	ACROSS	CENTRALITY	ECONOMIC RENT	CONSUMPTION	ACCESSIBILITY INITIAL	PER MILE	COSTS
CENTRAL PLACE	1	39.00	58.00	1.33	5364.00	1.00	0.00	0.00	
CENTRAL PLACE	3	69.00	97.00	1.33	4814.00	1.75	0.00	0.00	

		GROSS	COSTS	NET
CENTRAL PLACE	1	6822.14	5364.00	1458.14
CENTRAL PLACE	3	9178.50	4814.00	4364.50

Figure 2

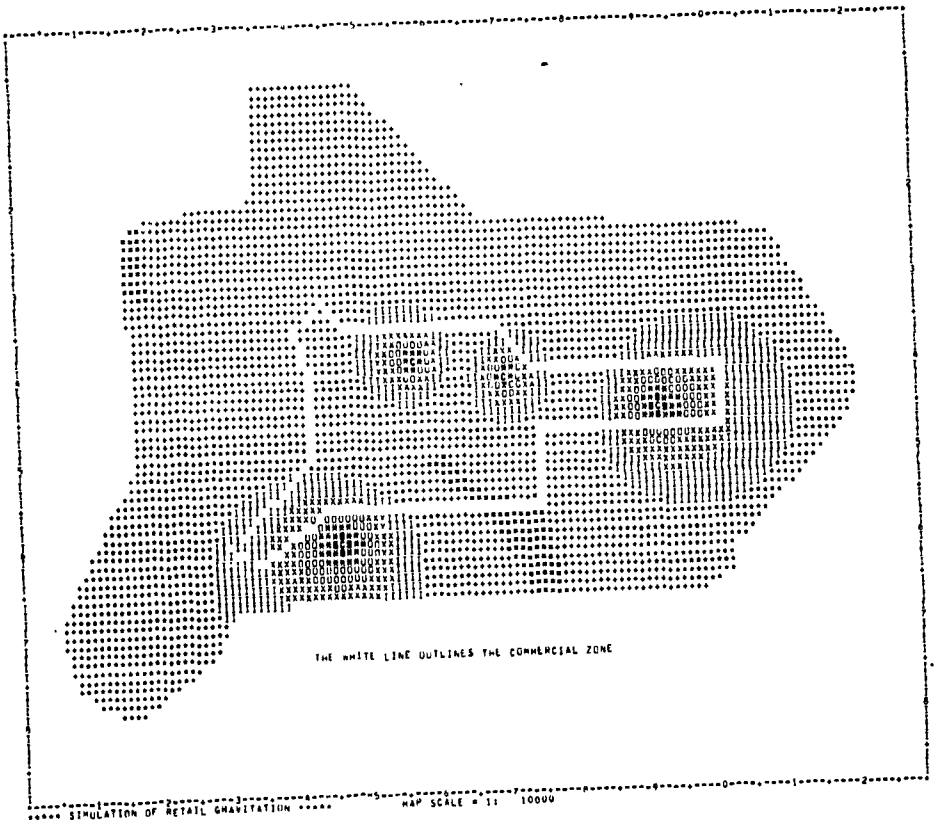
tion. Initially, students only specify the row and column coordinates of the fourth parlor plus values for centrality, economic rent, and consumption. In establishing a location they must consider the potential consumer surface and the trading areas of the three existing parlors shown by the probability contours. In addition they must locate within the area zoned commercial, outlined by the white line. One existing parlor falls outside this area. Students are informed that this parlor was established before the zoning laws came into effect. After selecting a location and the appropriate parameter values, the students submit this information to the computer, which creates a new probability contour map based on four parlors. (See Figure 3 for sample output.) The new computer output also contains the net income figures which the students use to determine if they have selected a good location. In Figure 3, the first parlor recorded a loss even though the new parlor had a profit; thus, from the community planner's perspective the selected location is poor. Generally, several attempts are needed before finding a location which allows all four parlors to show profits.

In the next stage, students consider accessibility costs. A new probability contour map is given to them showing the same parameter values listed in Figure 2, as well as values for accessibility costs. Two parameters exist under accessibility costs, namely initial and per mile costs. Initial costs represent any transportation costs other than costs per distance. Cost per distance is recorded under cost per mile. The map's fractional scale is used to calculate the number of miles between a printer cell and a pizza parlor. Straight-line distances are computed between points. For the fourth pizza parlors students are allowed to establish a per mile cost. They can also determine an initial cost but since only meter parking exists for the parlor, they must have a minimum initial cost of five cents. Under these new conditions students might find that they must select a new location for the fourth parlor since the profit and loss situation will most likely change.

RESULTS

This exercise is used in an urban geography course which is taught every semester with an enrollment of 30-35 students. One lecture period is required to cover the operational aspects of the exercise. Students work on the exercise over a three week period during which time various spatial concepts are being discussed in class. An average of ten computer runs is made for every student resulting in 300 to 350 probability contour maps being created by a class each semester. An advanced version of the exercise, not discussed in this paper, is used in a course titled Quantitative Geographic and Planning Models. It permits students to experiment with network distances through regression analysis, to develop permeable and impermeable barriers, to construct various isoplethic consumer surfaces, and to use other central place activities rather than pizza parlors.

Students enjoy the exercise and generally consider it a positive learning experience. Many comment on the difficulty of locating four profit-making pizza parlors within the available space. However, they seem to gain from the exercise a greater appreciation of spatial organization as a factor influencing people's activities. Some students express a desire to work with more variables and to be permitted to make changes in the three existing parlors. Experience has taught the author that at this level most students are not capable of handling such advanced conditions. Overall students do not demonstrate any concern about the quantitative aspects of Huff's model. In fact, they appear to be so engrossed with the spatial elements of the exercise that they do not recognize the existence of the model. In this respect the author may have failed since one of the objectives of the exercise was to get students to appreciate the quantitative bases of spatial concepts. However, based on student comments and enthusiasm the exercise appears to be a success.


THE WHITE LINE OUTLINES THE COMMERCIAL ZONE
SIMULATION OF RETAIL GRAVITATION
MAP SCALE = 11 10000
LEGEND
PROBABILITY CONTOURS FOR CONSUMER TRADING AT A CENTERS
PIZZA LAND OR HEARTBURN ALLEY
STUDENT NAME
INPUT PARAMETER DATA
LOCATION COORDINATES
DOWN
ACROSS
CENTRALITY
ECONOMIC RENT
CONSUMPTION
ACCESSIBILITY INITIAL
PER MILE
COSTS
CENTRAL PLACE 1
CENTRAL PLACE 2
CENTRAL PLACE 3
CENTRAL PLACE 4
39.00
59.00
1.33
5364.00
1.80
0.00
0.00
57.00
1.53
4868.00
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53.00
1.53
4814.00
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0.00
0.00
61.00
71.00
1.53
5000.00
1.80
0.00
0.00
GROSS
COSTS
NET
CENTRAL PLACE 1
$080.87
5364.00
-283.13
CENTRAL PLACE 2
$238.76
4868.00
793.76
CENTRAL PLACE 3
$311.17
4814.00
797.17
CENTRAL PLACE 4
$079.70
5000.00
79.70

Figure 3

ACKNOWLEDGMENT

The author achnowledges a grant from the State University of New York Faculty Grants for the Improvement of Undergraduate Instruction for the preparation and testing of the computer system associated with this exercise.

ROUTE AND PORT CONSIDERATIONS AMONG EXPORTERS: AN EXPLORATORY ANALYSIS

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A large body of geographic literature has examined the function of ports, classifying them, delimiting their hinterlands and forelands, and assessing their traffic structure, patterns and interfaces with various transportation modes and networks. However, few studies have been concerned with the factors firms consider when choosing a route and port for transshipment of their goods, and few have looked at how these considerations vary according to the characteristics of the trading firms themselves. This exploratory study will assess the relative importance of the various routing considerations and evaluate relationships between the attributes of firms and their route and port selection criteria.

FIRM ATTRIBUTES AND CONSIDERATIONS

Several geographic studies of ports have explicitly discussed considerations or variables weighed by shippers in making routing and port selections.(1) Collectively, these studies identified fifteen influential factors which were included in a questionnaire distributed by the author, and designed to obtain ratings for each on a seven point, unimportant (one) - important (seven), scale (Table 1). In addition, the questionnaire was designed to elicit information

TABLE 1

QUESTIONNAIRE VARIABLES

	Route & Port Considerations	Code		Firm Attributes	Code
1.	Seasonality	SEY	1.	Percentage of Output Exported	POE
2.	Frequency of Overseas Sailings	FOS	2.	Value of Output Exported	VOE
3.	Total Transit Time	TTT	3.	Firm Chooses Own Route and Port	FC
4.	Inland Carrier Rates	ICR	4.	Foreign Buyers Choose Route and Port	FBC
5.	Physical Facilities at Port	PFP	5.	Freight Forwarders Choose Route and Port	FFC
6.	Ocean Carrier Rates	OCR	6.	Containers Utilized	CU
7.	Labor Delays and Port Labor Problems	LDP	7.	Percentage of Exports Containerized	PEC
8.	Port Terminal Charges	PTC	8.	Ohio Location	OL
9.	Pilferage Problems	PP	9.	Pennsylvania Location	PL
10.	Diversity of Overseas Areas Served	DAS	10.	New York Location	NYL
11.	Container Facilities and Services	CFS	11.	Commodity Type: General (1) or Bulk (0)	CT
12.	Banking and Financial Services	BFS	12.	Number of Overseas Areas Exported To	NOA
13.	Customs Efficiency	CE			
14.	Efficient Freight Forwarders	EFF			
15.	Total Costs	TC			

about firm characteristics that might influence the considerations weighed in choosing a route and port for transshipment. No attempt was made to obtain detailed data on the internal characteristics of each firm's decision-making structure or its decision makers (e.g., years of exporting experience, personal characteristics of the prime decision makers,) since such variables are likely to influence the decision to trade or not to trade more than the route and port selection process itself.(2) Rather, attributes of the firms such as the type of commodity exported, use of containers, locus of decision-making, and relative and absolute dependency on trade were collected. (Table 1)

THE SAMPLE

To obtain data that would satisfy the requirements of this study, the questionnaire had to be sent to firms considering similar port and route selections and similar types of goods movement, thus ensuring that any variation in choice resulted from differences in the firms themselves rather than variations in the types of shipments. To satisfy these requirements, the questionnaire was sent to all manufacturing firms reported to be engaged in foreign exporting in an area equivalent to the hinterlands of the major Lake Erie ports of Buffalo, Cleveland, and Toledo as well as in an area of hinterland competition among the North Atlantic ports of New York, Philadelphia, and Baltimore.(3) The actual study area included western New York, western Pennsylvania, and all of Ohio. The firms in this region had a large number of alternative routes and ports from which to choose and hence had to weigh many or all of the considerations identified in Table 1.

The questionnaire was addressed to each firm's export manager, traffic manager, or foreign sales director, depending upon its organizational structure.(4) A total of 295 questionnaires were sent out and 57 usuable responses received (19 percent of total). Twenty-eight of the responding firms were located in Ohio, 18 in Pennsylvania, and 11 in New York, with the response rate roughly the same in each state. Nearly all the firms exported goods in the manufactured products category and the value of exports ranged from $18,000 to $28 million, with an average of $5.5 million. A majority of the firms shipped under 10 percent of their total output abroad, but several exported over 50 percent of their output. Products were exported to all world regions, but most shipments were bound for Western Europe.

ANALYSIS

In order to obtain an overall picture of which route and port considerations the firms deemed most important, the fifteen considerations listed in Table 1 were ranked by the mean score they received on the seven point unimportant-important scale (Table 2). The standard deviation for each consideration was also calculated. The results indicated that the firms as a whole held cost and time considerations as the most important determinants in choosing a route and port for overseas shipments. Two service considerations also proved to be relatively important: the presence of efficient freight forwarders and the diversity of overseas areas served by a port. Among the less important considerations were seasonality and factors related to the costs incurred and services obtained in the ports themselves. The standard deviations for each of the fifteen considerations were large, suggesting that there was a fair degree of variance in the ratings of the route and port selection factors. This variance is an interesting result given the relative homogeneity of the firms with respect to the type of commodities produced.

To assess how the attributes of the firms were related to the importance they placed on the various route and port choices, simple correlation analysis was employed (Table 3). Although the sample of firms is relatively small,

TABLE 2

RANK, MEAN SCORES, AND STANDARD DEVIATIONS FOR THE FIFTEEN ROUTE AND PORT CHOICE CONSIDERATIONS

Rank	Consideration	Mean Scale Score	Standard Deviation
1	Total Costs	4.99	3.77
2	Total Transit Time	4.95	3.42
3	Frequency of Overseas Sailings	4.93	4.33
4	Labor Delays & Labor Problems at Port	4.62	3.38
5	Efficient Foreign Freight Forwarders	4.54	3.56
6	Inland Carrier Rates	4.20	2.76
7	Diversity of Overseas Areas Served	4.18	2.73
8	Ocean Carrier Rates	4.08	3.20
9	Port Terminal Costs	3.77	2.56
10	Physical Facilities at Port	3.67	2.18
11	Customs Efficiency	3.54	2.21
12	Pilferage Problems	3.43	2.07
13	Seasonality	3.38	2.46
14	Container Facilities and Services	3.23	2.08
15	Banking and Financial Services	2.79	1.59

TABLE 3

STATISTICALLY SIGNIFICANT SIMPLE CORRELATIONS BETWEEN ROUTE AND PORT CONSIDERATIONS AND TWELVE FIRM ATTRIBUTES*

	SEY	FOS	TTT	TC	ICR	PFP	PTC	PP	DAS	CFS
CU	.31	.47						.27		.61
PEC			-.32							.50
VOE		.29			.28					
NQA		.45					.33	.33	.26	
FFC										.29
NYL	-.30	-.51		-.31		-.27				
PL		.28				.37				
DL	.26									

*Simple correlation coefficients greater than .34 significant at the .01 level. All others significant at the .05 level.

the results of this exploratory analysis should nevertheless suggest the kinds of relationships that exist between the attributes of firms and their route and port choices.

Four variables representing various firm attributes had no significant associations with the route and port choices (POE, CT, FC, and FBC). Eight other firm attributes had at least one statistically significant relationship with the route and port variables, although the correlation coefficients were generally low to moderate in size. Both variables related to the use of containers were correlated significantly with route and port considerations. Firms using containers for moving at least a portion of their exports (CU) rated seasonality, the frequency of sailings, pilferage problems, and the availability of container services and facilities as important selection criteria. Containership sailings are frequent by virtue of tightly scheduled and regular services, quick port turnaround times, and increased line-haul speeds.(5) Pilferage problems are also reduced through the use of containers.(6) The positive relationship between container use and seasonality suggests that firms which use containers are interested in continued service throughout the year and feel it is important to avoid the service disruptions that port seasonality can cause.

The greater a firm's reliance on containerized shipping (PEC), the less importance it attaches to total transit times, for firms shipping a high volume of freight via containers have developed timely transit systems, or "pipelines", and no longer need to place much emphasis on time considerations; firms who do not use containers or use them little remain concerned about transit times.

The value of a firm's exports (VOE) was positively correlated with sailing frequencies and inland carrier rates. Sailing frequencies are important to larger exporters because these firms are both more likely to have complicated international marketing and distribution needs and to export to more world regions than smaller exporters. For firms involved in a large volume of exports, inland freight bills can be a major cost item which could easily reduce their competitiveness in foreign markets should these costs become exorbitant.

Firms exporting to a relatively large number of foreign regions (NOA) rated sailing frequencies, the diversity of overseas areas served by a port, pilferage problems, and port terminal charges as important factors. Pilferage becomes an important consideration when a firm exports to a large number of overseas areas because handling and waiting times in ports tend to increase and because it is more difficult to keep effective track of items when they are shipped to many separate destinations. The increased handling, storage, and waiting times on docks that arise when shipments are going to many different regions means that the costs incurred at the port are greater and hence are given more careful consideration.

Taken as a whole, the decision-making variables (FC, FBC, and FFC) did not correlate significanlty with the route and port choice considerations (many of the firms in the panel used two or even all three of these decision categories). Only the variable representing those cases where freight forwarders decided (FFC) on the routes and ports utilized correlated with a consideration: the availability of container services and facilities. And although the state location variables (NYL, PL, OL) were at best very gross measures of differences in locational environments, firms in all three states rated the various considerations differently. Reasons for these differences could not be readily ascertained from the data but this finding does pose an interesting future research question.

CONCLUSIONS

This heuristic study found that there is great diversity among the various considerations firms weigh when choosing routes and ports for exporting goods. In addition, significant correlations were found to exist between certain attributes of exporting firms and the considerations they rated as important or unimportant in choosing a route and port for transshipment. Many of the relationships found beg further investigation. The results of similar and more encompassing studies could have considerable public policy and planning implications with respect to governmental attempts to foster exporting activities.

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DYNAMIC MIGRATION MODELING*

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The large and growing body of literature concerned with migration has made significant contributions to our understanding of multiregional population growth. Yet, only a small proportion of this literature is concerned with the theory of migration, and among the many empirical studies, relatively little work has centered upon the actual motives which underlie the decision to migrate.

