PROCEEDINGS OF THE

TENTH ANNUAL MEETING

of the

NEW YORK-NEW JERSEY DIVISION

ASSOCIATION OF AMERICAN GEOGRAPHERS.

" NEW YORK- NEW JERSEY DIVISION.

Held at the
Skylands Conference Center
Ringwood, New Jersey
October 24-25, 1969

Sponsored by the
New Jersey Department of
Conservation and
Economic Development

Volume III
May 1970

Published by the Division
Price: $2.50 (Members of the Division)
$4.00 (Non-members and Libraries)

FOREWORD

The current volume of the Proceedings . . . is part of the continuing effort of the New York - New Jersey Division to provide its members and the geography profession with a record of the annual meeting of the Division. It is hoped that the publication of the Proceedings . . . will simulate greater participation in the annual meeting by the membership of the Division.

These Proceedings . . . include the program of the Tenth Annual Meeting of the New York - New Jersey Division of the Association of American Geographers, held October 24 - 25, 1969, at the Skylands Conference Center, Ringwood, New Jersey, together with a roster of divisional officers and appointees for 1968 - 69 and 1969 - 70. It also includes the full text of the papers given at the five arranged sessions.

As in the previous Proceedings . . . papers appearing in this volume underwent relatively little editorial alterations. All papers were retyped and the position of the footnotes was altered to provide a uniform format. The Editor assumes the responsibility for all errors which result from retyping. Certain tables and illustrations were copied by an electronic stencil cutter and faithful reproduction was assured for only those drawings having definite sharp contrast. The authors and the Editor may agree that this was not the most ideal method for handling illustrative material; however, it was the best one available under the present budgetary restraints.

The Editor wishes to express his appreciation to Dr. Kemble Widmer, New Jersey State Geologist, and to the staff of the New Jersey Bureau of Geology and Topography for their invaluable assistance in conducting the meeting at Skylands and in preparing this copy of the Proceedings . . . Particular thanks is due to Dorene Sarnoski, who operated the MT/ST and retyped all papers and prepared the stencils. Geologists Carol Lucey and Barbara Munn cut the electronic stencils and ran the mimeograph machine. They are to be thanked for their perseverance in circumventing the mechanical and electronic gremlins, and for proofreading the copy before cutting the final stencils. The collation and binding was done commercially. Thanks is also due to LTC Wesley C. Smith, United States Military Academy for the updated cover design.

Theodore W. Kury
Editor

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of the

NEW YORK - NEW JERSEY DIVISION

ASSOCIATION OF AMERICAN GEOGRAPHERS

Skylands Conference Center
Ringwood, New Jersey
October 24-25, 1969

FRIDAY, OCTOBER 24

12:00 noon - 4:00 p.m.: Tours of Skylands and the adjacent Highlands

4:00 - 11:00 p.m.: Registration, Dining Room, Skylands Manor House

7:00 - 8:30 p.m.: Opening Address: The Skylands Concept, by Alfred Guido, Assistant to the Commissioner, New Jersey Department of Environmental Protection

8:30 - 9:00 p.m.: Coffee Break

9:00 - 10:30 p.m.: (Two concurrent sessions)

A. SETTLEMENT GEOGRAPHY OF NEW JERSEY, Auditorium
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Peter O. Wacker (Rutgers--The State University): "Early Street Patterns in Pennsylvania and New Jersey: A Comparison"

John E. Brush (Rutgers--The State University): "Some Aspects of the Growth and Morphology of Villages in Central New Jersey"

A. Philip Muntz (National Archives and Records Service): "The Highland Forests: Four Centuries of Change"

B. URBAN DEVELOPMENT IN NORTHERN NEW JERSEY, Great Hall
Chairman: George W. Carey (Rutgers--The State University)

Robert M. Hordon (Rutgers--The State University): "The Application of Graph Theory to the Simulated Water Transfer Networks of Northeastern New Jersey, 1970-1985"

Michael R. Greenberg (Columbia University): "Urbanization, the Management of Public Water Supply Systems, and the Water Supply Crisis: The Case of Two Municipal Water Systems in the New York Metropolitan Region"

Steven B. Frakt (Rutgers--The State University): "Some Comments on the Social Dimensions of Sewage Treatment Plant Location"

SATURDAY, OCTOBER 25

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9:00 - 11:30 a.m.: (Three concurrent sessions)

C. URBAN GEOGRAPHY, Great Parlor
Chairman: John Volkert (Central Staff of the New York State Assembly)

Richard A. Mitchell (State University of New York at Buffalo): "Consumer Town Selection"

Paul R. Beaudet (State University College, Buffalo): "Public Recreation Units in the Buffalo Area: A Preliminary Investigation of Their Use, Non-Use, and Problems as Viewed by Area Residents"

Raymond W. Waxmonsky (State University College, Buffalo): "Growth Potentials of the Primary Metals and Engineering Industries of the Buffalo Metropolitan Area"

D. PHYSICAL GEOGRAPHY/REMOTE SENSING, Great Hall
Chairman: Nicolay P. Timofeef (State University of New York at Binghamton)

Bruce N. Johnson (Syracuse-Onondaga County Planning Agency): "Physical Characteristics of Abandoned Farmland in South Central New York State"

Norbert P. Psuty (Rutgers--The State University): "Beach Nourishment by Eolian Processes, Paracas, Peru"

John B. Kellom (Autometric/Raytheon Company): "Remote Sensing of Water Pollution Along the Mohawk and Upper Hudson Rivers"

Philip S. Justus (United States Military Academy): "Paleogeographic Aspects of Continental Drift"

E. REGIONAL DEVELOPMENT, Auditorium
Chairman: Kennard W. Rumage (State University College, Brockport)

Edward F. Bruner (Syracuse University): "The Soviet Approach to Remote Area Development: The Far Eastern Example"

Robert G. Jensen (Syracuse University): "Attitudes, Ideology and Soviet Land Use Policy"

William Hanne (United States Military Academy): "Landscape Atlas of the U.S.S.R."

James E. McConnell (State University of New York at Buffalo): "A Model for the Analysis of the International Commodity Trade of EFTA and LAFTA, 1953-1965"

11:00 - 11:30 a.m.: Business Meeting, Lower Auditorium

12:00 noon - 5:00 p.m.: Luncheon and Field Trips

A. "Historical Geography of the North Jersey Highlands," conducted by Theodore W. Kury (State University College, Buffalo)

B. "Urban Geography of Northern New Jersey," conducted by George W. Carey (Rutgers--The State University)

C. "Geology of New York-New Jersey Highlands," conducted by Kemble Widmer (New Jersey State Geologist)

6:00 - 7:00 p.m.: Reception, Great Hall

7:00 - 8:30 p.m.: Dinner, Lower Auditorium

FRIDAY AND SATURDAY, EXHIBITS, Library

A. A slide show of Northern New Jersey and Southern New York, United States Military Academy "Classroom in the Sky" Project

B. Geologic relief map and stratigraphic cores, New Jersey Bureau of Geology and Topography

OFFICERS AND APPOINTEES OF THE DIVISION
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EARLY STREET PATTERNS IN PENNSYLVANIA AND NEW JERSEY: A COMPARISON[1]

Peter O. Wacker
Rutgers University

Geographers have taken an increasing interest in investigating cultural patterns present in eastern North America. Attention has been directed toward initial complexes of culture traits transported across the Atlantic by Europeans, subsequent alteration of these complexes, and the formation of culture hearths from which new complexes, characteristically American, diffuse. Kniffen, for example, has devoted himself to house types, Zelinsky has investigated, among other things, religious and place-name distributions, and Trewartha's work on settlement types is well known.[2]

Generally speaking, the efforts of these geographers have been directed toward delineating culture hearths and culture regions by means of mapping the distributions of selected cultural elements through time and also toward an inquiry into the nature of the process of cultural diffusion.

Recently, the study of street patterns has emerged to join the investigations of other cultural phenomena. Edward Price, in his article entitled "The Central Courthouse Square in the American County Seat,"[3] has indicated that southeastern Pennsylvania, in addition to being the source area for certain farm practices, house types, the Kentucky rifle and the Conestoga wagon, was also the hearth of the central courthouse square. His maps of the diffusion of this distinctive element of

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[1] Grateful acknowledgement is due the Rutgers University Research Council for financial support for the research leading to this paper as part of a larger project.

[2] Fred B. Kniffen, "Folk Housing: Key to Diffusion," Annals of the Association of American Geographers 55 (December, 1965), 549-577; Wilbur Zelinsky, "An Approach to the Religious Geography of the United States: Patterns of Church Membership in 1952," Annals of the Association of American Geographers 51 (June, 1961), 139-193 and "Generic Terms in the Place Names of the Northeastern United States," Annals of the Association of American Geographers 45 (March, 1955), 319-349; and Glenn T. Trewartha, "Types of Rural Settlements in Colonial America," The Geographical Review 36 (1946), 568-596. Many other examples could be cited. Most recently, a folklorist, Henry Glassie, has published a book entitled Pattern in the Material Folk Culture of the Eastern United States (Philadelphia, Pennsylvania: University of Pennsylvania Press, 1969), which deals extensively with many of the joint concerns of folklorists and cultural geographers.

[3] The Geographical Review 58 (January, 1968), 29-60.

the cultural landscape correspond quite closely with those of Kniffen and Glassie showing the diffusion of building types and methods westward in the eighteenth and early nineteenth centuries.[4] More recently, Richard Pillsbury, in a stimulating paper entitled "The Urban Street Pattern as an Indicator of American Culture Regions,"[5] has shown that street patterns can be as effective a parameter as word usage, religious patterns, and house types in identifying the culture regions and subregions of Pennsylvania.

My own direct interest in these two studies is that of a cultural geographer now concerned with preparing an historical cultural geography of New Jersey ending with the beginning of the nineteenth century. For several years, as part of my undergraduate course in historical geography, I have designed class research problems which give students an entree into the use of primary materials and the methodology used in historical cultural geography. Last year, I decided to have my class engage in a preliminary investigation of seventeenth- and eighteenth-century county seat and street patterns in New Jersey to see whether the state fit the models proposed by Price and Pillsbury for Pennsylvania. The results were so interesting that I repeated the students' research myself to make absolutely sure of its accuracy and expanded the project to more precisely fit the methodology followed by Price and Pillsbury. Although Pillsbury ended his study early in the nineteenth century and Price in the twentieth, my own work, as part of a larger study, terminates at the end of the eighteenth century.

Pillsbury's conclusions were based on his interpretation of data resulting from the study of three hundred and fifty-eight "urban" places in Pennsylvania founded before 1815. An 1830 Post Office list was used to identify places suitable for study. Those places having little business were deleted from the list.[6] All available local histories were scanned to glean information on founding dates. At least two central place functions had to be present to justify an "urban" designation. The form of the street patterns was analyzed through the use of the earliest map available of suitable scale. In many cases nineteenth-century county atlases had to be utilized, and the earlier pattern inferred from the local histories.

Pillsbury identified four distinctive street patterns in Pennsylvania. These included the Irregular, Linear, Rectilinear, and Linear-R forms. The term Irregular referred to any street pattern which had more than one linear element and appeared

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[4] Fred B. Kniffen and Henry Glassie, "Building in Wood in the Eastern United States: A Time-Place Perspective," The Geographical Review 56 (January, 1966), 40-66.

[5] Unpublished paper read at the annual meeting of the Association of American Geographers at Washington, D. C. in the summer of 1968. Pillsbury's "Urban Street Patterns of Pennsylvania Before 1815," (unpublished Ph.D. dissertation, Department of Geography, Pennsylvania State University, 1968), contains this study in full.

[6] Less than $24.00 per year.

to be without any recognizable plan. The Linear form consisted of only one linear element. Rectilinear patterns were those which were based on parallel streets with cross streets intersecting at constant angles. The Linear-R type consisted of a single main street with flanking rear access lanes intersected at right angles by additional access lanes.

Pillsbury constructed a series of maps showing the distributions of these plans through time. The Irregular plan proved to be the most important pattern in Pennsylvania before the Revolution and by 1815 was widely distributed, although its dominance was clearly in the southeast, southwest and northern border area. The distribution of Linear towns was essentially the same as that of the Irregular towns. On the other hand, the Rectilinear plan was confined almost entirely to central and western Pennsylvania. The Linear-R plan had much the same distribution as did the Rectilinear plan.

It can readily be seen then that Pennsylvania's street patterns have a distinctive regional expression. Central and western Pennsylvania are characterized by the dominance of Rectilinear and Linear-R plans, southeastern, southwestern, and northern Pennsylvania are characterized by the linear or irregular nature of the street patterns.

Pillsbury explained these distributions largely but not entirely as a function of culture history. The Irregular and Linear patterns he associated with three major groups who were essentially medieval in their material culture. These included settlers who had come to Pennsylvania from western and central Europe before the middle of the eighteenth century, and Americans of New England and Virginia backgrounds.

The Rectilinear and Linear-R plans, however, were generally associated with settlement in central and western Pennsylvania during the second half of the eighteenth century by people who had been affected by the Classical Revival. Interest in Rectilinear town plans had preceded the eighteenth century in Europe with the discovery and translation in the fifteenth century of De Architectura by Vitruvius, a Roman architect. Military planners became enamored of the rectilinear format and many new European towns were built in this way, especially when defense was an important consideration. These ideas were also present in the eastern United States during the seventeenth century. New Haven, Connecticut, for example, which was planned in 1638, has been cited as following almost entirely the Vitruvian ideal.[7]

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[7] Anthony N. B. Garvan, Architecture and Town Planning in Colonial Connecticut (New Haven: Yale University Press, 1951), pp. 45-49.

Other early Rectilinear plans include Charleston, South Carolina in 1672, Yorktown, Virginia in 1691, and the early colonial towns of Georgia. Philadelphia, with its grid street pattern and distinctive open square, was laid out in 1682.[8] Yet in only one of these cases was there a tendency to develop similar plans as the interior was settled. Only in Pennsylvania did the Rectilinear pattern become regionally important in the mid-eighteenth century and then spread westward.

Pillsbury seeks the reason for the adoption of rectilinearity in Pennsylvania in the Classical Revival which had affected many of the new settlers from the Rhineland and Northern Ireland and also the decision makers of the colonial period. The Proprietors, for example, universally used the idea in laying out county seats after 1741. This policy was continued by the state government and also by entrepreneurs who founded many new urban places in Pennsylvania in the latter part of the eighteenth century.

The distinctive distribution of town plans in Pennsylvania may be compared with distributions of house types, word usage, and religious patterns (Fig.W1). As a matter of fact, the street patterns indicate subregions in southeastern and southwestern Pennsylvania not fully revealed by studies of the distributions of folk house types, or religious affiliations. The town plan, then, would appear to be another element which can be added to the complex of culture traits which characterize southeastern and south central Pennsylvania as a major culture hearth or source region in the United States.

Following essentially the same methods Pillsbury used in gathering data, ninety four street patterns of places possessing "urban" status by 1800 were identified in New Jersey (Fig.W2). On the basis of these data, New Jersey's urban street patterns were found to contrast significantly with those of Pennsylvania. Of the ninety-four places studied, only nine had Rectilinear street patterns, thirteen had Linear patterns, fifty-two were Irregular, and in the case of twenty places I could not honestly determine on the basis of the available data whether a Linear or an Irregular pattern was present when the place reached the threshold of two central place functions. Not one Linear-R pattern was identified in the entire state. Contrasting these findings with Pillsbury's would yield the following results: By 1800, of 244 urban places in Pennsylvania by that date, 48% were of the associated Rectilinear or Linear-R types, 30% were Irregular, and 22% were Linear. In New Jersey only 10% were Rectilinear, 14% were Linear, 55% were Irregular and 21% were Irregular or Linear.

The contrast in relative numbers between Pennsylvania and New Jersey in regard to Rectilinear places is heightened by the fact that of the nine New Jersey Rectilinear places, five had been established during the seventeenth century, while in Pennsylvania only one, Philadelphia, had been established before 1700. If one looks

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[8] An excellent source for early town plans in the United States is John W. Reps, The Making of Urban America: A History of City Planning in the United States. (Princeton: Princeton University Press, 1965).

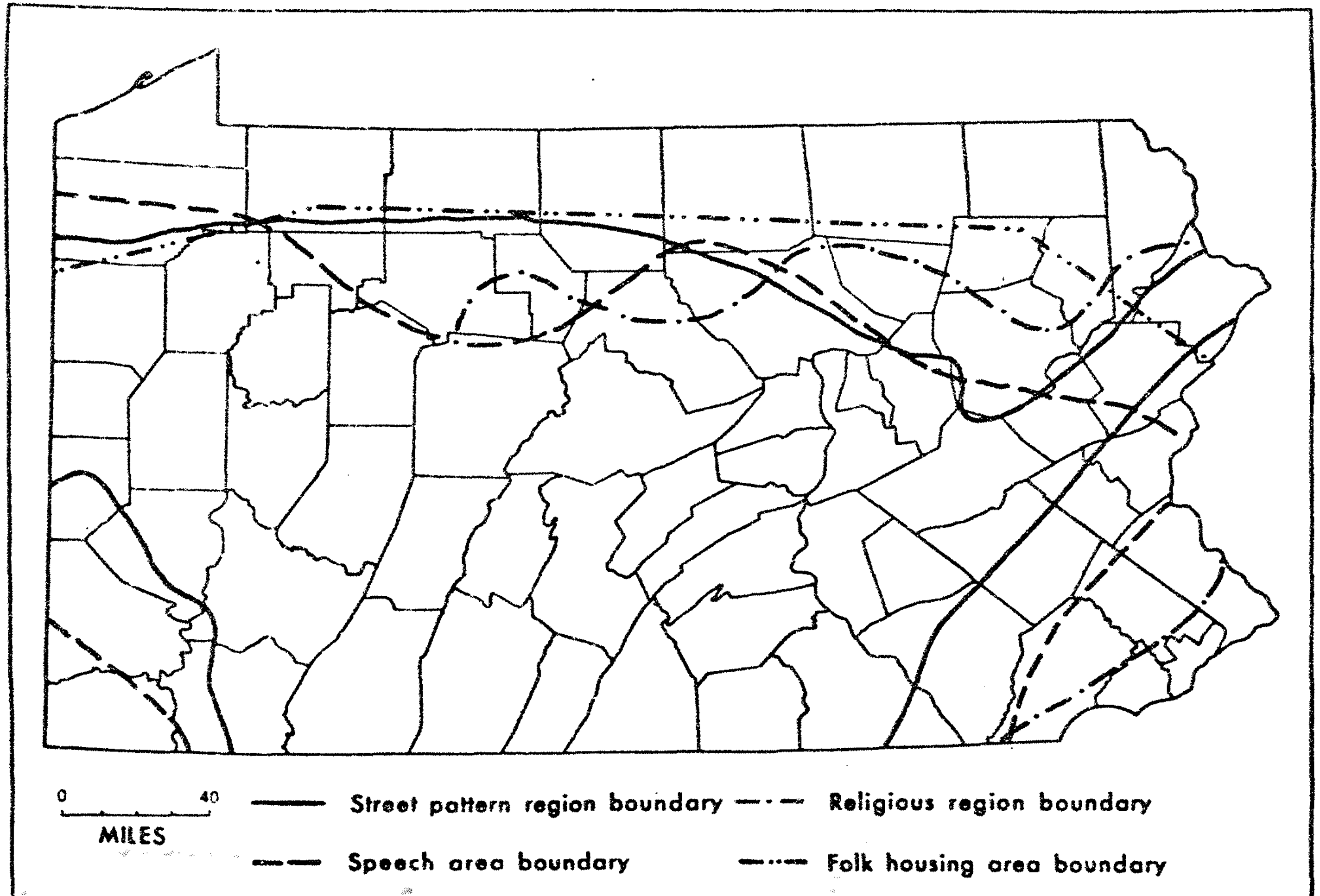

Figure WI. Culture area boundaries in Pennsylvania. (From Pillsbury).

