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A Synergism of Plagues: "Planned Shrinkage," Contagious Housing Destruction, and AIDS in the Bronx

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Techniques adapted from population and community ecology, quantitative geography, and epidemiology are applied to ecosystem and environmental index data on the Bronx in an attempt to understand the origins and potential impacts of rampant spread of human immunodeficiency virus (HIV) and its sequelae of acquired immunodeficiency syndrome (AIDS) in that borough: Recent work by Drucker and Vermund (1987), ("Estimating Prevalence of Human Immunodeficiency Virus Infection in Urban Areas with High Rates of Intravenous Drug Abuse: A Model of the Bronx in 1987," Poster presented at the Third International Conference on AIDS, June 2, 1987) estimates HIV seroprevalence levels of from 8 to 21% among men of age 25–44 in the South Bronx, at this writing, comparable to the cities of Central Africa. It is found that the "South Bronx" process of fulminating, contagious urban decay which devastated the region in the 1970s, and its associated forced population migrations, spread intravenous drug abuse, the principal HIV vector in the Bronx, from a geographically contained center in the South-Central Bronx to a virtually borough-wide phenomenon. This has significantly complicated attempts to contain HIV infection, both by shredding the social networks which are the natural vehicles for education, and by vastly enlarging the area requiring intensive targeting. Since the "planned shrinkage" municipal service cuts which triggered the "South Bronx" burnout persist, and since levels of housing overcrowding now approach those of the early 1970s in the Bronx, it is expected that a new outbreak of contagious urban decay will occur, likely again dispersing population and seriously compromising any in-place HIV control strategies. If overt AIDS itself becomes a contributor to urban deterioration in overcrowded neighborhoods susceptible to "South Bronx" process, we could then see a nonlinear ecosystem coupling between AIDS, contagious urban decay, and population shift. Elementary mathematical models are provided. Thus, in striking contrast to the middle-class male homosexual community, successful control of HIV infection in the Bronx, and by inference in other devastated ghetto communities, seems predicated on quick reestablishment of demographic stability: The tools to make the tools for control must first be reconstructed. Necessary elements of any program toward this end are briefly outlined. AIDS in the Bronx and similar areas, like tuberculosis, seems increasingly a marker disease of extreme poverty, and again like tuberculosis, may well form an important reservoir for further spread or resurgence of the disease.

I. INTRODUCTION

The Bronx is symbol of a systematic[1] catastrophe in American cities which, by the early 1980s, had degenerated from the "urban crisis" of the 1960s to an accelerating complex of massive low income housing loss, resulting

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"homelessness," disruption of essential community networks, rising drug abuse and violence, and rapid deterioration of general public health. Into this interacting maelstrom of community destruction and poverty has come the great plague of the second half of this century, acquired immunodeficiency syndrome, AIDS, the overt sequelae of infection with human immunodeficiency virus, HIV, a contagious retrovirus with a long, variable, and asymptomatic infectious period which makes public health control a nightmare.

Rapidly spreading from foci in the male homosexual community, AIDS has become well established among nonwhite and Hispanic intravenous drug abusers and their sexual partners, and threatens to replace the Black Plague of London as "the poore's plague" of our time. Efforts to control AIDS among New York City's male homosexuals were basically too little and too late, resulting in massive HIV seroprevalence rates for that population. It is widely believed the next line of public health defense now lies in the urban ghettoes. If control of HIV infection in the intravenous drug-abusing population fails, general introduction of AIDS into the American heterosexual community seems increasingly likely, as has indeed already been the experience of Central Africa (Quinn *et al.,* 1986).

Just as the Bronx has led in other aspects of urban deterioration, symbolized generally under the term "South Bronx," so too it seems to lead in the spread of AIDS. Drucker and Vermund (1987) write:

> "Our findings reinforce the pivotal role of [intravenous drug abusers] in determining local geographic patterns of AIDS and for predicting increasing heterosexual exposure and consequent spread of HIV infection in the Bronx.
>
> The determination of local patterns of HIV infection is essential to anticipating disease burden and targeting public health activities . . . application of our model . . . places . . . [the Bronx] . . . in a fairly advanced stage of epidemic spread, with seroprevalence levels among men age 25–44 [of 8 to 21% in the South Bronx] similar to those found in some areas of Central Africa. . . . These are levels with ominous implications for future disease burden and for the future spread of infection, particularly to heterosexual contacts of [intravenous drug abusers] and to their children."

This paper explores interactions between the infamous "South Bronx" process of contagious housing destruction and community disruption and the spread of AIDS. It first focuses on the role of the South Bronx process in determining the geography of drug abuse, and hence of AIDS, and then on the possible effect of widespread, geographically concentrated AIDS outbreaks on accelerating rates of urban decay and subsequent possible patterns of forced migration of population which would, in turn, further spread AIDS. Finally, it examines implications of these synergisms for design of public health interventions, uncovering what may become an increasingly intimate relation between AIDS and housing in poverty neighborhoods of New York City.

II. CONTAGIOUS URBAN DECAY AND ITS IMMEDIATE DEMOGRAPHIC IMPACTS IN NEW YORK CITY

Between 1974 and 1978 the Bronx underwent a great and mysterious loss of housing and destruction of community which has become famous worldwide as the "South Bronx." In reality similar outbreaks devastated many other poor neighborhoods of New York City, including the West Bronx, Central and East Harlem and the Lower East Side in Manhattan, Bushwick/Brownsville/East New

York in Brooklyn, South Jamaica in Queens, and elsewhere. A fair understanding of the process is fundamental to the argument of this paper. The contribution of South Bronx urban desertification to spread of AIDS among minority communities, and the possibility of AIDS contributing in return to further desertification which may further spread AIDS itself, are the principal topics of this work.

Between 1972 and 1976, while demand for fire service rose sharply, some 50 New York City firefighting units were either disbanded outright or removed from or near high fire incidence, high population density overcrowded areas. During the same period the number of firefighters on individual companies was cut by 20 to 25%, and initial response to fires, a very critical factor, reduced from five to four, and by the 1980s most commonly to three fire companies. Fire department staffing fell from 14,700 to 10,200 between 1970 and 1976. Most fire company closings, and the reduction of initial response to fires, were made well before New York City's "fiscal crisis" of 1975, and were based on simple operations research models developed by an offshoot of the Rand Corp., the New York City Rand Institute, which had been given overall management of the fire department (Wallace and Wallace, 1977, 1980; R. Wallace, 1978).

From 1972 to 1976, coincident with the fire service reductions, engine company structural fire worktime, a composite of building fire number and seriousness, rose from 44,000 to 63,000 hr, some 45%. Most increase was concentrated in areas which already had high fire rates (NYC Rand Institute, 1969), such as Brownsville, East New York and the South Bronx, and accounts for the present "bombed out" aspect of these communities.

Most fire cuts, and many other housing-related municipal service cuts, are still in place as of this writing. R. Wallace (1982) and Wallace and Wallace (1977) show the effect on fire damage and human injury patterns, finding the reductions equivalent to ending an immunization program during a disease outbreak. As will be shown below, service deterioration continues into the 1980s.

In 1978 the Republican Leader of the New York State Assembly began examining outcomes of these policies, finding the fire service reductions were in fact part of a deliberate "planned shrinkage" or "redlining" program directed against minority neighborhoods (Duryea, 1978; Mega, 1978). More complete examination of the public record only provides substantiating detail, showing how official agencies predicted burnout of Brownsville, East New York and Bushwick in Brooklyn, as well as the Bronx, long before subsequent fire service reductions in or affecting those neighborhoods (Kirby, 1970; NYC Rand Institute, 1969; Jonat, 1972; see D'Amato, 1981, and Fried, 1976, for more discussion of the city's "planned shrinkage" program).

Recent scientific study shows the rapid South Bronx process of fire and housing abandonment to be a highly contagious form of urban decay, triggered into fulminating epidemic spread precisely by the deep "planned shrinkage" fire service cuts (Wallace and Wallace 1977, 1980, 1983, 1984; R. Wallace 1978, 1981, 1982; D. Wallace, 1983; see Dear, 1976, Odland and Balzer, 1979, Odland and Barff, 1982, and Odland, 1983, for studies of contagious housing abandonment). Underlying mechanisms of urban decay contagion were analyzed first by Dear (1976) in Philadelphia and, independently by Wallace (1978) for New York City. Dear (1976) describes contagious housing abandonment as follows:

> "The process of abandonment as it operates in space . . . suggests an initial broad scattering of abandoned structures, characterized internally by the occurrence of many small groups of abandoned houses. With the passage of time, this pattern is intensified; the broad scatter is maintained, although the small groups now contain a greater number of structures. A two stage process is clearly suggested; the initial abandonments occur and later consolidation follows. . . . It suggests a 'leader–follower' sequence which resembles the propagation of a plant species or the diffusion of information. It is essentially a contagious sequence."

Dear's seminal work includes the striking understatement that ". . . Contagion has major implications for our understanding of the dynamics of abandonment, and for later policy considerations."

Wallace's analysis is essentially similar to Dear's, suggesting, however, that great, or simply visible, fire damage may seriously exacerbate the process of urban decay contagion by encouraging landlord abandonment and a migration of population which may carry with it the housing overcrowding which renders buildings "susceptible" to contagious urban decay in the first place. Thus, according to Wallace, adequate municipal services can act as a kind of immunization against some mechanisms of contagious urban decay, for example, by limiting fire damage. See Wallace and Wallace (1983) for a small area study similar to Dear's.

Work by Odland *et al.* (1979, 1982, 1983) independently confirms Dear's work using data from Indianapolis, and discusses as well what are essentially epidemiologic threshold theorems for its propagation. Odland's work does not yet seem to have received proper attention.

Figure 1 shows a numerical index of citywide fire damage from 1959 through 1986, constructed by a principal component analysis (PCA) of building fire number and seriousness measures. Annual numbers of structural fires (within buildings), "serious" fires (requiring five or more units working for extinguishment), and "extra alarm assignments" (EAA) were subjected to PCA. EAA are calculated by counting each two alarm fire as one extra alarm, each three alarm fire as two extra, and so forth, forming the annual or other sum. Annual data from 1959

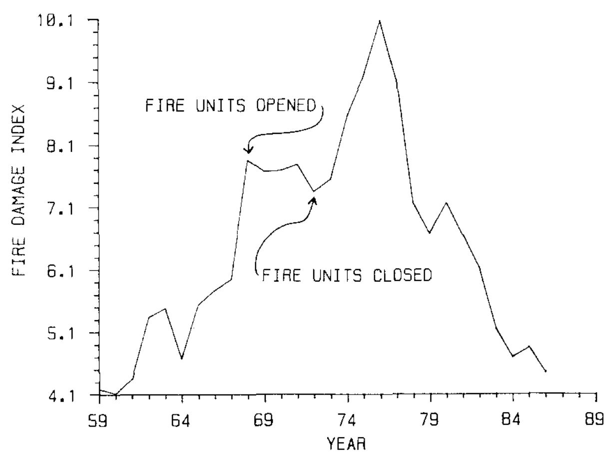


FIG. 1. Fire epidemic curve for New York City, 1959–1986. This is an annual structural fire damage index, constructed by a principal component analysis of number and seriousness of building fires. It represents the rate of both housing decay and of community disintegration.

through 1986, normalized to zero mean and unit variance, were then projected onto the eigenvector accounting for the greatest proportion of variance, and the result offset so zero fires gives a zero index. See R. Wallace (1982) for details of the method.