One may conceive of many factors which lead to migration. Among these, economic reasons are perhaps mentioned most frequently. At the intraurban level, much recent work has focused on migration which is based upon a residential search process which seeks to maximize an individual's utility. Smith et.al. have recently illustrated such an approach.(1) Such models are a function of the characteristics of both the housing stock and the population. Interactions between the two purport to give insights into the intraurban migration process. At the interurban level, there has been increasing interest in attempts to link characteristics of the job market with models of migration. The early work of David (1974) and Todaro (1969) has been followed by the development of matrix models of a Markov type, chiefly due to the efforts of MacKinnon.(2,3,4,5) These models are functions of the characteristics of the job market, and the main focus lies on the interactions between the job market and the labor force.

An attractive framework for models of this type is provided within the literature of ecology. A whole spectrum of models has developed which are designed to look at interactions between species. They provide interesting output in the form of equilibrium, stability, and sensitivity conditions. The models are usually couched in a differential or difference equation format, and have proven to be extremely flexible in their ability to adapt to a wide variety of situations.

In the next section, a simple model of species interaction is discussed. Following this, more elaborate models are discussed, and their relevance to urban population dynamics is indicated.

AN ELEMENTARY MODEL FROM ECOLOGY

Within the ecological literature, models of species interaction have been developed extensively. Best known among these is the predator-prey model, initially developed by Lotka and Volterra.(6,7) The model is based upon a set of differential equations which give the changes in predator and prey populations over time. A prime objective is to determine the long-run fate of both populations. Such a model seems to provide an attractive analogy which may be useful in modelling the migration process. In our context, predators in the system may be thought of as analogous to individuals searching among cities for economic opportunity in the form of job vacancies, and within cities for maximum utility, which is a function of residential location choice. Likewise, prey represent the housing and employment opportunities for which the predators are searching. Implementation of the model would then result in a temporal account of both population and economic opportunity.

The predator-prey model starts by making an assumption about the growth of prey in the absence of predators. The simplest assumption which might be made is to assume that the prey will increase exponentially:

*Awarded 1980 prize for the best student paper submitted to the Annual Meeting of the Middle States Division.

(1) $dx/dt = ax \ , \ y = 0$

where x denotes the size of the prey population and y the size of the predator population. Similarly, we must make some assumption about the predator population in the absence of prey. Initially, it might be assumed that the predator population will decline exponentially:

(2) $dy/dt = -py \ , \ x = 0$

To complete the specification, we need only to make an assumption concerning the rate of interaction, or rate of catches of prey by predators. Lotka and Volterra assumed that this rate was proportional to the product of the two populations. With interaction allowed, equations (1) and (2) may be rewritten as:

(3) $dx/dt = ax - bxy$

(4) $dy/dt = -py + cxy$

To examine the fate of each population over time, it is useful to first look at the equilibrium situation; that is, the point at which the populations are not changing over time. This may be stated as:

(5) $dx/dt = dy/dt = 0$

implying that:

(6) $x(a-by) = 0, \ y(-p+cx) = 0$

Thus the non-trivial equilibrium solution of interest is:

(7) $y = a/b, \ x = p/c$

Much can be learned about the dynamics of the system by examining the nature of the solution near the equilibrium point. Several possibilities are obvious. The system may:

1) Approach the equilibrium value E, but never reach it. Here E is known as a stable equilibrium point.

2) Move away from E. In this case, E is unstable.

3) Move in some cyclic fashion about E.

To find which one of these possibilities results from assuming the Lotka-Volterra system [equation (3) and (4)], we begin by generalizing (4) and (5) to:

(8) $dx/dt = F(x,y)$

(9) $dy/dt = G(x,y)$

Then form the matrix A, made up of the elements:

$a_{11} = dF/dx \qquad a_{21} = dG/dx$

$a_{12} = dF/dy \qquad a_{22} = dG/dy$

The matrix A is then known as the community matrix, after May.(8) Stability of the system may then be analyzed by examining the nature of the eigenvalues of the matrix A. The eigenvalues may be found by solving the equations:

$$(10) \qquad \det |A - \lambda I| = 0$$

Solving equation(11) for the Lotka-Volterra system given in (4) and (5) yields $\pm i\sqrt{ap}$ for the eigenvalues. In this special case where the eigenvalues are purely imaginary, populations move cyclically around the equilibrium value. Furthermore, the amplitude of the cycle is wholly dependent on the initial conditions, and any disturbance from the cycle leads to the establishment of a new cycle about the equilibrium value. In this special case, the system is termed neutrally stable, or structurally unstable. Thus, the direction of populations undergo distinct phases during a cycle:

a) The prey population is in abundance.

b) The predator population increases and cuts down on the prey population.

c) The predator population declines due to the decline in the number of prey.

d) The predator population falls sufficiently to allow prey to start increasing.

e) The predator population begins to increase due to the increase in prey.

RELEVANCE TO MIGRATION DYNAMICS

Although the preceding discussion does not claim to provide a reasonable model of population dynamics, its value lies in its flexibility. The model provides an attractive basic framework from which assumptions may be modified to provide more realistic models of interaction.

For example, the Lotka-Volterra system may be extended to the n-predator, n-prey case as follows:

$$(11) \qquad dx_i/dt = x_i(t)\left(a_i - \sum_{j=1}^{n} \partial_{ij}\, y_j(t)\right)$$

$$(12) \qquad dy_i/dt = y_i(t)\left(-b_i - \sum_{j=1}^{n} \beta_{ij}\, x_j(t)\right)$$

Such extensions are useful if it is desirable to disaggregate the model. Thus, it may be more realistic to consider a system with several predator "species," or several types of laborers. Likewise, prey species may correspond to housing or employment types.

Time delays have also been incorporated into predator-prey models.(9) Migration is lagged to the degree that migrants do not possess perfect information about the job market. Individual perceptions persist through time, and migration is thus partially a response to dated information.(10)

Other models may incorporate spatially heterogeneous environments.(11) These models are characterized by predators diffusing towards more favorable environments. In any model of migration, it would be desirable to incorporate the diffusion of migrants towards better housing and employment opportunity. Control of predator-prey systems has also received some attention.(12) Such work may lend insights into the indirect control of migration streams through the development of housing and employment opportunity.

Each of the preceding modifications will affect the stability of the system. Many extensions drive the system to a stable limit cycle. Like the Lotka-Volterra system, populations fluctuate cyclically, but the important difference is that if the system is displaced from the cycle, it eventually returns to the original cycle. A large class of systems may be shown to exhibit either a stable limit cycle or a stable equilibrium point. The theorem is due to Kolmogorov and is discussed by May. Other modifications may be destabilizing in the sense that they tend to drive populations away from any equilibrium point or stable limit cycle.

While few predator-prey models have been concerned explicitly with migration, Chewning has recently published some interesting results.(13) Consider a region with N habitats and allow migration between habitats. Chewning shows that limited migration can have a stabilizing influence on locally unstable population dynamics. In our context, this is somewhat analogous to people migrating between cities to equalize utility levels. Utility levels are stabilized to some degree by the process of migration which acts as an equilibrating factor.

Perhaps the most valuable contribution of predator-prey models is their potential for providing a link between micro and macro theories of migration. The models are predicted upon explicit individual types of search behavior and yield macro temporal distributions. While the Lotka-Volterra model assumes a random spatial search process, more realistic models are characterized by search processes biased in the direction of greatest opportunity. Predator-prey models might be conceivably coupled with the well-developed job-search literature to provide a more unified body of migration theory.

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A NEW APPLICATION OF THE HEXAGONAL PATTERN OF CENTRAL PLACE THEORY

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The hexagonal pattern and hierarchy of classical central place theory has been considered inadequate for describing city location because of its strict basic assumptions, in particular an isotrophic surface, homogeneous distribution of people and/or towns, and economically rational consumers. Isard developed a modified hexagonal pattern to compensate for real world distortions.(1) Others have tried to identify and measure nested hierarchies and hexagonal patterns in actual situations.(2) Now the hexagonal pattern is being used to divide a metropolitan area in an experiment to provide efficient telephone service. This paper will compare this use of a hexagonal pattern, which has no dependence on geographic theory, with geographic central place theory and will try to determine whether it might prove useful in better understanding and applying central place theory to the real world.

THE BELL SYSTEM APPLICATION AND ITS COMPARISON TO CENTRAL PLACE THEORY

The American Telephone and Telegraph Company is using a hexagonal pattern in a field trial provision of mobile telephone service to customers in Chicago, Illinois. In providing mobile telephone service, the object is, briefly, to use the airwaves as an extension of the wire telephone network and provide automatically switched voice connections to and from mobile subscribers. Traditionally mobile telephone systems have used one centrally located land station to serve mobile units throughout a metropolitan area. Under this system, however, the use of available radio channels is inefficient because each can be used for only one connection at a time in the entire service area. This limits severely the number of mobile subscribers that can be served and has led to the development of long waiting lists for mobile service. For example, only 700 customers can be served in New York City, and each call has a 50 percent chance of completion on the first attempt.(3) In an effort to increase the availability of mobile telephone service, AT&T has recently developed a system which uses radio channels more efficiently by confining them to fractions of a metropolitan area so that the same channels can be reused repeatedly elsewhere in the service area.(4) Each reuse of a channel means that additional traffic, and hence additional subscribers, can be handled.

The new system, called Advanced Mobile Telephone Service (AMPS), involves the division of the total physical area to be served into subareas or cells. The cells must be of some shape which will tile a plane; three which immediately come to mind are triangles, squares, or hexagons. AT&T chose the hexagonal cell or transmission area because this shape covers the greatest area for a given center to vertex distance and thus permits a given service area to be covered with fewer transmitter sites.(5) This is highly analogous to central place theory, in which the hexagon is the most efficient shape because it provides maximum packing of market areas while minimizing movement costs.(6) The reasoning for choosing the hexagon in both patterns is basically the same which is not surprising since the overall goals are the same: to supply a maximum number of consumers at the minimum total cost, whether the cost is measured in terms of distance travelled or transmitter sites.

A hierarchical pattern develops in central place theory because the distance consumers are willing to travel varies with the nature of the good. As a result, in Walter Christaller's central place theory, the service areas of lower order threshold goods nest in the larger service areas of higher order

threshold goods and a hierarchy of central places providing goods and services develops.(7) A central place at a given level of the hierarchy provides goods and services of lower order central places along with additional goods and services needing a larger threshold population. August Lösch's theory, based on different assumptions, develops into a different hierarchy in that central places do not provide goods and services of those in lower levels of the hierarchy.(8) The resulting pattern is one of superimposed hexagons with different orientations and different relations of lower to higher level service centers.

In contrast to the patterns of traditional central place theory, AMPS's pattern is completely non-hierarchical. Each mobile unit (analogous to a customer) is always served by the nearest transmitter site (analogous to a marketplace). Thus, there is no general superimposition of larger higher order cells on smaller lower order ones. Moreover, there is an identical upper limit on the number of customers which each cell can serve. When the increasing density of the customer population pushes some cell to this limit further growth can be accommodated only by increasing the number of cells. This is accomplished by subdividing existing cells into new ones of half the radius and so augmenting the original transmitter sites with new sites located halfway between them. Their positions are now on alternate vertices and they transmit and receive only within the 120 degree angle of the legs forming the angle so that each transmitter operates at different frequencies. This subdivision can be carried out over only the portion of a metropolitan service area where user density demands it; the remainder of the area retains the larger cells suited to lower density conditions. The system can thus make a gradual transition and respond sensibly to the increased usage.(9) This process of cell division can be regarded as analogous to the specialization of market centers in geographic theory where larger systems will have large centers providing more and more services. Here, however, the types of services provided remain identical and the specialization is geographic; the increasing density causes each center to specialize in a smaller and smaller service area.

The AMPS cell splitting causes the cluster to be rotated counterclockwise 120 degrees while the internal geometric relations within the cluster are preserved. Lösch also rotated his pattern but his objective was to maximize agglomeration of activities at one center and consequently to maximize agglomeration of services at all central places.

IMPLICATIONS FOR GEOGRAPHY

The fact that the Bell System has devised a modified central place theory with no reference to Geography's accomplishments is interesting for its own sake. However, there are points which can be valuable for geographers. One is that when physical transportation facilities depending on terrain are replaced by radio signals propogating in a uniform medium, a practical network of service providing centers can assume the perfect hexagonal pattern usually found only in theoretical work. In addition, the actual implementation of the system recognizes the need to adjust the hierarchical pattern somewhat to meet real world siting limitations. The AMPS system is engineered to permit individual sites to be located up to one quarter cell radius from their exact theoretical location because the location of transmitter sites is affected by the terrain and already "existing high-elevation structures."(10) However, this margin of error could prove troublesome as cell size decreases with increased density. Another point is that although hexagons provide maximum packing while minimizing transportation costs because of small vertex to center distance, the service providing centers can adequately serve their trade areas with no "central" central place. Of course, this is possible because only one level of good is being provided. With a larger threshold requirement, a central location is necessary as is illustrated by the original omni-

directional centrally located antenna. Once the density grows, however, this central transmitter is no longer needed because the vertex transmitters can adequately serve.

Perhaps geographers are being too critical of themselves and their theory. Maybe they should not try to modify central place theory but rather to expand on it, as some already have done. Central place theory is basically sound in its groundings and is applicable to real world situations. The fact that mathematical relations are not always true, or more accurately, rarely observed should not be alarming in explaining patterns. Central place theory is not a cure-all and is not applicable in all situations; the underlying assumptions are rather limiting. But as is evidenced in AMPS, the basic point, that a hexagonal pattern is a viable way of providing a service, is sound. It may be, then, that although central place theory's hexagonal hierarchy falls short of explaining actual city location, this is because of the strictness of the assumptions required and because no city exists only as a central place. The fact that the relative and absolute location of cities is affected by other factors was recognized by Christaller himself and later used by Preston, but the basic tenets of the theory may still be applicable in appropriate situations. Geographers can look at their theory more positively, realizing that it has severe limitations, but that its hexagonal hierarchy has been used to provide a service to a population of consumers in a real metropolitan area. Perhaps central place theory should be used in practical applications in connection with particular services. In other words, geographers can use their theory to devise patterns of provision of specific goods and services to consumers, without regard or with little regard to already existing structures of central places.

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THE SPATIAL DISTRIBUTION OF MORTGAGE FUNDS BY TYPE OF LENDING INSTITUTION IN THE PHILADELPHIA SMSA

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The spatial distribution of mortgage funds has recently become a controversial issue. Charges are made by neighborhood groups that redlining (the denial of housing loans on the basis of location) exists in certain areas of the city. Lending institutions involved in the home mortgage market generally deny in public that their lending shows any discrimination because of the geographic location of a property. The U.S. Congress, under pressure from various public interest groups, passed the Home Mortgage Disclosure Act in 1975.(1) Data are now available from 1976 to ascertain the spatial distribution of mortgage funds in urban regions. The focus of this study is the Philadelphia urban area.

THE STUDY AREA

The redlining studies in the past focused on redlining within city neighborhoods.(2) However, a fundamental question appears to be the relative spatial flow of mortgage funds from banks that have offices both within the city as well as branch offices in suburban locations. In this study, data are collected for thirty-five mortgage-granting institutions that have offices in the city of Philadelphia as well as the four contiguous surrounding Pennsylvania counties that comprise the Standard Metropolitan Statistical Area (SMSA).

The Home Mortgage Disclosure Act of 1975 requires banks and savings and loan associations with assets in excess of $10 million to disclose the location of all their mortgage and home improvement loans. The information for the first year (1976) was required to be reported by zip code; the subsequent three years of the disclosure act required mortgage data in large metropolitan regions to be released at the census tract level. In this study, the zip code level of analysis was used for 1976 and 1977, the two full years available when the data were gathered in the summer of 1978. Although this level of aggregation does not permit the micro-level study available with census tract data, it does permit an analysis of relative city vs. suburban allocation of mortgage monies.

THE ANALYSIS

It is hypothesized that the spatial distribution of mortgage funds will vary by the type of lending institution that is writing the mortgage. Because mortgage-granting institutions vary considerably in their organization and function, it does not seem appropriate to include them in one category.

Savings and Loan Associations (S & L's) are required by regulation to place approximately 80% of their assets into the housing market.(3) The Federal Home Loan Bank Board, the licensing agent and regulator for most S & L's, states that the institutions are to foster thrift and home ownership. Because savings and loan associations grew out of neighborhood need for local resources to finance home-buying, it is hypothesized that the S & L's have invested more of their assets within the city of Philadelphia than two other major categories of lending institutions, mutual savings banks and commercial banks. Mutual savings banks, like the savings and loan associations, have a cooperative structure in which the depositors are the owners. However, mutuals usually have far greater assets than S & L's and a wider range of lending activity because lending is not limited to home mortgages. Commercial

banks represent a corporate structure rather than a cooperatively managed savings institution. Much of the investment by commercial banks is directed toward industrial and commercial ventures rather than home financing. It is therefore expected that the commercial banks and mutual savings banks will invest less within the inner city housing market because of their greater investment opportunities in other regions.