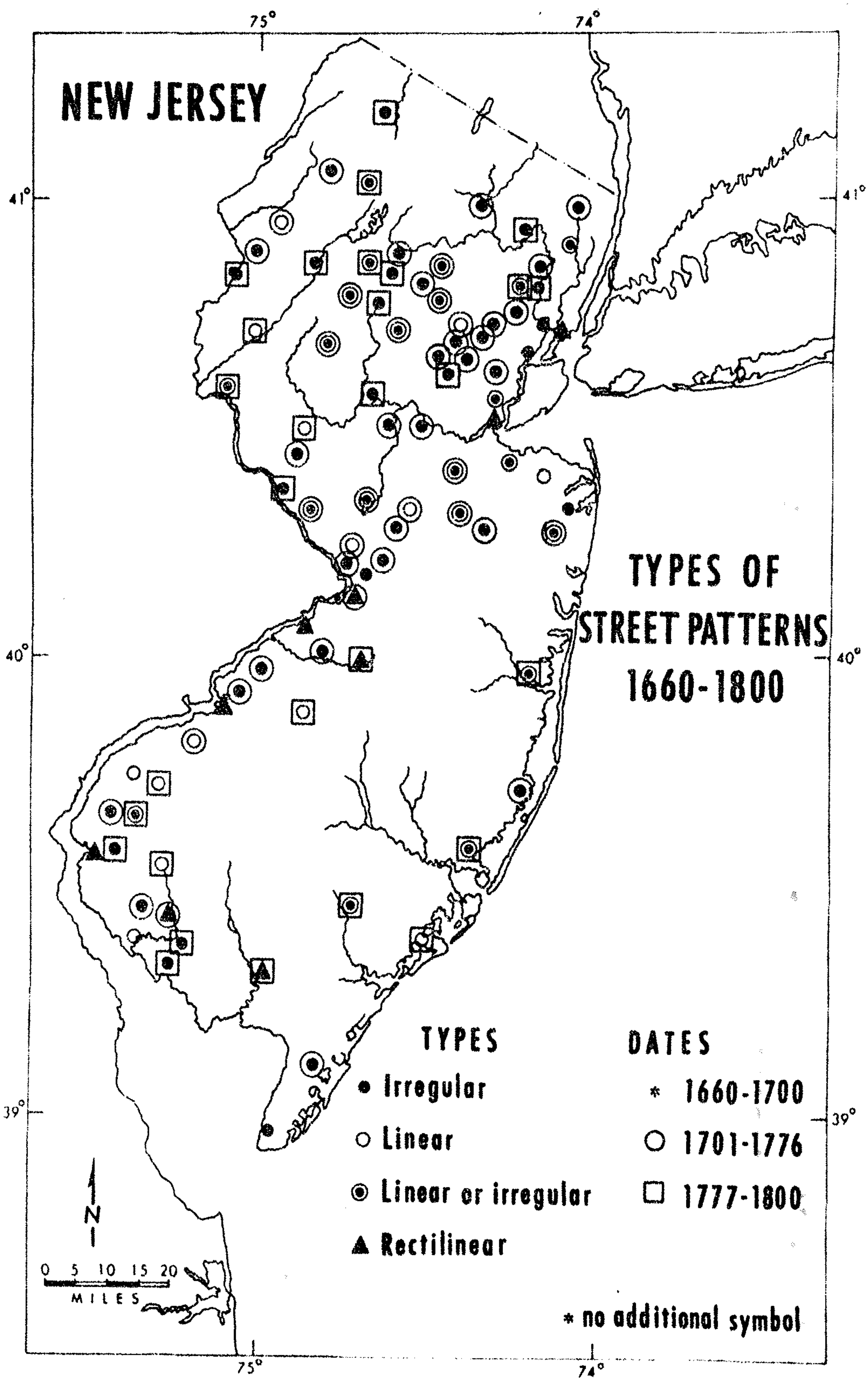
75°
74°
41°
40°
39°
NEW JERSEY
TYPES OF
STREET PATTERNS
1660-1800
TYPES
• Irregular
○ Linear
◉ Linear or irregular
▲ Rectilinear
DATES
* 1660-1700
○ 1701-1776
□ 1777-1800
* no additional symbol
N
0 5 10 15 20
MILES

Figure W2.

at the seventeenth-century statistics for an extremely small sample one finds only ten urban places in Pennsylvania and twelve in New Jersey. Of Pennsylvania's ten places, nine or 90% were Irregular or Linear. In New Jersey five of twelve patterns, or 42% were Rectilinear.

A further contrast is in the form of the Rectilinear places themselves. The "Philadelphia square" which characterizes many later eighteenth-century urban places in Pennsylvania was present in New Jersey before it appeared at Philadelphia. Bergen, established in 1660 by the Dutch as a village community in order to provide protection from the Indians, was laid out around a Philadelphis square (Fig.W3). In the form of Bergen Square this is still present in Jersey City today. Perth Amboy, with its market square in the Philadelphia form, was surveyed in 1683, Gloucester City with essentially the same square in 1689. Both Salem, platted in 1675, and Burlington which was laid out in 1677, were Rectilinear without possessing squares.[9]

The other four Rectilinear places in existence by 1800 were all founded more than sixty years later for entrepreneurial purposes and were all within an area of Pennsylvania influence within the state. After 1800 several new urban places were established and rectilinearity became an accepted convention. Camden, which was platted in 1773, for example, but by our criteria did not become "urban" until 1815, was originally designed with a Philadelphia square.[10]

It might be well to note at this point that "planning" per se and rectilinearity do not necessarily go hand in hand (Fig.W4). Rectilinearity is an ideal New Englanders especially, but also Scots and Germans, planned several Irregular and Linear settlements in New Jersey during the seventeenth and eighteenth centuries. New England-settled places which were planned included Elizabethtown, Newark, Middletown, Shrewsbury, Woodbridge, and Greenwich in the seventeenth century

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[9] The sources on these places, in order, include Charles H. Winfield, History of the County of Hudson, New Jersey (New York: Kennard & Hay Stationery Manufacturing and Printing Company, 1874), p. 72; W. Woodford Clayton, History of Union and Middlesex Counties, New Jersey (Philadelphia: Everts & Peck, 1882), p. 603; Isaac Mickle, Reminiscences of Old Gloucester (Philadelphia: Townsend Ward, 1845), p. 35; Thomas Cushing and Charles E. Sheppard, History of the Counties of Gloucester, Salem, and Cumberland New Jersey (Philadelphia: Everts & Peck, 1883), p. 367; and Evan M. Woodward and John F. Hageman, History of Burlington and Mercer Counties, New Jersey (Philadelphia: Everts & Peck, 1883), p. 112.

[10] George R. Prowell, The History of Camden County, New Jersey (Philadelphia: L. J. Richards and Co., 1886), pp. 418-419.

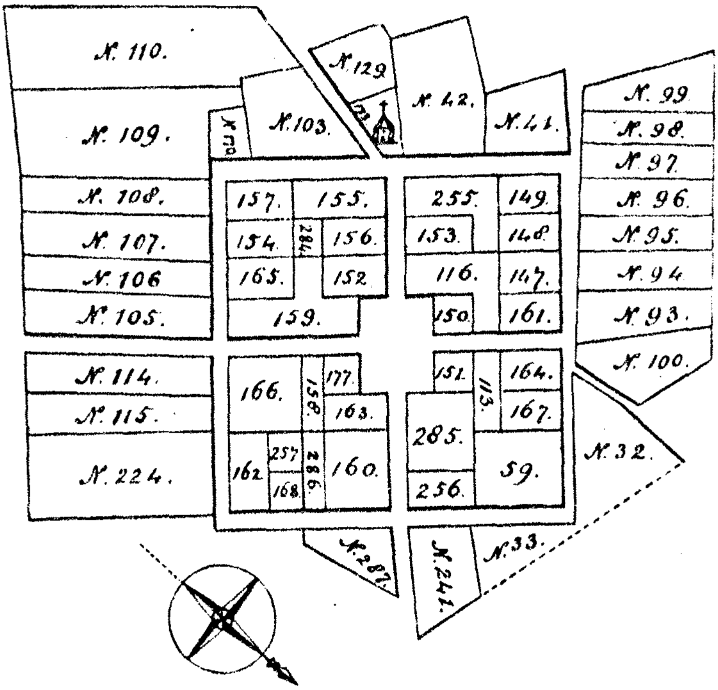

Figure W3. Bergen in 1660. (From Winfield).

and Chester in the early eighteenth century. Scots settled Matawan in the late seventeenth century. Moravians planned Hope as an Irregular compact village in 1774.[11]

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[11] The sources on these places, in order, include Frederick W. Ricord, History of Union County, New Jersey (Newark, New Jersey: East Jersey History Company, 1897), pp. 7, 101; Frank J. Urquhart, A History of the City of Newark, New Jersey 1666-1913 (New York: The Lewis Historical Publishing Company, 1913), Vol. I, p. 92; Franklin Ellis, History of Monmouth County, New Jersey (Philadelphia: R. T. Peck and Co., 1885), pp. 520, 573; Clayton, 552-553; Cushing and Sheppard, 512; A History of Morris County, New Jersey (New York: Lewis Historical Publishing Company, 1914), Vol. I, p. 177, Ellis, 830; and George W. Cummins, History of Warren County (New York: Lewis Historical Publishing Company, 1911), p. 168.

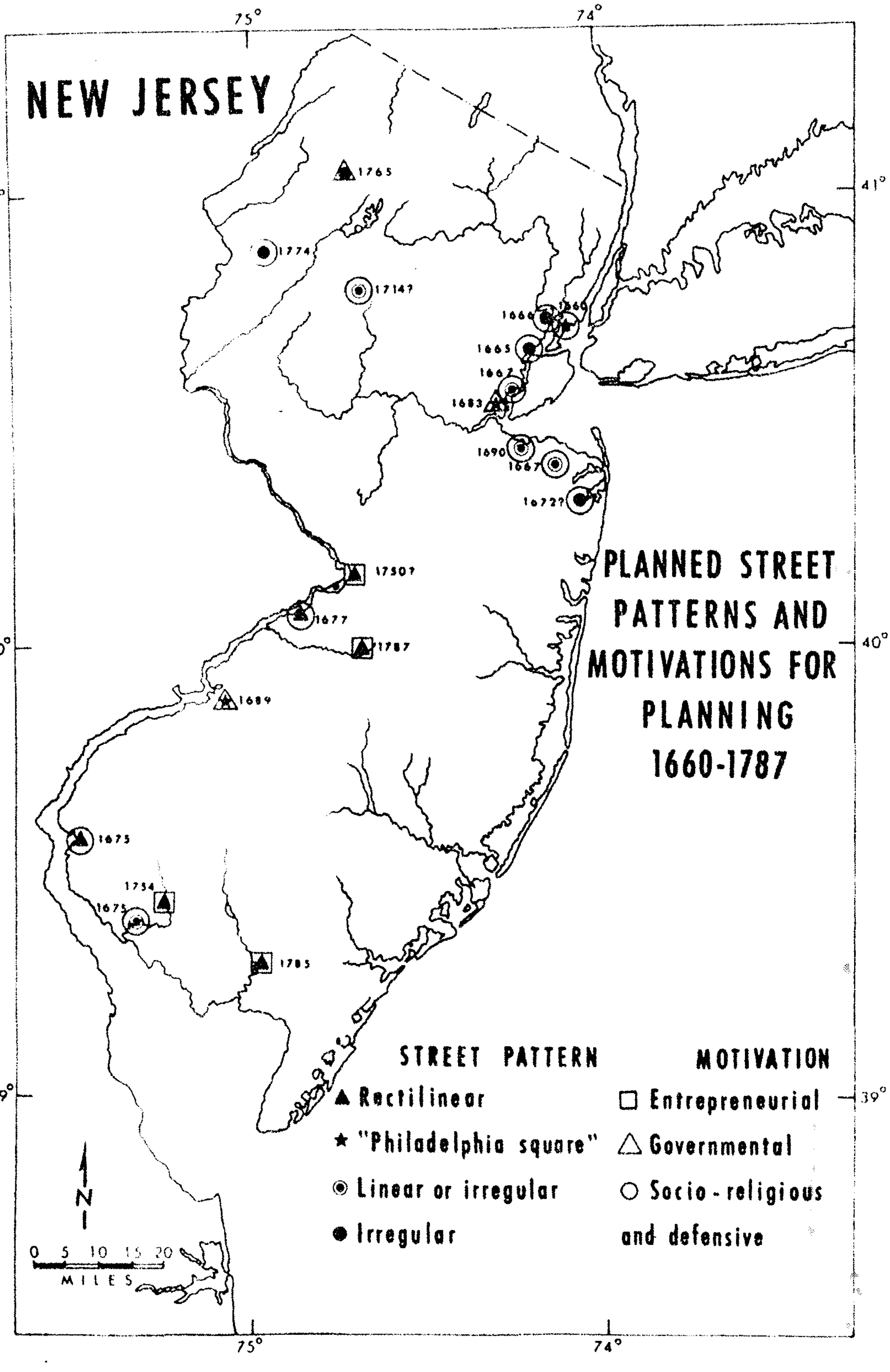
NEW JERSEY
PLANNED STREET PATTERNS AND MOTIVATIONS FOR PLANNING 1660-1787
75°
74°
41°
40°
39°
1765
1774
1714?
1666
1666
1665
1667
1683
1690
1667
1672?
1750?
1677
1787
1689
1675
1754
1675
1785
STREET PATTERN
Rectilinear
"Philadelphia square"
Linear or irregular
Irregular
MOTIVATION
Entrepreneurial
Governmental
Socio-religious and defensive
N
0 5 10 15 20
MILES

Figure W4.

Evidence on the majority of urban places in existence in New Jersey by 1800 indicates that they were unplanned and irregular at the time they crossed the "urban" threshold defined. Sited on major roads, often at stream crossings or where waterpower was available, these settlements coalesced around a church, store, tavern, or mill.[12] New Brunswick, which developed at a ferry site preceded by an aboriginal fording place, is a case in point. Records indicate the gradual extension of an irregular street pattern through local ordinance during the eighteenth century, often following existing property lines.[13]

Clearly, New Jersey's urban patterns do not parallel Pennsylvania's. At a time when Pennsylvanians were in the throes of a Classical Revival and planning Rectilinear towns, most Jerseymen were thinking in a different mold. Although receiving influences from elsewhere, New Jersey apparently is part of the older medieval pattern characterizing the seaboard states, not a culture hearth from which innovations spread, as is so in the case of southeastern and south central Pennsylvania.

New Jersey also proved to contrast with Pennsylvania in the morphology of her eighteenth-century county seats. Edward Price's definitive study of county seat types embraced more than one thousand such locations in the United States, with data being collected, often on the site, from local historians, county and state records, county histories, and county atlases. Price's findings indicate the origin of the central courthouse square in southeastern Pennsylvania in the first half of the eighteenth century. Central squares were well known in Europe at the time but generally did not contain principal public buildings in a central location. Notable exceptions to this rule occurred on the German-Polish border zone and in Northern Ireland, where Londonderry's "Town House" was standing in the center of its Philadelphia-type square in 1622.

In Pennsylvania in the early eighteenth century several urban places were laid out in accordance with rectilinearity and the appearance of a central Philadelphia-type square. In the case of Lancaster, which was platted after the formation of the county in 1729, a courthouse was placed in the center of a Philadelphia-type square in 1739. According to Price, it is quite possible that Scotch-Irish settlers decided on such a placement of the courthouse in remembrance of the Philadelphia-type square and its centrally placed "Town House" in Londonderry. Price also cites evidence to indicate the spread of this idea from its hearth in southeastern Pennsylvania by emigrants from the region, often of Scotch-Irish background. By 1750 the central courthouse squares were showing up in states south and west of Pennsylvania.

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[12] For some examples, see Peter O. Wacker, The Musconetcong Valley of New Jersey: A Historical Geography (New Brunswick, New Jersey: Rutgers University Press, 1968), pp. 127-131.

[13] John P. Wall, "History of the Streets in New Brunswick, New Jersey," Special Collections Department, Rutgers University Library.

In New Jersey, which Price was not able to visit and gather data locally, nineteen county seats had contained county courthouses by 1800 (Fig. 5). Two of these possessed Philadelphia-type squares. One was Perth Amboy, where the first courthouse was probably erected in 1686 and was placed on one of the major streets, but well away from the central market square. By 1718 the courthouse had been shifted to the northeast corner of the same street and the public square. The Gloucester County courthouse was erected in 1696 in Gloucester City in a location I have not been able to ascertain. A new courthouse was built in 1719 and was placed on the town's Philadelphia-type square. In 1788 Woodbury became the county seat. The new courthouse was then built at a crossroads, not in or on a square.[14]

Nine of the nineteen New Jersey county seats had their courthouses erected after the residents of Lancaster had chosen to place theirs in the center of a central square. Not one of the New Jersey county seats reflects a similar tendency, however, despite the fact that in several cases the site chosen for the courthouse had little or no prior street pattern to influence the actual location of the building or prevent the design of a Rectilinear town with a central square. In Bridgeton, Cumberland County, for example, the courthouse was put in the middle of the main road in 1748. Within six years the town was laid out in a largely rectilinear fashion without changing the relative location of the courthouse. Flemington was a Linear village chosen to be the county seat and a courthouse was built on the street in 1792. Morristown largely grew after the county courthouse had been built there in 1755. The courthouse was first built in the middle of an irregular green, and then was later moved to a street running off the green. Newton, planned as a new town on an unoccupied site, had its courthouse erected in 1763 on land donated by the owner of the property on which the town was to stand. The courthouse was built facing a green at an odd angle. The town plan was largely Irregular. Somerville, a small Irregular village, became the location of the Somerset County courthouse in 1799. The congregation of the Dutch Reformed Church which offered to share in the cost of the structure, later changed its mind, but the courthouse was finally built in a block shared with the church.[15] Clearly, the Pennsylvania pattern of courthouse squares is not found in New Jersey. This, despite the fact that courthouses built on but not in central squares are quite early in the state.

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[14] The sources, in order, include the following: William A. Whitehead, Contributions to the Early History of Perth Amboy and Adjoining Country (New York: D. Appleton & Company, 1856), p. 250; Prowell, 586-588; and Cushing and Sheppard, 168.

[15] The sources, in order, include the following: Cushing and Sheppard, 583; James P. Snell, compiler, History of Hunterdon and Somerset Counties, New Jersey (Philadelphia: Everts & Peck, 1881), 325; Andrew M. Sherman, Historic Morristown, New Jersey: The Story of Its First Century (Morristown: The Howard Publishing Company, 1905), 67; Snell, History of Sussex and Warren..., 151-153; and Snell, History of Hunterdon and Somerset..., 572.

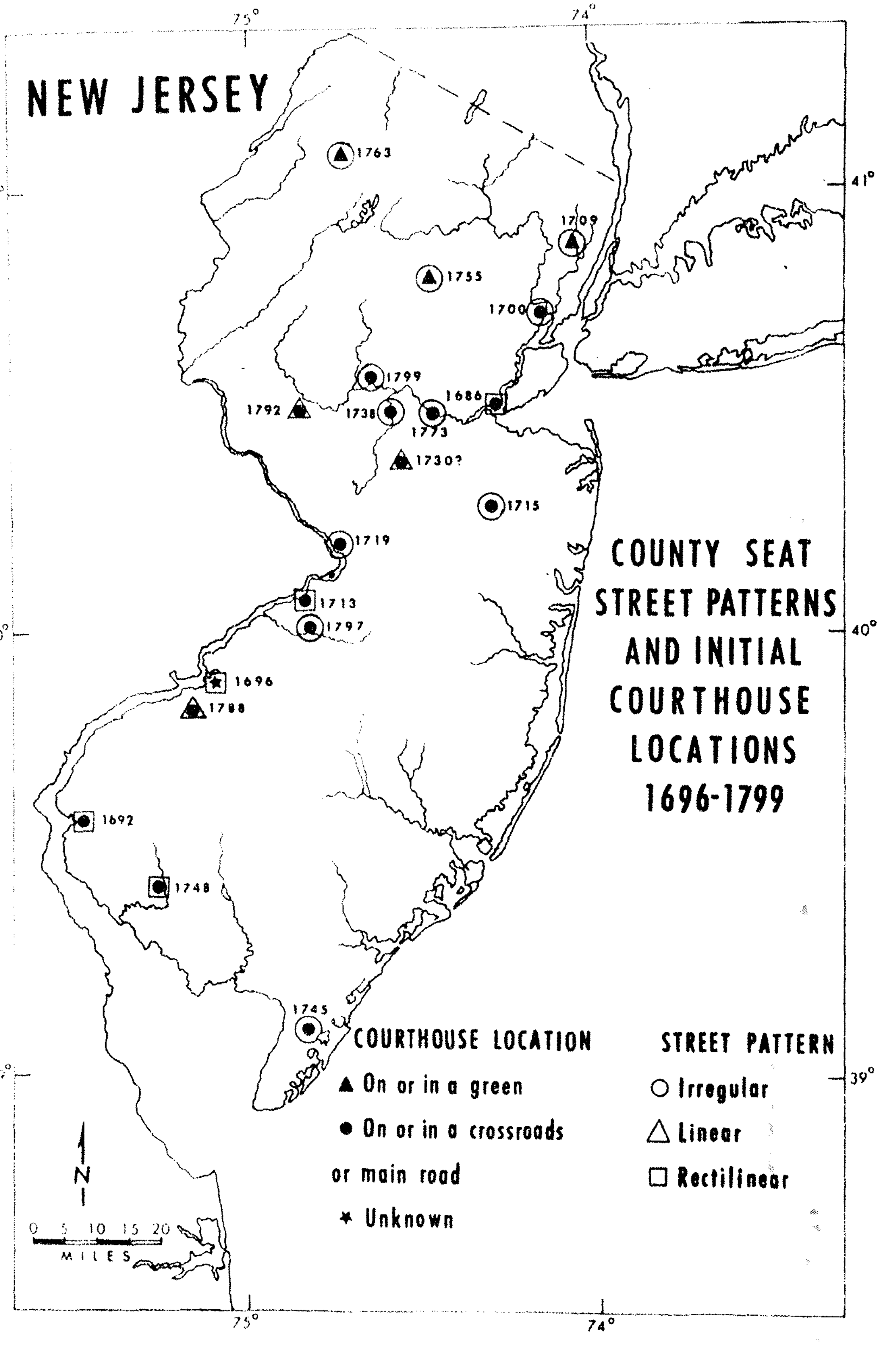
NEW JERSEY
COUNTY SEAT
STREET PATTERNS
AND INITIAL
COURTHOUSE
LOCATIONS
1696-1799
75°
74°
41°
40°
39°
1763
1709
1755
1700
1799
1686
1792
1738
1773
1730?
1715
1719
1713
1797
1696
1788
1692
1748
1745
COURTHOUSE LOCATION
▲ On or in a green
● On or in a crossroads or main road
✶ Unknown
STREET PATTERN
○ Irregular
△ Linear
□ Rectilinear
N
0 5 10 15 20
MILES

Figure W5.