Virtually all the index increase after 1967 was concentrated in overcrowded ghetto neighborhoods which already had serious fire problems.

Efforts at control are evident between 1968 and 1972, when some 20 new fire companies, plus supervisory units, were established in the highest fire incidence districts of the city, the traditional solution to the traditional problem of fire increase. Increased fire service efficiency, discussed below, interrupted some mechanisms of contagion and stabilized fire damage, an index of rapid urban decay, between 1968 and 1972 (Wallace and Wallace, 1977; R. Wallace, 1978, 1981, 1982).

The effect of subsequent fire service reductions is also evident between 1973 and 1976. The decline in fire damage after 1976 represents, not improvements in fire service, but the massive "removal" of "susceptibles"—the burnout of vast areas of overcrowded housing from under their inhabitants.

Using official fire service monthly data from 1/68 through 12/86 an index of building fire controllability can be constructed, one of many possible, by examining the relative rate at which building fires required extra alarm assignments for extinguishment. The method, a time series equivalent to analysis of covariance (ANCOVA), is described in Green (1979). It is essentially a principal component analysis of the covariance matrix between log-transformed data, and compensates for the statistical intractability of ratios. Green shows how the usual statistical tests can be applied to the different index values obtained by projecting the original data onto the principal components. If the eigenvectors have elements of differing sign, then the index can be considered analagous to a ratio. That is, if $m(T_i)$ is the index value at time T_i, and N_{eaa} and N_{str} respectively the number of extra alarms and structural fires, A and B the eigenvector components, then a relation of the form $m(T_i) = A \ln(N_{eaa}) - B \ln(N_{str})$ would represent a generalized number of extra alarms per number of structural fires. The equivalence to ANCOVA can be seen by back-solving the relation above determining an index value at time t for one relating the numbers of extra alarms to the number of structural fires, i.e., solving for N_{eaa}. Each distinct index value $m(T_i)$ determines a different relation between number serious and number structural fires: $N_{eaa} = \exp\{[m(T_i) - B \ln(N_{str})]/A\} = \exp\{[m(T_i)]/A\} \times [N_{str}]\hat{}(A/B)$ where the last term is N_{str} raised to the power (A/B). This nonlinear function, different for each index value $m(T_i)$, is analogous to the different linear relations determined by ANCOVA (Tatsuoka, 1971). Under ANCOVA one would, in our circumstances, search for significantly different linear relations of the form $N_{eaa} = m(T_i) \times N_{str} + B(T_i)$ for different time periods T_i.

Figure 2 shows results smoothed with a moving average. Higher values on the vertical axis mean greater tendency for structural fires to require extra alarm assignments for control, or to become large multiple alarm fires.

Effects of fire service improvements between 1968 and 1972 are evident, as, after a lag, are the impacts of subsequent and continuing service reductions.

Other indices of fire service quality, including reported fire insurance losses,

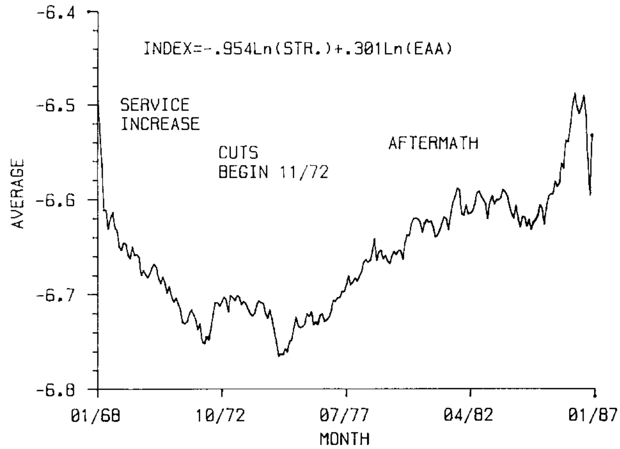


FIG. 2. Relative rate at which structural fires require extra alarm assignments in New York City, 1/68 through 12/86, using a time series equivalent to analysis of covariance. The index is smoothed with a 13-month running average. A higher value means relatively more extra alarm assignments per number of structural fires. Note the three evident periods: Service improvements from 1968 through 1972, with improving ability to control large fires; many rapid cuts, 1972–1976; and then the aftermath, greatly lessened capacity for preventing large fires. The indices for mid-1975 through early 1977 are distorted by the simple inability of the system to deliver needed extra alarm assignments during the epidemic peak. Other indices, for example, relative rate of serious fires (those needing five or more units working for extinguishment), civilian deaths, serious firefighter injuries, or insurance losses, provide a better picture of service during the peak. The EAA index should, however, be sensitive outside of the 1975–1977 period. Beginning 1982 and accelerating through 1986, we see the worst fire control index since 1968, when the housing stock had relatively fewer dilapidated "conflagration breeders," and more space for displaced families.

relative rate fires requiring five or more companies working, or relative rate of serious firefighter and civilian injury, show different aspects of fire service deterioration. See Wallace and Wallace (1977) and R. Wallace (1978, 1981, 1984) for further treatment of these matters.

The service deterioration of the 1980s suggests some form of fire/abandonment epidemic recurrence is increasingly likely in new, rapidly "ripening" overcrowded neighborhoods like the Northwest Bronx or Crown Heights and Flatbush in Brooklyn or Hamilton Heights, Inwood, and Washington Heights in Manhattan. This possibility, and its considerable implications for AIDS control, will be examined in more detail later.

The data above are citywide. Closer study of spatiotemporal patterns (R. Wallace, 1981, 1988a, b; Wallace and Wallace 1983, 1984) shows a fire/housing abandonment outbreak concentrated in the city's poorest, most overcrowded, and most deteriorated minority neighborhoods. An essential feature of that concentration has been coupling between propagating fronts of urban decay, fire and housing abandoment on the one hand, and the mass forced transfer of population. Figure 3 shows the location of fire department engine companies and community school districts in the city's Bronx section.

Figure 4 relates average fire department engine company occupied building fire

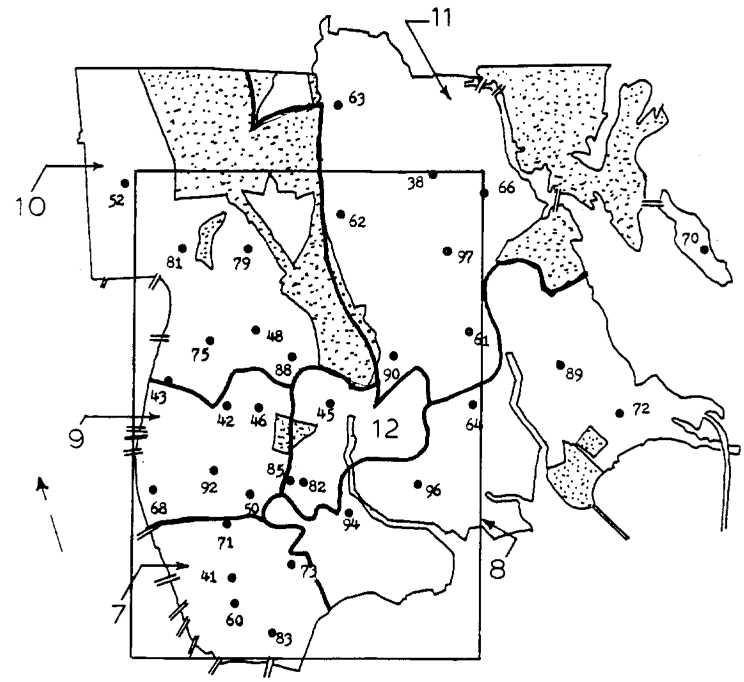


FIG. 3. Location of New York City Fire Department engine companies in the Bronx. Engine companies pump water on a fire until it is extinguished. The occupied building structural fire worktimes of the engines in the outlined rectangular area are mapped in Fig. 9. Community School District boundaries are also shown. The small numbers are fire company designations, the large indicate Community School Districts.

worktime per Bronx school district district to the number of pupils transferring out of that district between 1972 and 1978, an index of migration. The relation is very good, suggesting the unprecedented fire load indeed contributed strongly to outmigration. Figure 5 shows the citywide geographic pattern of pupil transfers for 1974–1975, the time occupied building fires were most extreme in the South-Central Bronx: Note the strong dominance of the citywide pattern by transfer from the South-Central into the West and Northwest Bronx.

Figures 6a and 6b, adapted from a New York City Planning Commission report (Planning Commission, 1982), take the matter further, showing respectively the areas of the city's greatest housing loss and of greatest change in black population between 1970 and 1980. They are almost exactly complementary: Minority neighborhoods like the South and Central Bronx, Brownsville/Bushwick/East New York and Central Harlem disintegrated suddenly under their inhabitants while nearby neighborhoods were forced to receive demoralized refugees.

Figure 7 shows the citywide change in patterns of welfare dependency between 1967 and 1977 (Hayes, 1978). Note that the West Bronx, which was not even classified as a poverty area in 1967, had by 1977, according to Hayes, become the "worst" such.

Clearly the fire/abandonment epidemic has already forced a vast transfer of

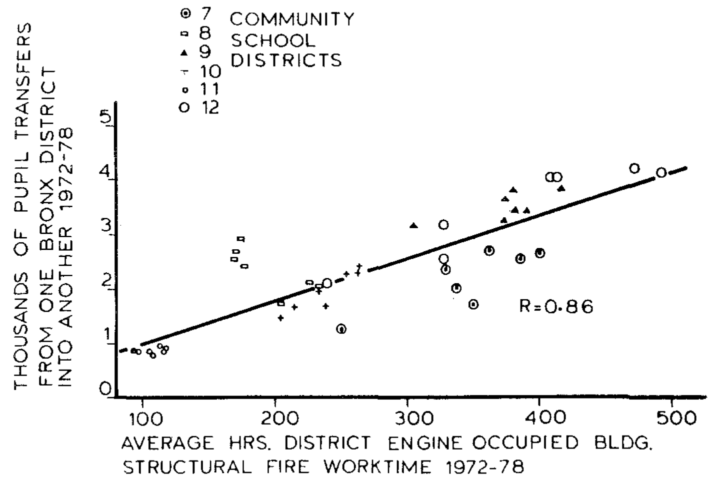


FIG. 4. Thousands of school children transferring from one Bronx school district into another as a function of the average district engine company occupied building fire worktime. The exodus of Fig. 5, below, correlates highly with destruction of occupied housing.

population within the city, stressing not only the disintegrating communities, but those overburdened by refugees. Of particular interest here is the patterns of population movement in the Bronx.

Figure 8 shows the relation between engine company worktime and the percentage of badly overcrowded housing, defined by the census as housing with more than 1.51 persons per room, by the Bronx Community Planning Board. Overcrowded housing has more concentrated cooking, smoking, use of electricity on often overage wiring systems, generation of highly flammable household trash, and other human activity leading to fire occurrence, accounting for the linear relation for 1972 and 1973. By 1974 the fire service system had been so deeply cut that it was unable to meet service demand, giving a "resource-limited" logistic curve. Figure 8 strongly suggests that badly overcrowded housing units are the most susceptible to contagious urban decay.