During the two-year period of 1976-1977, the eight commercial banks surveyed loaned $172,777,200 in conventional mortgages (Table 1). Of this

Table 1

SPATIAL DISTRIBUTION OF COMMERCIAL BANK MORTGAGES - 1976, 1977

County	Number of Mortgages	Value of Mortgages in Dollars	% of Total Mortgage Value by Region	Value of Mortgages in Dollars Per Capita
Bucks	456	14,186,545	8.2	34.18
Chester	360	11,916,728	6.9	42.86
Delaware	541	30,561,593	17.7	50.68
Montgomery	621	20,860,703	12.1	33.43
Burlington	26	979,500	.5	3.03
Camden	131	4,118,688	2.3	9.03
Gloucester	21	673,753	.3	3.89
TOTAL - suburbs	2,158	83,297,511	48.2	- -
Philadelphia	1,508	18,049,090	10.4	9.26
SMSA	3,666	101,346,601	58.7	- -
Outside SMSA	2,065	71,423,599	41,3	- -
TOTAL - All Loans	5,731	172,770,200	100.0	

total, 10% was loaned within the city of Philadelphia and 48% was loaned in the suburban counties of the SMSA. Within the eight-county SMSA, the highest percentage of toal mortgages and the greatest per capita value of mortgages were made in suburban Delaware County. It should be noted that the three New Jersey counties of Burlington, Camden, and Gloucester have small mortgage values, not because they are being redlined, but because state banking laws do not permit the Philadelphia-based banks to have branch offices across state lines. Thus few mortgages are granted in New Jersey by the Pennsylvania-based banks.

An item of considerable interest is the 41% of the total mortgages by value granted by commercial banks which was loaned beyond the eight-county SMSA. The lending institutions do not have to disclose the location of these

mortgages; however, there is some evidence that these mortgage monies are invested far beyond the local SMSA through correspondent banks in rapidly growing Sunbelt metropolitan regions.(4)

The spatial distribution of savings bank mortgages and savings and loan association mortgages shows nearly identical percentages of the total mortgage monies going into the city of Philadelphia (Tables 2, 3). Although the savings

Table 2

SPATIAL DISTRIBUTION OF
SAVINGS BANK MORTGAGES - 1976, 1977

County	Number of Mortgages	Value of Mortgages in Dollars	% of Total Mortgage Value by Region	Value of Mortgages in Dollars Per Capita
Bucks	360	10,827,125	5.0	26.08
Chester	420	16,560,250	7.7	59.57
Delaware	1,469	43,342,910	20.1	71.87
Montgomery	1,104	40,233,438	18.7	64.47
Burlington	5	158,500	.1	4.91
Camden	35	1,113,375	.5	2.44
Gloucester	6	136,500	.1	7.89
TOTAL - suburbs	3,400	112,372,098	52.1	- -
Philadelphia	2,923	58,622,844	27.2	30.07
SMSA	6,323	170,994,942	79.3	- -
Outside SMSA	1,513	44,688,254	20.7	- -
TOTAL - All Loans	7,835	215,683,196	100.0	

and loan associations invested a higher percentage of their total mortgages in the suburbs (68.4%) than the savings banks (52.1%), the savings and loan associations only invested 4.1% of their mortgage money outside the Philadelphia SMSA, compared to the 20.7% of the total savings bank mortgage money that left the SMSA. In a pattern similar to the commercial banks, the savings and loan associations and the savings banks placed the most mortgage funds in the contiguous suburban counties of Montgomery, Delaware, and Bucks.

Table 3

SPATIAL DISTRIBUTION OF
SAVINGS AND LOAN ASSOCIATION MORTGAGES
1976, 1977

County	Number of Mortgages	Value of Mortgages in Dollars	% of Total Mortgage Value by Region	Value of Mortgages in Dollars Per Capita
Bucks	716	23,429,862	15.2	56.45
Chester	235	8,015,562	5.2	28.83
Delaware	576	19,379,363	12.6	32.14
Montgomery	1,436	50,227,256	32.7	80.49
Burlington	40	1,154,875	.7	3.58
Camden	86	2,716,750	1.7	5.96
Gloucester	3	85,000	.1	4.91
TOTAL - suburbs	3,093	105,008,669	68.4	- -
Philadelphia	1,987	42,239,475	27.5	21.60
SMSA	5,071	147,248,144	95.9	- -
Outside SMSA	196	6,328,325	4.1	- -
TOTALS	5,268	153,576,469	100.0	

CONCLUSIONS

The original hypotheses of the study were only partially supported by the data. The commercial banks located in the Philadelphia region invested only 10% of the total value of their mortgages in the city, compared to the 27% of the total value of mortgages invested by savings and loan associations and savings banks within the city of Philadelphia. The biggest difference in the spatial investment pattern of mortgage monies by type of lending institution was not the pattern between city and suburb as originally hypothesized, but rather the percentage of mortgage funds that left the SMSA. The savings and loan associations invested 96% of their mortgage funds within the Philadelphia SMSA. By contrast, the savings banks invested 79% of their mortgage funds within the Philadelphia SMSA and the commercial banks similarly invested only 60% of their mortgage funds.

The results of this research indicate the need to investigate further the regional flow of mortgage money. If data can be obtained, flows of mortgage funds from one region to another could lend valuable insight into current analysis of interregional growth disparities.(5)

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RESIDENTIAL ORGANIZATION IN A MEDIEVAL TOWN: GREATER GWALIOR (INDIA), AS AN EXAMPLE

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The spatial pattern of residential segregation observed in Indian towns of medieval origin follows the ecological principle of dominance inherent in traditional Indo-Aryan planning practices. As indicated in the plans of the Silpa-Sastra, an ancient Indian city planning compendium, the royal fortress palace or the residence of feudal lords were to be the focus of a capital town around which the council buildings and the dwelling houses were to be grouped in order to precedence. The underlying idea was the maintenance of proper coordination and stable cultural patterns among socio-economically diverse communities.(1) Many new towns and capital cities of India established during medieval times conform to such a pattern. Accordingly, large portions of land immediately surrounding the palace were allocated to those who ranked high on the scale of social status. The less privileged were housed on the outskirts of the city. The hierarchical residential profile thus reflected a close correspondence with proximity to royal residences. Such spatial arrangements induced through social and cultural processes have been further supplemented by present day economic conditions. The contemporary residential segregation thus shows a reinforcement of an old pattern and the current broader patterns of residential and population densities also convey a very strong imprint of historical processes.

In this paper, the actual processes at work in sifting and sorting various social groups in metropolitan Gwalior, an important town of medieval origin in northern India, are analyzed. It is observed that the changing functions of the erstwhile complex of palatial buildings from residential to commercial uses have, in fact, accentuated the initial pattern of residential segregation. The paper concludes with a brief comment on the difference in the residential patterning of Indian and Western cities.

The present city of Greater Gwalior (population 384,772)comprises the three distinct townships of varying size, population, and functional characteristics. Old Gwalior, situated at the northern fringe of the Gwalior fort, is the oldest settlement and has lost much of its earlier importance. Two miles south of Gwalior is a township called Lashkar which grew with the Marathas. It was developed as standing camp in 1810 by the Scindhias. Morar, the third township was founded by the British in the year 1844 as a cantonment.

Although the city is multi-nodal in its physical structure, the overall pattern of residential composition is now dominated by one township--Lashkar. In order to understand the role of Lashkar one needs some background on the creation of the three townships.

Greater Gwalior is located in a rock basin encircled on three sides by the hills between the Vindhyan mountain in the south and the Gangetic Plain in the north. The gap was often used by routes that linked the plain with the Gulf of Cambay and the west coast. This route was frequently used by the Mogul armies in Indian history. Thus,the geographical location of the valley on a major north-south route and the superb protection offered to it by an easily defensible site must have been the deciding factors in the founding of Gwalior as a fortified town, the bourg in Vance's scheme.(2) However, the defensive element which contributed to the initial location of Gwalior appears to have restricted its functional importance as a residential locality. The old town of Gwalior existed as a mere functional appendage to the fort and was composed primarily of the residences of lower class people who worked in the fort as

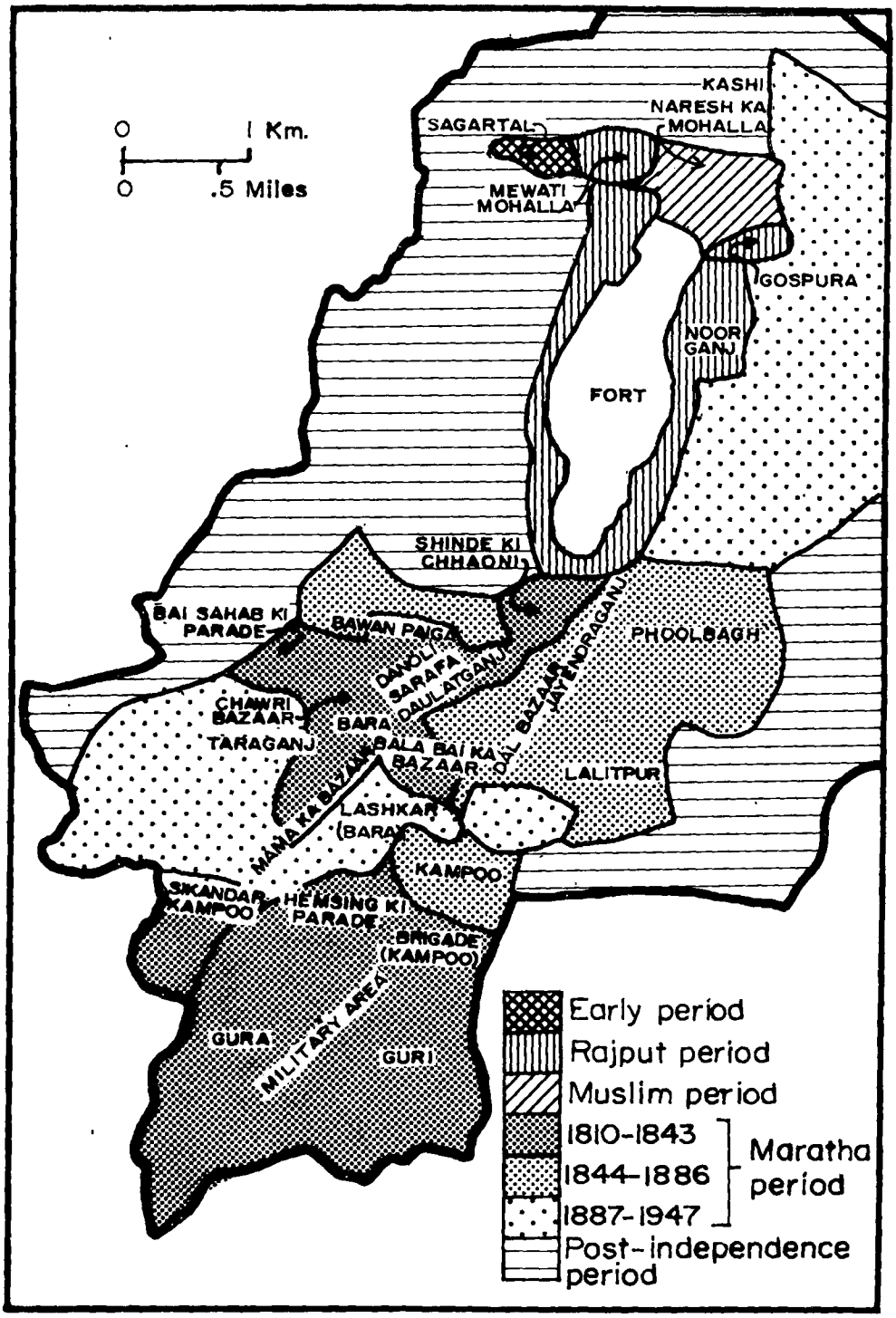

Figure I. Development of residential localities in Lashkar

servants and technicians. For the most part the fort was used by its absentee owners as a prison. Thus the township was never quite extablished as a complete residential and commercial complex.(3) Furthermore, many political upheavals deprived it of steady and stable growth. Morar Cantonment was the extra-territorial settlement of the British with no provision for outside civilian intrusion. In contrast, Lashkar had the good fortune to enjoy the royal patronage of the Scindhias.

Lashkar (meaning camp) was originally established in the form of what may be termed a "faubourg." It grew in accordance with two distinct functions, civil and military. The army population was chiefly lodged in Kampoo, as the cantonment of the Lashkar Brigade was called. (Figure 1) It may be seen that the southern section of the township of Lashkar was given over to military camps. Around the military encampments, large pieces of land were earmarked for army chiefs and businessmen who were also afforded various subsidies for construction of their residences. Thus, a series of palatial buildings with spacious yards began to be build on what was once vacant land. Satellites in the shape of smaller houses belonging to the servants of the sardars (courtiers) grew up in time. This gave rise to a whole range of units locally known as goths and paigas according to the status of the sardars concerned in a decreasing order of importance. These palatial building complexes of the courtiers were known as wadas in Marathi, the language of the Scindhia rulers. The core area of Lashkar is still known as Bara (the equivalent term in Hindi) after these wadas.

Patterns of residence were in the main patterns of social segregation and the key was the principle of hierarchical ordering. This ordering arose from the direct influence of social ranking on spatial patterns. Thus living in close proximity to the king was correlated with high social status. It should perhaps be pointed out that the king represented an institution performing much the same role as that of a medieval church. The king was a symbol of authority, and his palace as a seat of power and wealth was the focal point around which the high officials, traders, and the merchants congregated not only for royal patronage but also to be within reach of all those who came into and went out of the city. It is interesting to note how with the shifting of the residences of different members of the Scindhia family, different sections of the city attained significance and became annexed to the earlier establishments. Laskar continued to grow along axes determined by these palaces.

The layout of the roads in this area has been governed by the presence of the "Bara" whence they radiate like the spokes of a wheel. Thus the overall pattern of the transportation network was to add glory to the royal buildings, wadas, and palaces in the Bara area emphasizing their accessibility from all directions. The centrality of Bara in terms of accessibility has played a crucial role in the change of functions in this area when it has no longer remained a residential sector for the king and his associates and has become the commercial hub of the city. Despite the expansion of the business area, the residences were never removed entirely from the invaded sectors of Bara. The lack of the social mobility and economic viability characteristic of Western cities is reflected in the mixed commercial and residential pattern, especially in the central zone. Those who own the shops wish to be located close to their work. Accordingly, in the localities situated in the immediate neighborhood of Bara, the ground floor of the houses facing the road is given to trade and commerce and the upper portions are utilized for residential purposes (Figure 2). This is the feature along the main throughfares but the interior built-up area is almost entirely given to residences. The township of old Gwalior and Morar feature the same pattern although without the intensity and areal extension characteristic of Lashkar.

As the center of activity and the most developed section of the city, the central area of Lashkar is the scene of noteworthy competition for land. This

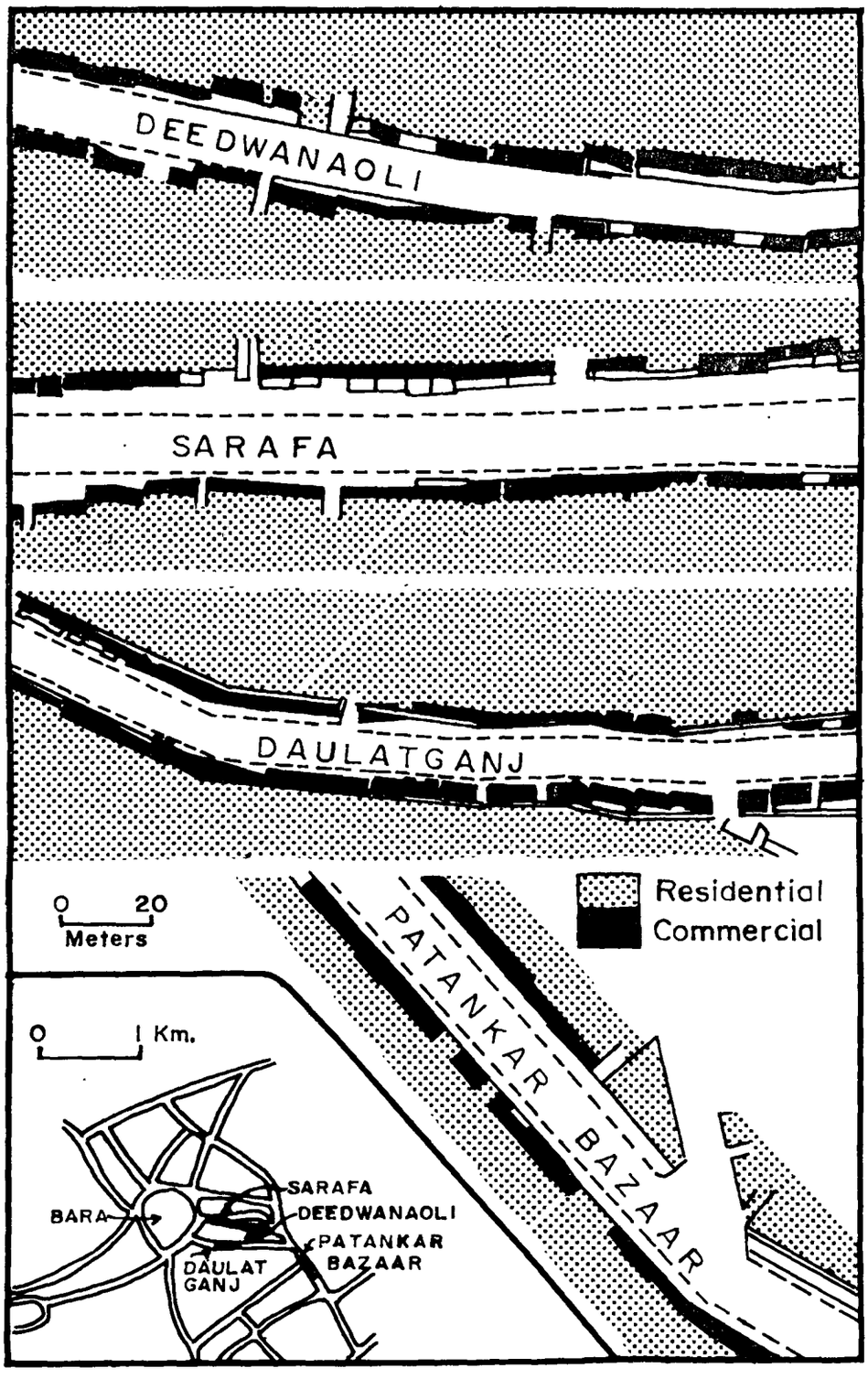

Figure 2. Mixed residential and commercial pattern in Lashkar

has in turn resulted in high land values. Thus, only those who can bid for land can stay in the central city. Besides this affluent merchant class, complexes of huge wadas belonging to ex-officials of the royal court are occupied, even today, by their descendants. Thus, in contrast to a Western city, in Greater Gwalior we find the most affluent section of the population residing in the heart of the city. In fact, these people own considerable portions of recently developed areas at the edge of the city, but they prefer to live in the central city and rent out their suburban houses. The higher class residential areas in the peripheral sections of the city are "housing colonies" which were built by the Government to accommodate the population transferred to the city during the reorganization of states in 1957. Apart from these, there are a few private colonies situated away from the central city which may be designated as higher class residential areas.