New Jersey, then, in both the case of basic street patterns and the placement of courthouses in county seats, mirrors the patterns of the older Atlantic Seaboard colonies which reflect the transferral of culture traits directly from European hearths, not response to great innovations in a New World. On the other hand, southeastern and south central Pennsylvania, with its distinct assemblage of culture traits, is a true culture hearth from which a new complex of culture traits has spread, the street and courthouse square patterns being but two more examples of a mounting list of traits peculiar to that hearth.

Several questions remain unanswered, however. One concerns the role of the Classical Revival. Pillsbury attaches great value to classicism in explaining the ready acceptance of rectilinearity in Pennsylvania, while Price does not consider it as a factor in the acceptance and spread of the courthouse square. In New Jersey, however, it is interesting to note the case of the first county seat erected on a new site after 1800. This was Belvedere, a place name itself reminiscent of classicism,[16] not of a northwestern New Jersey county town. Belvedere was chosen as the seat of Warren County in 1825. The site for the courthouse had been donated by an entrepreneur who had platted the town in a rectilinear fashion and had provided a central public square to be faced by the courthouse. The local newspaper, the Belvedere Apollo, was in existence at the time the place became the county seat, and the Belvedere Classical Academy opened its doors in the 1840's after the town's founder had donated some property.[17]

Another factor which is poorly understood is the relative role of the entrepreneur in Pennsylvania and New Jersey in the eighteenth century. In Pennsylvania risk capital was attracted to development of new town sites in Rectilinear plats. Artisans, many of them German, flocked to such places to carry on small-scale manufacturing. In New Jersey this situation does not seem to have existed. Thus, even in places which were still within the frontier zone in New Jersey during the 1750's and 1760's street patterns continued to evolve in an irregular medieval pattern rather than be planned in a rectilinear fashion by entrepreneurs.

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[16] See Wilbur Zelinsky, "Classical Town Names in the United States: The Historical Geography of an American Idea," The Geographical Review 57 (October, 1967), 463-495.

[17] Snell, History of Sussex and Warren..., 475-476, 540.

SOME ASPECTS OF THE GROWTH AND MORPHOLOGY OF VILLAGES IN CENTRAL NEW JERSEY

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It is the purpose of this paper to present some observations on the growth of small agglomerated settlements in central New Jersey. The findings are based on field studies of eight small villages and hamlets on the outer margins of the major metropolitan belt of northern New Jersey. Califon (No. 1, Figure 1) is located on the South Branch of the Raritan River in its upper valley, situated within the Appalachian Highlands. Oldwick (No. 2) is in the Piedmont Lowland, south of the Highland border. Neshanic Station and Neshanic (Nos. 3 and 4) are on the South Branch of the Raritan River in the Piedmont near the foot of Neshanic, or Sourland, Mountain. The Millstone villages (Nos. 5 and 6) and Rocky Hill (No. 7) are located on the Millstone River in the Piedmont. Crosswicks (No. 8) is situated on the Inner Coastal Plain, far to the south on Crosswicks Creek, a tributary of the Delaware River.

During a period of ten years, beginning in 1956, I found it worthwhile to spend a few weeks in each of five years investigating these several villages with the help of graduate students at Rutgers, taking them as case studies in connection with the course on settlement geography. Thus, I owe acknowledgment of the labor invested by some fifty students enrolled at various times in the course.

Procedure

It is not appropriate here to give the details of the procedure. Perhaps it is sufficient to say that the location and present use of all dwellings and other principal used structures was determined and identified on a base map derived from existing topographic quadrangles and cadastral surveys. A door-to-door census of the occupants was undertaken in some of the villages and in most of them the date of construction and certain features of house design and construction were recorded. The field work was supplemented by collecting local histories and investigating the archives and libraries in New Brunswick and Trenton for old maps, census records and other documentary evidence of the past. The results were embodied in papers prepared by the students under my direction.

Our findings would seem to merit attention for the insights obtained regarding settlement morphology and interpretation of the growth trends of such rural population clusters in an urbanizing region. The results may not qualify as strictly historical geography because we started with the present landscape and sought explanation of what is observed today. Yet much attention has been given to the geography of the past and to the evolution of settlement forms and functions through time. It was, and is, my

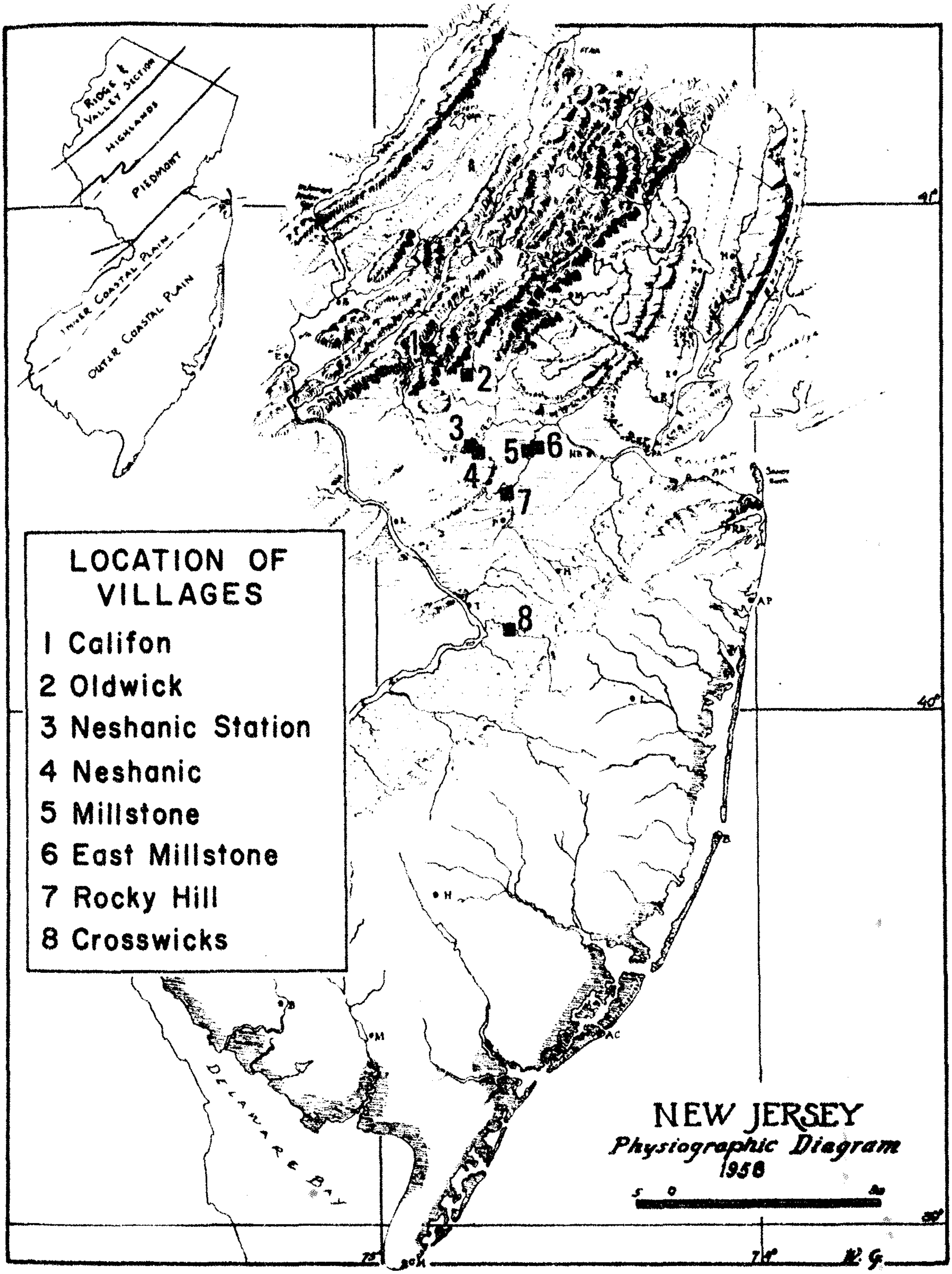

Figure B1

Base Map by William Goodwin, Department of Geography, Rutgers University, 1958.

conviction that the present-day geography of any area contains much which cannot be understood without reference to the past. At the outset I did not have a theory to be tested. But it is anticipated that comparative studies such as these will provide the basis for deducing a conceptual framework.

Before going any farther, I want to emphasize the attractiveness of such small-scale settlement studies. The foremost advantage is comprehensibility. When a small place has retained its identity for a century or more, one gains satisfaction from being able to trace its development from first-hand investigation. This is much more difficult to accomplish in a large town or city. There is the additional advantage of investigating the past while visible evidence of it still exists. We were often able to see defunct mills, old churches and taverns and sometimes identify original dwellings. We could identify sites of non-existent structures and old roads, bridges, or railroad alignments, whereas in densely urbanized areas these things have usually been destroyed and superceded by new construction. Furthermore, the method is a useful supplement, or counterpoise, to the abstract theoretical work so popular among geographers today. Thousands of other small agglomerated settlements await fruitful study in New Jersey and New York.

Results

All the villages studied had origins between 200 and 250 years ago and much of their growth has been associated with the agricultural economy as it developed prior to the 1920's. Although their functions as farm service centers and industrial sites have been largely superceded, these settlements are far from being lifeless or abandoned. Population varied from about 250 to 1,000 at the time of our studies and in certain instances rapid growth is occurring now, as the settlements assume new functions. Today the old settlement nuclei might be described as "fossil" villages embedded in a matrix of "exurban" rural landscape with express highways, commercial strips, shopping centers and housing tracts intruding upon the formerly agricultural area. Crosswicks, for example, is only 15 miles east of Trenton and six miles from an exit on the New Jersey Turnpike, while Oldwick is about one mile from an exit on Interstate Highway 78, 18 miles west of Somerville.

I want to direct your attention to certain features of the growth and morphology of Neshanic, Crosswicks, Rocky Hill, Oldwick and Califon.

Neshanic and Neshanic Station form a contrasted pair of agglomerations (Figure 2).[1] The earliest site of growth was in Neshanic at the branching of roads near a church

[1] Field studies were carried out in September-October, 1960, by the following students: Carl L. Hansen, Daniel Horodysky, John McNamara, Andrew R. Kardos, Charles B. Packard, Robert J. Sell, Robert A. Simko and Richard F. Veit.

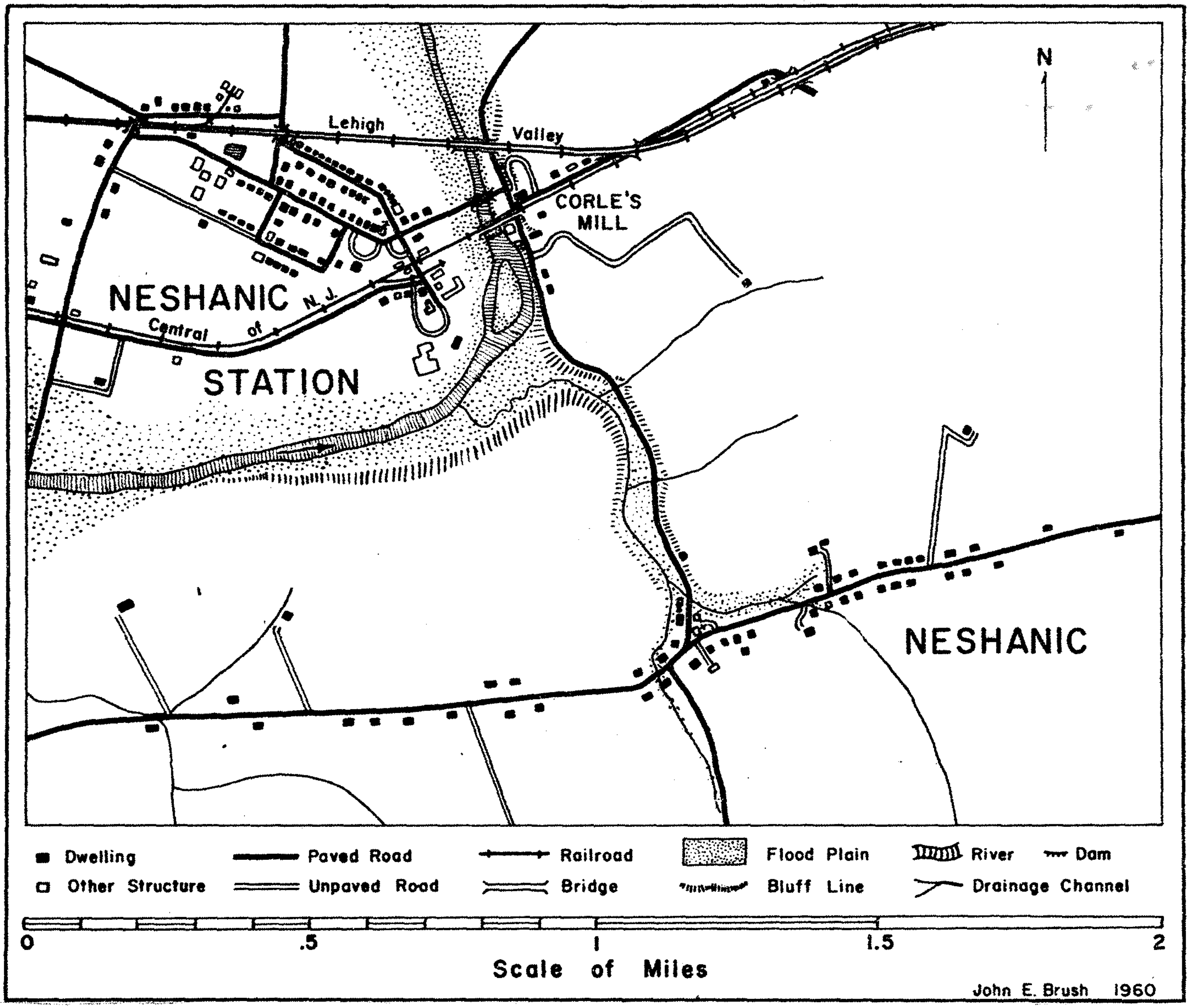

Figure B2

Neshanic Station and Neshanic: 1960

Source: Field Survey by Department of Geography, Rutgers University of the Dutch Reformed denomination, organized in 1752 and built between 1759 and 1772.[2] The church is believed to have been preceded by a tavern located across the road, perhaps as early as 1700 or 1710, which served as a lodging place for travelers en route by stage across New Jersey on the Amwell Road (New Brunswick to Lambertville).[3] By 1880 an unplanned strassendorf-like settlement grew up along the main road, consisting of 25 dwellings, inhabited by about 120 persons.[4] In addition to the hotel-tavern and church the village by this time had a general store and a blacksmith shop. By 1960 the population was about 175, the number of dwellings had approximately doubled, and now old Neshanic was extended nearly two miles along the main road. Most of the growth since 1880, however, has been concentrated on low-lying land near the Raritan, opposite Corle's Mill (Figure 2) which was established by the first decade of the 19th century.[5] There was first a grist mill, then a flour mill at this site, driven by water taken above the dam from the Raritan where it passes below a sharp bluff on the right bank. Settlement expansion occurred on the opposite side of the river, mainly along a series of streets laid out with platted houselots in Neshanic Station, following construction of the Central Railroad of New Jersey in 1864 and the Lehigh Valley Railroad in 1872.[6] Farm trade was attracted to Corle's Mill and Neshanic Station from distances of two to three miles or more and a variety of businesses flourished here from the 1880's to the 1940's. It was an attractive place to live and many substantial homes were built, some of which are now occupied by commuters who travel 20 to 50 miles to work. By 1960 the number of dwellings in the newer settlement was approximately double the number in old Neshanic and the population about 350. Of course, railroad service is virtually abandoned today, although for seven or eight decades ending in the 1950's the rails were the "lifelines" of many such small service centers in New Jersey. The only significant new feature at the date of our survey was the small chemical plant near the river in Neshanic Station, which used truck transportation exclusively and was dependent on the abundance of ground water for processing plastic color concentrates.

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[2] George B. Scholten, History of the Reformed Protestant Dutch Church of Neshanic, New Jersey. Neshanic, New Jersey: 1952, pp. 5-13.

[3] James P. Snell, History of Hunterdon and Somerset Counties, New Jersey. Philadelphia, Pennsylvania: Everts and Peck, 1881, pp. 786, 864.

[4] Tenth Census of the United States, 1880, Schedule 1. Somerset County, Hillsborough Township. Ms. in Rutgers University Library, New Brunswick, New Jersey.

[5] James P. Snell, Op. cit.

[6] John T. Cunningham, Railroading in New Jersey. Newark, New Jersey: Associated Railroads, 1951, p. 27.

The geographic pattern of the main village of Crosswicks suggests some kind of planning because of the arrangement of streets and dwellings around an old Quaker Meetinghouse set in the midst of extensive grounds (Figure 3). I have tried to reconstruct the growth pattern on the basis of our field survey,[7] old maps and published records. It is clear that Friends (Quakers) had an important role in Crosswicks from the beginning of English settlement in this part of New Jersey, but the evidence shows that the village, which has something of the appearance of a New England town center with a green or common, evolved without a preconceived plan. The first house of worship was built by Friends in 1692 at this locality,[8] called Crossweeksung by the Indians.[9] It is recorded that two Friends families took up land fronting on Crosswicks Creek in the early 1680's and that land was donated by them for the original meetinghouse and burial ground.[10] The present Meetinghouse was erected in 1773 to replace a smaller structure, which dated from 1706 and stood in the northwest corner of the Quaker Meeting Grounds (Figure 3). It seems, however, that the nucleus of settlement by the end of the 18th century,[11] comprised the frontage on both sides of a winding aboriginal trail, going southeastward from the fording place (later utilized by successive bridges) and ascending the bluff to the well-drained natural terrace south of the flood plain. (See Figure 3, Occupied Area before 1780.) Subsequent expansion of settlement at Crosswicks occurred during the 19th century on streets which were platted with regular houselots bordering the Quaker Meeting Grounds on the west and south and on the north side of the stream adjacent to the main road to Trenton.[12] Other religious groups had peripheral sites in

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[7] Field studies were carried out in September-October, 1964, by the following students: Steven F. Buckley, Jerry D. Farren, John Gross, Kingsley Haynes, Reid Kirchberger, Toivo Lamminen, Harry Margulis, Bruce Marich, Theodora Martin, Peter Muller, Edward Olas, Edward W. Roberts, Kashi Nath Singh, David B. Smith, and Michael L. Thaller.

[8] E. M. Woodward and J. F. Hageman, History of Burlington and Mercer Counties, New Jersey. Philadelphia, Pennsylvania: Everts and Peck, 1883, p. 275.

[9] Henry H. Bisbee, Place Names in Burlington County, New Jersey. Riverside, New Jersey: The Burlington Publishing Co., 1955, p. 31.

[10] E. M. Woodward and J. F. Hageman, Loc. cit.; and manuscript map dated October 31, 1834 of original land surveys, also showing existing roads and houses as of the map date, in possession of the Crosswicks Friends Meeting. This map is reproduced in Chesterfield Township Heritage, Burlington County, New Jersey. Crosswicks, New Jersey: Tercentenary Committee, 1964, p. 18.

[11] See Christopher Colles, A Survey of the Roads of the United States of America 1789. Edited by Walter W. Ristow. Cambridge, Massachusetts: Harvard University Press, 1961, p. 164.

[12] J. D. Scott, Atlas of Burlington County, New Jersey. Philadelphia, Pennsylvania: 1876, pp. 52, 77.