Figures 4 and 8, in conjunction with the maps of population transfer and of occupied building fire spread, were used by R. Wallace (1985) to identify the fire/abandonment epidemic as a shock front phenomenon which drives an associated solitary wave of displaced population before it. Figure 9 shows the cumulative total engine company occupied structural fire worktime, for the rectangular outlined region of the Bronx in Fig. 3, 1971 through 1977, 1971 through 1980, and finally 1971 through 1983. Concentration of badly overcrowded housing is shown in the same figure, constructed by assigning a Community Planning Board's percentage of badly overcrowded housing to its engine companies. Between 1977 and 1983 total aggregate fire damage to occupied buildings, an index of serious urban decay, shot rapidly from the South-Central into the Northwest Bronx. In 1970 the centers of occupied building fire and overcrowded housing coincided. By 1980 a population wave had propagated before the rapidly spreading front of urban decay. More complete study shows an advancing, threefold process in geographi-

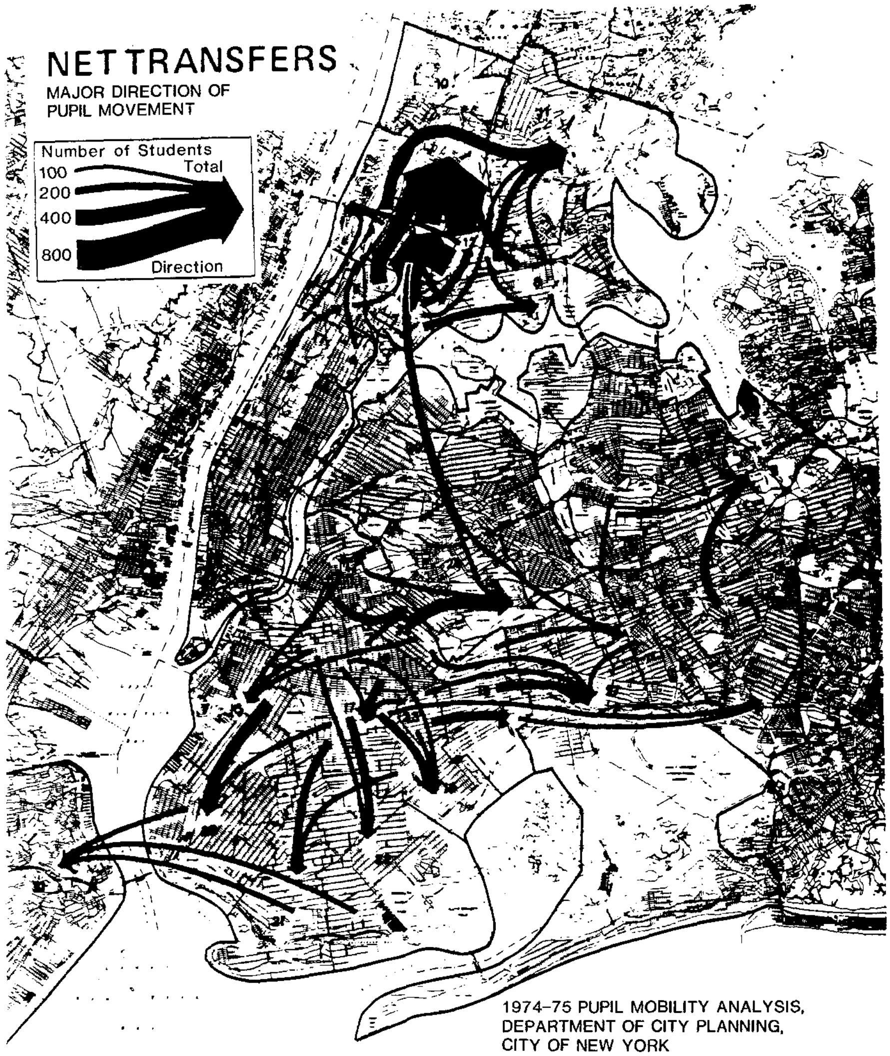


FIG. 5. New York City Planning Commission map showing the magnitude and direction of pupil transfers, 1974–1975, the year of maximum occupied structural fire worktime in the South-Central Bronx. Note the particularly strong migration from the South-Central into the West and Northwest Bronx which strongly dominates the citywide pattern.

cally sequential areas of, first, housing deterioration, followed by occupied building fire, followed finally by a spreading stain of housing abandonment and vacant building fire. These move in echelon through the Bronx and, similarly, through a large part of New York's Brooklyn section.

As with most contagious phenomena there is, for New York's fire/abandonment epidemic, strong possibility of recurrence if the pool of "susceptibles" is renewed, i.e., in newly overcrowded neighborhoods. Between 1970 and 1980 some 1.3 million non-Hispanic whites left New York City, allowing their evacuated

FIG. 6a. Census tracts which lost more than 500 housing units between 1970 and 1980. Before the fire service cuts of the early 1970s, these were also the neighborhoods of highest fire incidence.

housing to be reoccupied by displaced minorities. As discussed, overcrowded housing units are the "susceptibles" for contagious urban decay, and the number of structural fires is an index of number of "infecteds."

Figure 10 shows thousands of badly overcrowded housing units—those with more than 1.51 persons per room—vs thousands of structural fires from 1960 through 1984. The overcrowded housing data are from Stegman (1985). Notice the decline in overcrowded units between 1970 and 1978: Overcrowded housing burned out when fire service was cut. It was suddenly no longer possible to sustain the same degrees of cooking, smoking, use of electricity, generation of highly flammable trash, and general concentrated human activity. The resulting forced migration of the poor overloaded recipient neighborhoods, such as the

FIG. 6b. Change in black population, 1970–1980: Minority neighborhoods saw their housing disintegrate under them after the fire service reductions of the 1970s. Entire communities were dismembered and displaced into nearby areas.

West Bronx, causing a flight by the middle class. In the Bronx the large apartment houses which the well-to-do evacuated, often tenanted by the elderly or others with small families, had more and larger rooms than the crowded, burning tenements of the South-Central Bronx: More living space became available to the poor, and housing overcrowding decreased below epidemiologic threshold, causing a temporary abatement of spreading urban decay. Since 1978 the continuing process of housing destruction has caught up with white outmigration and begun a recompaction of the poor. By 1984 the percentage of overcrowded housing had

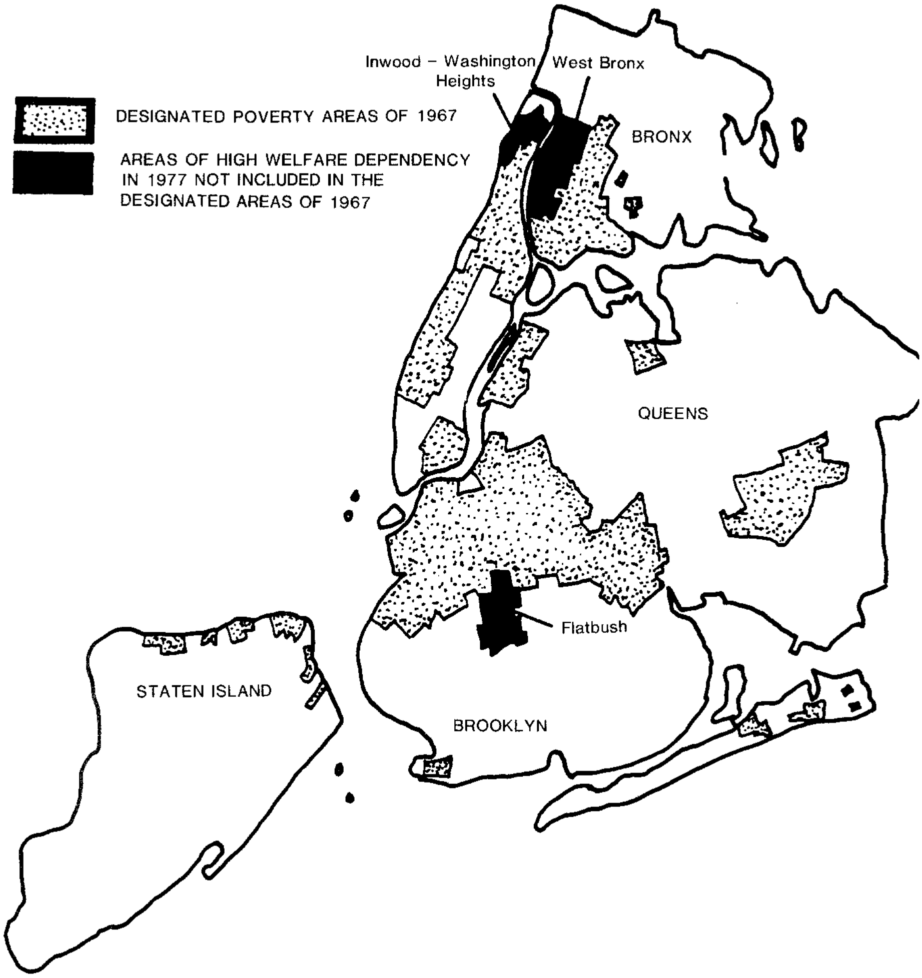


FIG. 7. The spread of high welfare dependency in New York City between 1967 and 1977, after Hayes (1978). The West Bronx, which was not even classified as a high-welfare poverty area in 1967, had by 1977, according to Hayes, become the "worst" such area.

begun to approach that of 1970. At present levels of fire-related municipal services it is no longer possible to maintain such crowded units, suggesting that a fire epidemic recurrence is increasingly likely. Thus Fig. 10 is the "phase diagram" of a recurrent epidemic (Bailey, 1975; Jordan and Smith, 1977). We have had one citywide outbreak and, when the rapidly increasing number of overcrowded units exceeds some threshold, will likely have another. See R. Wallace (1981) for an elementary quasi-stochastic treatment of some of these matters.

III. EFFECT OF THE HOUSING DESTRUCTION EPIDEMIC ON THE GEOGRAPHY OF DRUG ABUSE IN THE BRONX

The geography of drug abuse in the Bronx indeed is largely the geography of

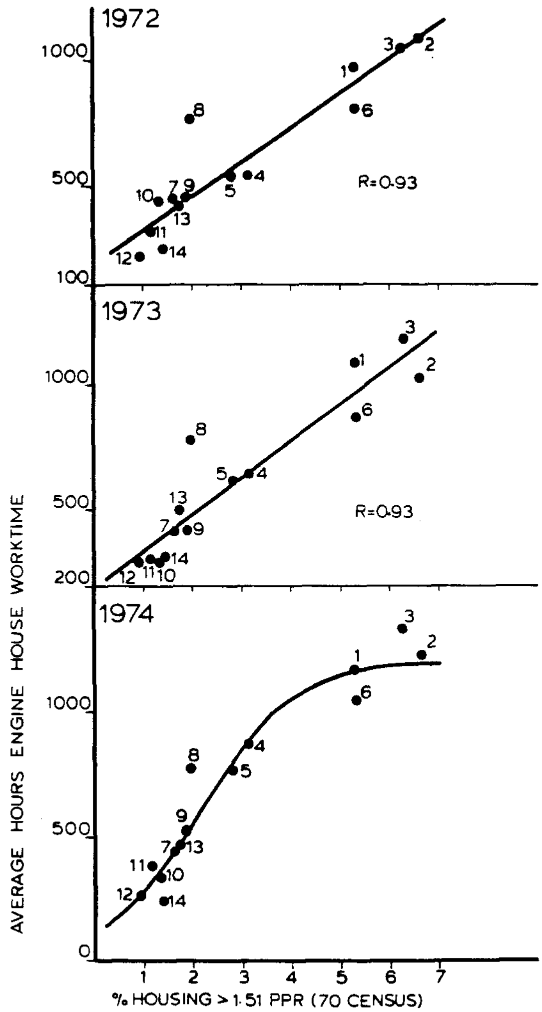


FIG. 8. Average Bronx Community Planning Board total engine company worktime (all responses), 1972–1974, as a function of the 1970 percentage of "badly overcrowded" housing (>1.51 persons per room), according to the census. The "topping out" in 1974 represents a resource-limited inability to service total demand, that is, service shortfall at a time of increasing demand. Overcrowded housing will have many fires, by obvious mechanisms.