The present day pattern of population distribution in the cities of the West clearly show declining central cities. In the absence of easy accessibility in a wide ranging Indian city, it has never been possible for this decline to take place to the degree that has become characteristic in the case of Western cities. In Greater Gwalior, for example, the city's outer zone is far from dominantly residential. Within the inner zone of Lashkar 59 percent of the total land is given over to residence. This percentage decreases very rapidly and drops down to 7 percent at the outer margins. The corresponding figures for Gwalior township exhibit the same tendency, the residential area occupying 51 percent of the inner zone and 5 percent of the outer zone. Morar is no exception, 47 percent of the total land is devoted to residence in the inner zone, a figure which drops to 5 percent in the outer zone.

The original pattern of residential concentration at the oldest centers of the city is thus reinforced by a continuing desire for ready access to the workplace and to commercial and service facilities. This is reflected in the decreasing percentage of land devoted to residence with distance from the inner zones of all the three townships with a corresponding decrease in population densities. The correlation of distance to population and housing density is negative and high (Figure 3). This decrease is, however, very rapid in Lashkar as compared to Gwalior and Morar. In Lashkar, within a distance of 2400 years, population and housing density have fallen from 54 to 2 persons and 57 to 2 houses per 1000 square yards respectively. In Gwalior, the population and housing density have fallen from 23 to 3 persons and from 18 to 4 houses per 1000 square yards respectively within a distance of 3300 yards. In Morar, the fall in population and housing density is from 11 to 1 persons and from 10 to 1 houses per 1000 square yards within a distance of 2800 yards. It may be inferred that the central part of Lashkar is more compact in population concentration than Gwalior and Morar, and in fact the majority of the people of Greater Gwalior cluster in Lashkar township. Certainly the centripetal forces are more powerful than the centrifugal ones in shaping the contemporary pattern of residential distribution, especially in Lashkar, where the pull of "Bara" is clearly discernible. The original causes of such spatial congregation and abrupt gradient, as have been discussed may be summed up in the words of Brush as "protection, prestige, and proximity."(4) This characteristic feature is observable in the indigenous Indian cities in general, and the Indian cities of medieval origin in particular.

ACKNOWLEDGMENT

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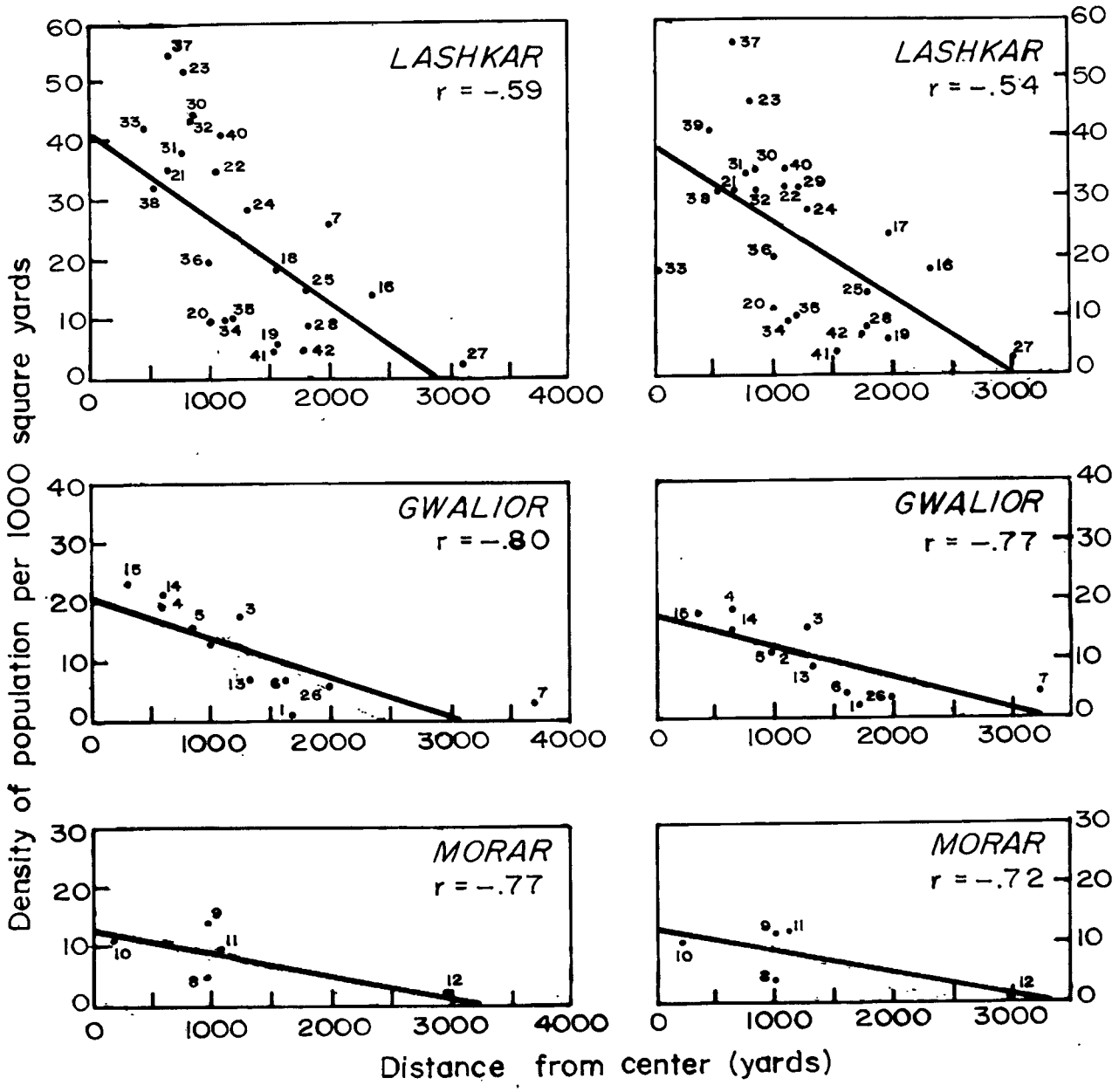

Figure 3. Population and housing lapse rates in Greater Gwalior

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AGRICULTURE IN NORTHERN GREECE

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The economic and physical rehabilitation of Northern Greece's basic economic activity - agriculture - commenced as soon as the Second World War ended. However, progress was very slow at the beginning because the Civil War between 1947 and 1949 caused hundreds of farmers to abandon their homes and farms in favor of the security centers in towns and cities.

Since the majority of the farmer-refugees were destitute, the government shouldered the main burdens of resettlement after the defeat of the insurgents. It provided agricultural tools, seeds, fertilizers, goats, sheep and draft animals. Totally destroyed villages were rebuilt, and potable water provided. New roads were constructed to connect the once isolated rural villages with the larger towns and cities of the region. Some of the resettled villagers were provided with houses and other community services such as electricity.

To improve the economic conditions of the people in the border areas and to repopulate the deserted villages found there, a special recovery program, known as the Border Area Settlement, was initiated in 1953. The most important objective of that program remains the encouragement of the villager to stay in the village. If Greece permits the Borderline villages to become depopulated, this will create a political vacuum between the neighboring Communist countries and the greek coastal populated areas. Despite the heavy cost, the government should bring to the villagers the so-called urban amenities. Otherwise the villagers, especially the young ones, will migrate either to the cities of Greece or to foreign countries. During the early part of the sixties, a substantial number of young men and women from these villages went to West Germany. As a result, most of the villagers - the ones who remained behind - are middle-aged. Their life has improved somewhat because the money which they received from the emmigrants enabled them to buy such items as electric stoves, television sets, and washing machines. But despite this improvement, life in the villages is monotonous, and the villagers, too, now want to migrate to the city.

An additional agricultural problem that continues to plague Northern Greece is land fragmentation. The average land holdings range from one to four hectares per family. Even the small holdings are usually broken up into five to twelve plots, widely scattered among the lands of the village. In the plains the typical Northern Greek farmer has only 4 to 7 hectares. In contrast, the average wheat farmer in the Great Plains of the United States had between 140 and 280 hectares.

The prevalence of small farms has made it impossible for the majority of the farmers to specialize in the production of crops for the market. Hence, most farm households are primarily subsistence units and not agricultural business enterprises. Even the commercialized farms are in their character subsistence farms, especially those in the tobacco growing areas. The only true agricultural business enterprises in the region are those cultivating and processing sugar beets.

Although there have been marked increases in per capita production thanks to improved farming techniques, the demands of farmers have been increasing steadily since 1960. Their inability to find satisfaction from their own production has forced them to look for jobs outside the agricultural sector. Many migrated to Australia and West Germany. The remainder feel economically insecure, and many lost their hope in the future. They are looking now to the European Common Market for their survival. They hope that the ever-expanding European Market will absorb their unsold agricultural production. In my

opinion, this is a false hope. Without improvement in quality, the European Common Market will not buy Greek agricultural crops. In the meantime, frustration, discontent, and tension keep mounting in the agricultural areas, especially in the tobacco growing region. The solution to these problems becomes daily more difficult. Partly to alleviate this situation, the government is encouraging the expansion of industry.

A further problem that confronts the agriculture of Northern Greece is the high cost of production. This cost conceivably could be reduced by encouraging farmers to consolidate their fragmented land holdings. Such factors as long established cultivation, shortage of land, unrestricted rights of transfer, and pressure of population have encouraged overgragmentation of land. Consolidation has been successful in some areas.

Despite opposition from farmers, many villages in the Vardar River plain have consolidated their holdings. A new law, which states that at least 50 per cent of the farmers must oppose land consolidation, has helped spread the process of conversion. Also, the farmers have become familiar with the advantages of land consolidation: more intensive cultivation, greater use of machinery, low production cost, higher net income per peasant family and rational crop-cultivation. Land consolidation will not only increase production, but would improve the quality of the crops, and enable the Greek farmer to compete successfully with counterparts in the European Common Market.

There has been a rapid increase in farm mechanization since 1960. Today the farmers of the region have all the machinery they need to carry out their work: tractors, harvesting and threshing machines. The employment of tractors in the plains has produced tangible results because of the presence of good soil, level to rolling land, and larger sizes of farm plots. In the mountainous areas, however, where most of the land is rocky and broken into small plots, draught-animals will continue to be of major importance.

The most popular makes of tractors are Fordson, Hanomag, Zetor and John Dear. Much of the mechanical farming equipment is from United States, Great Britain, West Germany, and Czechoslovakia, although the technological contribution of the Communist Bloc has been increasing steadily since 1960. To operate, maintain, and repair the machinery, the Ministry of Agriculture, together with the American Farm School, is offering instruction to qualified farmers. The main obstacles that confront farm mechanization are the high cost of fuel and expensive replacement parts. The mechanization of agriculture has ameliorated the constant shortage of agricultural workers during the peak periods of work. Further land consolidation will also reduce the demand for workers.

The application of fertilizers, insecticides, and pesticides has led to an increase in agricultural production. However, if the use of fertilizers is to increase, the cost should be reduced. At present the region's fertilizer plants - one in Kozani and one in Kavala - provide the farmers of the region with all the fertilizer that they need. It must also be remembered that a rapid increase in the utilization of fertilizers may encourage indiscriminate use, which may do more harm than good. Today the farmer like the urban dweller has to protect the environment. In the United States in some agricultural communities potable water has been polluted because of indiscriminate use of fertilizers.

Other means of increasing agricultural production include bringing new land under irrigation. The construction of new diversion dams and the extention of the present irrigation network make it imperative for Greece to reach an agreement with the Communist countries concerning the control of rivers. With the exception of the Aliakmon, the other large rivers with a substantial

flow during the dry period originate in the Communist Bloc countries. The watersheds of Strymon, Nestos, and Evros are in Bulgaria, and that of Vardar in Yugoslavia. Only a small segment of the drainage basins is situated in Northern Greece. Hence any attempt by Yugoslavia or Bulgaria to extract more water or to build diversion dams would undermine the efforts of Greece to develop the Greek portions of the river basins. It is for this reason that Greece is concentrating on expanding the irrigated land of the Aliakmon River.

Despite the presence of these obstacles, the agriculture of Northern Greece has experienced a remarkable improvement. This was largely due to the combined efforts of the farmers, agronomists, agricultural cooperatives, the Agricultural Bank, the American Farm School, and United States technical and economic aid. The Greek peasant is now learning the meaning of progressive agriculture. He has come to know that, unlike traditional agriculture, progressive agriculture involves making choices. He has to decide for himself whether to cultivate today or tomorrow, what crops to grow, what source of draft power to use, or which fertilizers are best for his purpose. He knows that, in a progressive agriculture, crops are mainly produced for sale, and he realizes that such farming involves a separation of agricultural decisions from other consideration. The Greek farmer is moving toward a more productive agriculture because he is now more willing to take the responsibility for his own decisions.

The attitude of the government toward him is very favorable. It believes that he can cultivate new exportable crops. It has confidence in him as a progressive farmer. It has become cognizant of the importance of varied requirements for his agricultural and industrial growth. It believes that he has the capacity to manage his own affairs.

The rising confidence of the farmer is now the best resource of Northern Greece. Unlike the economic resources of labor, land, and capital, this psychological resource need not be economized. The discovery that he can increase production on his small plot of land without waiting for more land not only builds confidence to try another change but also communicates success to his neighbors.

CHANGING AGE STRUCTURE OF FARM OPERATORS IN THE NORTHEAST, 1959-1974

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A previous paper noted, for the counties of the Northeast, the direct relationship between the average age of farm operator and loss in farms and agricultural acreage.(1) For the period 1954-74, the correlation between farmers' average age and the percentage rate of change in number of farms was -0.77. For each of the four five-year segments, however, the correlation was lower, ranging from -0.58 for 1954-59 to -0.03 for 1969-74. A similar pattern, with a progressively weakening relationship and a higher twenty-year correlation (-0.59, in this case) occurred for the loss in farm acreage.

Given these varying results as the time span was altered, the geographic association between age of operator and decline in farms and acreage warrants closer inspection. This paper treats operator age by ten-year cohort to provide a more detailed examination of age structure. Change is examined for two overlapping ten-year periods, 1959 to 1969 and 1964 to 1974. Prior to 1959, age tabulations in the U.S. Census of Agriculture were reported only as a measure of central tendency; thus, a more detailed treatment of aging and agricultural trends is restricted to ten-year cohorts viewed only over these ten-year periods. The level of temporal aggregation thus falls between the five- and twenty-year periods used in the earlier study.

REGIONAL CHANGE IN AGE STRUCTURE

Between 1959 and 1974, the number of farm operators in the Northeast declined from 252,000 to 125,000, a reduction of more than fifty percent. As might be expected, this decline was age selective. Population pyramids for these two years, using the cohorts younger than 25, 25-34, 35-44, 45-54, 55-64, and 65 and older, are shown in Figure 1. Comparing 1974 to 1959, the cohorts 45-54 and 55-64 increased as a percentage of all operators, those over 64 and 35-44 declined, and the groups 25-34 and under 25 remained virtually the same relatively. In absolute numbers, every cohort diminished in size.

Direct causes of these changes are restricted to death, retirement, occupational change, change in census definitions, as well as new entrants. Errors in reporting contribute to these changes too, but their effects cannot be considered because they remain unknown. Allocating this net reduction precisely among these causes is, of course, impossible. Age structure, however, suggests that certain causes are of greater importance. To illustrate, almost all of the 47,300 operators reported as 65 or older in 1959 may be assumed to have retired or died by 1974. The great majority of the 15,600 operators younger than 35 in 1974 may be presumed to have entered farming after 1959. Therefore, the resultant change would account at best for only 32,000 of the 127,000 net reduction in operators. Even if all of the 54,500 farmers between the ages of 55 and 64 in 1959 had died by 1974, combined with the resultant change of the 32,000 described above, there would still be a loss of 41,000 operators to be explained largely by occupational change or early retirement. Not more than 9,800 of these remaining 41,000 operators might have been omitted from the enumeration because of changes in the Census definition of a farm. Only two definitional changes were made: in 1974, the criterion for "number of acres in place" was abolished and the criterion for minimum value of agricultural products sold was increased from $50, or $250 if the farm had fewer than ten acres, to a single, $1,000 threshold. (2) According to Census Bureau estimates, combined for the nine Northeastern states, only 9,792 farms admissible under the 1959 definition were excluded by the 1974 rules.(3) Obviously, a substantial number of farmers either retired before their sixty-fifth birthdays or changed jobs.