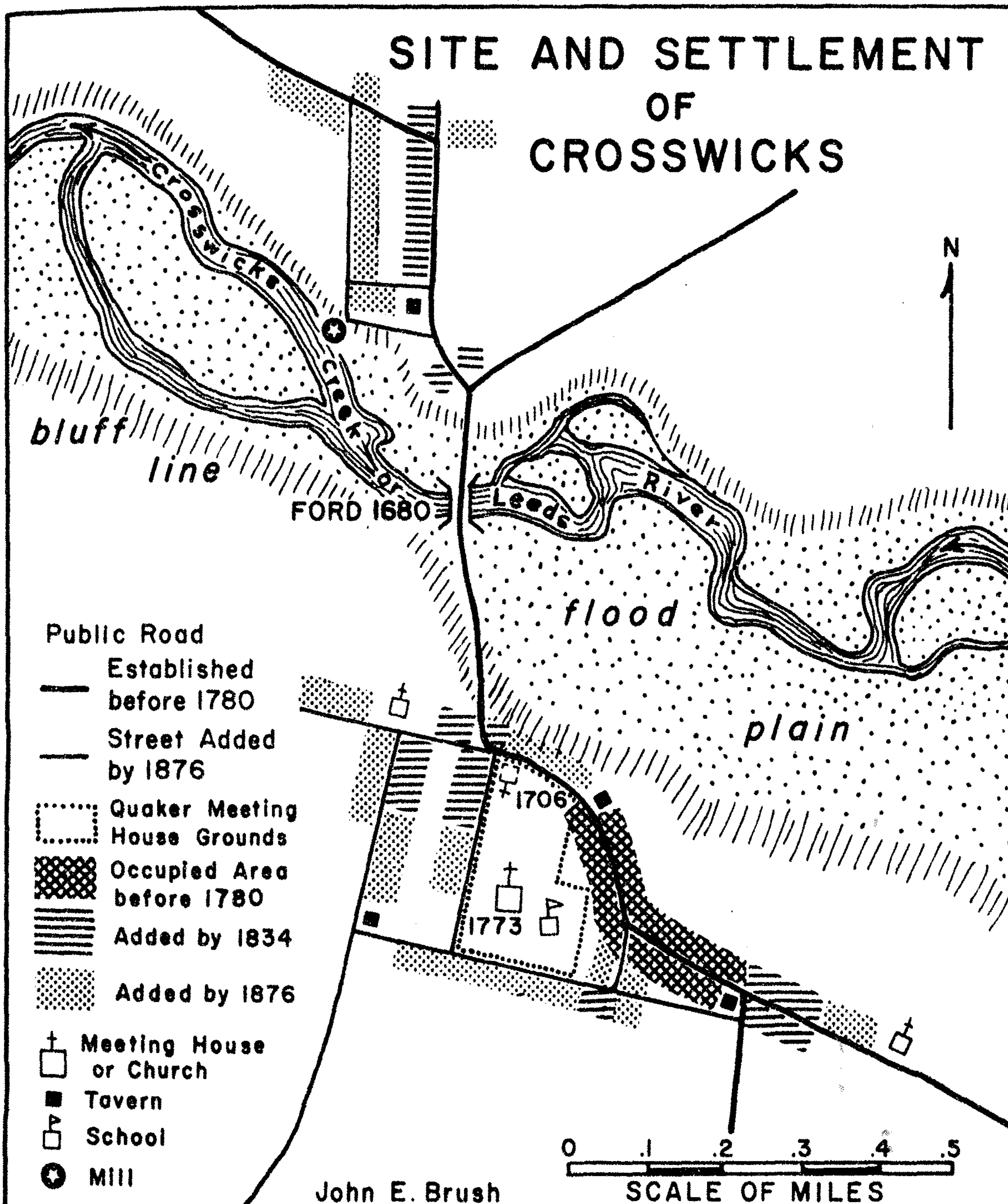

Figure B3

Site and Settlement of Crosswicks

Source: Field Survey by Department of Geography, Rutgers University the 19th century: the Methodists, at the eastern end of the village from 1790 to 1884,[13] and the Orthodox Quakers, one block west of the 1706 Meetinghouse site, from 1833.[14]

Four taverns and a grist mill were significant features of early Crosswicks. (See Figure 3.) The oldest tavern, established in the late 17th century, is at the road fork one quarter of a mile east of the Quaker Meetinghouse.[15] Three other taverns in existence by 1834 were all located on main roads in or near the village. The mill site in North Crosswicks was utilized as early as 1700 and is believed to have been one of the two oldest in West Jersey.[16] No railroad was built through Crosswicks.

While detailed results of similar studies in the other settlements cannot be presented here, it was found that incipient nucleation in the first century or so usually occurred around a tavern or a church, more often than not located near a stream crossing and/or a mill dam site. Further growth, especially in the last third of the 19th century, was concentrated near railroad depots and local milling industries. Once we had identified the sequence of events in each place, the present morphology of settlement could be interpreted readily in the light of institutional and economic factors.

Cycles of Settlement Growth

The geography of settlement in New Jersey reflects changing economic conditions over a relatively long period of continuous occupance, characterized by waves of population growth and urban expansion. In a previously analysis[17] I found that rural population growth predominated in New Jersey until 1840. Thereafter the state as a whole has become progressively more urban until today less than one in eight of the inhabitants are classed as rural by the Bureau of the Census. In the rural townships, the census record commonly shows a rise of population from initial farm settlement about 1700 or earlier until 1860 or 1870, e.g., Chesterfield Township, Burlington County (Figure 4) in which the main village of Crosswicks is located. The farm population declined sharply for three or more decades and then stabilized from about 1900 to 1920. The second cycle of growth in the rural areas of New Jersey began in the 1930's as a "back to the land" movement and was resumed after the Second World War as automobile travel and metropolitan sprawl became dominant throughout the state.

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13 Chesterfield Township Heritage, Burlington County, New Jersey. Edited by Gertrude M. Brick. Crosswicks, New Jersey: Tercentenary Committee, 1964, pp. 196-200.

14 Ibid., p. 146.

15 Ibid., p. 127.

16 Ibid., p. 202.

17 John E. Brush, The Population of New Jersey. New Brunswick, New Jersey: Rutgers University Press, 1958.

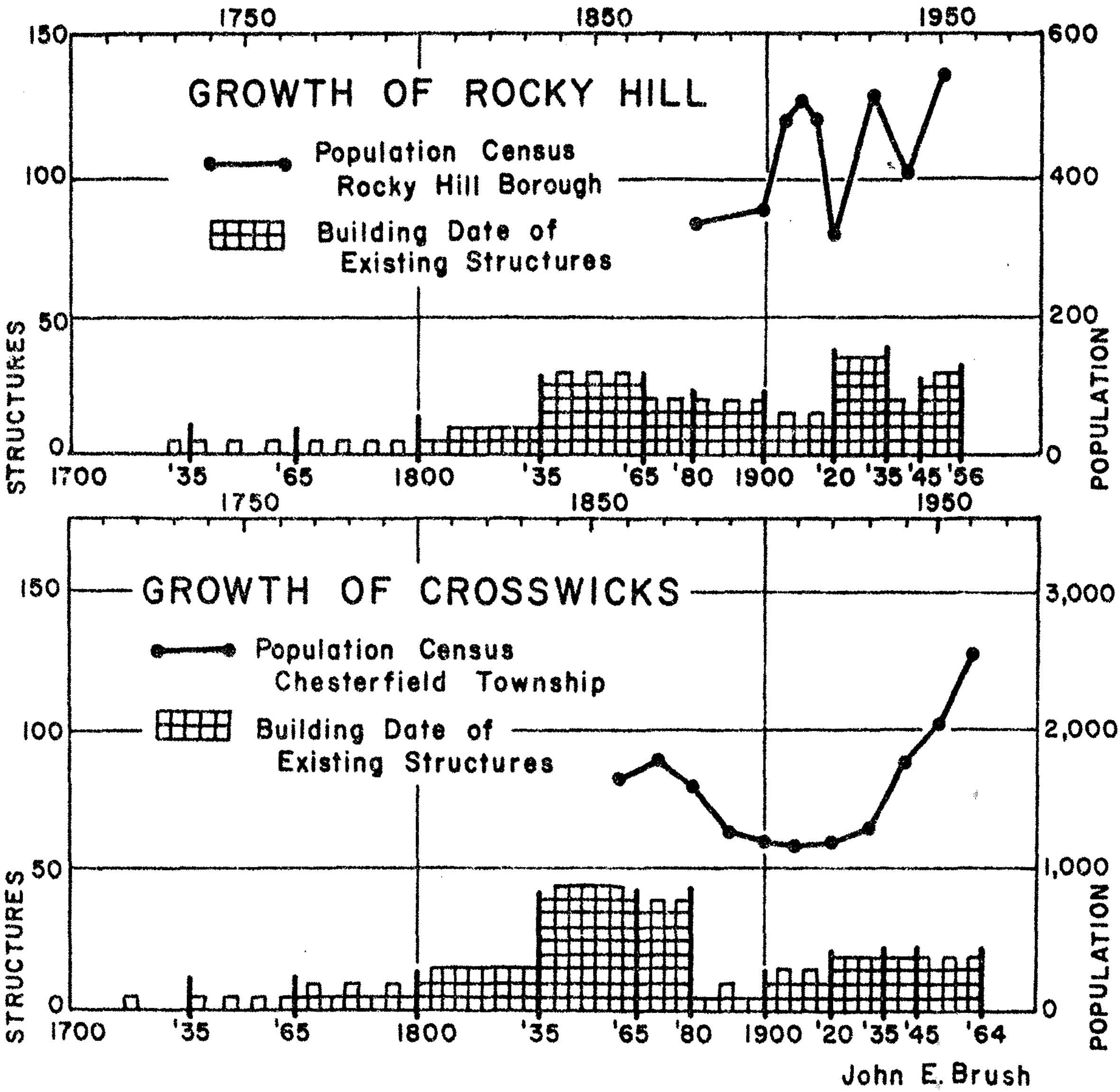

Figure B4

Growth of Rocky Hill and Crosswicks

Source: Department of Geography, Rutgers University

The varying effects of these two phases of development may be traced in Crosswicks and Rocky Hill (Figure 4) and in Califon and Oldwick (Figure 5). Separate census tabulations are not available for the majority of the settlements studied because they remained "unincorporated places" without legal status and hence their population has been included in whatever township each is situated. In the case of Rocky Hill, which was incorporated as a municipal borough in 1889, the population is seen to have fluctuated between about 300 and 500 for some fifty years. In the case of Califon, which did not achieve municipal status until 1918, the evidence from our counts of structures and those identified on maps of three earlier dates shows a late start and fairly continuous growth for the last one hundred years.

Physical expansion of urban settlements in the United States has occurred in irregular cycles of fifteen to twenty years duration. Data on building of residential housing and other structures from the 1850's to the present show that seven distinct periods of growth have occurred.[18] There was a cycle of building activity after the Civil War which reached a peak in 1871, followed by the late 19th century cycle, which rose to highest intensity in 1889. Then another cycle came in the early 20th century with its peak in 1909. This was followed in quick succession by a cycle after the First World War, which reached its climax in 1925, and the post-Depression Cycle in the late 1930's with its rise sharply curtailed after 1941. Finally, there was the long cycle after the Second World War with its first and highest peak in 1950, which continued at a high level with minor fluctuations until the mid-1960's. Low levels of building activity occurring for short periods between these upturns usually have coincided with general economic depressions. But the major construction cycles lasted two or three times as long as the cycles of prosperity in business. It is clear also that residential construction, which has become increasingly non-farm and urban-based, is widely and unevenly spread over the United States. Nevertheless, I have taken the known building cycles with adjustments of the beginning and ending dates so as to coincide with years ending whole or half-decades as a chronological frame of reference for grouping of dwellings and other buildings for which approximate dates of construction were obtained in our studies. For the period before 1865 I have adopted arbitrary time periods of approximately one-third of a century, following the dating practice in the Historical American Buildings Survey.[19]

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[18] Historical data on residential housing construction is compiled for cities and various other statistical areas, in Housing Construction Statistics: 1889 to 1964. U. S. Department of Commerce, Bureau of the Census, 1966. See also, Housing Starts, Construction Reports, Series C 20-67-7 (1963 to 1966). U. S. Department of Commerce, Bureau of the Census, 1967. See annual and monthly reports (Series C 20) for continuation of the same data. Earlier statistical data and general interpretations of the economic aspects of cycles in the construction industry will be found in C. D. Long, Building Cycles and the Theory of Investment. Princeton, New Jersey: Princeton University Press, 1940, and in J. R. Riggleman, "Building Cycles in the United States," Journal of the American Statistical Association, Vol. 28, 1933, pp. 174-183.

[19] Historic American Buildings Survey. A Catalog of the Measured Drawings and Photographs of the Survey in the Library of Congress, March 1, 1941. Washington, D. C.: National Park Service, 1941.

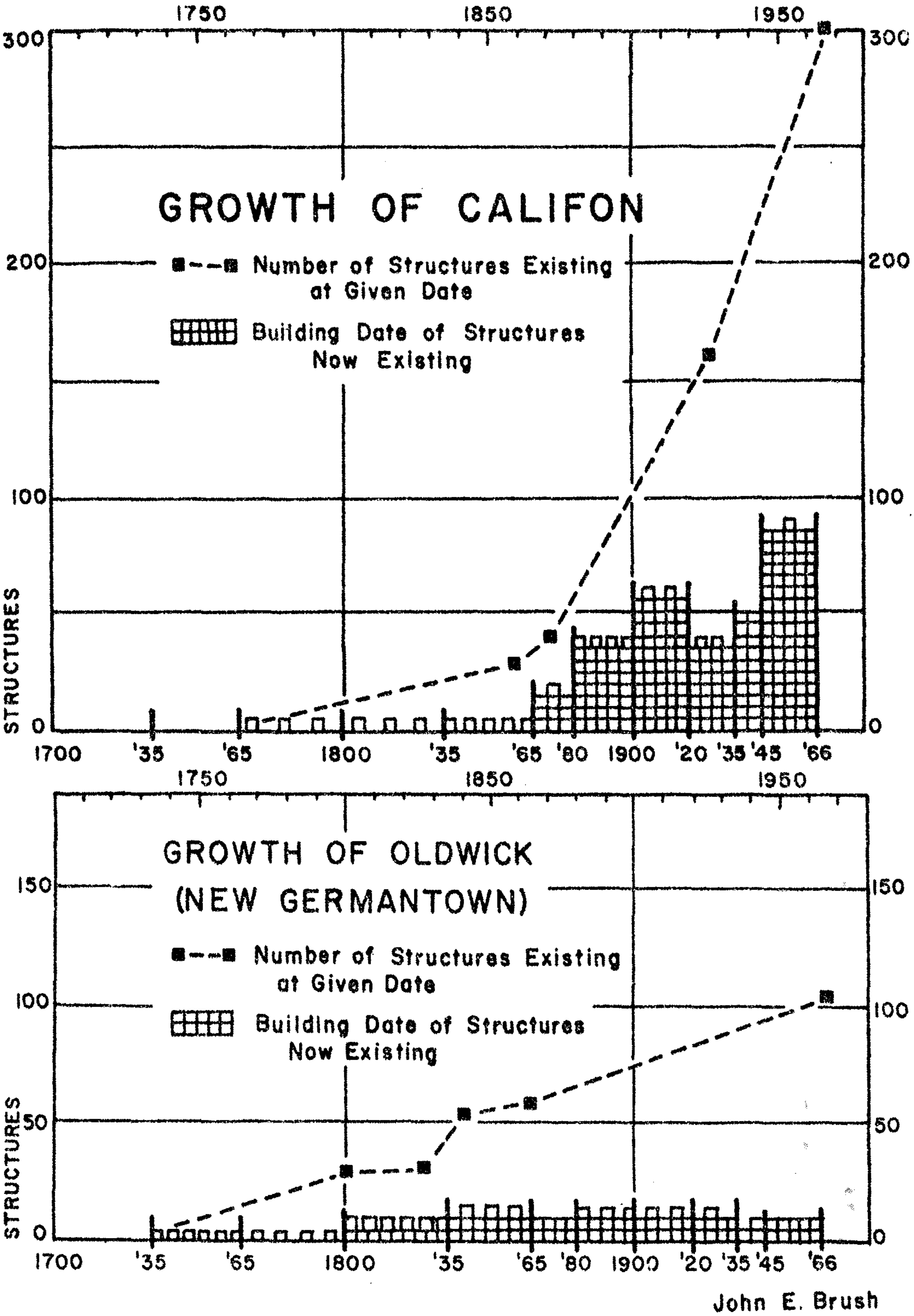

Figure B5

Growth of Califon and Oldwick

Source: Department of Geography, Rutgers University

No structures survive in the settlements under examination from earlier than the 18th century. Thus, there are in all eleven time periods, as follows:

Early 18th Century	1700 to 1735	Late 19th Century	1880 to 1900
Middle 18th Century	1735 to 1765	Early 20th Century	1900 to 1920
Late 18th Century	1765 to 1800	Post World War I	1920 to 1935
Early 19th Century	1800 to 1835	Post Depression	1935 to 1945
Middle 19th Century	1835 to 1865	Post World War II, or	
Post Civil War	1865 to 1880	Middle 20th Century	1945 to 1965

These are the time periods indicated by the heavy vertical lines and dates shown in the graphs of growth (Figures 4 and 5).

I recognize that a fully accurate depiction of development trends in the four villages should be derived from precise dating of every building erected, including those no longer in existence. Such exacting determinations were not feasible within the scope of our studies and, indeed, seem not to be attainable with exhaustive effort.[20] We endeavored to date the structures within the correct time periods. Yet uncertain and unknown dates eliminate from the counts between five and twenty per cent of all structures mapped. It is thought that the major trends of growth by periods are fairly accurately portrayed, however.

Our chronologic analysis demonstrates that what is seen now in the four villages is a 19th-century or early 20th-century landscape. Although nucleation of settlement may have been incipient as far back as 200 or 250 years ago, most of the development occurred after 1865 and it is hardly appropriate to call any of these places "colonial" or "pre-Revolutionary." Crosswicks is apparently older than the three other villages, but less than half, or eight out of seventeen, of the existing structures antedate the Post Civil War Cycle. In Oldwick the ratio of pre-Civil War structures to the remainder is three out of seven. Only one out of three structures in Rocky Hill was built before 1865. Almost nothing in Califon existed before the Civil War and only one of every four structures dated was built before 1900.

Conclusion

These exploratory studies have shown the ways in which the morphology of small unplanned settlements has developed and persists. The original highways and streets, the landholding divisions, the private dwellings and churches, or meetinghouses, are relatively conservative elements of New Jersey's settlement fabric. Commonplace domestic architecture is often the most durable evidence of the past.[21] Buildings used for retail stores and other commercial purposes and the industrial establishments are more readily abandoned, remodeled or replaced. Fortunately, many such unplanned villages and hamlets have been maintained

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[20] Studies were carried out in Oldwick and Califon during September-October, 1966, by Raymond W. Andrews, Frank P. Colpini, Bharat L. Bhatt, Stanley Dart, Steven B. Frakt, Michael H. Gordon, Noel P. Granzow, Gerhart H. Kellner, Robert F. Kossielski, Gale Paley, Thomas Sobieszczyk and Paul R. Swanson.

[21] John E. Rickert, "House Facades of the Northeastern United States: A Tool for Geographic Analysis, Annals of the Association of American Geographers, Vol. 57, 1967, pp. 211-238.

with pleasing qualities and an informal atmosphere which cannot be reproduced today at any price.[22] For this reason new residents have been attracted and seek to preserve the kind of landscape which belongs to an era before automobiles became ubiquitous.

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[22] Elizabeth G. C. Menzies, Millstone Valley. New Brunswick, New Jersey: Rutgers University Press, 1969.

CROSSWICKS FRIENDS MEETINGHOUSE, 1773.

The meetinghouse stands in the midst of extensive grounds now occupied also by the Crosswicks Community House, the white structure seen in the background. The large white oak in the foreground was living when Friends settled on farms hereabouts in the 1680's.

Photo by John E. Brush, 1968.

MAIN STREET, CROSSWICKS

A view southeast along the oldest street of the village, which originated as a winding trail leading to the ford over Crosswicks Creek.

Photo by John E. Brush, 1968.

MAIN STREET, CROSSWICKS

A view northwest on the same street. The dwellings were built before 1834 and some earlier than 1780.

Photo by John E. Brush, 1968.

THE HIGHLAND FORESTS: FOUR CENTURIES OF CHANGE

Alfred Phillip Muntz
The National Archives

The New Jersey Highlands, which extend approximately sixty miles across the northwestern part of the state, are in a number of respects representative of all those parts of the Appalachian hill lands that flank the western borders of Megalopolis. This generalization applies to many elements of the physical as well as the cultural geography of the area. It is true, for example, of the forests, which have always been a conspicuous if not the dominant feature of the Highlands. The forest and its products are recurring themes in many of the descriptions and histories of the area, and industries based entirely or in part on the forest resource were the economic mainstay of much of the region for more than two centuries. This was particularly true of the part of the New Jersey Highlands located north of the terminal moraine of the Wisconsin ice sheet, where farming was limited by large areas of scoured rock, thin and excessively rocky soils, and many poorly drained bogs and hollows. This is the area on which this paper is focused. Its purpose is to describe some of the more significant aspects of the changing forest geography of the glaciated Highlands in relation to human occupance over a period of four centuries, with particular emphasis on the period between 1700 and 1900, when the role of the forest was especially important.

<u>The Pre-European Forests</u> It is usually impossible to reconstruct exactly the forest conditions of any particular area during the period of Indian occupance, although several lines of evidence can be used as a basis for meaningful generalizations. With regard to composition, there seems to be general agreement among most plant geographers and ecologists that the major forest regions and associations have long been fairly stable, and that present day species are usually a reliable guide to those which existed before European settlement.[1] In the Highlands, the major exception to this generalization is the American chestnut, which was until the present century one of the most abundant trees throughout the vast oak-chestnut forest of eastern North America. The chestnut has been destroyed as an important tree by an introduced blight, and its place filled by other deciduous species, particularly oaks.

Although the scope of this paper precludes a detailed description of the forest communities within the Highlands, some mention of the

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[1] Hugh Raup, "Botanical Studies in the Black Rock Forest", <u>Black Rock Forest Bulletin</u>, No. 7, 1938, p. 83.