AIDS. Figure 11, based on data from the New York City Health Department, shows the cumulative 1980–1985 distribution of AIDS deaths in the Bronx by health area. Appendix 1 shows the unadorned map of Bronx health areas. There are some 63 such areas, constructed by amalgamation of census tracts. We exclude from this study health area (HA) 48, which is the city prison at Riker's Island.

The filled regions of Fig. 11 are the top ranking nine health areas for number of AIDS deaths, with the second tier of nine diagonally hatched. The highest number of AIDS deaths is presently found in HA 30.20, just east of the South Bronx.

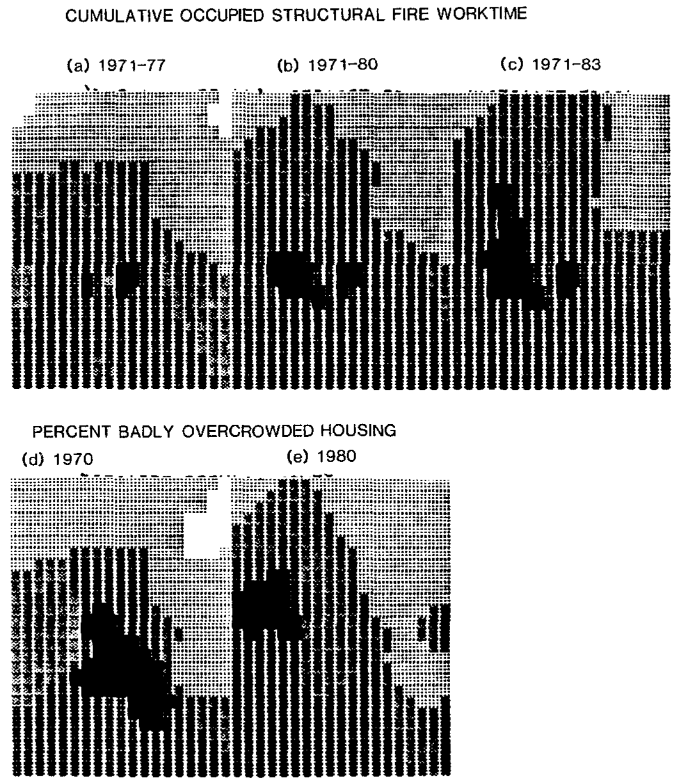


FIG. 9. (a) Total, aggregate 1971–1977 engine company occupied structural fire worktime for the rectangularly outlined area of Fig. 3, reduced to unit maximum to show only geographic concentration. Occupied structural fire worktime, which does not include fires in vacant buildings, is an index of rapid community decay. Note the concentration near engines 50 and 82. The apparent "hole" between engines 50 and 82 is an artifact of a limited response policy for engine 85. (b) Same as (a) for 1971–1980. Note penetration into the West Bronx, near the Highbridge region serviced by engine 68. (c) Same as (a) for the period 1971–1983. Note the rapid extension into the Northwest Bronx, near engine 75. (d) Map of percentage badly overcrowded housing, 1970 census (i.e., percentage >1.51 persons per room), made by assigning to each engine company its Community Planning Board percentage badly overcrowded housing. Note the rough coincidence of the center of overcrowded housing and the 1971–1977 aggregate engine company occupied building fire worktime of (a). (e) Same as (d), on the same scale, (i.e., digitized according to the maximum percentage badly overcrowded housing of 1970) for the 1980 census. Note how aggregate 1971–1980 occupied building fire damage seems to have driven population into the Northwest Bronx. Examination of pupil transfer data confirms this conclusion. Notice that by the 1980 census that the region near engines 50 and 82 had become relatively "free" of overcrowded housing: It had largely burned down, although even by 1984 engine 85 was making over 2000 runs a year, as busy as city average.

Similarly Figs. 12a and 12b show the average annual number of drug overdose deaths for the Bronx during the respective periods 1970–1973 and 1978–1982 (Community Service Society, 1984). Again the top ranking nine are filled and the second ranking nine diagonally hatched. For the time period 1970–1973, HA 29, in the South-Central Bronx, had the greatest number of drug overdose deaths, and for the period 1978–1982 it is HA 30.20.

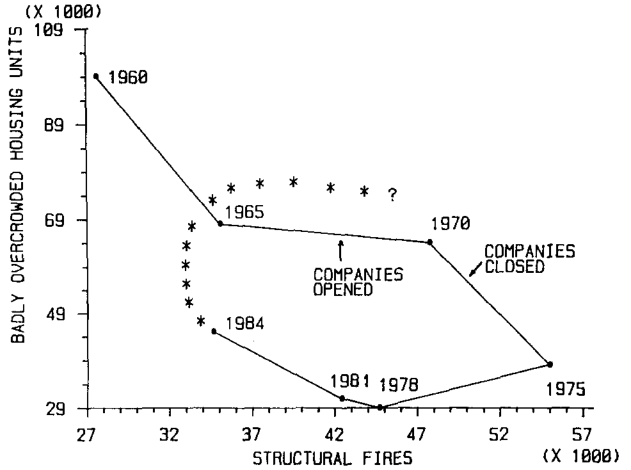


FIG. 10. "Phase diagram" showing number of badly overcrowded housing units in New York City—the epidemiological "susceptibles" for contagious urban decay—and the number of structural fires—an index of the number of "infecteds"—from 1960 through 1984. The census defines badly overcrowded housing units as those with more than 1.51 persons per room.

Note the great general similarity between the drug death map for 1978–1982 and that for cumulative AIDS deaths, 1980–1985. Not only is the health area with the greatest number of AIDS deaths also that with the greatest number of drug overdose deaths in the period 1978–1982, but the overall patterns are closely analogous. We could make a quantitative comparison by calculating the simple correlation by health area, or even the spatial correlation between the maps of Figs. 11 and 12b (Bennett and Wrigley, 1981; Ripley, 1981; Cliff and Ord, 1973), but Fig. 13 may perhaps spare the necessity. It shows the five Bronx health areas out of the nine having the highest drug deaths for 1978–1982, *which are also among the top nine regions for cumulative AIDS deaths*. The essential similarity in the two patterns becomes clear. The geography of AIDS in the Bronx is indeed basically that of drug abuse.

Notice we have focused on case numbers rather than rates. Changes in case numbers convolute population and disease shifts in a manner more useful to policy planning: Service needs are related to case loads. High rates are of principal policy significance only if population structure is stable and geographic regions are of similar population. That is, case numbers and case rates, which are case numbers normalized by population, give different pictures of disease structure which may have different uses.

To understand the geographic consonance of drug abuse and AIDS in the Bronx, and its full implications, more clearly, we reanalyze the data of Fig. 9. This shows, among other things, the change in distribution of badly overcrowded housing from the 1970 to the 1980 census, when assigned to fire company. Figures 14a and 14b reclassify that census information for the Bronx by health area. Again, the census defines badly overcrowded housing as that having more than 1.51 persons per room. We have found such housing to be most susceptible to the mechanisms

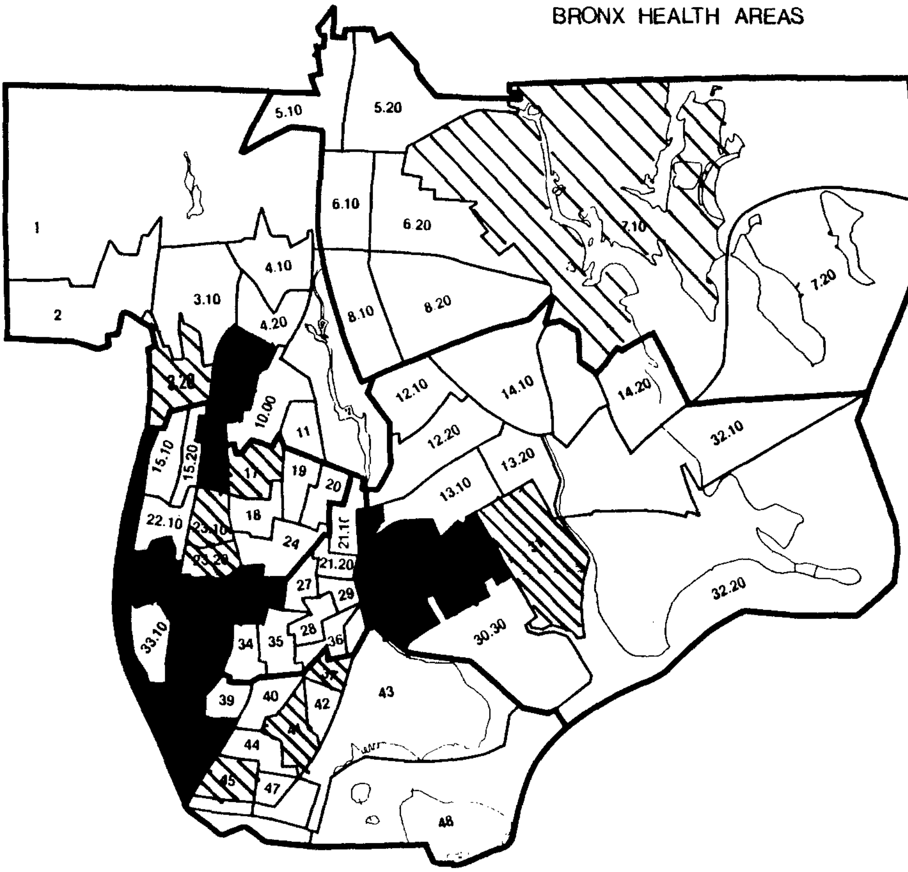


FIG. 11. Total cumulative 1980–1985 AIDS deaths in the Bronx, by Health Area. Filled regions are the nine highest and hatched the second nine highest ranked HAs. Highest HA is 30.20 just across the Bronx river from the South Bronx. Notice the split, geographically dispersed pattern, seeming to jump over the South-Central Bronx. Case numbers are of separate interest from rates, as they determine magnitudes of necessary intervention.

of contagious urban decay. In Figs. 14a and 14b the highest ranked set of 10 HAs is filled and the next highest ranked set of 10 diagonally hatched. For the 1970 census HA21.20 in the South-Central Bronx, with 8.1% has the highest percentage, while for 1980 HA16 in the Northwest Bronx, with 6.5%, is greatest. The ratios of maximum to mean are, respectively, $8.1/3.6 = 2.2$ and $6.5/3.4 = 1.9$. That is, the ratio of maximum to mean decreased proportionally more than the mean, consistent with the classic diffusion of population concentration as well as its transfer by migration.