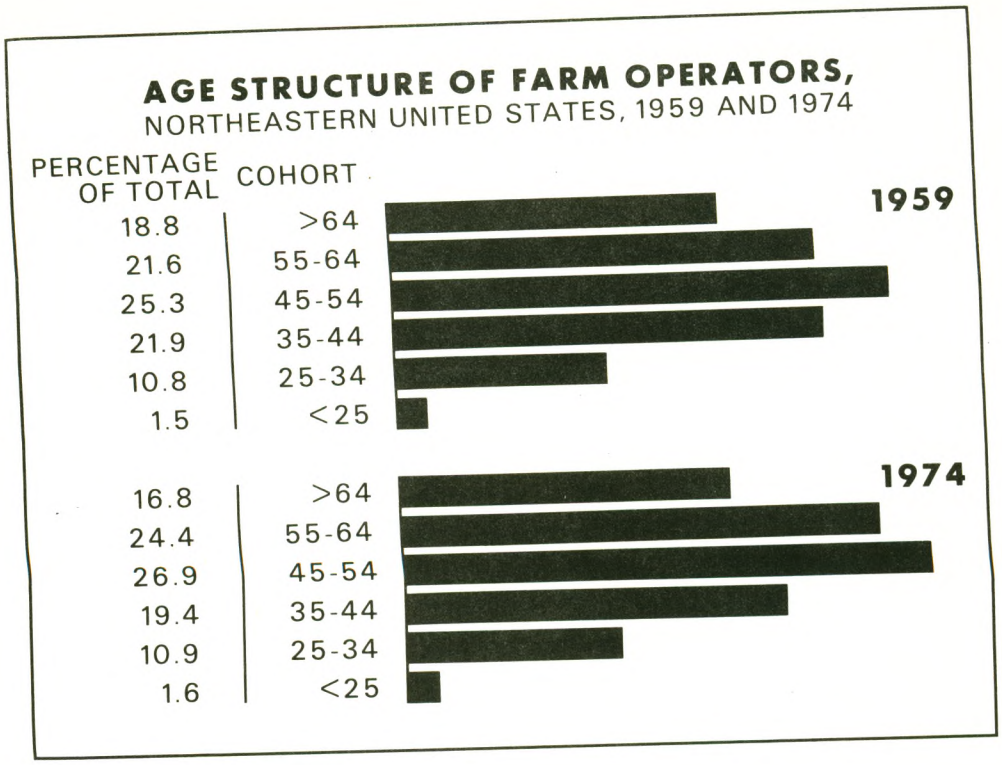


Figure 1

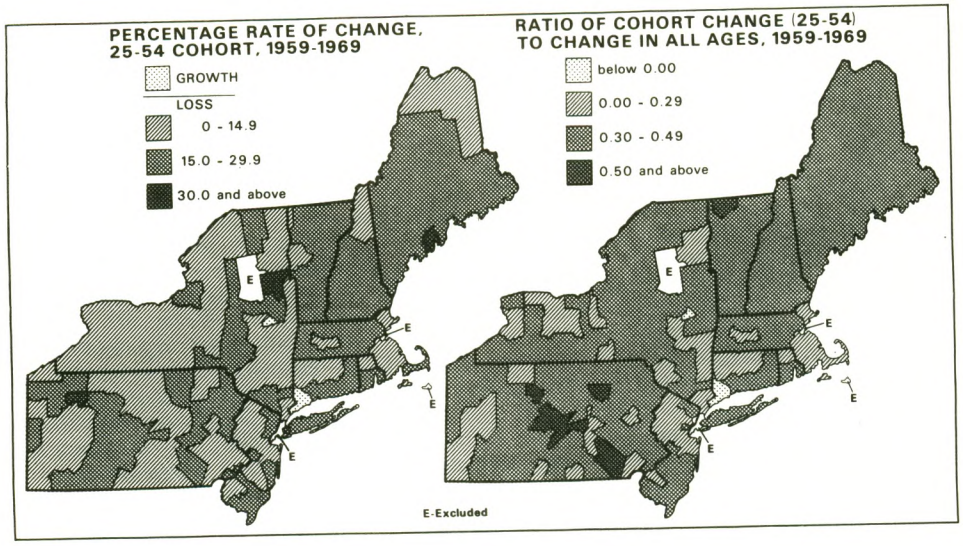


Figure 2

AGE-SPECIFIC CHANGE

This reduction in the ranks of middle-age farmers is closely related spatially to changes in both number of farms and acres of farmland. Rates of decline among operators in the cohorts 25-34, 35-44, and 45-54 were computed for the periods 1959-69 and 1964-74. These cohort-specific rates were correlated with percentage rates of change in number of farms and acreage in farmland among the 209 of the Northeast's 217 counties for which comparable data were available in the Census of Agriculture (Table 1). All 12 correla-

TABLE 1. PRODUCT-MOMENT CORRELATIONS BETWEEN COHORT-SPECIFIC RATES OF CHANGE AND RATES OF CHANGE FOR FARMS AND ACREAGE, 1959-69 AND 1964-74

Initial Year of Period	Percentage Rates of Change	
	Farms	Acreage
1959 Cohorts		
25 - 34	0.37	0.19
35 - 44	0.77	0.54
45 - 54	0.77	0.64
1964 Cohorts		
25 - 34	0.34	0.23
35 - 44	0.64	0.49
45 - 54	0.75	0.54

Source: Computed by authors.

tions are positive, indicating that counties with relatively large cohort-specific losses also experienced relatively large declines in both farms and acreage. As might be expected, these associations are stronger for farms than for acreage: for each operator there is at least one farm, but farm operations vary in size. For the younger cohort, 25-34 at the beginning of the ten-year periods, the geographic association is weaker. For both periods, this youngest cohort grew in number, with increases for the average county of 15 percent for 1959-69 and 25 percent for 1964-74. Although the relationship is not as strong, counties with substantial declines in farms and farmland generally had smaller percentage increases of younger operators. In these counties, presumably, agriculture was less stable as fewer younger men inherited or purchased farms. It also should be noted that the correlations for the two older cohorts are higher for the earlier ten-year period, 1959-69, which was not affected by a change in census definition.

These three age groups were combined into a single, thirty-year cohort for further analysis. Despite the continued entry of farmers into the operator category after age 25, as well as the premature death of some operators, change over a ten-year period in this 30-year cohort would largely reflect early retirement or change to a non-farming occupation. Rates of change computed for this age-group are supplemented by a second variable, the ratio of change in number of operators 25-54 to trends in the total number of operators. This ratio provides a crude estimate of the relative local importance of early retirement and occupational change in the decline of the cadre of operators.

The strong geographic associations of early retirement and shifts to nonfarming occupations with declines in the number of farms and farm acreage are shown in the upper-left-hand portion of Table 2. Change in the Census defini-

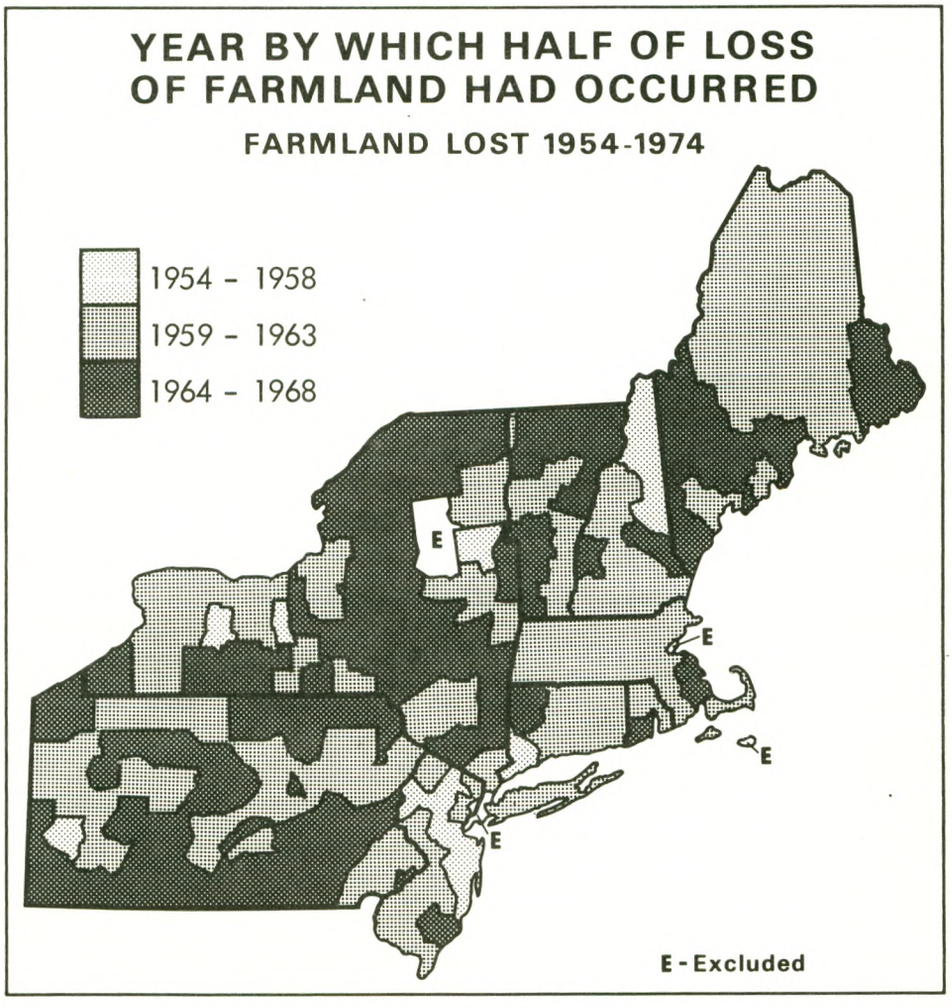
TABLE 2. PRODUCT-MOMENT CORRELATIONS BETWEEN RATES AND RATIOS FOR THE THIRTY-YEAR COHORT AND SELECTED RATES OF AGRICULATURAL CHANGE, 1959-69 AND 1964-74

Percentage Rates of Change	25-54 Cohort			
	Percentage Rate of Change		Ratio of Cohort Change to Change, All Ages	
	1959-69	1964-74	1959-69	1964-74
Number of Farms	0.84	0.82	0.24	0.39
Farm Acreage	0.68	0.66	0.05	0.29
Average Farm Size	0.14	0.07	0.14	0.03
Average Farm Value	0.16	0.00	0.07	0.01

Source: Computer by authors.

tion of a farm in 1974 does not seem to have affected these relationships. The spatial accordance of numerical trends in the 30-year cohort is stronger for change in number of farms than for change in farm acreage; counties with substantial age-specific losses of operators reported greater relative declines in agriculture. The cohort-specific pattern of trends in operators bears little similarity to change in regional patterns of average size and average value of land and buildings.

Change over the ten-year periods in the 25-54 cohort, expressed as a ratio of change in operators of all ages, relates much less directly to trends in farms and acreage than do percentage rates of change for the 30-year age group (Table 2). Although this ratio is less sensitive than the percentage rates as a correlate of agricultural change, the spatial patterns of rate and ratio are generally geographically congruent, as shown in Figure 2, for the 1959-69 interval. The product-moment correlation of the mapped rate and ratio is -0.47, but the map symbols have been ordered to emphasize visual similarity: counties with large negative rates of change generally had a high ratio of cohort change to change for operators at all ages. The corresponding Spearman rank-order correlation is even greater, -0.75. Both maps in Figure 2 portray generally similar patterns, particularly evident in New England, where larger-than-average declines in the 25-54 cohort (Figure 2, left) contributed significantly to overall change (Figure 2, right). Elsewhere in the Northeast, the regional pattern is more diverse, reflecting a greater range of well-being in agriculture. For example, in one of the principal agricultural counties of the nation, Lancaster County, Pennsylvania, the average age of operator was young--44.5 years in 1969 compared to the state's average of 50.5 years--and decline in number of operators of all ages was modest. More than 80 percent of all losses in operators was comprised of those in the 25-54 cohort but, in this county, farmers in the older segment of this 30-year cohort commonly pass the operation along to young adult offspring.(4) In less agriculturally prosperous parts of the Middle Atlantic states, where agricultural decline has been shown to have occurred earlier, the 25-54 cohort probably had already suffered significant losses (Figure 3).


YEAR BY WHICH HALF OF LOSS
OF FARMLAND HAD OCCURRED
FARMLAND LOST 1954-1974
1954 - 1958
1959 - 1963
1964 - 1968
E
E
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E - Excluded

Figure 3

CONCLUDING REMARKS

This paper, following the less precise treatment in an earlier work of age of operator, (5) demonstrates more emphatically that regional patterns of agricultural change transcend the age structure of farm operators. It is fallacious to assume that agricultural decline in the Northeast is solely and inextricably related to the aging of the farmer in that region: argiculturally marginal areas have lost many farms and some farmland seemingly when farmers retire or elect a different occupation. Thus, retirement and occupational change appear to outweigh the more traditional role of age alone in attempts to relate characteristics of the farmer to trends in agriculture in the Northeast.

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EFFECTS OF URBAN AIR POLLUTION UPON ARIZONA INSOLATION

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The intensity of solar energy available to the greater Phoenix, Arizona area was observed under conditions of extreme air pollution, at 09:30 on February 15, 1979. These observations were conducted by the authors and personnel from the Arizona State University Laboratory of Climatology and the Arizona State University Department of Geography.

The intensity of insolation (i.e., sunshine) was measured at two locations, using identical instrumentation. This instrumentation consisted of an Eppley normal incidence pyranometer and an Eppley precision spectral pyranometer at each sampling site. The normal incidence pyranometers were fitted with a filter wheel which enabled the observers to measure the intensity of solar radiation in various subspectra of the solar spectrum. Data were collected on the Arizona State University campus at an elevation of 355 m (1165 ft), and at Dobbins Point on South Mountain, 710 m (2330 ft). These sampling sites are both located within the Phoenix Metropolitan area, and are separated from each other by approximately 16 kilometers (10 miles).

From South Mountain one could observe a distinct layer of brownish polluted air trapped near the valley floor by a low level inversion. Strong radiant cooling had occurred during the preceding night. Skies were clear in the morning as they had been during the night, when cold air sank to the valley floor. While it was difficult for observers to see through the pollution layer to the valley floor, the top of this layer was only 101 m (330 ft) above the surface and approximately even with the top of Tempe Butte, which is adjacent to Arizona State University Laboratory of Climatology.

The total amount of global solar energy striking a level surface was observed to be 26% less on the valley floor when compared to values for South Mountain. Less than 2% of this can be explained by elevation differences. (1) Thus, the layer of polluted air was blocking a considerable proportion of the sun's energy from reaching the valley floor.

Measurements were also made of the intensity of the direct beam of the solar energy. This was found to be reduced by 25% under the layer of polluted air (see Table 1). Using optical filters, the observers were able to measure the intensities of various subspectra of the total solar spectrum. The shorter wavelengths of blue light were affected most strongly by the polluted air mass. Longer wavelengths of the near-visible infrared solar energy were able to more easily penetrate the pollution layer. The relatively high difference between the two stations as observed in the 695-780 nm spectral band (Table 2) is probably due to absorption of the solar energy by water vapor. Absolute humidity values of the polluted layer of air would have been much greater than the air above the inversion.

Tables 1 and 2 display the effect of the low level modified air mass present during the time of these observations. It should be noted that at the time these data were collected, the Phoenix area was experiencing an unusually high concentration of low level atmospheric pollutants. The gaseous and particulate constituents of the atmosphere tend to absorb and scatter various spectral wavelengths of solar radiation to a greater or lesser extent. Thus Table 2 indicates that the polluted air is blocking 40% of the violet light, while only 15% of the yellow light is blocked, and 20% of the infrared portion of the solar spectrum is being affected.

TABLE 1

INTENSITY OF SOLAR RADIATION
data in gm cal / cm^2 / min

GLOBAL INSOLATION

	South Mountain	Valley Floor	% Difference
	0.57	0.42	26%

DIRECT BEAM INSOLATION

Spectral Wavelenght	South Mountain	Valley Floor	% Difference
total solar spectrum	1.57	1.18	25%
395 nm	1.37	1.03	25%
475 nm	1.27	0.97	24%
530 nm	1.14	0.89	22%
570 nm	1.08	0.84	22%
630 nm	0.95	0.73	23%
695 nm	0.82	0.63	23%
780 nm	0.66	0.53	20%

TABLE 2

SPECTRAL INTENSITY OF THE SOLAR BEAM
data in gm cal / cm^2 / min

Wavelength	(nm)	South Mountain	Valley Floor	% Difference
395-475	(violet)	0.10	0.06	40%
475-530	(blue)	0.13	0.08	38%
530-570	(green)	0.06	0.05	17%
570-630	(yellow)	0.13	0.11	15%
630-695	(red)	0.13	0.10	23%
695-780		0.16	0.10	38%
780-	(infrared)	0.66	0.53	20%

It should be noted that all of the observations discussed in this paper were made under clear sky conditions. There were no clouds present and observers questioned on the valley floor were unaware of the polluted layer of air surrounding them. In these times of energy shortages, many people of the desert southwest are installing solar water and space heaters. A few people are experimenting with solar powered air conditioners. The desert climate provides a maximum of available solar energy to offset the ever decreasing supply of fossil fuels. (2) Yet, few are aware of the significant decrease in available solar energy associated with the processes of urbanization. Unfortunately, the meteorologic conditions which form the most dense urban pollution dome occur in the early winter mornings. It is suggested that

the magnitude of the solar interception by the pollution dome is significant enough to be important when calculating the most economically efficient size for solar space and water heaters.