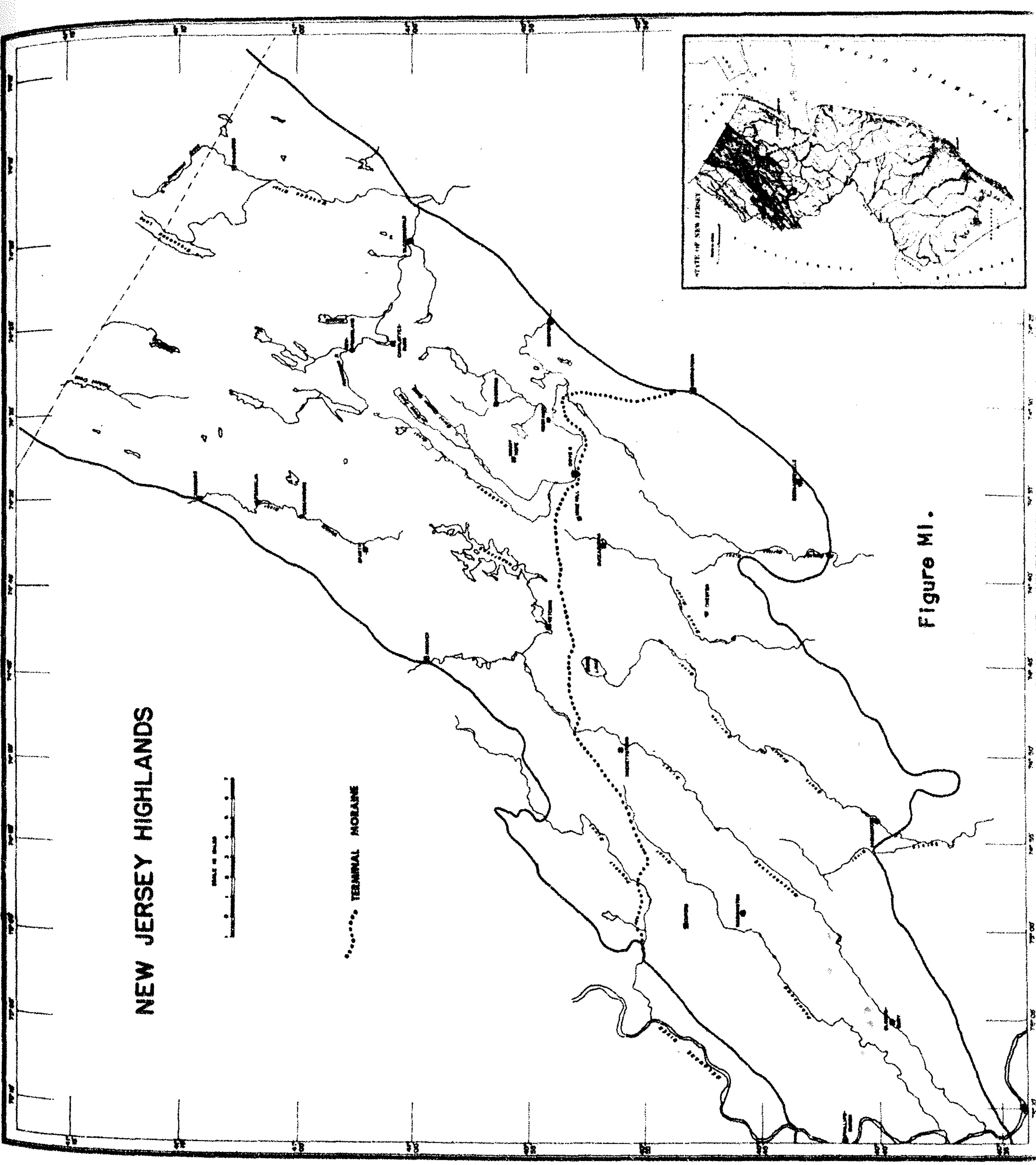

Figure MI.

major species and their distribution is in order. Oaks are the dominant species in the Highlands. Chestnut, red, black, and white oaks are all abundant, with chestnut oak occurring most frequently at higher elevations, especially on dry and rocky sites. Black birch and black oak are common associates of chestnut oak in these situations. On lower slopes, where soils are deeper and more moist, red oak is more common, in association with other oaks and the tulip tree, and also red and sugar maples, yellow birch, beech, ash, and hemlock. In sheltered valleys and along lower slopes of north-facing ridges, northern hardwoods may predominate, and almost pure stands of hemlock are not uncommon in cool ravines. Shagbark hickory and pignut are also present, especially on well drained uplands.

Swamps and bogs, which are numerous in the glaciated highlands, support a varied cover. Red maple is probably the most abundant tree on poorly drained sites, and elm and pepperidge are also common. On abandoned old fields, grey birch is a frequent pioneer; it is quickly replaced by mixed hardwoods when undisturbed.

It seems probable that the first Europeans to enter the Highlands encountered the same species that have been mentioned, although undoubtedly the relative abundance of various trees has varied considerably in both time and place. But what of the density and distribution of the pre-European woodlands? Present conditions are of little value in answering this question. Probably the most useful information can be found in the writings of early European observers. Surprisingly, most of these descriptions do not support the forest primeval concept that has so long prevailed in many of our historical and literary works. The notion of a boundless, unbroken and undisturbed forest extending from the Atlantic to the Mid-Western prairies is essentially a product of the romantic imagination rather than of objective analysis. Undoubtedly areas of undisturbed climax forest did exist in Eastern America in 1600, but it seems probable that the Indian population, in spite of its low density, had radically altered much if not most of the eastern woodlands long before the arrival of Europeans.

The principal agent of forest destruction or alteration employed by the Indians was fire. There is abundant evidence that Indian burning was frequent and widespread all along the Atlantic Coast and well into the interior.[2] The most important result of repeated burnings was the establishment and maintenance of an open, parklike forest in which relatively fire resistant species such as oaks, chestnut and hickory were favored. Although the Indian population of the northern Highlands was

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[2]Gordon M. Day, "The Indian as an Ecological Factor in the Northeastern Forest", Ecology, XXXIV, No. 2 (1953), 329-346; Alfred Phillip Muntz, The Changing Geography of the New Jersey Woodlands, 1600-1900 unpublished Ph. D. dissertation, University of Wisconsin, 1959, p. 36-39; Peter O. Wacker, The Musconetcong Valley of New Jersey Rutgers, New Brunswick, 1968, p. 29-30.

small, early surveyor's reports describe treeless areas and open woods that must have been the result of fire. Also, Peter Hasenclever, a Colonial ironmaster, complained that the trees of the area around Ringwood and Long Pond (now Greenwood Lake) produced an inferior grade of charcoal because they had been damaged by Indian burning.[3]

It would be erroneous to infer from the evidence cited that there were no areas of dense forest in the Highlands when the first Europeans arrived, or that open land predominated. Undoubtedly most of the area was wooded, but it must have been a complex woodland of varying density, consisting mainly of oak and chestnut with a considerable admixture of other deciduous species as well as hemlock and a few other conifers.

The Exploitation of the Highland Forests, 1700-1900. In 1684, the Highlands were apparently largely unexplored.[4] There is a record of settlement in the vicinity of Pompton Plains, along the eastern front of the Highlands, as early as 1700,[5] and at Pompton in 1697,[6] but apparently the narrow valleys west of the Ramapo fault did not attract settlement until much later. When settlers did enter the area, many of them apparently came as ironworkers rather than farmers. One of the first known settlers was Cornelius Board, who purchased land on the upper Ringwood River in 1736, and began operating a bloomery shortly thereafter. In 1740 he purchased large blocks of land from the East Jersey Proprietors near the place where Ringwood Manor was later built, and established a forge. Other purchases of mineral lands and manufacturing sites followed, the famous Ringwood company was established, and in 1742 a blast furnace, the first in the Northern Highlands, was erected.[7] Within a few years, other forges, bloomeries and furnaces were established at various sites on the Ringwood, Long Pond, Pequannock, and Rockaway Rivers and their tributaries, and the smelting and working of iron had become a major activity of the area.

Most of the accounts of the early ironworks indicate that they were established in empty areas. The historian Thomas Gordon wrote that the first settlers were " . . . rather manufacturers that agriculturists . . ." and that ". . . the narrow valleys of the mountain region . . . were only partially tilled for the subsistence of wood cutters and bloomers. The

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[3]Peter Hasenclever, The Remarkable Case of Peter Hasenclever, Merchant London, 1773, p. 84.

[4]Samuel Smith, The History of the Colony of New Jersey (reprint of 1765 ed.) Trenton, 1890, p. 186.

[5]Garrett C. Schenck, "Early Settlements and Settlers of Pompton, Pequannock, and Pompton Plains", Proceedings of the New Jersey Historical Society, New series, IV, 1919, p. 44-87.

[6]James M. Ransom, Vanishing Ironworks of the Ramapos, Rutgers, New Brunswick, 1966, p. 108.

[7]Ibid., p. 29-30.

forge was universally the precursor of the farm."[8] Although a recent study has shown that Gordon's generalization is not applicable to parts of the unglaciated highlands, where agricultural settlement did precede iron making,[9] it does seem to hold true for most of the northern Highlands.

The primacy of iron manufacturing in the area was directly related to its forests, and the relationship was one of both cause and effect. The forest supplied fuel for the iron industry in the form of charcoal, and there can be no doubt that the abundance of trees in the Highlands was a factor in attracting iron makers to the area. The industry required vast quantities of fuel, with the charcoal blast furnace being particularly voracious, and the availability of an adequate supply of wood was a prime consideration in locating an ironworks. Once established, the insatiable appetite for charcoal of the furnaces, forges and bloomeries led to complete deforestation of large areas. In spite of the very large tracts of forest land that were associated with the major ironworks, lack of fuel, indicating extensive deforestation, was reported well before the end of the 18th century. The following statement by the German scholar Johann David Schoepf, who traveled in New Jersey in 1783-84, is especially revealing in this respect.

> "The business of the mines and foundries, in New Jersey as well as throughout America, cannot be said to be on as firm a basis as in most parts of Europe, because nobody is concerned about forest preservation, and without an uninterrupted supply of fuel and timber, many works must go to ruin, as indeed has already been the case here and there. Not the least economy is observed with regard to forests. The owners of furnaces and foundries possess for the most part great tracts of appurtenant woods, which are cut off, however, without system or order . . . The Union, a high furnace in New Jersey, exhausted a forest of nearly 20,000 acres in about twelve or fifteen years, and the works had to be abandoned for lack of wood."[10]

The furnace mentioned by Schoepf was located in the unglaciated Highlands, but there are also reports of deforestation in the northern Highalands before 1800, and by 1834, according to the historian Thomas Gordon, the growing scarcity of fuel had led to the abandonment of many ironworks and had curtailed the operations of the remainder.[11] The Clinton Furnace, near Newfoundland, was reported to have been abandoned in 1837 because of lack of fuel,[12] and the construction of the Wawayanda

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[8]Thomas F. Gordon, A Gazetteer of the State of New Jersey Trenton, 1834, p. 185.

[9]Wacker, p. 102-103.

[10]Johann David Schoepf, Travels in the Confederation (1783-1784) (Translated and edited by Alfred J. Morrison) Philadelphia, 1911, p. 36-37.

[11]Gordon, p. 23.

[12]Ransom, p. 102.

Furnace at a remote site in the northwestern part of the Highlands in 1846 suggests that wood was no longer available at sites more advantageously located with respect to transportation and markets.

The history of the charcoal iron industry in the Highlands is complex, marked by fluctuations in the price of iron, technological changes, and various other factors which stimulated or depressed the industry drastically at different times. By the 1850's anthracite was being used widely in smelting iron, although charcoal was still used in several furnaces and in many forges[13]. According to one authority, the last charcoal forge in the Highlands was abandoned in 1879.[14] The accuracy of this date is of little significance here. The important point is that by the time of the Civil War, charcoal was of relatively little importance in iron smelting in northern New Jersey, and it ceased to be used shortly thereafter.

During the century and more in which the industry flourished, the forests of the northern highlands were cut drastically and repeatedly. It is unlikely that any major tracts of forest were spared by the coalwood and fuelwood cutters. Apparently maximum deforestation occurred in the mid-1800's, when large areas ". . . presented a perfectly bare appearance."[15] Substantiation of this statement occurs in the following description of the forests around the Sterling Furnace, located in the New York Highlands near the New Jersey boundary, in 1865. ". . . around Sterling, for miles, there is scarcely a stick as thick as a man's arm, but has been scraped off and consumed in the insatiable maw of the furnace."[16] The Sterling Furnace was converted to anthracite at this time, and the woods in that vicinity, and throughout the Northern Highlands, began a slow recovery. By 1900 the Highland forests were in much better condition than during most of the 18th century.[17]

Of course the forests were utilized for purposes other than charcoal making during the 18th and 19th centuries. Small farms were scattered throughout the area, and the woodlands were an indispensable resource to their owners. They provided fuel and fencing, and since most of the

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[13]Alfred Philip Muntz, "Forests and Iron: The Charcoal Iron Industry of the New Jersey Highlands", Geografiska Annaler, Vol. XLII, No. 4, 1960, p. 319.

[14]William S. Bayley, Iron Mines and Mining in New Jersey (Vol. VII, Final Report of the State Geologist) Trenton, 1910, p. 2.

[15]Geological Survey of New Jersey. Annual Report of the State Geologist for 1899, Trenton, 1900, p. 20.

[16]Ransom, p. 198.

[17]Geological Survey of New Jersey, Annual Report . . . . 1899, p. 20-21.

farms in the glaciated Highlands were little more than subsistence operations, their owners also depended on the forest for much of their cash income. This was derived mainly from cutting saw logs and other timber, fencing, and cordwood for fuel, with the last being the most important, since wood was everywhere the only fuel of significance until well into the 1800's. Although small quantities of anthracite were being burned in New York City and Philadelphia by 1820, and substantial amounts were being consumed by 1840,[18] in rural areas wood was the only fuel of importance intil well into the present century.

It is difficult, in this era of "automatic" heating systems, for us to imagine the enormous quantities of wood that were required by open fireplaces and woodstoves. Crevecoeur, in his Sketches of Eighteenth Century America, wrote "One year with another I burn seventy loads, that is, pretty near so many cords".[19] Since each cord contains roughly 128 cubic feet, Crevecoeur burned almost 9000 cubic feet of wood per winter. According to Benjamin Franklin, "An English farmer in America, who makes great fires in large open chimneys, needs the constant employment of one man to cut and haul wood for supplying them . . ."[20]

It has been estimated that a good wood stove is ten times more efficient than an open fireplace, and undoubtedly wood requirements were considerably reduced when stoves came into general use. Nevertheless the population of northern New Jersey must have required vast quantities of fuelwood, especially during the 18th and 19th centuries. Most of this population lived outside of the Highlands, and it seems likely that most of its fuelwood came from local woodlots and non-agricultural areas such as the Palisades and the Watchungs. There can be little doubt, however, that the Highland forests supplied large quantities of cordwood for use outside the region as well as for local inhabitants.

It is impossible to differentiate between cutting for coalwood and for cordwood, except that the latter was somewhat more selective and continued long after the charcoal industry was defunct. Its effect on the woodlands was probably less drastic than the clear cutting that characterized coalwood cutting. Like cutting for charcoal, cordwood cutting provided an important source of income for many residents of an area where opportunities for employment were extremely limited until the present century.

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[18] Robert G. Albion, The Rise of New York Port, New York, 1939, p. 135-137.

[19] St. John de Crevecoeur, Sketches of Eighteenth Century America, (Henri L. Bourdin, ed.) New Haven, 1925, p. 144.

[20] Benjamin Franklin, Observations on Smoky Chimneys, London, 1793, p. 49.

The cutting of trees for fencing, although less significant in terms of its effect on the forest than cutting for charcoal or cordwood, was an important activity in the Highlands. The most popular fences on most of the hill farms were of the style called snake or Virginia rail, which required more wood than any other . They were usually constructed of chestnut, which is extremely durable and splits cleanly and evenly. The remnants of some of these old chestnut fences are still visible in some parts of the Highlands, a testimony to the durability of the wood of one of the finest trees of the eastern forest, now unfortunately exterminated.

Commercial lumbering - that is, the cutting of trees for sawlogs, mine timbers, railroad ties, boat fenders, and pilings - was of some importance in the Highlands, although the activities of the coal and fuelwood cutters left little large timber for the sawmill operators. The Highland forests were the source of several other products. Before the paper box and bag era, when barrels were the standard containers, the cooperage trade was of considerable importance, and large quantities of staves and hoops were obtained from the woodlands. Tanbark was also produced, especially from the bark of the chestnut and hemlock, but this industry was never as important in the Highlands as in the northern hardwood forests where hemlock was more abundant. Finally, the forest were a source of livestock fodder in the form of grass, browse, and mast. Although the practice of running livestock in the woodlands was a damaging one, it had an important place in the subsistence agriculture that prevailed in much of the area.

The modern era It is not possible to date precisely the end of the era of exploitation of the Highland Forests. Its demise was a gradual process which extended over a period of many years and varied from one area to another. It seems clear, however, that the role of the forests began to change markedly in the last generation of the nineteenth century. One of the major factors was technological change and the emergence of a modern industrial society. Wood simply was not needed for the same purposes as in the previous two centuries, and the forest gradually ceased to be the mainstay of the the Highlands economy. The decline of the charcoal industry after the Civil War was perhaps the best illustration of the results of a changing technology, and its effects on the forest were pronounced, since it led to a fairly rapid rejuvenation of growth over large areas.

At about the same time there began to emerge a conservation ethic, marked by a growing concern over the abuse of natural resources. Conservation became a dominant theme in forestry in particular, and the State became involved in forest surveys, forest management, fire protection, and other programs intended to improve the condition of the woodlands.[21]

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[21]Geological Survey of New Jersey, Annual Report . . . 1899. This entire report is devoted to forestry in New Jersey.

Perhaps the most important factor of all in ushering in a new era for the Highland forests was the increasing urbanization of northern New Jersey. One of its effects was that the water requirements of the major cities increased rapidly, and the unpolluted rivers of the northern Highlands, which could be easily tapped by gravity systems, were a natural source of supply. In 1893, C.C. Vermuele described the potential supplies available in the major watersheds of the northern Highlands, and pointed out that the Pequannock River was already almost fully utilized by the East Jersey Water Company, which supplied the city of Newark.[22] It was widely recognized that the forested Highlands were an ideal watershed area, and in the 1899 Annual Report of the State Geologist (p. 7 and 8) Vermuele wrote "The value of this Highlands forests is in the favorable conditions which it makes for gathering ground for the streams supplying water to the cities of the northeastern part of the state. The brooks in the woods do not carry so much earthy material as streams which receive water from bare ground and ploughed fields. The water is clear and not turbid or roily and is suited to city supply. The superior quality of water from such wooded districts . . . makes it desirable that the forests in the Highlands should be kept, and not be cleared and put in farms." Vermuele's words were apparently heeded; the city of Newark systematically acquired almost all the Pequannock watershed, and developed a system that has provided water of exceptional quality since before the turn of the century. Other watersheds of the Highlands were also tapped, reservoirs were built and a large part of the Highland forests became a protected gathering ground for water that was consumed in the urban areas of northern New Jersey.

It is interesting that the establishment of the Newark watershed led to a diversification of the forest cover in various parts of the Pequannock drainage area. As part of a reforestation program, various conifers, especially Norway spruce, several species of pine, Douglas fir, and larch were planted. Although the total area affected was not great, the conifer plantations became a distinctive feature of the upper Pequannock basin.

The urbanization of northern New Jersey and a rising standard of living in the area inevitably led to a great increase in the demand for recreational land. The heavily wooded northern Highlands, located within a few miles of the metropolis, were a prime recreational attraction. It is impossible to treat the complex subject of recreational land use in the Highlands in this paper, but a few general observations might be in order. Historically, recreational use of the Highlands has been almost entirely on a private basis, and has been centered on the numerous lakes and ponds, both natural and man-made, that dot the area. Until very recently, the State showed little interest in developing the recreational potential of the Highlands. Fortunately this policy appears to have changed, as evidenced by recent programs of the New Jersey Department of Conservation and Economic Development, which have included the development of several

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[22]Geological Survey of New Jersey, Annual Report of the State Geologist for 1893 Trenton, 1894, p. 381.

state parks, forests and other recreational areas within the northern Highlands. It is questionable, however, if present programs have gone far enough in reserving vacant forest lands in the Highlands for public use. These lands, already an extremely valuable resource, will become priceless as Megalopolis continues to expand and develop. It is unthinkable that any part of the Highlands now in public ownership, such as the Newark watershed area, should not be preserved essentially in its natural state for recreation, using that word in its fullest sense. Even those who do not share Thoreau's belief that "in wilderness is the preservation of the world" would probably agree that not all of northern New Jersey should be roofed and paved. Through a series of unusual and fortunate circumstances, a large area of forest land, with a rich historical legacy, has survived within a few miles of the world's greatest metropolis. A truly civilized society would insure its preservation for itself and for future generations.

THE APPLICATION OF GRAPH THEORY TO THE SIMULATED WATER TRANSFER NETWORKS OF NORTHEASTERN NEW JERSEY, 1970-1985*

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Rutgers University

INTRODUCTION

The objectives of this paper are twofold: 1) to modify the beta index by introducing link weights; and 2) to apply these modifications to the simulated northeastern New Jersey water transfer networks that resulted from a separate study.

Graph theory is a branch of mathematics that can be used to examine the topological characteristics of many different kinds of networks. The topology of a network is concerned with those aspects of the geometry of a figure which are independent of distance and angularity, i.e., the pattern of nodes and links.

The application of graph theory to problems in geography is discussed by Haggett (7),[1] Cole and King (2), and Werner (15). Other applications include studies concerning the connectivity of highway systems (3), consumer behavior (9), nodal region delineation (12), the structure of transportation networks (4,5,10), historical geography (13), urban growth networks (11), the topology of river systems (14), and urban water supply transfers (8).

There are approximately 145 separately-managed water supply agencies in the nine northeastern counties of New Jersey.[2] Of these 145 agencies, 55 (38%) engage in major interagency transfers, form a more or less connected network, and account for the bulk of consumption in the study area. The agencies and the transfers among them have been abstracted into a pattern of nodes and links, the first step in a graph-theoretical analysis.