Unsurprisingly, the burnout of the South-Central Bronx which took place between 1970 and 1980 redistributed housing overcrowding along with population.

Figures 12a and 14a, showing drug death and housing overcrowding concentrations for 1970–1973 and for the 1970 census, respectively, are similar. They dis-

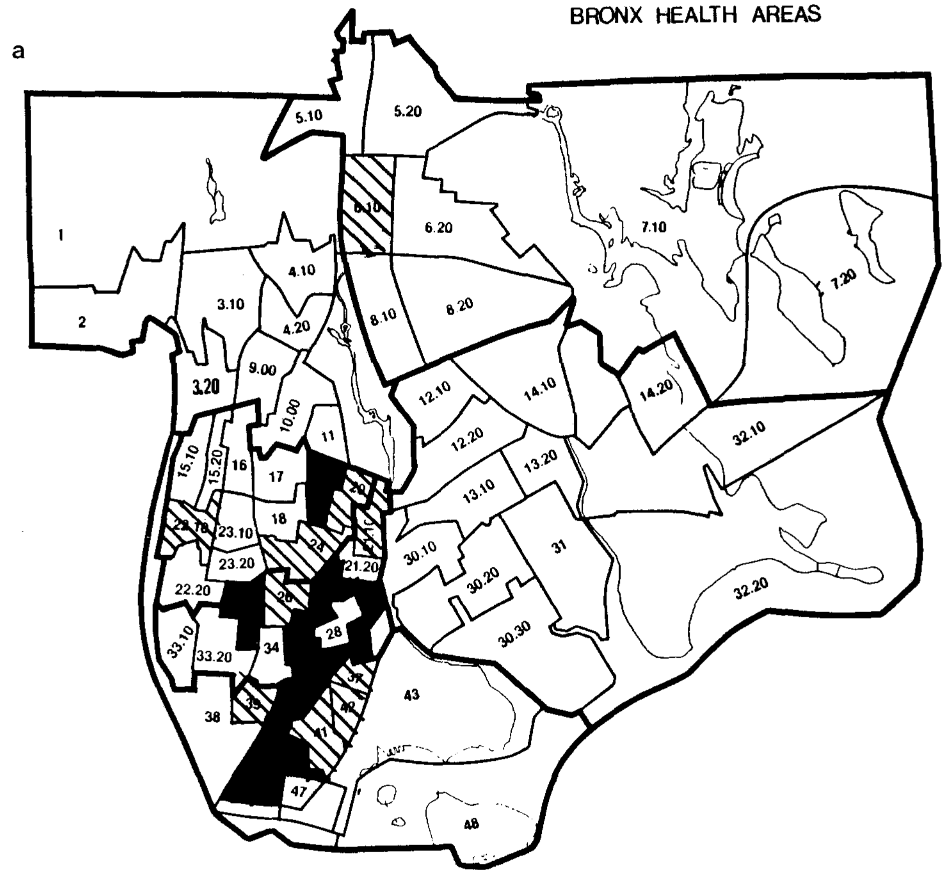


FIG. 12a. Cumulative drug deaths by ranked Bronx Health Area, 1970–1973. Filled areas are nine highest ranking HAs, and hatched the next nine. Note concentration in the traditional "poverty core" of the South-Central Bronx. HA 29, in the heart of the "South Bronx," is first ranked for this period.

play the same strong concentrations in the South-Central Bronx, the traditional 'poverty spine' of the Bronx. We could, again, use correlation by health area or spatial correlation by map to quantify the similarity, but that seems unnecessary.

Evidently the city's program of what Duryea (1978) called "planned shrinkage" and Mega (1978) called fire service "redlining" for the Bronx drastically changed the geography of drug abuse from being tightly and centrally distributed in the traditional poverty communities of the South-Central Bronx into a split and bifurcated pattern covering a much larger area, and embedded in a badly disorganized "community" of displaced and disoriented refugees whose social networks appear to have been seriously truncated by the process of displacement (Wallace and Bassuk, 1987). Community disorganization and the truncation of social networks have the gravest implications for success of AIDS control programs.

In fact, the city's planned shrinkage program seems to have significantly spread b

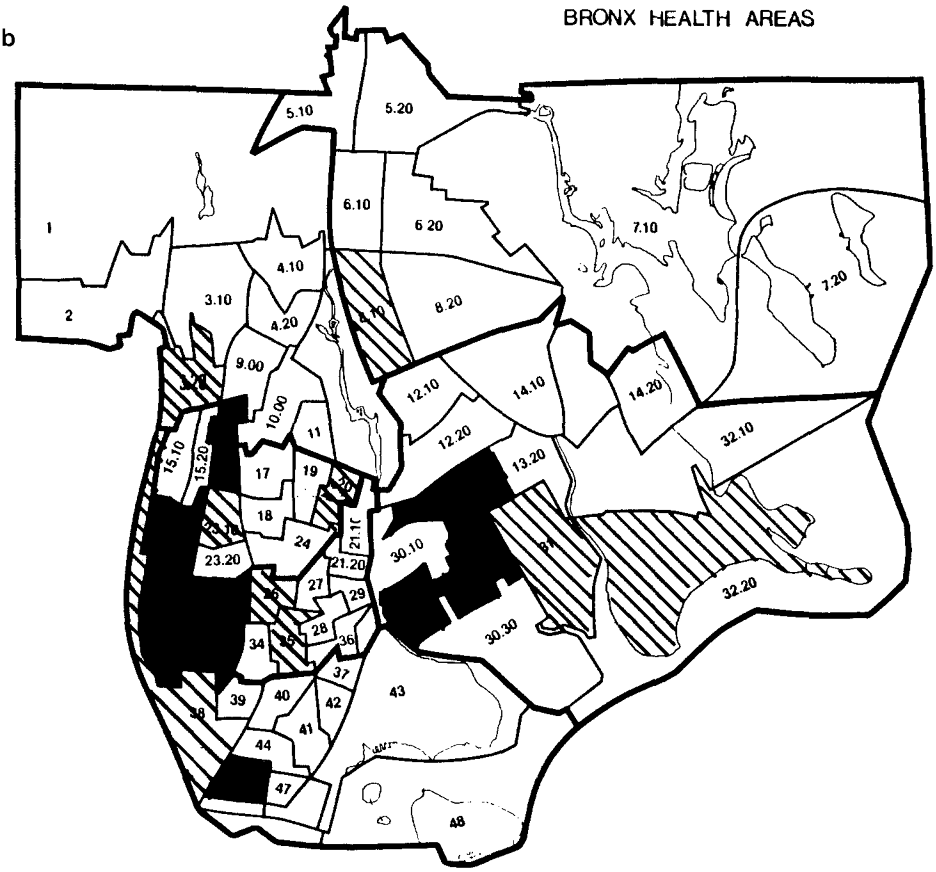


FIG. 12b. Cumulative drug deaths by ranked Bronx Health Area, 1978–1982. Again filled areas are the nine highest ranked and hatched the next ranked nine. Note the marked dispersal of high ranked areas. HA 16, in the Northwest, was not even ranked in the first 18 for 1970–1973, but is among the highest nine by 1978–1982. Similarly, in the East, HA 30.20, ranked highest for 1978–1982, did not rank even in the highest 18 for 1970–1973. HA 29, which ranked first for 1970–1973, now does not even rank among the highest 18. High ranking HAs now cover a vast region of the Bronx, and match fairly well the geographic pattern of Fig. 11, which shows distribution of cumulative AIDS deaths in the Bronx. Apparently the city's "planned shrinkage" program has dispersed coupled intravenous drug abuse and AIDS over much of the Bronx, vastly complicating the targeting control strategies.

AIDS in the Bronx by driving intravenous drug abuse from a relatively well-defined center in the South-Central Bronx to an almost borough-wide phenomenon.

The new center of badly overcrowded housing, HA 16, is also one of the nine highest in drug overdose deaths, 1978–1982. If recurrence of contagious urban decay takes place in the Bronx it will most probably center in those health areas with highest percentage of badly overcrowded housing. Since health areas with high overcrowding also have high absolute drug abuse levels (as opposed to the high rates of already depopulated areas remaining in the South-Central Bronx) such an outbreak would further disperse intravenous drug abuse throughout the

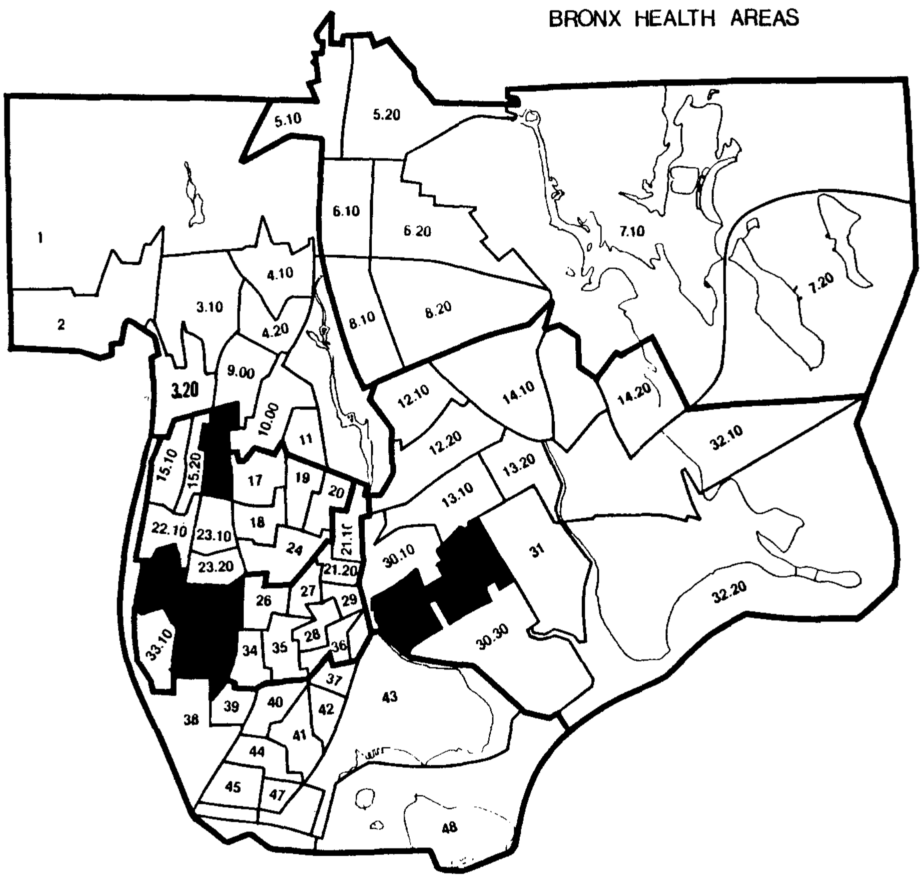


FIG. 13. The five filled Bronx Health Areas are among *both* the nine highest ranked in drug deaths for 1978–1982 and the nine highest ranked for cumulative AIDS deaths, 1980–1985. HA 30.20 ranks highest in each. Continued Bronx demographic instability should extend the "envelope" of coupled AIDS and intravenous drug abuse through an increasingly large section of the Bronx.