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SPECIAL SESSION ON CLIMATOLOGICAL APPROACHES TO THE ENVIRONMENTAL PROBLEMS OF THE 1980S

A SYNOPTIC CLIMATOLOGICAL APPROACH FOR ENVIRONMENTAL ANALYSIS

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Climatologists have available a variety of approaches which may efficiently evaluate the complex relationships between climate and dependent environmental variables. "Predictive" and "explanatory" models, incorporating water budget or energy budget parameters, have been commonly employed, and the statistical relationships resulting from such modelling have provided useful information.(1)

Methodologies which define climatological elements in terms of weather types or air mass frequencies (referred to as synoptic approaches) have been distinctly underutilized in environmental analysis, largely because it is difficult to quantify the complex interaction of meterological parameters inherent within a particular synoptic situation. This is unfortunate, as an applied methodology utilizing a synoptic approach is holistic in nature, and can be developed into a climatic index which characterizes similarities in general circulation patterns and active meteorological factors. The index may be utilized to investigate relationships between climate and certain environmental variables, such as air pollution concentration or stress on biological organisms, and to predict how these relationships might change in the future. Qualitative "air parcel trajectory" or "weather type" identification techniques have been recently utilized in environmental analysis,(2) but these are subjective approaches, and weather type categorization is often difficult and arbitrary in definition.

This paper will suggest a synoptic climatological index based on the quantitative and objective evaluation of air mass frequencies. An air mass is defined as "...an extensive body of air with more or less uniform conditions of temperature, moisture content, and lapse rate, in a horizontal plane."(3) An air mass therefore comprises a spatial unit exhibiting distinct climatic characteristics, rendering air mass identification of considerable value when applied to many problems involving regional climatic analysis. It is not difficult to identify an air mass which has retained its original distinguishing climatic properties. However, as the air mass moves out of its source region, identification becomes more difficult as property modification becomes significant and new air mass "transition stages" are formed.(4)

Considering the utility of the air mass in identifying a complex set of meteorological parameters as one cohesive unit, and considering the climatic homogeneity displayed by air masses, it is important to adopt a quantitative scheme to distinguish air mass types once they are moved from their source regions.

PROCEDURE

The initial step in the development of the air mass-based index involves identification of those meteorological elements which are most indicative of each particular air mass type. Those "air mass indicators" which measure moisture content and thermal characteristics of the atmosphere would appear to be most useful. These include dewpoint temperature, air temperature, relative humidity, potential temperature, and equivalent potential temperature. The first three indicators are by far the most accessible, and provide the most

vital climatic tools for air mass analysis. Potential temperature may be useful in the analysis of continental air masses where condensation is infrequent, but because it does not account for absorption of latent heat of condensation its utility is quite limited.(5) Equivalent potential temperature can compensate for this shortcoming, but the upper air data necessary for its computation are difficult to obtain at most locations. Of the first three indicators relative humidity may also be omitted from further consideration, as it is highly colinear with, and provides less information than, dewpoint. The dewpoint temperature takes on added significance in part because it is only slightly influenced by diurnal effects. The gradual rise and fall of dewpoint which accompanies air mass transition stages will therefore proceed uninterrupted during a 24-hour period. Additionally, dewpoint is relatively conservative with respect to microclimatic variations, lessening the influence of variations not attributed to the adjacent air mass. Air temperature represents an additional necessary inclusion, as certain continental air masses exhibiting similar moisture content but different thermal regimes are difficult to distinguish on the basis of dewpoint alone.

Secondary air mass indicators may be used in conjunction with dewpoint and air temperature variables to increase air mass differentiation. These indicators include cloud cover, wind direction and speed, visibility, atmospheric pressure, and diurnal variations in the previous variables. The synoptic index suggested here incorporates the following total air mass indicators for each day evaluated:

1. dewpoint temperature (°C)
2. air temperature (°C)
3. cloud cover (tenths of sky cover)
4. north-south wind vector (cosine of azimuth multiplied by wind speed)
5. east-west wind vector (sine of the azimuth multiplied by wind speed)
6. visibility (km.)
7. atmospheric pressure (mb.)

Each of these indicators is evaluated four times daily (1AM, 7AM, 1PM, and 7PM) to account for the effect of diurnal variation, and yielding a total of 28 climatic variables.

Sterling, VA (approximately 25 km. west of Washington, DC) was selected as the site of evaluation primarily because a continuous meteorological data record (1961-75) is available on SOLMET data tapes for this location. January was chosen as the initial month of study as air mass differential is most pronounced due to the strong north-south gradient in solar radiation income and associated thermal characteristics.

The statistical manipulation involved the use of principal components analysis (PCA) to reduce the data matrix to components which are orthogonal to each other.(6) Any colinearity existing among the air mass indicators is correspondingly eliminated. PCA results in a consolidation of the total amount of information in the data set because most of the variance contained in the 28 original variables is now explained by a smaller and less cumbersome number of components.(7) Selecting the number of components is an important aspect of PCA, and has traditionally been accomplished by utilizing components with eigenvalues exceeding 1 (eigenvalues describe the total variation explained by a component).

Each component is composed to some degree of all the original 28 air mass indicators. Each is understandable in terms of climatic reality (i.e., the first component, which explains the greatest amount of variance, might be a measure of air mass moisture content). Additionally, component scores may be assigned for each day, their value determined by prevailing meteorological conditions existing for that 24-hour period. Days with similar component scores should represent similar air mass types.

The daily component scores for the 465 January days over the 15-year study period were subjected to a clustering procedure, which fuses groups according to certain criteria. Clusters of groups with similar characteristics are developed, and the total number of clusters is determined by one of several available objective operations. Ward's Algorithm, the selected technique, is a hierarchical clustering algorithm which uses the error sum of squares as a criterion for grouping. The error sum of squares is defined as the sum of the Euclidean distance of each group member from the group mean. The criterion for joining clusters is that the increase in the total error sum of squares will be minimal, which tends to yield more homogeneous groups.(8)

The developed clusters therefore characterize homogeneous meteorological conditions, and each cluster represents a particular air mass type or transition stage.

RESULTS

The PCA generated a six-component solution derived from the original 28 variables (Table 1). Those indicators that represent important constituents of the component have highly positive or highly negative values or loadings; loadings near zero represent unimportant indicators.

The highest loadings in component 1 occur within the dry bulb and dewpoint temperatures, indicating that the thermal/moisture character of the air mass indicators explains the greatest amount of variation in the data. Component 2 is essentially an air pressure component, while component 3 is bipolar in nature as the explained variation appears to describe two contrasting processes. The north-south wind vector appears very important, and a diurnal aspect appears to gain some significance. The persistent directional change in loadings for air temperature, dewpoint temperature, and air pressure through the 24-hour period indicate that diurnal effects are represented in this component. Component 4 is loaded highly on visibility, while component 5 is bipolar and influenced by the east-west wind vector, as well as diurnal effects in sky cover and visibility. Component 6 is composed largely of sky cover.

Synoptic information for each day over the study period was expressed by these 6 components. The component scores were multiplied by their eigenvalues (explained variance) prior to clustering, to account for the relative importance of each component. Correspondingly, component 1 has the greatest influence on cluster determination, and each subsequent component has a lesser effect

A 12-cluster explanation was developed on the basis of Ward's Algorithm, with each cluster representing a typical air mass and/or synoptic situation. Four of these clusters are illustrative of air mass "transition stages," where one air mass is being supplanted by another. The mean values of the air mass indicators, as well as weather map analysis for the days within each cluster, provided the explanatory information necessary for air mass determination (Table 2).

The first cluster represents maritime tropical air, with a source region over the Gulf of Mexico and Caribbean Sea. The warmest temperatures and highest dewpoints accompany this mass of air, although its thermal characteristics in January are considerably diluted during its transport to northern Virginia.

Table 1: Six-Component Solution Generated by Principal Components Analysis

AIR MASS INDICATOR	TIME (HOUR)	COMPONENT LOADINGS[a] COMPONENT 1	COMPONENT 2	COMPONENT 3	COMPONENT 4	COMPONENT 5	COMPONENT 6
sky cover	0100	.337	-.077	.156	.174	.040	.406
	0700	.273	-.108	-.009	.167	-.127	.646
	1300	.174	-.126	-.111	.092	-.266	.539
	1900	.186	-.112	-.168	.047	-.389	.337
visibility	0100	-.235	.088	-.103	-.763	-.027	-.039
	0700	-.211	.092	.063	-.883	.061	-.033
	1300	-.049	.007	.059	-.632	.381	-.163
	1900	-.063	-.079	.068	-.423	.463	-.160
pressure	0100	-.240	.821	-.249	.130	-.184	.097
	0700	-.255	.931	-.102	-.030	-.168	-.022
	1300	-.212	.958	.097	-.107	-.050	-.084
	1900	-.159	.874	.230	-.096	.173	-.059
air temperature	0100	.919	-.121	.153	-.061	.060	.065
	0700	.923	-.153	.066	.041	.073	.205
	1300	.834	-.080	-.378	-.067	.002	-.193
	1900	.773	-.114	-.464	-.048	-.148	-.089
dewpoint temperature	0100	.901	-.211	.067	.166	-.013	.078
	0700	.900	-.231	-.068	.234	-.032	.175
	1300	.796	-.235	-.304	.289	-.221	.035
	1900	.710	-.149	-.401	.197	-.429	.022
north-south wind vector	0100	-.348	.078	.592	-.009	-.057	-.180
	0700	-.183	.047	.772	-.031	.066	-.150
	1300	-.097	-.047	.804	-.026	.172	.064
	1900	-.012	-.146	.542	-.068	.281	.225
east-west	0100	.117	.011	-.331	.379	-.234	.285
	0700	.041	.162	-.290	.318	-.442	.274
	1300	.082	.244	-.145	.182	-.696	.185
	1900	.063	.387	-.060	.025	-.606	-.094
eigenvalue[b]		6.494	3.799	2.976	2.550	2.177	1.502
explained variance		.232	.136	.106	.091	.077	.054
accumulated explained variance		.232	.368	.474	.565	.642	.696

a) Component loadings describe how much of the variance present in the original meteorological data is explained by a given component. High positive values indicate a strong direct covariation between the particular meteorological indicator and the component; high negative values indicate a strong inverse covariation; values near zero indicate little covariation.

b) Eigenvalues describe the total variation explained by the component. Dividing the eigenvalue by the total number of meteorological variables evaluated (in this case, 28) yields the proportion of explained variance described by that component.

Table 2

Mean Values of Selected Meteorological Indicators for Twelve Air Mass Clusters: 1 AM and 1 PM

CLUSTER	AIR MASS TYPE	TIME (HOURS)	SKY COVER (TENTHS)	VISIBILITY (km)	PRESSURE (mb)	T_{AIR} (°C)	$T_{DEWPOINT}$ (°C)	NORTH VECTOR[c]	EAST VECTOR[d]
1	maritime tropical	0100	4.9	12.39	1002.85	9.23	7.07	-2.54	-0.26
		1300	4.2	23.04	1004.44	11.64[a]	5.05	0.64	-1.04
2	Arctic	0100	0.5[b]	24.52	1013.04	-14.79[b]	-24.01[b]	3.29	-4.35
		1300	3.0	23.04	1014.90	-9.71	-18.60	4.00	-3.95
3	Arctic: adjacent anticyclone	0100	0.5[b]	26.71	1014.99	-10.08	-17.84	1.96	-1.68
		1300	2.5	29.40	1015.45	-2.61	-14.85	0.60	-2.48
4	Arctic: cyclogenesis	0100	3.1	16.65	1017.44[a]	-10.05	-15.22	1.27	-0.23
		1300	2.8	14.54	1012.82	-2.69	-9.23	0.85	0.53
5	continental polar: east-west ridge	0100	1.5	25.51	1010.06	-6.13	-13.26	1.37	-2.39
		1300	2.8	29.75[a]	1010.54	-0.44	-11.31	0.44	-2.61
6	continental polar: poorly-defined ridge	0100	2.2	20.11	1011.98	-4.91	-9.62	0.79	-0.59
		1300	3.1	23.92	1011.44	1.46	-8.25	0.45	-1.36
7	Pacific	0100	3.5	20.12	1002.10	4.54	-0.13	1.73	-2.33
		1300	3.5	27.09	1006.39	5.46	-3.66	1.63	-3.65
8	maritime polar: adjacent cyclone	0100	4.2	7.13[b]	1004.29	2.74	1.04	0.31	0.00
		1300	4.3	12.08	1000.77	5.98	2.26	0.19	-0.10
9	transition: after cold front passage	0100	5.0[a]	20.71	1000.46[b]	11.58	9.71[a]	-2.64	-1.29
		1300	3.3	26.54	1006.66	11.46	1.25	1.91	-2.45
10	transition: Arctic to maritime	0100	2.8	19.10	1008.98	-1.87	-6.49	0.62	-0.81
		1300	3.4	23.12	1009.05	3.50	-5.38	0.68	-1.97
11	transition: continental polar to maritime	0100	3.1	20.30	1006.47	1.54	-2.77	1.04	-1.42
		1300	3.7	23.15	1008.41	5.44	-2.95	0.77	-1.56
12	transition: cyclogenesis	0100	3.4	11.14	1009.81	-0.39	-3.20	0.58	0.20
		1300	4.7	11.75	1006.17	4.55	-0.41	-0.63	-0.88

a) indicates highest value of the meteorological indicator for all clusters
b) indicates lowest value of the meteorological indicator for all clusters
c) positive value indicates north wind, negative value indicates south wind. Magnitude of the number is proportional to wind speed.
d) positive value indicates east wind, negative value indicates west wind. Magnitude of the number is proportional to wind speed.

Low nighttime visibilities indicate the frequent presence of advection fog. the occurrence of maritime tropical air at this relatively northerly latitude is quire rare in winter.

Clusters 2, 3, and 4 indicate air masses from an Arctic Ocean source region. Cluster 2 is particularly extreme in its characteristics, exhibiting bitterly cold, dry air, strong northwesterly winds, and low percentage sky cover. In all cases of occurrence, this situation was accompanied by a deep, cold core trough over the Maritime Provinces, facilitating the intrusion, and lessening the modification, of this very cold air mass. Cluster 3 is somewhat less extreme in composition, and occurs when the responsible anticyclone is adjacent to the study area. Cluster 4 exhibits similar cold temperatures, but cloud cover is greater and visibility is lower. This cluster is generally characterized by cyclogenesis to the south and/or east or by the presence of a stationary front to the south. In most cases, this cluster accompanies coastal storm development and precedes heavy snow situations.

Clusters 5 and 6 represent continental polar air masses which originate over the snow and ice surfaces of interior northwestern Canada. This air mass is distinguished from Arctic air described previously by its more moderate thermal character.(9) A source region which is 1500 miles distant allows for significant modification to occur within continental polar air, while the more easterly location of the Arctic source region, coupled with upper air assistance from the responsible cold core trough, permits less modification of the Artic air mass. Trajectory analysis indicates that continental polar air masses are associated with a stronger zonal circulation at 500 mb, while Arctic air corresponds with upper atmospheric waves of great amplitude. Cluster 5 is a somewhat drier air mass than its cluster 6 counterpart (contributing to its higher visibility), and is generally associated with a surface anticyclone exhibiting an east-west ridge axis. The cluster 6 ridge axis is less definable, or even north-south in orientation.

A warm, dry, and relatively clear air mass with a source region over the Pacific Ocean is indicated by cluster 7 and corroborated by trajectory analysis. Initially over its source region, this air mass exhibits a cool temperature and high moisture content. However, Pacific air is modified adiabatically after crossing a series of western mountain ranges, and acquires characteristics that appear to be continental. This air mass intrudes to the East Coast only when upper atmospheric flow is truly zonal, which prohibits intrusion of polar or tropical air masses. It is correspondingly rare over the study area.

Cluster 8 represents a synoptic situation with mid-latitude cyclone domination. The prevailing air mass is therefore maritime polar. The cyclonic track passes either overhead or just to the west of the study region, allowing for some transition from maritime polar to tropical air. Notable is the low visibility and pressure, slight diurnal range in temperature and dewpoint, and small differential between these two indicators (high relative humidity).

The remaining 4 clusters represent the air mass transition stages. Cluster 9 is indicative of conditions immediately after the passage of a cold front, in which maritime tropical air has been replaced by a polar or Arctic air mass. Dramatic changes to higher visibility and air pressure, lower cloud cover and lower dewpoint are apparent. Only the most extreme cold front passages are included within this cluster. Other less dramatic examples of this transition type have been absorbed within the first eight clusters.

Clusters 10, 11, and 12 represent the much more gradual and time-consuming transition stages from cold/continental to warm/maritime air. Clusters 10 and 11 are both indicative of a surface ridge adjacent or just to the east. Winds are variable, and other meteorological parameters are intermediate in magnitude.

Cluster 10 is generally preceded by an Arctic air mass cluster, while cluster 11 is more commonly associated with continental polar air. Cluster 12 is a transition to maritime polar, and most commonly precedes cluster 8. Cyclogenesis to the south and/or west is indicated.