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*The work upon which this study is based was supported in part by funds provided by the U.S. Department of the Interior, Office of Water Resources Research, Grant No. 14-01-0001-1583. I have benefited greatly from discussions with Professors Leonard Zobler (Department of Geography, Columbia University), George W. Carey (Department of Urban Planning and Policy Development, Rutgers University), and Michael R. Greenberg (Department of Geography, Columbia University).

[1]Numbers in parenthesis refer to the works cited at the end of this paper.

[2]Bergen, Passaic, Hudson, Essex, Union, Morris, Middlesex, Somerset and Monmouth.

A variety of graph-theoretic measures of network structure have been developed in the literature. Kansky (10) provides an excellent summary of these indices. One of the indices, beta, is a descriptive measure of connectivity within a network. The input for calculating beta consists simply of the number of nodes and links, all weighted at unity. This last factor suggests several ways of modifying the beta index by introducing empirically-derived alternative link-weighting schemes.

THE BETA INDEX - MODIFICATION ONE

The first modification of beta (hereinafter called BM-1) incorporates a transfer coefficient resulting from an input-output model of water transfers in the New York Metropolitan Region(hereinafter called NYMR) that was developed by Carey (in 16). Instead of calculating beta with all links equal to one, BM-1 weights all links with the appropriate transfer coefficient for the specified time period. For example, if the entire consumption of a sink node S is furnished by a source node R, the link RS receives a weight of 1.0. If source R furnishes sink S with 45% of the latter's consumption, the link RS is weighted 0.45, and so on. In this fashion, BM-1 weights all links with a value ranging from zero to one, depending upon the importance of the link to the sink. A link weight of zero denotes the absence of a connection for that particular time period.

The calculation of beta and BM-1 for a sample network is indicated in Figure H1. Assume that R is a source node, S is a sink node, and T is an intermediate node in the sense that it both transfers and receives water. In part A, the links are weighted at unity; consequently, the beta index is 1.0. The same network is shown in part B, this time with the pertinent transfer coefficients indicated next to the link.

R supplies S with 70% of the latter's consumption; hence, link RS is weighted 0.7. R also supplies T with 10% of T's consumption; T, in turn, supplies S with 10% of S's consumption. Thus, links RT and TS are both weighted 0.1. Note that the actual flow in links RT and TS need not be equal even though the transfer coefficients happen to be the same in the sample problem. By simple subtraction, sink S is 20% self-sufficient, as it receives 80% (70% + 10% = 80%) of its needs from other sources.

Figure H1-D depicts the input-output matrix for the sample problem in part B. The rows and columns are considered sources and sinks, respectively, with the flow of water going <u>from</u> the row agency <u>to</u> the column agency. The bottom row, called diversions, represents the primary inputs for the system and specifically refers to water being diverted from reservoirs and aquifers. Note that this system is analogous to the producing and purchasing sectors of the economy in an interindustry accounting system (1).

With the appropriate transfer coefficients in the numerator and the number of nodes in the denominator, the sample BM-1 index is 0.3. It is readily apparent that BM-1 is a more realistic measure of functional linkage change within a network.

THE BETA INDEX - MODIFICATION TWO

The second modification of beta (or BM-2) also uses an empirically-derived method of link weighting. In this instance, each link is assigned a value ranging from zero to one depending upon the degree of utilization of the link's capacity. If link RS has a capacity of five units, and only four units are being shipped through the connection during the time period in question, the link receives a weight of 0.8, and so on.

Figure HI-C illustrates the calculation of BM-2 in a sample network. The beta index in part A is 1.0. The links in part C are denoted by a fraction - the numerator indicates the flow while the denominator shows capacity. Link RT has a capacity of ten units with only four units actually flowing; thus, RT is weighted 0.4. The sample BM-2 index is 0.5.

In sum, the unmodified and modified indices can be arranged on a spectrum of data availability and level of abstraction. The most abstract, and the one requiring information only on the number of nodes and links, is beta. If flow information is available, one can use theta, which is the total volume of interagency transfers divided by the number of nodes in the net. BM-1 is further up the spectrum, as it requires data on transfer coefficients. BM-2 may be the hardest to obtain, since it requires a capacity tableau for each network. Thus, the modified indices require more data and are less abstract than the unmodified indices.[3]

THE SIMULATED WATER TRANSFER NETWORKS

Carey (in 16) has developed a linear programming model of the water transfer systems of the NYMR which can be used to simulate future networks. In this paper, discussion will consider only the most complex network in the NYMR - that of northeastern New Jersey.

Greenberg (6) has developed demand projections for every water supply agency in the region for five-year intervals from 1970 to 1985. His projections formed the input to the Carey linear programming model, along with agency safe yield estimates and linkage capacities for all interconnections. The objective function was defined as potential delivery to final demand. Thus, the linear programming problem was formulated as follows: maximize the objective function given demand, safe yield, and transfer capacity

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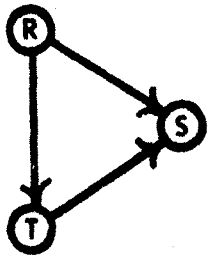
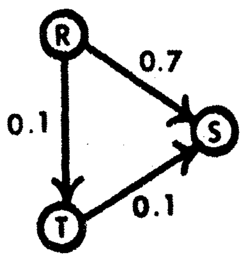
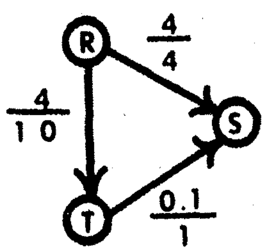
[3]Although not illustrated here, BM-1 and BM-2 reduce the computational bias inherent in calculating beta for small networks and facilitate inter-network differentiation.



A. $\text{Beta} = \dfrac{3 \text{ nodes}}{3 \text{ links}} = 1.0$



B. $\text{BM-1} = \dfrac{0.7 + 0.1 + 0.1}{3} = \dfrac{0.9}{3} = 0.3$



C. $\text{BM-2} = \dfrac{1.0 + 0.4 + 0.1}{3} = \dfrac{1.5}{3} = 0.5$

		Agency		
	From \ To	R	S	T
Agency	R	0	.7	.1
	S	0	0	0
	T	0	.1	0
Diversions		1.0	.2	.9

D. Sample input-output matrix

Fig. H1 Sample networks for calculating beta, BM-1, and BM-2.

constraints. An optimal solution for a simulated run is obtained when the demand for every agency is satisfied subject to the specified constraints.

One method of arriving at an optimal solution for each simulated period was to rearrange the network geometry. Existing links were expanded and new ones postulated between adjoining agencies before safe yield increments were programmed in. The rationale behind network redesign was to increase network connectivity and facilitate interagency transfers as much as possible as long as surplus water was available in the system. Only after network alteration had allocated all surplus water were planned safe yield increases brought in.

The computer simulations for New Jersey were based on the major net of 55 agencies. These agencies accounted for 80% of the total consumption of water in the nine counties in 1967. The proportion of transfers to total consumption was expected to grow from 36% in 1970 to 59% by 1985. To handle the projected demands, 21 existing links were increased in capacity and seven new links were postulated. The simulated BM-1, BM-2, and theta values rose from 0.67, 0.55, and 3.52 mgd in 1970 to 0.74 (+9.8%), 0.92 (+68.1%), and 8.16 (+131.8%) mgd in 1985, respectively. In the interest of brevity, only the 1970 and 1985 simulated networks will be illustrated.

The optimal solution for the 1970 demand projections required four link expansions while allowing a surplus of 58 mgd to remain in 11 source agencies. The model dropped 15 links that were not essential for the solution. The resulting digraph (Figure H2) is disconnected, with 14 nodes isolated from the major net. Jersey City (no.6) and Hackensack (no.5) form their own subgraphs. (See Table I for a list of the identification numbers for each agency.)

The simulated 1985 network (Figure H3) required two new links and 18 link expansions. Note that the link from Jersey City (no. 6) to Newark (no. 3) is of major topological and hydrologic importance, as it connects two of the largest source agencies in the network. The resulting interaction yields a complex pattern of water transfers, but one which is optimal in terms of water allocation.

Authenticity was realized in the simulations by insuring that all yield increments were introduced years after their probable date of construction and that all postulated links were based on either activation of existing but non-utilized links or on agency contiguity. A thorough discussion of the value of computer simulations as a means of designing networks for optimal allocation of a region's water resource is found in (16).

The simulated BM-1, BM-2, and theta values for the four projected time periods in New Jersey are shown in Figure H4. A marked upward trend is apparent in all cases. The non-linearity of the theta curve suggests that some form of logarithmic relationship may be in order. If one plots the values on semi-log paper (Figure H5), a definite linear relationship emerges. Apparently, B -1 and theta, and BM-2 and theta are related by an exponential function of the form:

$$Y = ab^X \quad \text{or} \quad \log Y = \log a + X \log b$$

The estimating equations and the standard errors of estimate are indicated in Figure H5. Although the samples are small (N = 4), the simulations suggest that as the connectivity of a network increases arithmetically, the volume of water being transferred increases geometrically.[4] The planning implications of this relationship are significant. For example, by increasing the number of links or the utilization of existing links arithmetically, the potential for interagency transfers increases exponentially. Therefore, the prospect of having deficient supply in certain agencies while others report surpluses should diminish rapidly as network connectivity increases, as long as total system supply exceeds total demand.

CONCLUSIONS

1) The modified graph-theoretic indices are less abstract than the beta index and require considerably more data to calculate, but they appear to be capable of more realistically assessing functional linkage change within a network.

2) The simulated networks of New Jersey have been abstracted into patterns of nodes and links. The resulting digraphs are models of the maze of pipes and conduits of all types and sizes that connect (or are projected to connect) one water system to another. As such, the models simplify reality, but only so as to better understand the structure of a complex system.

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[4]This finding is strengthened by an examination of 1961-1967 data. In particular, the slopes of the BM-2 and theta equations for the historica and simulated periods are similar and significant.

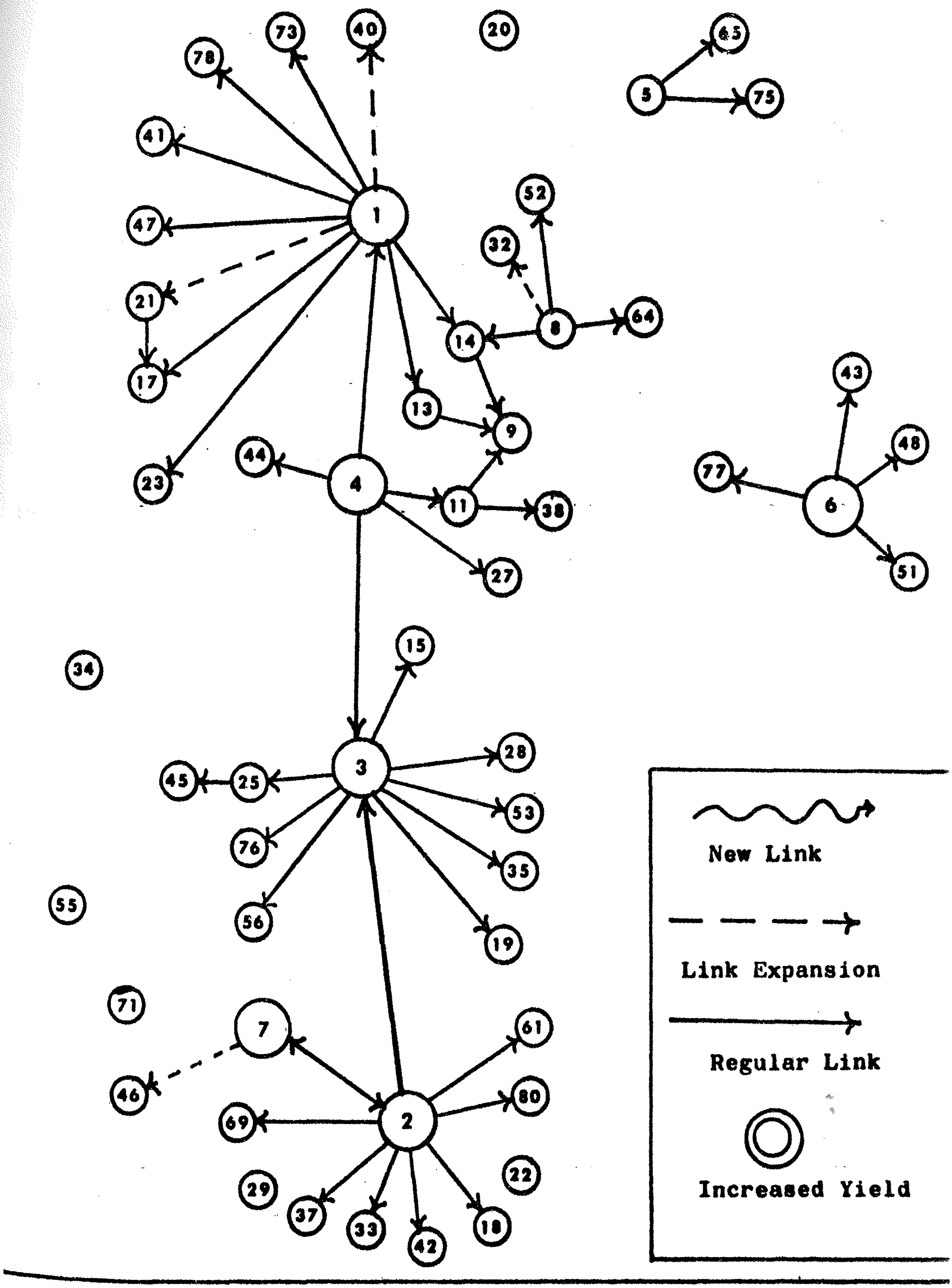

Figure H2. Northeastern New Jersey Water Transfer Network, 1970.

Table 1

LIST OF IDENTIFICATION NUMBERS FOR NORTHEASTERN NEW JERSEY WATER SUPPLY AGENCIES

1. Passaic Valley Water Commission
2. Elizabethtown W.C.
3. Newark
4. North Jersey District Water Supply Commission
5. Hackensack W.C.
6. Jersey City
7. Commonwealth W.C.
8. Essex Fells (Essex)
9. Cedar Grove (Essex)
11. Montclair (Essex)
13. N. J. Water Service Co. (Passaic)
14. Verona (Essex)
15. Bloomfield (Essex)
17. East Paterson (Bergen)
18. Edison (Middlesex)
19. Elizabeth (Union)
20. Fair Lawn (Bergen)
21. Garfield (Bergen)
22. Middlesex W.C. (Middlesex)
23. Nutley (Essex)
25. Pequannock Twp. (Morris)
27. Bayonne (Hudson)
28. Belleville (Essex)
29. Bound Brook W.C. (Somerset)
32. Caldwell (Essex)
33. Kilmer (Middlesex)
34. East Orange (Essex)
35. Essex County Hospital
37. Franklin Twp. (Somerset)
38. Glen Ridge (Essex)
40. Haledon (Passaic)
41. Harrison (Hudson)
42. Highland Park (Middlesex)
43. Hoboken (Hudson)
44. Kearny (Hudson)
45. Lincoln Park (Morris)
46. Livingston (Essex)
47. Lodi (Bergen)
48. Lyndhurst (Bergen)
51. North Arlington (Bergen)
52. North Caldwell (Essex)
53. North Jersey School - Totowa (Passaic)
55. Orange (Essex)
56. Packanack Lake (Passaic)
61. Rahway (Union)
64. Roseland (Essex)
65. Saddle Brook (Bergen)
69. Somerville W.C. (Somerset)
71. South Orange (Essex)
73. Totowa (Passaic)
75. Wallington (Bergen)
76. Wayne (Passaic)
77. West Caldwell (Essex)
78. West Paterson (Passaic)
80. Winfield (Union)

W.C. = water company
County names in parentheses

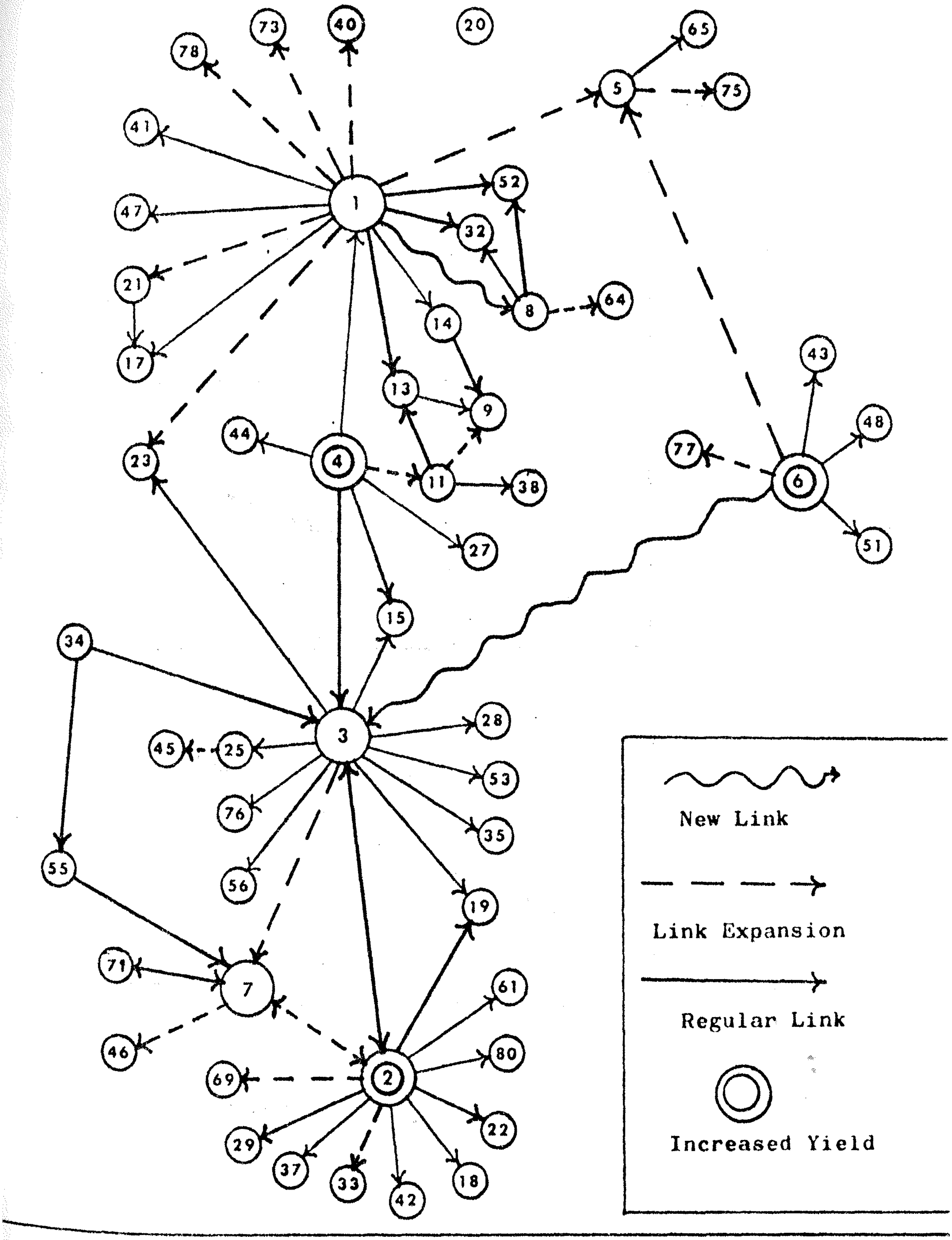

Figure H3. Northeastern New Jersey Water Transfer Network, 1985.