Bronx, making control of AIDS far more difficult as forced movement of population both outpaces geographically based programs and disperses the community networks essential for success of such programs. The spatial targeting of corrective programs has thus been considerably complicated. Questions of resource allocation have now become highly nontrivial, since intravenous drug abusers have been dispersed throughout a large part of the borough.

IV. POSSIBLE EFFECTS OF AIDS ON CONTAGIOUS URBAN DECAY

Essential municipal services in New York City have been reduced below levels needed to maintain urban population densities, particularly geographic concentrations of badly overcrowded housing. Thus we already, from Fig. 10, expect recurrence of the fire/abandonment epidemic in the newly overcrowded areas of the Bronx and elsewhere which are also centers of intravenous drug abuse, further a

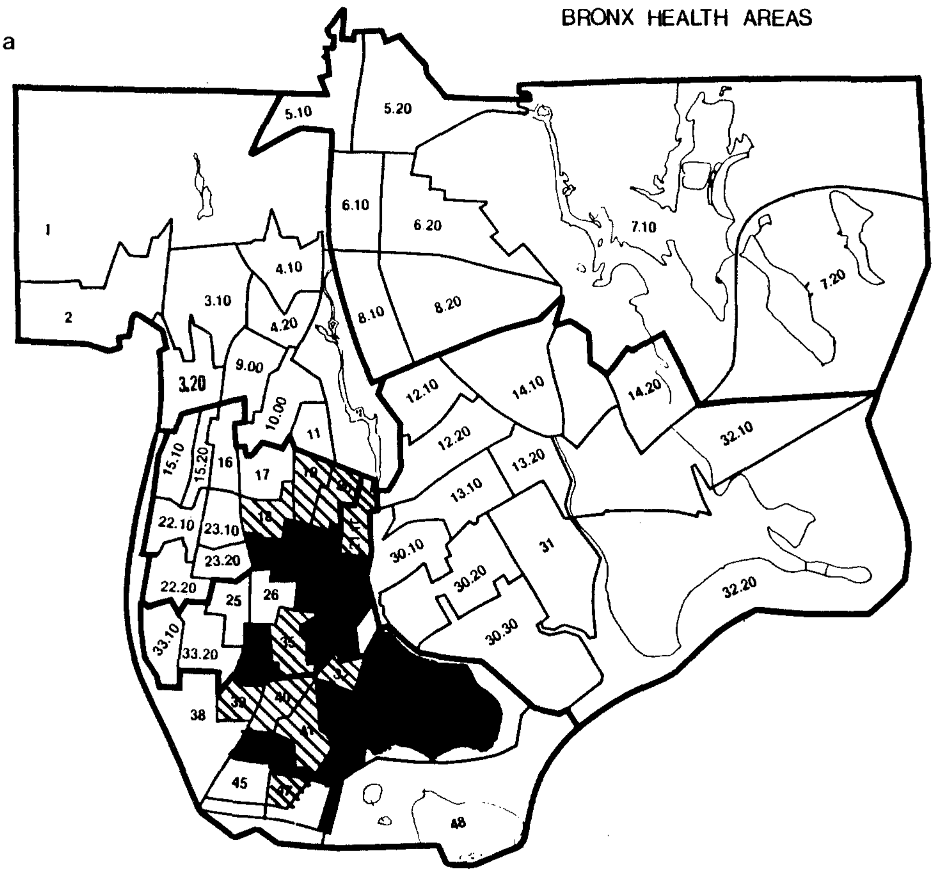


FIG. 14a. 1970 distribution of badly overcrowded housing by HA in the Bronx. Filled areas are the 10 highest ranked HAs by percentage of badly overcrowded housing, hatched the next 10 ranked. Badly overcrowded housing is defined by the census as having more than 1.51 persons per room. Again the poverty core of the borough dominates, with HA 21.20 ranked first. Maximum is 8.05%, mean is 3.65%, and their ratio is 2.21.

spreading AIDS. Here we explore the possibility that, if HIV infection is unchecked, subsequent widespread AIDS outbreak in these same neighborhoods could itself significantly contribute to the contagious urban decay cycle in a highly destabilizing positive feedback.

Several interaction mechanisms between urban decay and AIDS seem possible. First, landlords may be reluctant or unable to maintain services in buildings with large numbers of AIDS patients. This might arise from loss of rental income as those with AIDS are increasingly unable to work, or even to obtain welfare payments in the face of the bureaucratic "churning" and repeated demands for face-to-face interviews which are aimed at reducing welfare roles in New York City (Susser, 1982). In addition buildings with large numbers of AIDS patients may have difficulty keeping maintenance staff if the hysteria which traditionally b

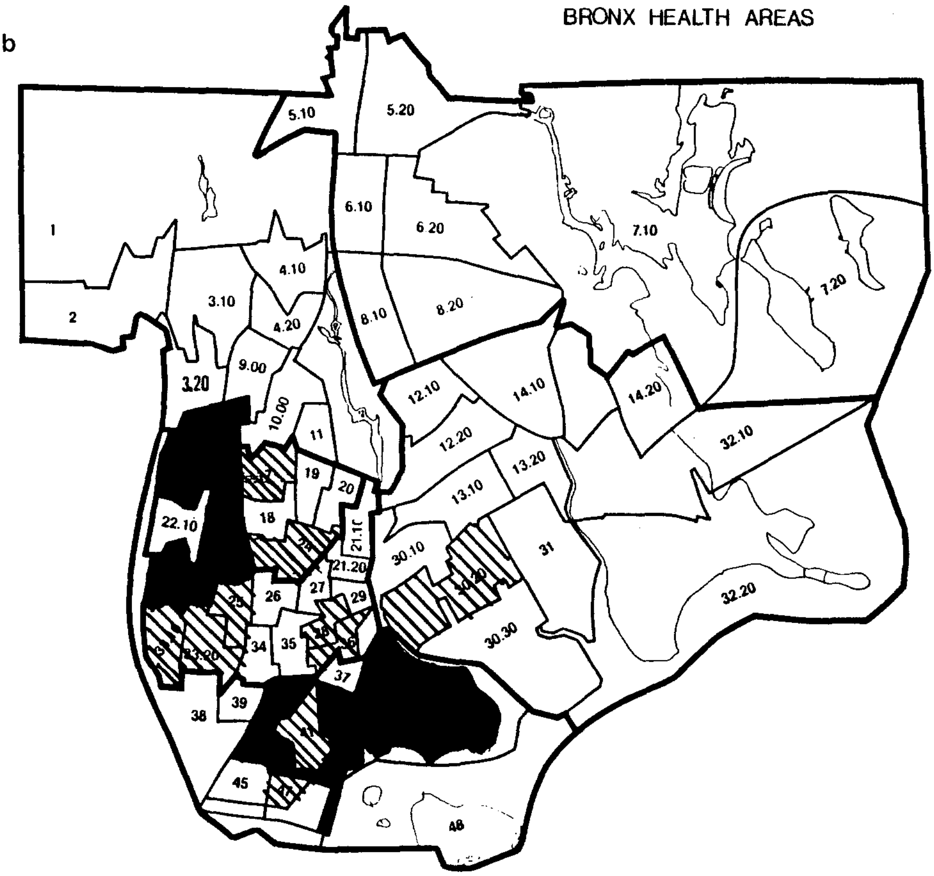


FIG. 14b. 1980 distribution of badly overcrowded housing by HA in the Bronx, as above. Notice the same bifurcation as for drug deaths. HA 16.00, in the Northwest Bronx has the highest level, 6.50%, borough mean is 3.42, and the ratio is 1.90. This change is consistent with an overall pattern of geographic diffusion of population. Neither HAs 16.00 nor 30.20 ranked in the highest 20 for 1970, although they do so now. The next outbreak of contagious housing decay in the Bronx will probably center in the region of highest housing overcrowding, if the pattern of the 1970s is followed. Since HA 16.00 is also a center of intravenous drug abuse, as measured by number of drug deaths, outbreak of another wave of "South Bronx" syndrome could drive a drug-abusing, and presumably HIV-infected, population further into the North Bronx.

accompanies plagues becomes more associated with AIDS. Eventually landlords may simply abandon buildings in poverty neighborhoods which house large numbers of AIDS sufferers, resulting in rapid deterioration. AIDS-abandoned buildings in turn might, under forseeable conditions of hysteria, become targets for deliberate firesetting.

Individual buildings, or even entire blocks, with large numbers of AIDS victims might simply become undesirable residence for those still able to move. Daily encounters with large numbers of people slowly dying of plague might become insupportable, driving the still-healthy in desperation to seek housing as yet "uncontaminated" by overt symptoms of disease.

Thus it seems likely that high geographic concentration of overt AIDS in neighborhoods already susceptible to contagious urban decay can itself contribute significantly to the epidemic spread of "South Bronx" deterioration. This would, in turn, greatly compromise attempts to control HIV infection for a very large population.

It is not difficult to mathematically model possible interaction between contagious urban decay and AIDS in the Bronx.

If we assume (1) Housing decay is contagious, (2) the rate of housing decay depends in part on the degree of housing overcrowding, (3) people flee or are driven from regions with high concentrations of urban decay, it is then possible to derive a simple "reaction–diffusion" model which leads naturally to a shock front of propagating urban decay driving before it a coupled solitary wave of displaced population (R. Wallace, 1985, 1988a). This model accounts fairly well for the patterns of Figs. 4, 8, and 9, at least during the periods of epidemic outbreak when the number of overcrowded housing units is above epidemiologic threshold, i.e., the propagating phases of Fig. 10. R. Wallace (1988a) shows how epidemic recurrence can be factored into the model, but this is too complex for our purposes here.

Two further reasonably plausible assumptions allow modeling the impact of AIDS: (4) If HIV infection has been allowed to propagate unchecked throughout the displaced population, so that a large fraction of the population is infected, then, in the initial stages, the number of persons with symptoms grows in time proportionally to the number without symptoms. (5) Population without symptoms will flee concentrations of population showing overt AIDS, and those with AIDS will be relatively less mobile.

The derivation of some of these equations is detailed in Appendix 2 of this paper, but some mathematical development is necessary to the argument here.

We begin by classifying housing as either "susceptible" to the contagious urban decay process or as afflicted and "infective." Let $\sigma = X + Y$ where σ is the total area density of housing, X that of susceptible, and Y of infective housing. For convenience we work in one spatial dimension, r. Let $\rho = \rho_n + \rho_s$ be the area density of precariously housed people, typically living in badly maintained, highly overcrowded units, where ρ_n represents those without overt AIDS symptoms and ρ_s those with symptoms. We assume, early in the process, that $\rho_n \gg \rho_s$. Then Appendix 2 shows

$$\frac{\partial Y}{\partial t} = \alpha\rho + Y(A - \beta Y) \approx \alpha\rho_n + Y(A - \beta Y), \tag{1}$$

where α is the rate at which housing overuse converts susceptible to infective buildings, β is the rate at which an infective building converts a nearby susceptible one to infective and $A = \beta\sigma - R$, where R is the rate at which infective buildings are repaired and reconverted to susceptible.