An air mass frequency table and calendar may be constructed from the results of the cluster analysis (Table 3). The predominance of Arctic and Canadian source region air masses is readily apparent. However, a year-to-year frequency evaluation illustrates great annual variations. For example, in 12 of the 15 study years, maritime tropical air intruded no more than once a month during January. However, in 1972, 6 days exhibited this air mass, including 3 consecutive days in the middle of the month. In 1970, Arctic and continental polar air masses occurred on 19 days during January, but only 5 days with these air masses were indicated in 1974. However, maritime polar air associated with mid-latitude cyclones was prevalent on 9 days during that month, which represented 28 percent of the total cases for the entire 15-year period.

The developed synoptic categories may be utilized as an objective index to understand and evaluate the effect of climate on selected environmental situations such as the influence of air pollution concentration on human morbidity. Extreme conditions, as well as transition situations, are well-expressed, and the synergistic effect of rapidly changing or long-term continuous conditions may be assessed. Additionally, the ability of this technique to identify a complex set of meteorological parameters as one cohesive unit is of considerable value. All casual elements are considered, the elements are all orthogonal, and the developed climatic analysis may be utilized as a powerful explanatory or predictive tool.

ACKNOWLEDGEMENT

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Table 3: January Air Mass Frequencies: 1961-75

CLUSTER	AIR MASS TYPE	TOTAL CASES[a]	YEARLY FREQUENCIES[b] 61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
1	maritime tropical	20	1	1	0	1	1	2	4	0	1	0	0	6	1	1	1
2	Arctic	8	0	0	1	0	0	1	0	2	0	3	0	1	0	0	0
3	Arctic: adjacent anticyclone	33	1	4	5	3	2	1	0	2	4	2	4	2	2	0	1
4	Arctic: cyclogenesis	20	5	2	0	2	4	0	2	3	0	1	0	0	0	1	0
5	continental polar: east-west ridge	45	4	1	3	3	3	5	0	2	7	3	5	1	3	2	3
6	continental polar: poorly-defined ridge	85	4	6	6	3	6	11	6	5	7	10	4	4	7	2	4
7	Pacific	33	2	0	2	5	4	2	1	2	2	1	1	1	5	5	0
8	maritime polar: adjacent cyclone	59	1	2	5	4	3	4	1	5	3	3	4	5	3	9	7
9	transition: after cold front passage	8	0	2	0	0	0	0	2	0	1	0	0	0	2	1	0
10	transition: Arctic to maritime	69	4	5	4	6	2	3	5	6	3	4	7	7	6	1	6
11	transition: continental polar to maritime	42	4	3	2	3	4	2	5	2	1	3	2	2	1	4	4
12	transition: cyclogenesis	43	5	5	3	1	2	0	5	2	2	1	4	2	1	5	5

a) Total number of days over the 15-year January study period within each cluster. Column totals 465 days.
b) Number of days within January of each year assigned to each cluster. Each column totals 31 days.

SOME COMMENTS ON COMPUTING REQUIREMENTS FOR CLIMATOLOGY

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INTRODUCTION

The science of climatology, particularly geographical climatology, has been transformed over the past two decades such that it is now characterized by the search for quantitative analogues to climate and climatic processes.(1,2) Under this modelling paradism, climatologists are developing a plethora of mathematical descriptions of the energy and mass exhanges that take place between the organic and inorganic components of the earth's surface and the atmosphere. Within geographical climatology, the emphasis has been, and should be, on those processes that occur in the planetary boundary layer (PBL), since the PBL is the most influential layer of the atmosphere with respect to determing the climatic portion of man's environment.

A variety of modelling strategies are being employed (e.g., empirical, stochastic, deterministic, mechanistic and analytical modelling) although, owing to their complexity, most functional versions of these models take the form of computer programs in order that a meaningful variety or range of computations can be made. Much climatological research therefore requires access to the kind of computing facility (usually digital) that can compile and execute those large and complex programs that paraphrase climatic systems. At the same time, computing resources have become essential to the efficient acquisition, quality control and management of climatic information. Beyond merely having access to a computer, the speed of computation and the efficiency of data retrieval have become important computing requirements which, to date, remain limiting factors in large-scale climatic research.(3) The overall computing power required for developing, testing and running computerized climatic models, and maintaining, retrieving and analyzing climatic data, make climatology one of the most computer-dependent disciplines of modern science. Geographical climatologists should, therefore, have a keen interest in the nature and evolution of the particular computing resources on which their research and teaching so heavily depend.

DISTRIBUTED VERSUS CENTRALIZED COMPUTING RESOURCES

Within many universities and research institutions as well as throughout the computing industry, a recent trend to replace centralized computing facilities with distributed resources is apparent. In the past, one or two "large" computers (usually compatible with one another) comprised an entire computing network. More recently, however, networks tend to be made up of an increasing number of "small" machines (often incompatible with one another) where each does a few rather specialized tasks. In a highly decentralized network, each machine performs a few functions very well, but a small machine cannot accomplish a wide variety of jobs nor can a small computer solve the very complex or large-scale problems common to climatology. From an electic climatological standpoint, consequently, the ongoing transition toward highly distributed networks, made up of generally incompatible and small computers, should be considered detrimental to research and teaching.

Proponents of increasingly decentralized facilities, on the other hand, argue that cost reductions, improved efficiency and the "dedication" of small computers to particular tasks or individuals make them more economically efficient. While this is often true when the usage of a particular machine is evaluated independently of the overall service provided by the network, sub-

stantial cost increases are usually accured by the large-scale, general user population owing to the diversion of economic and personnel support from large machines to many small computers. This problem can be particularly acute when the institution-wide budget for computing is no longer increasing. A number of the most serious consequences are outlined below:

1. Computing center personnel are spread over an increased number of machines which has the effect of diluting the quantity and quality of software and consulting support for any particular machine.

2. In order to be able to use the appropriate computer for any given job, the burden of learning the salient aspects of more than a single system (e.g., system editor commands, file structures, programming peculiarities and the meaning of error messages) falls on the researcher.

3. A costly overlap in services, available software, and peripheral devices usually occurs as each computer must have certain basics such as compilers, documentation, consulting and input/output devices.

4. When the number of machines that comprise the computing network are highly incompatible, then the cost associated with developing soft- and hardware links between machines increase exponentially with the number of computers (Figure 1).

Since the computing network at the University of Delaware is both typical and familiar to the author, a few of the problems associated with climatological computing at Delaware should serve to illustrate the above-made points.

At the University of Delaware, the Computing Center (UDCC) has increasingly moved in the direction of decentralization to the point where the network now consists of five moderate-sized and largely incompatible computers, a DEC KL-10, a Burroughs B7700, a PDP 11/70, an HP2000 and a CDC CYBER 173 (Figure 2). The current status of the two largest machines (the B7700 and the DEC KL-10), particularly their incompatibilities, has presented some rather significant barriers to climatological computing at the University. Not too long ago, for instance, the University purchased a large (21 x 16 inches) flatbed plotter and then installed it in such a way that it can only be driven by the DEC KL-10. Previously, however, all the map plotting software had been developed on the B7700.(4) As a result, it is currently impossible to plot a large choropleth map, for example, even though both the hardware and software are available. If an interested user were willing to become familiar with both the DEC KL-10 and B7700 systems and then further invest the time necessary to translate the B7700 FORTRAN code into DEC KL-10 compatible FORTRAN, one could then plot a large choropleth map. Since UDCC does not now have sufficient personnel working on either machine (largely as a result of decentralization), the cost of such an incompatibility must be absorbed by the users, or the plotter will effectively remain unavailable to those who wish to plot maps. Other nuisances, such as a lack of card reading and punching capability on the DEC KL-10 (the designated "research machine") and incompatibilities between magnetic tapes encoded by the different machines, contribute to a diminished computing capacity with respect to climatological requirements. These represent only a few of the many symptoms which have appeared as a result of distributing hardware resources as well as software, consulting and systems specialists over five computers.

RECOMMENDATIONS AND CONCLUSIONS

Since large computers can do both small and large jobs, if properly configured, and small computers can only do small jobs efficiently, the climatologist should endeavor to preserve and improve upon the large-centralized com-

Number of Possible Interconnections Between Computers That Comprise a Network

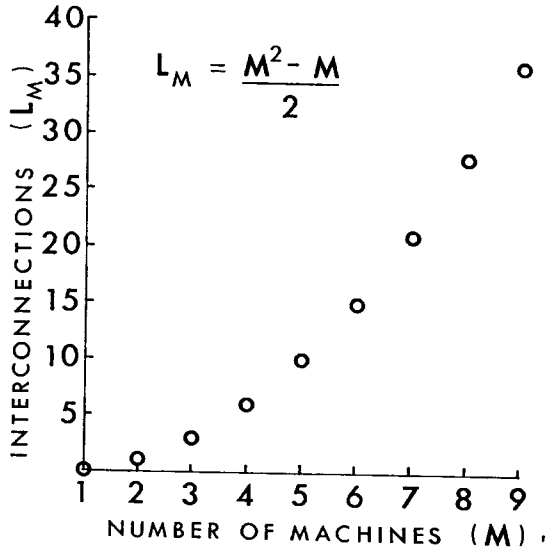

Figure 1

Schematic Diagram of the UDCC Computing Network

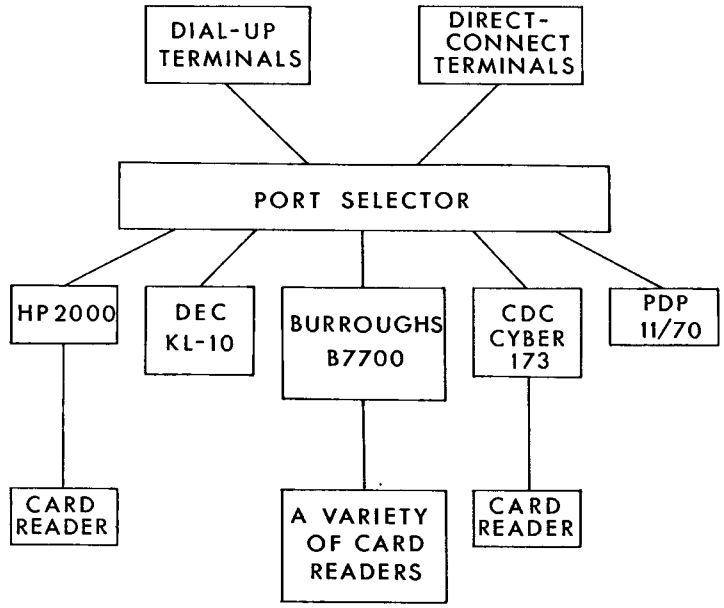

Figure 2

puting facility. This does not mean that small computers do not have important uses, but their acquisition and support should not diminish a university's or research institution's commitment to a large-central facility. At the same time, when a computing center purchases one or more small machines their compatibility with the large-central system should be an important consideration in their selection. By maximizing compatibility, it is insured that the capabilities of the small computer will be readily available to the general user population. Climatologists should also continually seek to upgrade the quality of the central system's software library in order that a wide variety of complex tasks will be increasingly easy to perform. Such program packages as SPSS, BMDP, IMSL, SYMAP, CALFORM, DISSPLA and a variety of compilers as well as a powerful system editor should, at a minimum, be available on a large-central system. Moreover, all general users should have interactive access to all computers in the network through a variety of terminals. As graphics and mapping have become central to climitalogical analysis, the acquisition and maintenance of up-to-date plotters and plotting software should be of major interest. Climatologists, perhaps more than other geographrs, should have a strong commitment to the preservation and enhancement of large-centralized computing facilities for without such systems the vicissitudes of climate may never be adequately explained.

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SPECIAL SESSION ON THREE MILE ISLAND: RISK EVALUATION AND EVACUATION RESPONSES

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The events that occurred between March 28 and April 13, 1979, at Three Mile Island, Pennsylvania, quickly focussed national attention on hazards that are associated with the production of electrical power from nuclear sources. The debate over the peaceful uses of atomic power has been raging for many years, but it quickly reached a crescendo with the events in Goldsboro (Figures 1 and 2). Shortly thereafter, the largest anti-nuclear demonstrations in this country took place, first in Washington D.C. on May 5, 1979 with over 100,000 attending, and then in New York City on September 23, 1979 with more than 200,000 attending. Events at TMI have also fueled the "anti-nuke" groups throughout the country leading to occupations of nuclear power plant construction sites (Seabrook, New Hampshire), and the closing of some plants due to safety (particularly those with the same design specifications as TMI--Babcock and Wilcox).

THE HAZARDS OF NUCLEAR POWER

Hazards associated with nuclear power are not limited to the production of power in nuclear reactors. Every other aspect of the nuclear fuel cycle is involved (1,2). Table 1 presents a brief overview of these hazards. If attention is focussed on that event which has the most potential for catastrope--a nuclear powerplant accident--the following observations can be made. There are currently 70 nuclear reactors with operating licenses in this country and an additional 92 which are under construction. Active commercial reactors are located at 48 different sites primarily on the eastern seaboard. Almost 25 million people live within 30 miles of all operating reactors. Ninety-three million people live within 50 miles. The reactors at Indian Point, New York, are closest to the largest number of people. Over 17 million residents of the greater New York City area live within 50 miles of this Hudson River site. Other reactors in heavily populated areas include Zion and Dresden (Illinois); Salem (New Jersey); Pilgrim (Massachusetts); Peach Bottom, Beaver Valley, Three Mile Island (Pennsylvania); and Haddam Neck and Waterford (Connecticut) (3).

On March 28, 1979 the Number 2 unit at the Three Mile Island nuclear generating station in southeast Pennsylvania experienced the most serious accident yet to affect a commercial U.S. facility. However, TMI was not unique. There have been other major accidents involving nuclear power plants (e.g. Enrico Fermi, and Brown's Ferry).

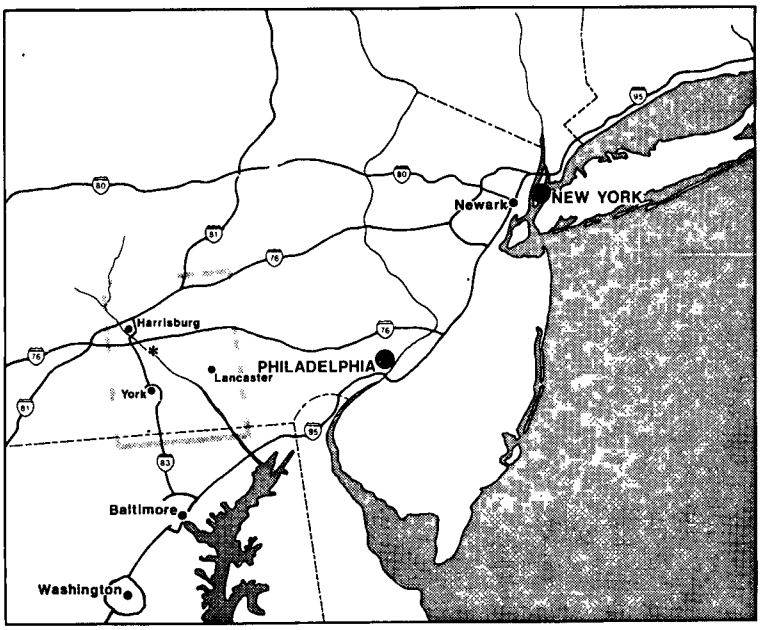

Figure 1 Study Area Location

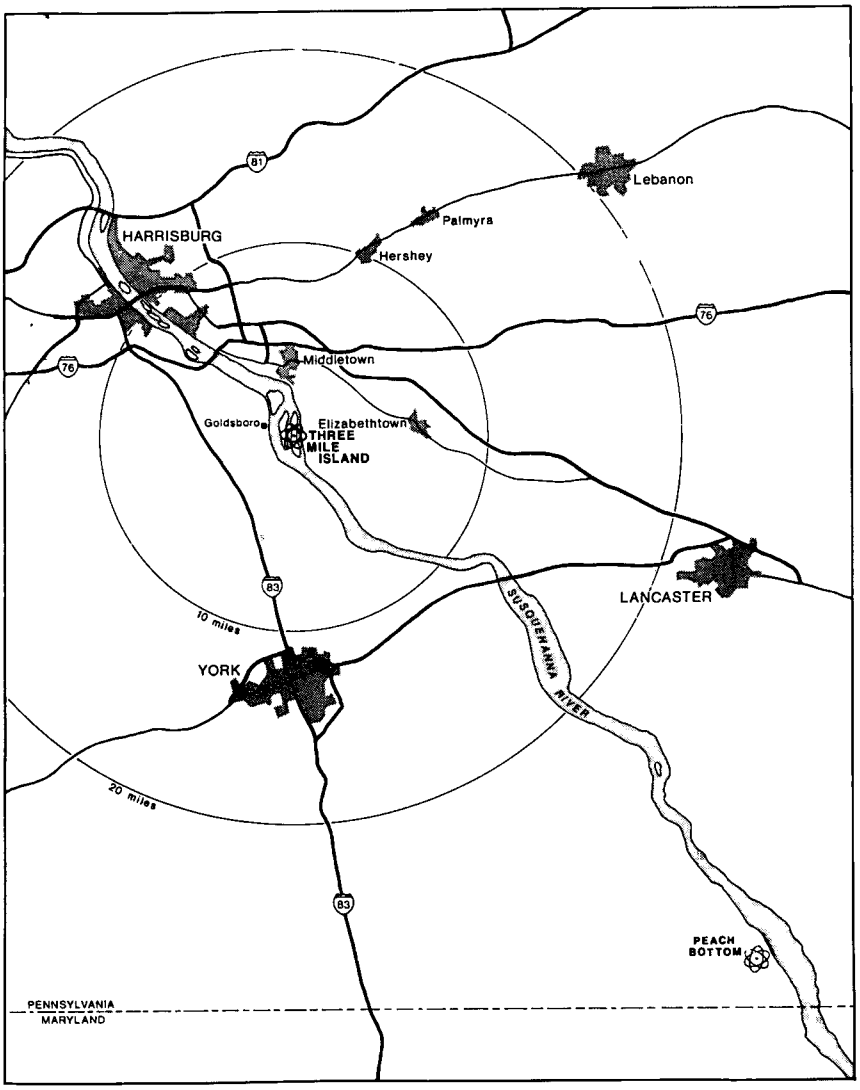

Figure 2 Sampling Radius

TABLE 1

HAZARDS FROM NUCLEAR POWER

Fuel Cycle

- Resource Extraction
- Resource Refining
- Fuel Reprocessing
- Waste Management
- Transportation

Power Production

- External
  - natural hazards
  - sabotage and theft
  - environmental
- Internal
  - sabotage and theft
  - human error
  - normal operating procedures
  - systems failures/malfunctions

SURVEY DESIGN

Events at TMI provided a good opportunity to examine human responses to this technological hazard. Topics of primary interest included the perceived risk of reactor accidents and the adequacy of, preparation for, and management of massive, rapid evacuation.