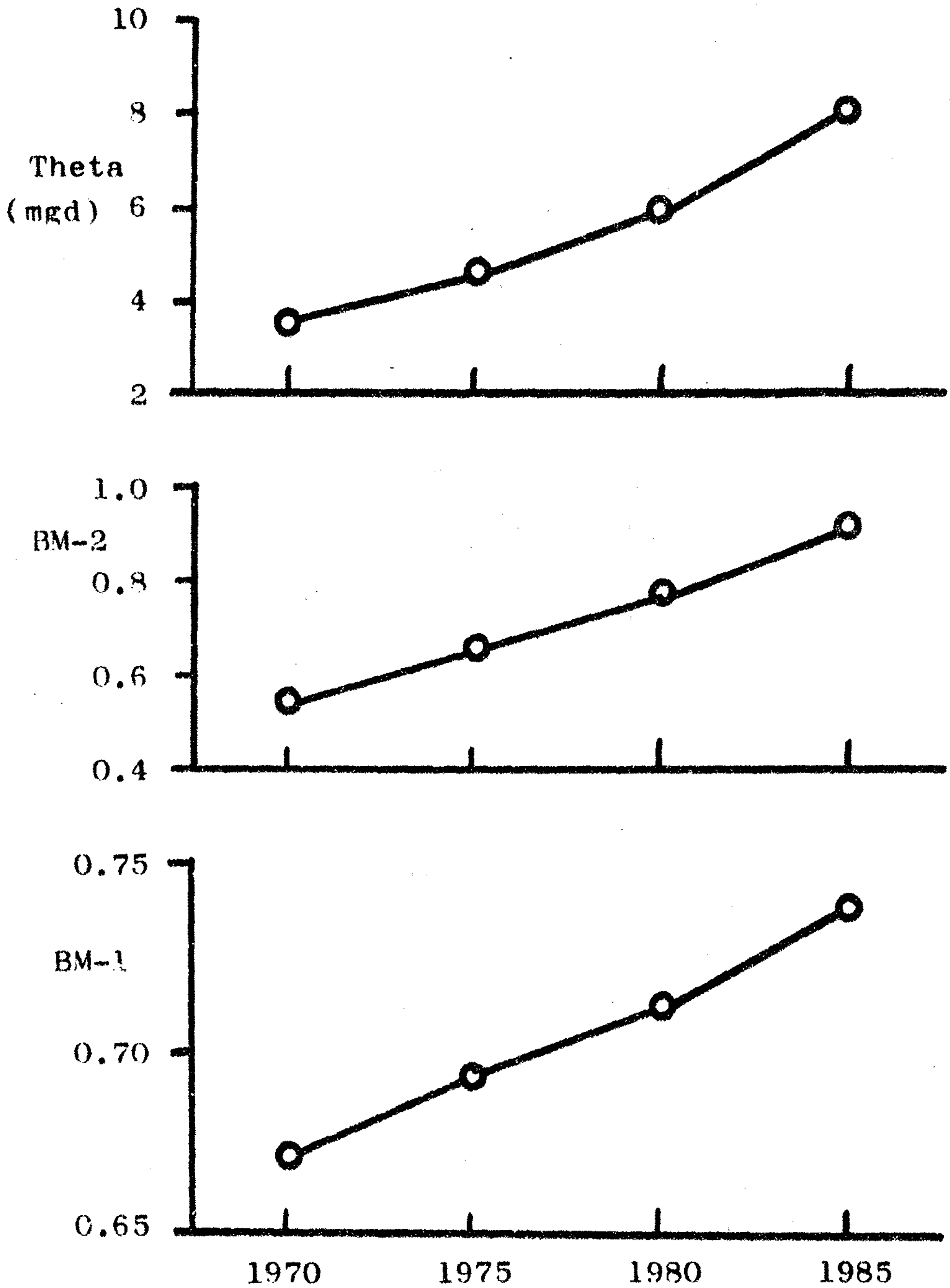

Fig. H4 . Northeastern New Jersey, graph-theoretic indices, 1970-1985.

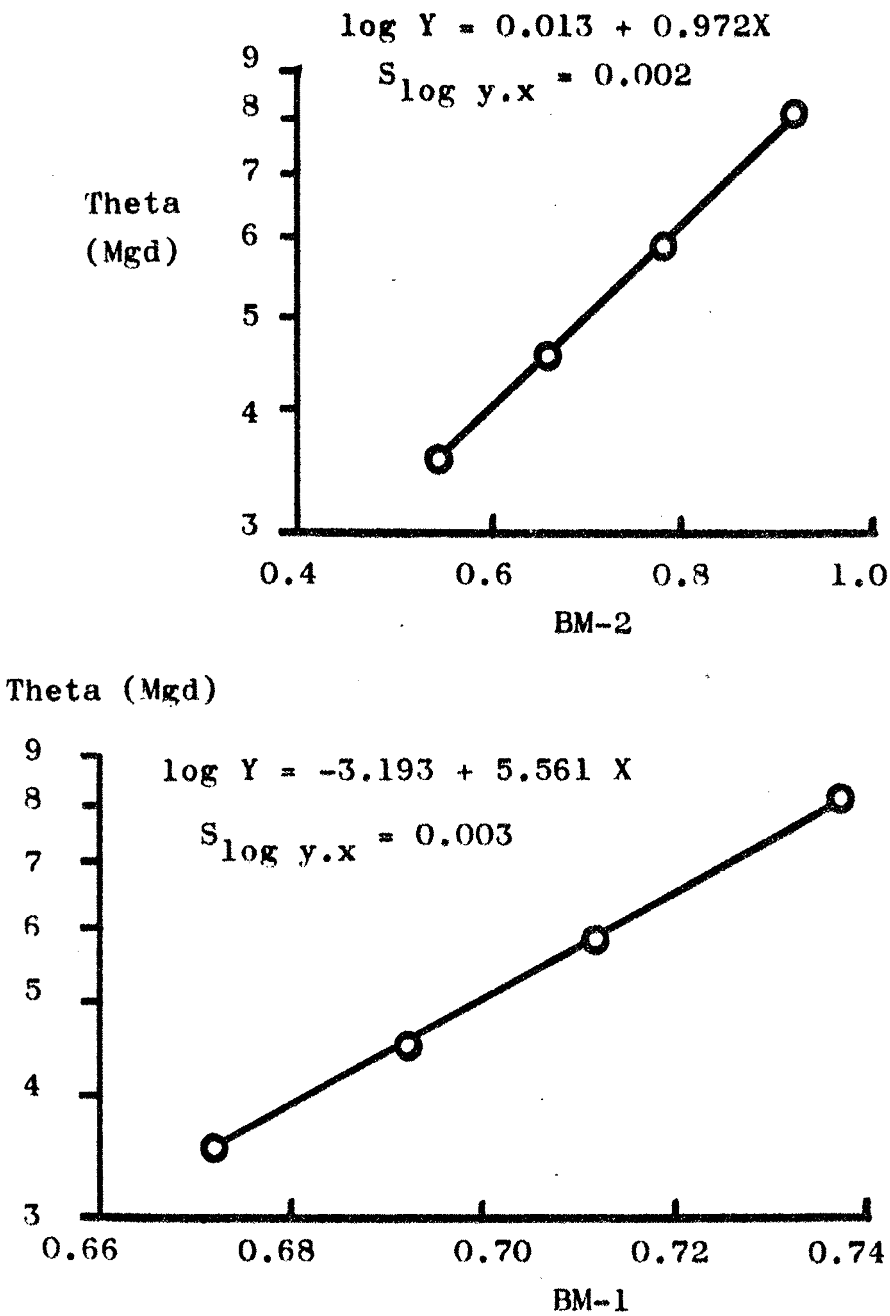

Fig. H5. Relationships between the graph-theoretic indices for northeastern New Jersey, 1970-1985.

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URBANIZATION, THE MANAGEMENT OF PUBLIC WATER SUPPLY SYSTEMS, AND THE WATER SUPPLY CRISIS: THE CASE OF TWO MUNICIPAL WATER SYSTEMS ON THE NEW YORK METROPOLITAN REGION[1]

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American citizens grow, build, and buy more than any other group in the world. They also demand more public services. The increase in the number and variety of public services provided in a more affluent and urbanized society combined with the increase in the variety and speed of the mass media have resulted in intensified scrutiny of these services. Judged by the mass media's coverage, public services may be broadly dichotomized into controversial and noncontroversial groups. Transportation, health services, education, and law enforcement seem to be constantly in crisis. Not only must the service be provided, but its success is dependent upon the public's subjective evaluation. Usually, the public initiates the crisis.

Power, water supply, fire protection, solid and liquid waste disposal experience periodic crises. Their performance is less controversial because their services are more standardized. In several cases judgement is monitored by machine. Consequently, the public service manager, rather than the public, usually initiates the crisis. This paper examines the role of the management of municipally controlled water supply systems in initiating and solving public water supply crises in the New York Metropolitan Region (NYMR).[2] The study is feasible because the NYMR is not dominated by a single wholesaling

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[1]This research was funded by the Office of Water Resources Research USDI, grant no. 14-01-0001-1583 made to Barnard College, Columbia University. The author is indebted to Mr. Edwin T. Erickson, Division Engineer of the Newark Division of Water Supply and Mr. James A. Neary, Water Works Superintendent of the Yonkers Bureau of Water for the use of agency records.

[2]Privately owned public systems which account for about one fifth of Regional output are not considered. Their managerial objective is profit maximization. As a result they tend to avoid restrictive measures unless forced to do so by a political authority.

and/or retailing agency.[3] It is hypothesized that management's reaction to a possible supply-demand problem is a function of each agency's unique supply and demand characteristics. A planning implication of the hypothesis is that water supply crises have been artifacts of narrow operational responsibilities. In turn, this would suggest that integration of the myriad of independently managed systems would alleviate, if not eradicate, most public water crises.

The hypothesis is tested by examining two municipal, public water supply systems with opposite supply and demand characteristics from the late nineteenth century through the water crisis of 1965-1966. The paper is divided into three sections: (1) an overview of the study area; (2) a chronology documenting the reaction of the two systems to similar regional supply-demand circumstances; and (3) a speculation regarding the nature of future public water supply crises.

Summary of Findings

It is found that the hypothesis is supported until World War II. Since the Second World War, a tendency toward equifinality in management practices has developed in the densely urbanized portions of the Region. It is suggested that this tendency toward similar management practices will be escalated in the future.

The Study Area

A test of the hypothesis requires a parallel examination of a series of crises in systems with a variety of supply and demand characteristics. The paucity of available records argued for an in-depth study of two systems. Newark, New Jersey and Yonkers, New York were selected. Presently Newark and Yonkers contrast the most among the more populous cities in the NYMR and perhaps among the cities in the larger area of Megalopolis.[4] Newark is generally identified with heavy industry, a low income population, and population emigration, Yonkers with suburban living, an upper middle income population, and population immigration.

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[3]Generally agencies in the arid west and the number of systems in the more humid east are dominated by a single wholesaling and/or retailing agency. See Garrett A. Smith, Jr., "A Method for Comparing the Water Distribution Structures of United States Urban Regions," in Leonard Zobler, George W. Carey, Michael R. Greenberg, and Robert M. Hordon, Benefits from Integrated Water Management in Urban Areas -- The Case of the New York Metropolitan Region, A Report Submitted to the Office of Water Resources Research, USDI, April, 1969.

[4]Jean Gottmann, Megalopolis: The Urbanized Northeastern Seaboard of the United States (Cambridge, Massachusetts: Twentieth Century Fund, 1961.

A comparison of relative population change, median family income, and the value added by manufacturing demonstrates their present polarity. In 1960, forty-two cities in Megalopolis had more than 75,000 residents. Between 1950 and 1960, only thirteen of these communities lost a greater share of their population than Newark. Conversely, Yonkers ranked third in positive population change.[5] In 1960, Newark ranked thirty-seventh in median family income, Yonkers ranked fourth.[6] And in 1963, Newark ranked tenth in per capita value added by manufacturing, Yonkers ranked thirty-seventh.[7]

However, the present contrast is of relatively recent origin. In the late nineteenth century, per capita value added by manufacturing was greater in Yonkers than in Newark.[8] Population emigration from Newark and mass suburbanization in Yonkers were not manifest until the close of World War II. Previously, Yonkers had recorded higher relative population growth, Newark higher absolute growth.

Per capita water demand reflects these observations. Total per capita demand is presently fifty percent greater in Newark (Table I). It was similar until the depression of 1929. Domestic per capita demand was parallel through the Second World War. Then growth in upper middle income families living in single family homes raised domestic per capita demands in Yonkers twenty percent above Newark's. While Yonkers has lost several of its largest water-using industries, Newark has outstanding representation in the heaviest public water-using industries such as food and chemical.

In addition to their present contrasting demand patterns, the two communities have assumod opposite positions in obtaining their supplies. Newark has become a source agency for as many as a dozen neighboring systems, while Yonkers has become dependent on the New York City supply. Overall, if the hypothesis is valid the systems' policies should have become progressively dissimilar.

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[5]U.S. Department of Commerce, County and City Data Book: 1967 (Washington: U.S. Government Printing Office, 1967), Table A-2.

[6]*Ibid.*, Table 4.

[7]U.S. Bureau of the Census, Census of Manufactures - 1963 - Area Statistics (Washington, D.C.: U.S. Government Printing Office, 1963).

[8]In 1890, per capita value added by manufacturing was $322 in Yonkers, $261 in Newark. By comparison it was only $188 in the present seventeen-county New York and northeastern New Jersey Standard Consolidated area.

FIG. GI

NEWARK AND YONKERS

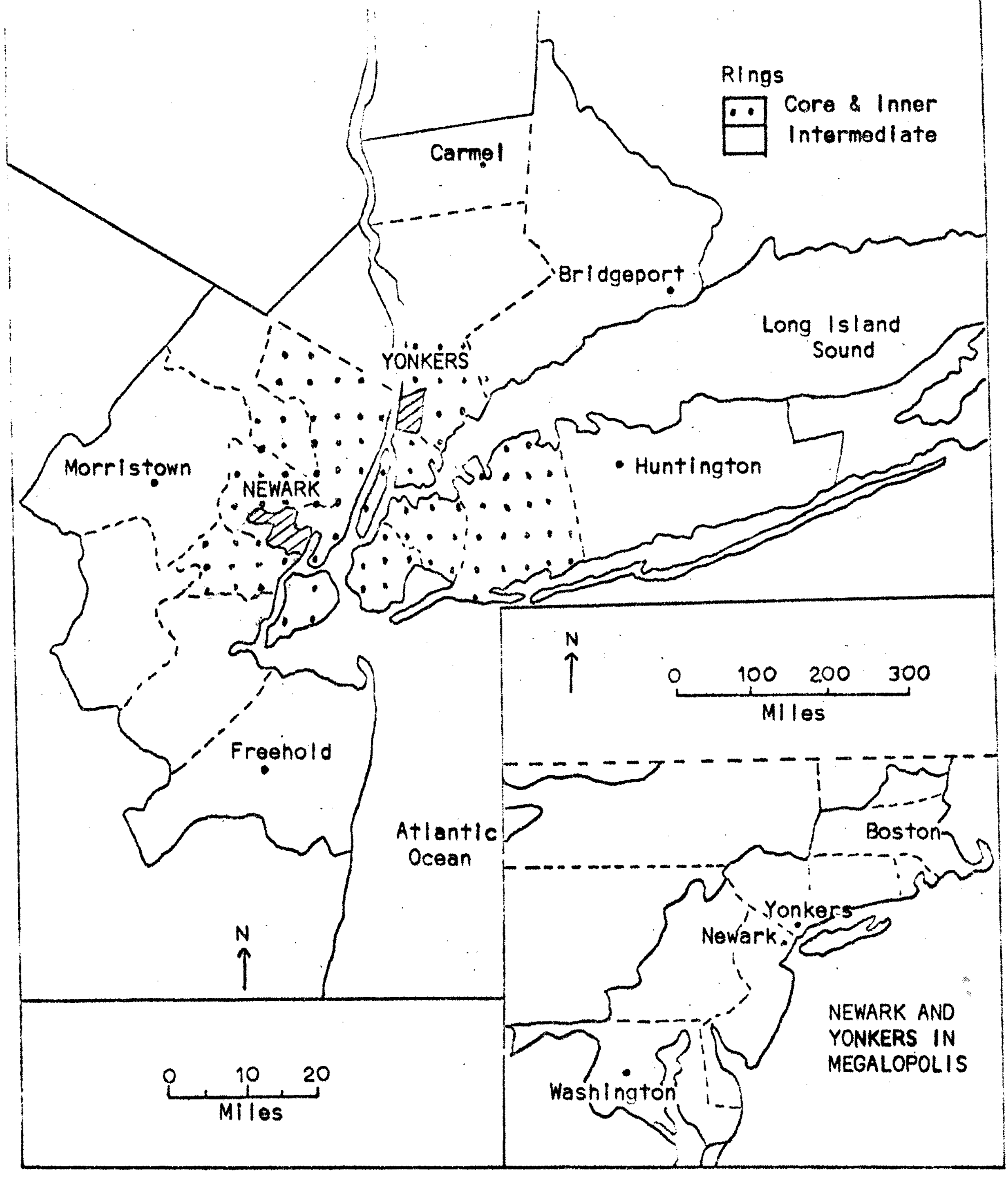

TABLE I -- Gallon Per Capita Daily Water Consumption: Yonkers and Newark: 1900-1961[9]

	Total			Yonkers		Newark	
Year	Newark	Yonkers	Yonkers' Use As Percent of Newark's	Domestic	Comm.-Indus.	Domestic	Comm.-Indus
1900	98	76	78	--	--	--	--
1915	110	117	106	--	--	--	--
1925	106	113	107	37	38	38	48
1935	105	92	88	40	20	42	41
1945	147	100	68	45	21	48	72
1955	159	127	80	64	19	54	78
1961	190	129	68	72	17	61	98

A Chronology of Water Supply Crises in Newark and Yonkers

Analysis of agency records suggested a three-stage sequence of crises paralleled by urbanization: (1) Pre-World War I -- local crises and limited management reactions as hypothesized; (2) World War I to World War II -- local crises still dominate, but management reactions become more pronounced; and (3) Post World War II -- a tendency toward equifinality in management's perception and reaction to crises, refuting the hypothesis.

The Late Nineteenth and Early Twentieth Centuries

The hypothesis is supported by evidence prior to World War I. Management's decisions varied according to local conditions. In 1874, Newark's chief engineer, G.H. Bailey, decided against participation with Jersey City to develop lakes and streams in the northern part of New Jersey because the City's supply was adequate (Newark, 1874). Jersey City's supply was threatened by salt water intrusion, Newark's was still satisfactory. Between 1874 and 1877, daily consumption rose forty-two percent due to the economic recovery following the depression of 1873. It was planned to reinvestigate new supplies. However, the drilling of wells and the metering of the seventy-eight largest consumers temporarily matched the growth increment (Newark, 1879). In 1886, daily consumption was almost double consumption a decade earlier. In response metering of industrial consumers was intensified. And in turn, consumption per tap decreased twenty-one percent between 1881 and 1886 (Newark, 1886). Thus, management's reactions to the first problems were specific and limited.

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[9]Source material for this table are annual reports of the two agencies. To conserve space in the text references are cited by city and year.

However, in 1889, ten years after its original recommendation, Newark contracted for 27.5 mgd in the Pequannock watershed. The action had been forced by a combination of local growth and urbanization upstream along the Passaic River which had polluted Newark's Belleville supply. By 1891 daily demand was almost three times consumption fifteen years earlier. Consumer response to climate added to the growth increment set off a specific reaction aimed at a specific mechanism threatening the supply. During the months of June, July, August, and September fans had caused an "extraordinary increase" in consumption. Consequently all but motors for church organs were metered. By 1894, consumption per tap in these months had been driven down twenty percent (Newark, 1894). Thus, in Newark the first crises were manifestations of national trends in urbanization and economic fluctuations, and local trends in supply. The crises were met by specific measures aimed at holding demand until the supply could be incremented.

By 1895, consumption was almost four times the use of two decades earlier. The first serious crisis was just ahead. The early warning was high winter demands, caused by residents allowing their water to run during the cold winters (Newark, 1895). In 1898, daily demand reached 27.4 mgd. During the blizzard of 1898, average daily consumption rose forty percent above the supply of 27.5 mgd (Newark, 1898). Besides securing the rights to another 15 mgd through well drilling and purchase, Newark embarked on its first extensive metering program. In 1893, five percent of the services were metered, by 1903 forty percent. The effect on those consumers tabbed most "wasteful" by inspectors was marked. Consumption dropped eighteen percent between 1898 and 1903. The supplementary 15 mgd was not needed (Newark, 1899, 1900, 1903).

In 1900, Newark's supply was increased one hundred percent when it obtained rights to the Pequannock system. Policy immediately changed. In 1910 and 1911, the system was able to profit from a small drop in regional precipitation which adversely affected the supplies of neighboring agencies without access to a major surface supply. Thus, prior to World War I, Newark's position changed from a system facing periodic crises to one profiting from others' crises.

Yonkers' water supply circumstances were similar to those of Newark's suburbs. In 1900, Yonkers was dwarfed by New York City to the south and its population was too small (47,931 or about one-fifth of Newark's) for the development of large-scale surface systems. Yonkers' supplies were limited to local sources, while New York City developed surface supplies in northeastern Westchester. As a result management's reactions were similar to those of Newark's suburbs. Unlike Newark, in Yonkers metering had been adopted and proceeded as the system expanded (Yonkers, 1898). Yet water was purchased in 1895 and 1896 (Yonkers, 1895, 1896). In 1898, new wells saved water to factories from being turned off (Yonkers, 1898). And in 1910 and 1911, while Newark sold water, Yonkers had to purchase water, despite improvements in its storage and purification systems (Yonkers, 1957). Thus, in the early twentieth century, supply conditions dictated policy. A crisis in Yonkers tended to be paralleled by a profit for the Newark system. While Newark's management was able to use metering selectively, Yonkers was forced to institute universal metering.

World War I to World War II

In the period from 1910 through the depression of 1929, the city of Yonkers experienced its largest population increase, while Newark grew at a lower rate, but recorded a higher absolute increment. The result was a radical change in water supply policy in Yonkers and an escalation of the previous trend in Newark.

In Newark, the last demands of the First World War and construction of Port Newark initiated a second crisis to surplus cycle. Between 1915 and 1916, use rose from 42.6 to 47.7 mgd, or less than three percent away from the supply. Previously, metering had been directed largely at industrial and commercial consumers. Domestic consumers were the new targets. Domestic consumption per capita declined substantially. Total consumption dropped from 118 to 114 gpcd. This step permitted the enlarging of a watershed reservoir which satisfied demand until 1924 (Newark, 1917, 1924). In 1924, metering of industrial consumers, probably those recently settled in Port Newark, was intensified to keep demand under 50 mgd until the existing watersheds storage capacity could be expanded. Per capita demand was kept steady and absolute consumption was kept within the available supply. With the addition of a new system in 1930, Newark, unlike Yonkers, had no problems with the "drought" (Yonkers Statesman, February 17, 1931) of 1929-1932. Thus, the second crisis to surplus cycle in Newark was similar to the first. The reaction to the crisis was the application of metering to an increasing percentage of the population to stabilize demand. When the supply was incremented the system again profited from a crisis in neighboring communities.