If fire-related municipal services are suddenly cut then fire size increases (Wallace and Wallace, 1977; R. Wallace 1978, 1981, 1982), hence visible fire damage becomes more common, raising the "infectivity" parameter β, and the increase in fire size makes repair more difficult, decreasing R. Thus sudden cuts in fire service can be expected to change A from negative to positive, triggering processes described below.

Condition (4) above gives, during the early stages of the AIDS outbreak, the expression

$$\frac{\partial \rho_s}{\partial t} = \chi \rho_n - \gamma \rho_s \approx \chi \rho_n \tag{2}$$

where χ is a constant of proportionality and γ the rate of "removal" of those with AIDS from the population. In the early epoch we assume $\chi\rho_n \gg \gamma\rho_s$. The approximation in Eq. (2) will not hold in the later stages of the coupled epidemic process, as ρ_n declines through conversion to ρ_s. We are thus operating in the usual "fast" vs "slow" time, or "adiabatic," approximation common in nonlinear systems (Jordan and Smith, 1977).

From Figs. 4–8 we assume that the human population without overt symptoms diffuses away from concentrations of urban decay on the one hand, and from concentrations of those with overt AIDS on the other, as well as being converted from asymptomatic to symptomatic. In one spatial dimension, r, this is expressed as (Okubo, 1980)

$$\begin{aligned} \frac{\partial \rho_n}{\partial t} &= \mu \frac{\partial^2 Y}{\partial r^2} + \kappa \frac{\partial^2 \rho_s}{\partial r^2} - \chi \rho_n \\ &\approx \mu \frac{\partial^2 Y}{\partial r^2} + \kappa \frac{\partial^2 \rho_s}{\partial r^2} \end{aligned} \tag{3}$$

μ is the diffusion coefficient for fleeing concentrated urban decay and κ that for fleeing concentrations of those with overt AIDS symptoms. Again, those with AIDS are considered less mobile than those without overt symptoms. The approximation assumes flight, by diffusion, from concentrations of AIDS operates much more quickly than the depletion of asymptomatic population by the disease, so that the $\chi\rho_n$ term is negligible compared to diffusion.

We now have the fundamental system of equations, in this approximation, which appears more than adequate for our purposes.

Taking $A > 0$ we seek a propagating wavefront, under the stated approximations, of the $Y = Y(u)$, $u = t - r/v$ where t is the time and v the (fixed) velocity of front propagation. Then $\partial/\partial t = d/du$ and $\partial/\partial r = -(1/v)\, d/du$. We assume that at "plus infinity," well beyond the urban decay front, the density of displaced population is zero. Then "at plus and minus infinity" two equilibrium values of Y are found possible, the condition for propagation of a traveling wave or shock front for the common "diffusion–reaction" system (see, for example, Fife, 1979; Rosen, 1974; Leven and Segel, 1985).

Substituting the expressions for the partial derivatives into Eqs. (1), (2), and (3), integration, assuming Y, $\rho = 0$ far ahead of the urban decay wave front, and some further elementary manipulation outlined in Appendix 2 give solutions

$$Y(u) = (1/2)\, Y_\infty\, [1 + \mathrm{Tanh}(u/\tau)] \tag{4}$$

and

$$\rho_n(u) = [\mu/(v^2 - \kappa\chi)](Y_\infty/2\tau)[\mathrm{Sech}^2\,(u/\tau)], \tag{5}$$

where

$$\tau = M/A,\ Y_\infty = A/\beta,\ A = \beta\sigma - R,$$
$$M = \left[1 - \frac{\alpha\mu}{v^2 - \kappa\chi}\right].$$

See Fig 15. Urban decay, in this model, moves as a classic "shock front" (Landau and Lifshitz, 1959) driving before it a hump of displaced population without overt AIDS symptoms.

This development implies, if the shock front "thickness" $\Delta \equiv v\tau$ is to be positive, that $M > 0$ or $v^2 > \mu\alpha + \kappa\chi \equiv c^2$.

Assuming an approximately constant number of displaced people in the leading edge of the population front, N_n, we obtain, after some manipulation,

$$N_n = \int_{-\infty}^{\infty} \rho_n dr = \frac{\mu V}{v^2 - \kappa\chi}\left(\frac{A}{\beta}\right). \tag{6}$$

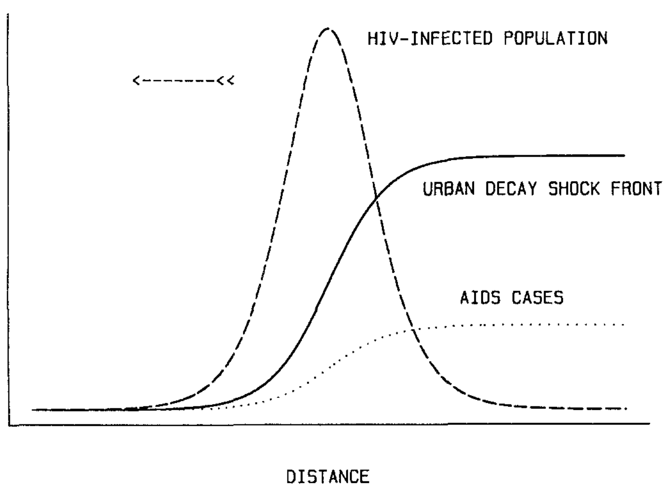


FIG. 15. Coupled shock fronts of urban decay and AIDS, with associated solitary wave of forced migration, according to the approximate calculation of the text. The coupled process advances to the left with a velocity depending additively on both rates of urban decay and AIDS outbreak. In the absence of intervention, an HIV-infected population, without overt AIDS, flees before the synergistic advance of urban decay and AIDS, bringing the housing overcrowding consequent on poverty which is the origin of susceptibility to contagious urban decay.

N_n is the (approximately) constant displaced population without overt AIDS. The whole process is assumed to be propagating from minus to plus "infinity," and thus to be removed from boundaries.

The relation for $\rho_n(u)$ is very similar to that of a classic solitary wave, propagating in phase before the shock front of urban decay (Bhatnagar, 1979).

From the conditions $v^2 > c^2 \equiv \mu\alpha + \kappa\chi$ and $A \equiv \beta\sigma - R$ follows

$$N_n < \frac{CA}{\alpha\beta} = \frac{C}{\alpha}(\sigma - R/\beta)$$

and, finally, a threshold condition for wave propagation:

$$\sigma > \frac{\alpha N_n}{\sqrt{\alpha\mu + \kappa\chi}} + \frac{R}{\beta}. \tag{7}$$

This is analogous to Kendall's threshold theorem for spatial propagation of an epidemic (Bailey, 1975) in that a certain minimum area density of housing is required for propagation at a given level of municipal services, building repair rate, and AIDS presence.

The effect of AIDS on this process is evident in the expressions for shock front velocity and for the minimum area density of housing needed for threshold: Velocity of spread of the decay process, and of forced migration, is increased and the needed threshold area density of housing decreased by factors of $\kappa\chi$. Thus, in this model, AIDS can markedly accelerate urban disintegration if HIV infection has been allowed to proceed unchecked.

From Eq. (3) it is evident that overt AIDS, as given by ρ_s also propagates as a shock front with velocity v in this model:

$$\frac{\partial\rho_s}{\partial t} = \frac{d\rho_s}{du} \approx \chi\rho_n = \frac{\chi\mu}{v^2 - \kappa\chi}\frac{dY}{du}.$$

Integration with respect to u gives $\rho_s(u) \propto Y(u)$, assuming $\rho_s = 0$ far ahead of the front. Again see Fig. 15.

Thus, in New York City—the HIV capital of America—geographic spread of urban decay, AIDS, and the forced migration of population may all be closely intertwined and mutually synergistic in a complex way not likely to be adequately addressed by more simple models which do not properly account for the fundamental demographic instability of poverty areas in the city. This has certain ominous implications, particularly regarding current policy planning, which we will explore later.

Some caution regarding mathematical modeling of ecosystems, as done here, is prudent. Pielou (1977) summarizes the proper role of such modeling as: "[The] usefulness . . . [of models] . . . consists *not in answering questions but in raising them*. Models can be used to inspire field investigations and these are the only source of new knowledge as opposed to new speculation."

We have, in this section, raised significant questions as to how AIDS occurrence might synergistically accelerate New York City's continuing demographic instability. That instability, we know, has already had profound effect on transmission patterns of HIV infection through dispersal of intravenous drug abusers in forced migrations. More bluntly, we have proposed a likely model for large scale ecological collapse, based on a simple extension of past South Bronx experience which, some might say, is itself a case history of large scale ecological collapse. The particular model realization given here is less interesting than the general questions of possible synergisms between AIDS and community stability it exemplifies.

There is already a large literature on the geographic diffusion of disease. See, for example, Diekmann (1978) and Britton (1982), who also examine epidemic traveling waves. The innovation here lies in recognizing the possibility of coupling between two different contagious phenomena, urban decay and disease. The appalling results then follow directly.

V. DISCUSSION

Examination of Figs. 11 and 12b, showing for the Bronx respectively the cumulative distribution of reported AIDS cases, 1980–1985 and reported drug abuse deaths 1978–1982, not unexpectedly confirm assertions that the present geography of AIDS in the Bronx is indeed driven by intravenous drug abuse. Comparison of Figs. 12a and 12b shows the change in geography of Bronx drug abuse from the period 1970–1973 to 1978–1982, apparently the result of forced migration from areas of the South-Central Bronx which suffered massive loss of housing and community in the contagious urban decay epidemic outbreak of the 1970s. Drug abuse has spread from a geographic concentration in the South-Central Bronx into diffuse centers ranging from the Northwest to the East Bronx, a much larger area. In addition general deterioration of indices of public health, including homicide and infant mortality (R. Wallace, 1988a), among other things, suggests serious disruption of personal, domestic, and community networks accompanied the burnout and forced migration of affected ghetto communities. Homicide and infant mortality in particular seem closely, and inversely, tied to stability or strength of social networks. Work by Stack (1974) and Susser (1982) suggests the establishment of effective social nets may require literally decades.

These matters have obvious implication for the control of HIV infection. First, the "planned shrinkage" forced migration in the Bronx has mixed previously disparate populations, in particular dispersing intravenous drug abusers—whose sexual partners are at particular risk for HIV infection—throughout a large section of the borough. At the very least this could result in more widespread and rapid heterosexual HIV transmission than if drug-abusing populations had remained spatially concentrated in the South-Central Bronx. Mechanisms range from simple diffusion of population to impact of social network disintegration on patterns of nonintravenous drug abuse and related sexual practices.

Further complicating control, the effectiveness of AIDS education programs depends critically on the penetration of social networks associated with local leaders and leading institutions, and on the length and strength of those networks.

Bronx social networks have been disrupted, making it necessary to contact more individuals or groups more intensely to attain the considerable degree of education and compliance needed to interrupt HIV spread. In addition population dispersal of intravenous drug abusers has made it necessary to target particularly intensive educational campaigns over a much larger geographic area, likely requiring considerably greater resource investment.

It is difficult to escape the inference that demographic instability resulting from the city's planned shrinkage program has made interruption of HIV transmission in the Bronx, and hence control of AIDS, incredibly difficult.