The responses of individual residents to the TMI accident were surveyed using a mailed questionnaire. The questionnaire was mailed on April 21, 1979, nearly one month after the accident. The sampling plan used a stratified random sample based on direction and distance from TMI. The area was divided into five-mile concentric zones and four quadrants resulting in a sampling plan that consisted of twenty sampling units (Figure 2).

Telephone directories were used to obtain the names and addresses of potential respondents. Names were picked at random from those directories which covered each of the sampling units. The initial sample size was 1000 (200 respondents per zone) but this was decreased to 922 as the remainder were undeliverable. A total of 359 were returned to the research team resulting in a response rate of 39%. The highest response rate was found in zone 2 (6-10 miles) and the lowest in zone 5 (greater than 20 miles).

There are a number of biases inherent in the sampling design. Due to the choice of quadrants, residents in the urban centers (Harrisburg) were overrepresented while residents in the rural areas were underrepresented. Since a telephone directory was used to generate names, potential respondents who did not have a telephone were not included. Finally because of funding limitations, the length of the questionnaire was restricted. In light of our quick response in getting into the field and with these sampling caveats in mind the sample is fairly representative of the people in the area. What are the residents' estimation of risk and what kinds of coping actions did they undertake in the wake of the accident at Three Mile Island?

INFORMATION TRANSMISSION

The process of information transmission during the early days of the situation was hindered by two factors: 1) a high degree of confusion about the actual events and ensuing consequences; 2) a general reluctance on the part of officials to release certain critical facts to the public. As a result, decisions of great importance were made by individuals in light of ambiguous and often conflicting information.

The first news release of Wednesday morning quickly reached a large segment of the sample. Nearly one-third of the respondents indicated that they were aware of unusual circumstances at the power station by 10 o'clock that morning. By the evening of the 29th, six out of ten respondents had heard of the radiation leak and by Thursday evening, an additional fifth of the sample had learned. The remaining 18% had heard of the events by late Friday afternoon.

In spite of the sizeable portion of the responses indicating an almost immediate awareness, there remains the question of why 20% first learned nearly two days afterward, and an equal amount fifteen hours after that. A possible explanation may relate to the individual perception of risk. The events which transpired before Friday were not seen as unusual or hazardous. This was prior to the Governor of Pennsylvania's evacuation advisory message. Analysis of the group for their perceived risk indicates that more than half did not perceive the situation as dangerous. Yet, nearly one-third of these people evacuated.

This raises questions about the perceived reliability of information sources in a time of crisis. The federal government--in the form of the Nuclear Regulatory Commission and Harold Denton--was singled out as the most reliable source of information. President Carter, as a write-in choice, was perceived as most reliable by 2% of the sample.

What may be the most important aspect here is that one out of ten respondents felt that no reliable information was provided by any source. An analysis of their behavior shows that less than half of these people evacuated or made any preparation to do so. The implication is that if such a trend exists in the general population, those involved with public safety are faced with managing a sizeable unconvinced portion of the population in an emergency situation.

RISK ASSESSMENT

One hundred forty households (39%) were fully or partly evacuated after the TMI accident. While the official advisory message related to pregnant women and children within a five-mile radius, only 20% of our sample had preschoolers and 2% had a pregnant women in the household. The high percentage of voluntary evacuations indicates a general tendency on the part of respondents to assume the initiative in assessing the immediate danger and to take actions to cope with it.

In addition to those households with evacuating members, another third made some preparation to evacuate such as filling the car's gas tank, withdrawing money from the bank or related measures. Other precautions included remaining indoors, keeping informed, and praying. Fourteen percent of the sample assessed the dangers of the situation but listed employment responsibilities or other constraints as reasons for remaining in the area.

The perceived long-term risk assessment provided some unexpected results (Table 2). Generally, the respondents in our sample were optimistic in their outlook for continued and future use of nuclear power.

TABLE 2

FUTURE USE OF NUCLEAR POWER STATIONS

Recommendation	%
Close all permanently	21
Close stations similar in design to TMI	10
Modify existing	64
No change	3
No answer	2
Total	100

DISRUPTION OF DAILY LIFE

The impacts of the events at TMI were examined for the influence on specific aspects of daily life. Though the total disruption as acknowledged by the sample is moderately low, certain individual aspects experienced significant change (Table 3).

Nine aspects which were felt to be of importance in everyday life were grouped into four categories: community aspects (value of house and property, willingness to continue living in the area, involvement in community affairs); personal (physical and mental well-being); institutions (power companies, government, science); religion (faith in God). For each of these, respondents indicated an increase, decrease, or no change after TMI.

Increases - which by design indicate a positive change in attitude - account for 8% of the responses. More than half of the increases were a result of an increased faith in God. More than a quarter of the responses were decreases. Institutional aspects were the big losers with trust in power companies (-31%), trust of government (-18%) and trust in science (-12%) comprising most of the decreases. The total change (increases and decreases) was relatively low suggesting that most of our sample felt some amount of change but less than what might have been expected.

The biggest casualty of all was the power companies. Seventy-five percent of the respondents recorded a decrease in trust toward them. Although the government was perceived as the most reliable source of information, 43% of the sample felt a decrease in their trust of this institution.

As stated earlier, increased faith in God accounted for most of the positive change resulting from the TMI incident. In an area of Pennsylvania that has deep religious roots this was not unexpected. Half of the respondents felt an increased faith but many of those respondents who indicated no change also felt compelled to indicate that their faith in God was high to begin with. As one person replied, "Nuclear power is a bad thing, but I am ready to leave this wicked old world anytime the good Lord wants me."

EMERGENCY PLANNING

Emergency management officials were caught totally off-guard and without satisfactory emergency response plans when they were told by the NRC to extend their evacuation plans from 5 miles to 10 miles and later to a 20-mile radius around the power plant. This increased the total number of people that might have to be evacuated from 27,000 to 700,000. Lack of preparedness was due to

TABLE 3

GENERAL DISRUPTION IN DAILY LIFE
(in %)

	Increase	Decrease	No Change
Community	19	22	42
Personal	4	16	25
Institutional	20	61	23
Religion	57	1	10
Total	100	100	100

the state's uninvolvement in regulation and inspection of the plant and a reliance upon the NRC to determine an adequate planning basis for nuclear emergency response.

Emergency planning in Pennsylvania is done by local and county emergency management personnel and coordinated into the emergency response program outlined by the Pennsylvania Emergency Management Agency (PEMA). PEMA serves only in an advisory function and interacts with state and county officials.

Six risk counties (Dauphin, York, Lancaster, Lebanon, Cumberland, Perry) were designated by PEMA. The host counties (designed to accommodate evacuees) were based on size and available facilities. Apart from the fact that host counties and communities were located more than 20 miles away, distance from TMI was not a factor in their selection. All of the risk counties, excluding Duphin, elected to accommodate the majority of their potential evacuees within their own boundaries.

REASONS FOR VOLUNTARY EVACUATION

Evacuees were asked to indicate specific cues which encouraged them to leave the area. A majority (68%) cited Thornburgh's advisory message as a major factor in their decision to depart. This was directed at pregnant women and mothers with young children living less than 5 miles from TMI. Twenty-one percent of those citing the advisory message lived outside the 5-mile radius and only 29% of all evacuating families reported pre-school children.

Nearly 50% cited anticipated consequences such as harm to children and family or possible core meltdown as reasons for leaving their residences. A noteworthy minority (7%) expressly stated concern over the long-term effects of radiation on their health as a reason for leaving. Other cues were confusior and uncertainty (41%), lack of leadership on the part of elected officials and Metropolitan Edison officers, and conflicting information (21%). All of these contributed to a confused understanding of what was actually happening at the reactor site. For example, "The situation is under control; however, please be prepared to leave the area if you hear a siren." This allowed for a wide range of interpretations by the impacted populace.

Confusion cues are significant. A sizeable percentage of the evacuees left, not because there was consistent information on which to base their evacuation decision, but rather because such information was lacking. This raises two questions: 1) if information was released more consistently, would the same number have evacuated; and 2) what are the individual and social costs incurred because of misinformation or lack of clear information?

DESTINATIONS OF EVACUEES

Seventy-four percent of the evacuated families chose to stay with friends or relatives. None of the respondents in our sample utilized an official evacuation reception center, such as the one in Hershey. Two-thirds of the evacuees remained in southeastern Pennsylvania within 20-50 miles of the reactor site. It is important to note the large number of evacuees who elected to remain within their respective counties of origin. They simply moved to places in that county they considered safe or where they could find accommodations with friends or relatives. This raises some serious questions as to whether evacuees actually removed themselves far enough from danger in the event of a major catastrophe.

FACTORS INFLUENCING EVACUATION DECISIONS

As expected, proximity to the reactor site proved to be an important factor in the decision to evacuate. The proportion of those respondents who evacuated decreases with distance from 47% in the 5-mile zone to 12% outside the 20-mile radius. The impact of Thornburgh's advisory statements is clearly visible in that there is a sharp reduction in the percentage of respondents evacuating from beyond the 10-mile radius.

The presence of pre-school children proved to be another strong factor in the decision to evacuate. Over half of the sample reporting pre-school children evacuated. The age of respondents was found to be inversely related to evacuation. Younger age groups were more likely to evacuate than those people over 50. Education also proved to be a significant factor in evacuation.

ESTIMATES OF EVACUEES

Estimates of evacuees from their respective zones were calculated from the sample proportions and the 1975 Census figures for the region. Possibly 195,900 (Table 4) persons evacuated from the 20-mile radius during the crisis. What are the policy implications of such an exodus?

CONSEQUENCES OF THREE MILE ISLAND FOR GEOGRAPHICAL RESEARCH AND PUBLIC POLICY

Governments in the United States generally fail to come to grips with potentially serious environmental issues until crises bring them into focus (e.g., oil spills and the Argo Merchant or Santa Barbara channel blowout; Hurricane Agnes and federal disaster relief policy; Love Canal and toxic waste disposal). There is strong evidence that the Three Mile Island accident will be a similar watershed event which modifies public policy and introduces other far-reaching changes in our approach to the business of government and academic research.

Approximately one million people living near the plant were directly affected by the threat of death or injury for a period of between one and two weeks. During that time an even larger number of downwind residents, living in the cone of dispersion which stretched across eastern Pennsylvania and the Middle Atlantic seaborad, regarded themselves as potential victims. The crisis held national attention for ten days. Six major federal investigatory groups began work including a Presidential Commission and several Congressional committees. Administrative bodies from the Nuclear Regulatory Agency to the Federal Emergency Management Agency undertook intensive reviews of their performance. There was an outpouring of national and local public interest groups on behalf of campaigns to reduce or eliminate commercial nuclear power generation. Curiously, university researchers were not as conspicuous among those who responded to Three Mile Island as might have been hoped. Most of the major public research funding organizations do not supply support money on a contingency basis for quick response studies of emerging disasters. Hence, only a handful of relatively poorly funded academic research groups entered the field soon after the accident.

TABLE 4

PROJECTED EVACUATIONS BY ZONE

Zone	Estimated Evacuees	Standard Error of Estimation
0-5	15,690	5.06%
5-10	55,961	6.23%
10-20	124,249	8.36%
Total	195,900	

Nonetheless, a wide range of proposals have emanated from the investigating groups. For the most part these focus on the need for better training of power plant personnel, for better regulation of plant design and certification, for programs designed to allow impacted populations and institutions to recover the costs of nuclear disasters, and for more careful site selection.

The confidence of investors in the future of nuclear power has been severely shaken, and orders for new facilities have largely ceased. Cancellations of existing orders have increased sharply. Public opinion polls indicate that, at least in the short term, fewer people now favor commercial nuclear power generation than at any previous date.

None of these trends and events are necessarily conclusive indicators of certain change in public policies concerning nuclear energy. However, they are strongly suggestive of such changes. These may be classified into several groups arranged in order of increasing generalization and spread of consequences.

More careful regulation of nuclear power stations seems inevitable as a first step. It may well be that the Nuclear Regulatory Commission will be modified or abolished so that its developmental, regulatory, and investigative roles can be allocated to different institutions. Even though it is difficult to determine the present Administration's position on national energy policy, and notwithstanding public tendencies toward "high technology" solutions to energy shortage problems, it is unlikely that nuclear energy is destined to play a larger role in the nation's energy budget. In many respects the Three Mile Island experience highlights the inadequacies of fragmented, decentralized, pluralistic governments during emergencies. It may be that more attention will now be paid to developing alternative institutions. Whether these will be consensus seeking or authoritarian structures is an intriguing question.

Three Mile Island has thrown the subject of hazard mitigation into high relief as a public policy issue. We are now witnessing a proliferation of federal agencies and regulations aimed at risk management (e.g., OSHA, NSF's Division of Technology and Risk Assessment, NFIP). This appears to reflect at least a partial failure of existing hazards mitigation systems. Paralleling these events is a growing debate on the status of hazard in American life.

Accompanying the concern for hazard is a growing public reluctance to place much confidence in the institutions and practitioners of science and technology. As citizens are being exhorted to "participate" in governmental decisions, the prestige and mystique of scientific "experts" appear to be in decline. Technology misuse (e.g., Vietnam) and failure (e.g., Teton Dam) exacerbate this situation.

All of these changes may be viewed in a heuristic context. In C.P. Snow's formulation, the course of human affairs reflects the operation of two "cultures"--science and humanism. Either "culture" can provide rules for action, although in modern times science has been more influential. Perhaps we are now witnessing the emergence of an era where uncertainty is a dominant condition for which we have yet to devise appropriate rules of action.

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ABSTRACTS

GEOGRAPHICAL FACTORS INVOLVED IN THE DECISION TO ESTABLISH THE CAMP COMPLEX AT AUSCHWITZ

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The establishment of the extermination camp complex at Auschwitz was, in large part, based upon a favorable assessment of selected geographical factors of site and location. The combination of site and location factors were believed by the Nazis to be sufficient to assure the attainment of two major objectives, namely to maximize the secrecy of the camp complex, and to maximize the efficiency of the operation of the camp complex.

THE POLITICS OF GEOGRAPHIC INFORMATION SYSTEMS IN NEW YORK STATE

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As a result of a campaign promise made by Governor Nelson Rockefeller in 1966, a geographic information system called the Land Use and Natural Resource (LUNR) Inventory was developed in New York State. The Inventory includes 130 categories of land use and land cover data mapped on overlays to U.S. Geological Survey 7 1/2-minute topographic maps. The computer products of LUNR are tabular listings of data and line printer maps.

Since its inception, the fate of the LUNR Inventory has been tied to the status of a state-level planning organization. This paper describes the political forces which caused the eventual demise of the state's commitment to the information system. The future of LUNR and its proposed successor, the Land-Related Information System, is described, and some conclusions drawn regarding the likelihood of future implementation under present governmental structure.

HUMAN GEOGRAPHY AS A PALIMPSEST: EXAMPLES FROM AN AMERICAN CITY

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The palimpsest, "a parchment, tablet, etc., that has been written upon.. two or three times, the previous...texts having been imperfectly erased and remaining" serves as a model for the historical and cultural landscapes that form the data of historical geography. The city of Buffalo, New York, and environs provides a number of examples of past landscapes erased, renewed and reused.

SOME RANDOM THOUGHTS ON THE ENERGY CRUNCH AND ITS RELEVANCE TO COLLEGE GEOGRAPHY

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Academic geographers would do well to capitalize on the current obsession with energy problems. We are eminently qualified to exploit this issue by training, experience and disposition. Of particular value is our ability to sythesize complex and disparate information to facilitate a wider view.

We have an opportunity to 1) contribute more forcefully to public education regarding energy matters through wholeheartedly embracing energy as a geographic topic of top priority and 2) elevate the general esteem for geography by demonstrating its relevance and its unique informational and methodological contributions, using the energy crunch as a rallying focus. Thus, a valuable service to the body politic could at the same time constitute a boost for the image of the discipline.

Coupling energy with other highly topical, closely related geographic subjects -- population pressure, environmental/conservation problems, the world food supply -- presents an even more attractive direction to pursue in a reoriented curriculum.