The cause of demographic instability, the contagious urban decay cycle, persists in the Bronx, largely from the city's continuing failure to provide levels of critical municipal services needed to maintain urban levels of population density in ghetto neighborhoods. Figure 10 suggests recurrence of the fire/abandonment epidemic as the number of badly overcrowded housing units, now associated closely with the city's accelerating crisis of "homelessness' (R. Wallace, 1988b; Wallace and Bassuk, 1987), rapidly rises beyond 1970 levels. Recurrence, if it indeed takes place, would trigger another demoralizing round of forced migration, utterly disrupting any conceivable HIV control program in the Bronx.

Further analysis indicates that overt AIDS could itself become a highly significant contributor to the contagious urban decay cycle, resulting in a lower outbreak threshold and more rapid ecosystem collapse. The mathematical model above illustrates possible mechanisms and consequences of the synergisms.

The citywide maps of Section II suggest the results of Section III, which focuses on the effect of widespread forced migration on patterns of drug abuse and AIDS in the Bronx, are likely replicated for those sections of Brooklyn and Manhattan which suffered significant contagious urban decay. Analysis remains to be done.

Finally, Anderson and May (1988) have recently speculated that heterosexual spread of AIDS in "developed" nations may be a deceptively slow but relentless process facilitated by promiscuous sectors of the population. Their model, however, neglects implications of other internal population heterogeneities. Among America's "third world" urban ghettos the rate of drug-facilitated heterosexual spread may be very rapid. Such a large and growing reservoir of heterosexual AIDS might well then affect the rate of HIV infection of the more "developed" population.

VI. CONCLUSIONS

Control of AIDS for the Bronx, and by inference for other areas suffering outbreaks of contagious urban decay, in striking contrast to the case of the middle-class male homosexual community, seems predicated first on control of demographic instabilities affecting poor minority neighborhoods. Without return of stability, euphemism for an end to the city's planned shrinkage program of essential service withdrawal directed against minority districts, public education to control HIV infection cannot take effect or, at least, will be very seriously compromised by continued shredding of social networks. Instability from the first wave of contagious urban decay has already made control of AIDS, and many other diseases (R. Wallace, 1988a), extraordinarily difficult, not only in the Bronx, but for New York City as a whole. AIDS now threatens to become convoluted into the very decay cycle which has hastened its spread.

Mathematical models of the AIDS epidemic now fashionable, for example those derived from "urban systems analysis," often assume an underlying stability to population structure, and may entirely neglect major spatiotemporal population shifts or the shredding of social networks. Such models cannot be used to analyze AIDS control programs for the Bronx or other similar areas of New York City: Population structure is highly, almost explosively, unstable. In addition, such models seem often to neglect any detailed consideration of spatial diffusion.

Reestablishment of stability to New York City's minority areas, including the Bronx, requires a threefold, closely coordinated program involving, in order of increasing cost:

(1) restoration of such critical municipal services as fire extinguishment and sanitation, so as to interrupt contagious urban decay;

(2) intensive community organizing to strengthen and expand individual, domestic, and community social networks; and

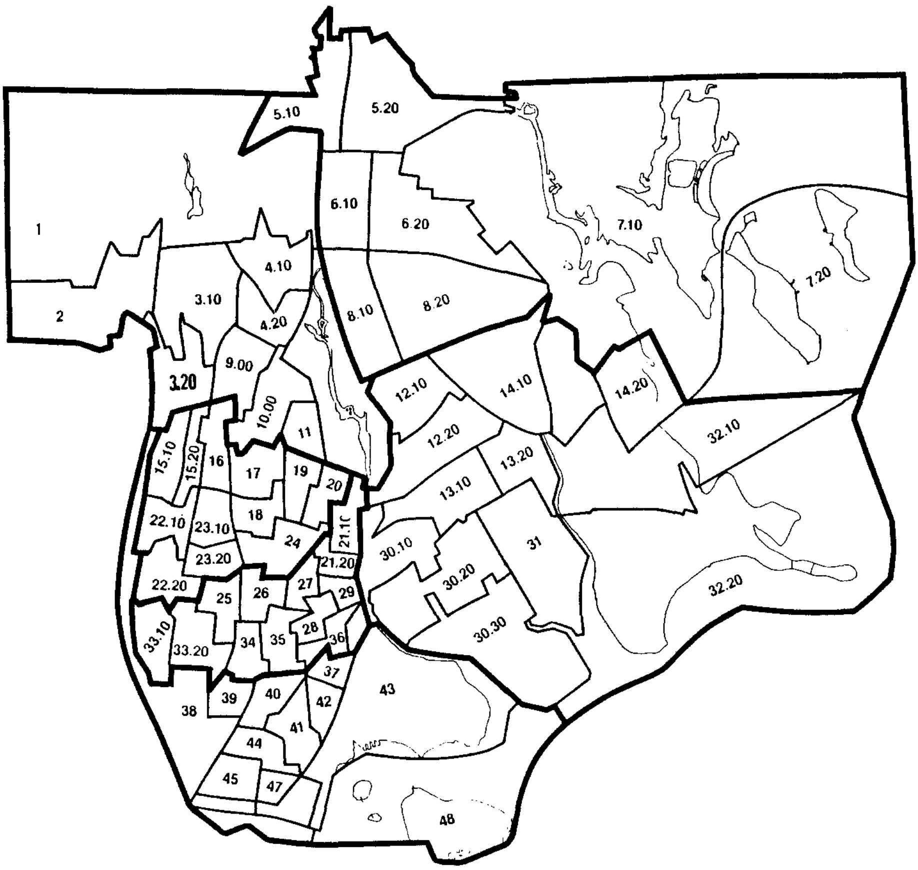
(3) considerable attention to stabilization and extension of low income housing availability, either by construction, renovation, or regulation. Further, the targeting of such programs must, for maximum effect, be adjusted to the state of the particular communities involved, which will change in both space and time. The "life cycle" of contagious urban decay is complex, like that of a parasite, and successful intervention will require understanding and exploitation of the cycle's particular vulnerabilities.

As stated elsewhere (R. Wallace, 1988a) it is strange, 100 years after the beginning, and 60 years after the success, of New York City's great Reform Movement, that it is necessary to again argue persuasively for adequate fire extinguishment and sanitation services for the poor, along with adequate housing, as essential underpinnings to public health. The structure of plagues has, of course, regularities related to those of the communities in which they occur. Plague most often begins at the bottom of the socioeconomic hierarchy and works its way up. AIDS, ignited here somewhat atypically first in the middle-class male homosexual community, seems likely now to settle generally into that traditional pattern, for which significant improvement in the living conditions of the poor has often proven an ultimately necessary control strategy. In this regard, it seems likely the large and growing reservoir of heterosexual AIDS in "third world" urban ghetto populations of the Bronx and elsewhere could significantly affect the rate of heterosexual transmission within "developed" populations, providing many extremely large pockets with very great force of infection. Current models of heterosexual AIDS spread assume considerable and highly unrealistic population homogeniety with regard to factors other than rate of sexual activity (Anderson and May, 1988).

Prompt and considerable investment to improve the living conditions of the poor seems more than just good public health practice. It may be an absolutely essential underpinning to the Nation's health, particularly to the control of AIDS.

APPENDIX 1

MAP OF BRONX HEALTH AREAS



APPENDIX 2

DETAILS OF THE EQUATIONS OF CONTAGIOUS URBAN DECAY

We begin by classifying housing as either "susceptible" to the contagious urban decay process or as afflicted and "infective." Let $\sigma = X + Y$ where σ is the total area density of housing, X that of susceptible and Y of infective housing. For convenience we work in one spatial dimension, r. Let ρ be the area density of precariously housed people, typically living in badly maintained, highly overcrowded units. Let Q be the fraction of occupied units which are badly overcrowded. Then

$$\rho = LQX \tag{A1}$$

L a constant. Take

$$\frac{\partial Y}{\partial t} = [f(Q) + \beta Y]X - g(Y) \tag{A2}$$

where β is the "contagious infectivity" rate, $f(Q)$ an appropriate function of the fraction of overcrowded housing units, and $g(Y)$ a function determining the rate at which infected housing is repaired. The $\beta\ XY$ term represents the contagious effect of blighted on susceptible buildings, while $f(Q)$ represents the rate at which overcrowding causes building decay. See Fig. 8. The repaired housing is assumed immediately to become susceptible: Data show rehabilitated buildings in "South Bronx" areas without adequate fire protection often burn again. If $f(Q)$ and $g(Y)$ are taken as simple linear proportions, then

$$\frac{\partial Y}{\partial t} = (DQ + \beta Y)X - RY \tag{A3}$$

with D and R constant.

Remembering that $X = \sigma - Y$, and $\rho = \mathrm{LQX}$, we set $\alpha \equiv D/L$ and $A \equiv \beta\sigma - R$, obtaining

$$\frac{\partial Y}{\partial t} = \alpha\rho + Y(A - \beta Y). \tag{A4}$$

This is the basic relation leading to Eq. (1) above.

For the Bronx we assume $\rho = \rho_n + \rho_s$, where ρ_n is the population without overt AIDS symptoms and ρ_s that with. We assume $\rho_n \gg \rho_s$ during the first stages of the AIDS process, i.e., that contagious urban decay proceeds on a "fast" time scale and AIDS on a "slow," so that $\rho \cong \rho_n$. This is an "adiabatic" approximation with evidently limited validity. See R. Wallace (1988a) for further discussion of model limitations.

The standard trick (Okubo, 1980) of hunting for a traveling wave, letting $Y = Y(u)$ with $u = t - r/v$, v the (fixed) shock front velocity, gives the relations $\partial/\partial t = d/du$ and $\partial/\partial r = -(1/v)d/du$. Substituting these for the partial derivatives in Eqs. (1)–(3) of the text, letting Y, $\rho = 0$ ahead of the shock front, and elementary rearrangement gives

$$\rho_n\left(1 - \frac{\kappa\chi}{v^2}\right) \approx \frac{\mu}{v^2}\frac{dY}{du}$$

so

$$\frac{dY}{du}\left(1 - \frac{\alpha\mu}{v^2 - \kappa\chi}\right) = Y(A - \beta Y).$$

$$\text{Defining } M \equiv \left[1 - \frac{\alpha\mu}{v^2 - \kappa\chi}\right]$$

gives

$$M\frac{dY}{du} = Y(A - \beta Y) \tag{A5}$$

whose integration, with the stated boundary conditions, results in Eqs. (4) and (5) of the text.

Including a term of the form $D\rho_n$ in Eq. (3) allows exploration of the impact of demographic rates of change among the precariously housed. Here $D = \lambda - \chi - \delta$ where χ is as before, δ is the non-AIDS death or emigration rate and λ is the rate of population reproduction or growth. Asymptotic expansion then shows if $D > 0$, that is, under net demographic growth, then the peak of displaced population without overt symptoms grows exponentially in time as the wave front propagates. If, however, $D < 0$, for example if those soundly housed ahead of the wave front evacuate their neighborhoods, leaving large apartments to be reoccupied by the displaced poor—as indeed seems to have happened in the Bronx—then the front only propagates a finite distance before stopping. Resumption of net demographic increase could presumably then reinitiate front propagation.

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