In Yonkers as urbanization continued the supply problem intensified. In 1924, Yonkers permanently connected its system to New York City's supply.[10] After 1924, one can generally measure urban growth in Yonkers by the increments of water purchased from the New York City system (Table 2).

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[10] In 1905, the New York State Legislature gave Westchester communities the option of withdrawing water from the New York City supply at the per capita rate used in New York City.

TABLE 2 -- Water Purchased from the City of New York by the City of Yonkers: 1925-1965

Year	Water Purchased (mg)	Percent of Water Used in Yonkers
1925	483	10
1936	537	14
1945	735	14
1955	4394	55
1965	6435	74

Source: Yonkers' agency records.

The change in source was matched by a change in the reaction of management to crisis: reluctance to impose restrictions. In 1931, New York City urged Yonkers to ration water. The management asked for voluntary restrictions, and promulgated minor restrictions governing street cleaning (Yonkers Statesman, January 30 and February 17, 1931). While Yonkers was disputing New York's call for restrictions, Newark was able to sell almost thirteen percent of its supply. Thus, prior to the Second World War, Yonkers and Newark were managed with local perceptual ranges: crises were local and actions to meet them reflected local constraints. These constraints had been established forty years earlier when Newark's tax base was sufficient for the establishment of a surface system, while east of the Hudson River New York City's dominance influenced policy. Overall, the Region's water systems may be characterized by the highly independent systems shown in Figure G2-A.

World War II to the Present

The post World War II period has been marked by a tendency toward equifinality in system management in the densely developed portions of the Region. Crises and management solutions have been relatively similar.

In Newark not until the demand generated by World War II had been sustained did consumption threaten the supply again. As in the 1890's consumer reactions to climate gave the early warning. In 1944, 1947, and 1948 high summer temperatures initiated short-term supply problems due to the unauthorized use of fire hydrants (Newark, 1944, 1947, 1948). Finally, in 1949 a thorough set of restrictive measures was imposed. After intensifying the metering of all consumers and appealing for voluntary restrictions involuntary restrictions were promulgated for the first time in the last two months of 1949: the use of water for street cleaning was eliminated, car washing was prohibited on four weekdays, large air conditioning units were required to have water saving devices installed, and pressure was cut in given areas (Newark, 1949). In turn, between

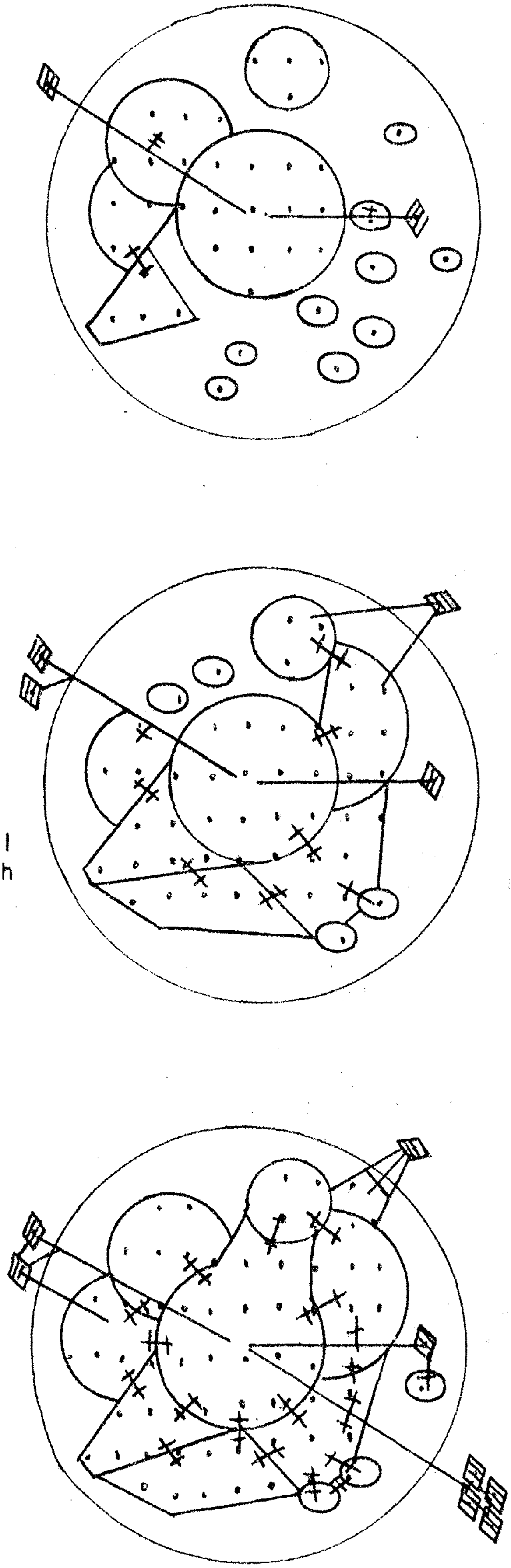
FIG. G2

URBAN WATER SYSTEM MODEL

A. Pre World War II

B. World War II through 1965

C. Projected



Legend

- Non Local reservoir
- Aqueduct
- Inter-connection
- Service Area

1948 and 1950, daily per capita consumption dropped fourteen percent: from 159 to 139 gpcd. Thus, in Newark growth resulting from World War II produced the simultaneous intensification of metering of all consumers and involuntary restrictions both for the first time. However the effect only compared to the initial effect of metering at the turn of the century.

Post World War II growth also produced the first widespread involuntary restrictions in Yonkers, though again quite reluctantly. From December 8, 1949, through January 18, 1950, The New York Times had daily front-page articles on what was called the worst drought in New York City's history. The following were among the harsher measures and threats proposed by New York City: no auto washing (New York Times, December 8, 1949), the threat of metering 150,000 multiple dwelling units (New York Times, December 10, 1949), threatened cutback of industrial use, especially breweries and soft drinks, cutoff of school showers (New York Times, December 12, 1949), threat of prison for those caught violating the restrictions more than once (New York Times, December 21, 1949), and a series of shaveless and bathless Fridays and Saturdays. Between 1948 and 1950, per capita distribution in New York City dropped twenty-four percent: from 150 to 121 gallons.

In 1950, Yonkers obtained almost forty-five percent of its water from New York City sources. Despite the indirect pressure of the media and direct pressure from New York City, involuntary restrictions were not promulgated in Yonkers until February 25, 1950 (Yonkers Herald Statesman, February 25, 1950). Between 1948 and 1950, use in Yonkers fell twelve percent, half of the decline in New York City. However, per capita consumption fell from 114 to 100 gallons, twelve percent less than New York City. In short, as in the 1930-1931 problem, Yonkers with the New York City supply to draw on was reluctant to impose restrictions. When it did, the measures were similar to those imposed in Newark. Urban development was the reason. Both systems had obligations requiring involuntary restrictions to achieve the desired short-term effect.

The role of urbanization in overriding local supply and demand conditions is clearly illustrated by the 1949 crisis. In contrast to the series of articles noted above, Meigs stated that "the New York 'drought' of 1949 simply accentuated the long-term trend of increasing demands for water."[11] Examination of precipitation records in the Newark watershed and the Central Park station support Meigs' contention. The precipitation deficit in the five years immediately preceding the restrictions was less than the deficits in previous local crisis periods: 1908-1912, 1914-1918, and 1928-1932. Thus, demands initiated by the Second World War and sustained by urban growth generated comprehensive involuntary restrictions by both agencies for the first time.

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[11]Peverll Meigs, "Water Problems in the United States," Geographical Review, 42 (July, 1952), p. 363. Meigs was the Chief of the Climatological and Physics Section, Pollution Branch, Office of the Quartermaster.

The tendency toward similar management perception and reaction was strongly manifest during the 1965-1966 crisis. Between 1950 and 1965 Newark and Yonkers assumed their present opposite socioeconomic characteristics. And Newark became a larger supply agency, Yonkers a larger sink of New York City. Nevertheless, the Newark and Yonkers systems declared involuntary restrictions only twenty days apart: Newark through Governor Hughes (June 12, 1965) and Yonkers (July 2). The restrictions were similar in both communities and more thorough than the 1949-1950 sets; no filling of pools, no auto washing by individuals, no lawn sprinkling, no street cleaning, and no air conditioning devices without water-saving attachments (New York Times, June 13, 1965; Yonkers Herald Statesman, July 2, 1965).

Between 1948 and 1950, consumption had dropped fourteen percent in both Newark and in Yonkers. Between 1964 add 1965, use dropped six percent in Newark, eleven percent in Newark and its suburbs, and fourteen percent in Yonkers. Because of its coincidence with the mid-year, a more accurate view of the impact of the restrictions is obtained by examining monthly averages. In the months affected by involuntary restrictions, consumption declined twelve percent in Newark, twenty-three percent in Yonkers. Relative to the 1949-1950 drought and to one another, the data suggest that the effect was more marked in Yonkers because of that City's growth between 1950 and 1965 in single family residential land use, the sector cost affected by the restrictions. The effect may have differed, but the policy was similar. As the difficulties of meeting increasing absolute increments have grown short-term measures aimed at holding demand until supply can catch up have become more widespread, more stringent, and more uniform.

The tendency toward equifinality among systems in densely developed portions of the Region is supported by an examination of the spatial distribution of demand contractions during the latest crisis. If urbanization is responsible, the less developed portions of the Region should have demonstrated limited or no restrictions during the 1965-1966 period. They did. Between 1964 and 1965, distribution by public systems dropped from 2.2 bgd to 2.0 bgd. Restrictions were rarely required in the intermediate ring. They were in the core and inner rings. Between 1964 and 1965, distribution declined in eleven of the twelve counties entirely or partially in the core or inner rings. Conversely, consumption dropped only in one of nine intermediate ring counties.

This sharp distinction reinforces the relationship between density of development, nature of source, and managerial policy. The average agency in the core and inner rings operates at a larger scale than its counterpart in the intermediate ring. The first distributes more water at a greater density than the second (Table 3). Consequently, except where geological conditions leave little choice, the larger agencies have developed surface sources requiring substantial capital investments over extended periods. Surface systems were rapidly depleted during the 1962-1966 period. Conversely, systems on the Region's periphery, generally operating on a smaller scale, rely on relatively underutilized ground water, less frequently on lakes and small streams.

TABLE 3 -- Water Distribution Data: Core and Inner, and Intermediate Rings

Measure	Core and Inner	Intermediate
Number of agencies	116	274
Distribution per agency (mgd)	16.57	.96
gpcd	147	112
Distribution in mgd per square mile	1.46	.08

At the county scale, the two exceptions reinforce the general pattern. Nassau was the only county in the core and inner rings to increase distribution between 1964 and 1965. All of Nassau's public water supplies are groundwater which can be mined during a crisis. Monmouth was the single county in the intermediate ring to record a drop. The largest agency in the county, supplying more than half of the water, is largely dependent on surface supplies.[12] Thus, management in the densely developed portions of the Region demonstrated similar policies, while their counterparts in the less urbanized areas reacted individually or not at all.

Speculation: Future Water Supply Crises in the NYMR

Additional regional trends in system management suggest that the tendency toward equifinality revealed by this historical study is likely to be escalated in the future. Uniform reaction is suggested by the increasing size of retailing systems, the increasing costs and therefore size of water supply projects, and research suggesting the benefits of interconnecting systems. In the model pictured in Figure G2-C not only would long-term local crises be minimized, but short-term seasonal and daily peak problems might be alleviated by systems responding automatically to any intraregional problem. In addition, interregional exchanges might minimize regional crises.

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[12]Monmouth Consolidate draws much of its supply from Swimming River, Shark River, and Whale Pond Brook.

SOME COMMENTS ON THE SOCIAL DIMENSIONS OF SEWAGE TREATMENT PLANT LOCATION

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The sewage treatment plant is an essential element in the movement to upgrade the quality of the environment, yet ironically it is often viewed in itself as a detriment to the environment from people who face the prospect of having such a facility located in their neighborhood. Past protests against these plants in the New York Metropolitan area have been based on perceptions of the facilities as "detrimental to the health and welfare" of the community,[1] a depressant on real estate values[2] and "an affliction to the eyes . . . an attack upon the nose."[3] In Harlem, plans for a 220-million-gallon-daily plant were attacked as "an affront to minorities" and an indignity imposed on the community which would allow everyone to "know at once where Harlem begins."[4]

The public at large is apparently not alone in its low opinion of a sewage plant's character. New Jersey's Assistant Director for Water Pollution Control has offered this assessment of the environment surrounding the state's treatment plants:[5]

> Today there are more than 750 sewage treatment plants serving communities or parts thereof operating in New Jersey . . . Each of these treatment plants is the center of a blighted area in its locality. No one voluntarily makes his home near a disposal plant.

A recent report co-authored by New Jersey's Commissioner of Health and its Director of the Division of Clean Air and Water also makes reference to "many of the existing treatment plants [which] are focal points of local blight."[6]

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[1] New York Times, Feb. 16, 1965, 29:1.

[2] Ibid., June 10, 1947, 6:4.

[3] Ibid., March 20, 1947, 29:1.

[4] Ibid., April 5, 1968, 29:1; April 26, 1968, 45:1.

[5] Robert S. Shaw, "The Stony Brook-Millstone Valley: A Case Study of the Regional Approach to Sewerage Collection and Treatment," New Jersey Municipalities, May, 1967.

[6] Roscoe P. Kandle and Richard J. Sullivan, Anticipated Capital Needs for Sewerage Facilities in New Jersey, New Jersey Department of Health, Feb., 1969.

In view of this apparently wide-spread negative attitude towards sewage treatment plants and the possible blighting effects these facilities may introduce, research was undertaken to gauge the social dimensions of sewage treatment plant location. Hopefully an analysis of the real and perceived effects of treatment plant location on a community's social ecology might be useful in formulating an overall system design for an urban water resource program.

This paper is a report on one aspect of the proposed research: the effect of sewage treatment plant installation on local real estate values. Despite the above indications that the public perceives these plants as an obnoxious intrusion into their environment, an analysis of the area surrounding two New York City plants before and after their construction has given no support to the hypothesis that property values are adversely affected by the introduction of a sewage plant. These findings, although drawn from an admittedly small sample and subject to the methodological qualifications discussed below, do raise some interesting questions as to whether an "information gap" between planners and the public is partly to blame when tensions mount over proposed projects of this sort. If this is the case, perhaps perceptions which lead to disruption of the system design might be overcome by increasing the information concerning the project which is available to the community.

Bitter political struggles and social unrest can often result from protests of a local community against the location of such public works as sewage treatment plants, highways, airports and the like. Quite apart from these unfortunate consequences, another result of public opposition to undertakings of this type can be a sudden change in the overall system design of which the particular facility is but one element. Since it is the nature of systems that a change in one part is met by adjustments in its other elements, the delay or abandonment of a sewage plant or highway route can impair the effectiveness of an urban area's water supply-waste disposal system or transportation system. It is therefore imperative from the standpoint of the overall system -- not to mention, of course, the welfare of the people involved -- that planners and decision makers consider the social impact of a public works policy, less community opposition to individual elements cause a disruption in the system design.

An illustration of this last point is offered by the local reaction to the previously cited Harlem treatment plant. The facility, to be located along the Hudson River from 137th to 145th Streets, is one element in New York City's planned eighteen-plant sewage system, the general design of which dates back to the City Planning Commission's 1941 Master Plan of Sewage Treatment Plant Sites and Tributary Areas.[7] Aside from the comments mentioned earlier, Harlem leaders were also outraged at the plant's architectural design, which called for enormous fountains and water displays to decorate the twenty-two acre roof. They believed that the community could make better use of parks and playgrounds rather than fountains on

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[7]U.S. Dept. of Health, Education and Welfare, Proceedings, Conference in the Matter of Pollution of the Interstate Waters of the Hudson River and Its Tributaries, Sept. 28-30, 1965, p. 391.

the roof. The net result of the controversy is that the fountains have been eliminated and a group of local residents is advising the city on how the area surrounding the plant might best be utilized to meet the needs of the community.[8] It is unfortunate that it took a few years to bring together the public and the planners since the plant will now undoubtedly remain in the design stage for some additional time. Construction was originally scheduled to begin in December, 1968.[9] Meanwhile, New York City's effort to establish an efficient waste-water system is still plagued by the raw sewage which is dumped into the Hudson and Harlem Rivers from Manhattan's West Side and Northern tip.

If it were possible to measure the social costs of projected projects in the manner that economic costs and engineering constraints are utilized for cost-benefit analysis, it might be possible to identify in advance those areas in which community concern might pose a threat to the system. Apparently little work has been undertaken along these lines in regard to water resources. For example, the Bibliography on Socio-Economic Aspects of Water Resources, issued by the Office of Water Resources Research in 1966, lists only a relatively few entries under "social aspects", and most of these are actually concerned with cost-benefit analysis. The present sutdy is one small attempt to fill this void by comparing the perceived view of sewage treatment plants as blighters of the environment with real estate data for the area surrounding two of these facilities.

The Owls Head Sewage Treatment Plant in Brooklyn and the Rockaway Plant in Queens (Figure F1) both began operation in 1952. Under the assumption that any blighting effect which these plants may have had on their local environments would be reflected in the census block data on apartment rental rates and private home values between 1950 and 1960 was made.[10] These two plants were selected for study on the basis of the available data and also for the fact that their construction early in the decade allowed ample time for long-range results to be reflected in the 1960 census.

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[8]New York Times, November 11, 1968, 43:2.

[9]U.S. Dept. of Interior, Federal Water Pollution Control Administration, Proceedings, Conference in the Matter of Pollution of the Interstate Waters of the Hudson River and Its Tributaries, Second Session, Sept. 20-21, 1967, p.175.

[10]The census classifies housing units as "renter-occupied and "owner-occupied." For simplicity the assumption is made that the former are apartments and the latter are private homes. In addition, the 1950 census includes vacant units in its computation of the average rents and home values for each block, whereas the 1960 cnesus bases its figures only on occupied units. The net effect of the elimination of vacant units in 1960 is considered to be of minimal significance for this study since all blocks are equally affected. The change would have an effect only if a block had a large number of vacant units, relative to the number of occupied units, in 1950 whose value differed considerably from the value of the occupied units.

If the facilities did act as a depressant on real estate values, one might expect that a positive relationship would exist between distance from the plants and the rate of increase of rental rates and home values. That is, blocks nearer to the plants would show smaller percentage increases than blocks farther away. (It should be noted that all values would be expected to rise in absolute terms due to inflation.) Data were compiled for blocks within a one mile radius of each plant. The results are given in Figures F2 through F4.[11]

No apparent relationship between distance and rate of increase of rent or home value stands out on these scattergrams. It is possible, however, that some spatial pattern is masked by the aggregation of all data by distance, irrespective of direction. To test whether sectors of varying socio-economic characteristics exist about the Owls Head plant[12] and whether within these sectors there is variation in rent and home value with distance from the plant, four lines were drawn at random in different directions out from the plant. For each line a comparison of distance from the plant with rent and home value was made for the blocks touching on that line. No relationship was found in any of the four cases.[13]

One question which this report has not dealt with is over how great a distance would one expect any blighting effects of a sewage plant to be felt? Intuitively, the local environment of the plants studied here was believed to be less than one mile. Measurements were taken for distances up to a mile in order that comparison could be made between blocks near the plant and areas which were not likely to be affected by the plant. But might this "affected area" -- that area in which people perceive tha plant as a threat to their environment -- be larger than one mile? Or might it be a matter of only one or two thousand feet, in which case the data for Owls Head would be of little value since the nearest residential area is about 1400 feet from the sewage facility?

It would seem that the affected area would be partly a function of aspects of the visible environment, not the least of which in a congested urban area would be the size of the buildings. It is possible that if an individual's vista were limited by tall buildings he might not perceive the existence of a sewage plant, even though the actual physical distance between the individual and the plant was small. Clearly, further research along these lines will have to consider a more sophisticated concept than strict linear distance as an explanatory variable.

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[11]No graph is presented for owner-occupied units around the Rockaway plant due to the relatively small number of occurrences there.

[12]This method could not be applied to Rockaway in view of its location on a narrow penninsula.

[13]These scattergrams are not included in this paper.

It must be emphasized that no field work was undertaken in connection with this study. The author is unaware of features in these two areas which may have influenced the values of the housing units. Nevertheless, the data do suggest that sewage plants do not necessarily bring conditions of blight to a neighborhood, at least as the blight is reflected in rents and home values. This raises the question of whether in some cases the blight is inadvertently introduced by the public themselves by means of a self-fulfilling prophecy. How much of the social cost of a public project and how much of the resultant system disruption can be traced back to community perceptions which are based on inadequate information?

The lack of any negative effect on real estate values around the Owls Head facility illustrates that social costs might possibly be reduced by a program which increases the information available to the community. In the case of this plant, which was opposed by residents of the area, a program was instituted to meet this opposition as described in the following passage:[14]

> . . . the site is less than 2000 ft. from residences. Bay Ridge dwellers wondered whether elimination of a widespread condition would not breed one of another nature and dump it right in their laps. Visits to other city treatment plants and explanations of the elaborately planned design features for elimination of objectionable odors broke down their protests over the plant site.

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[14]"Owls Head Sewage Treatment Plant," Diesel Power and Diesel Transportation, Vol. 30, No. 3, March, 1952, p. 30.

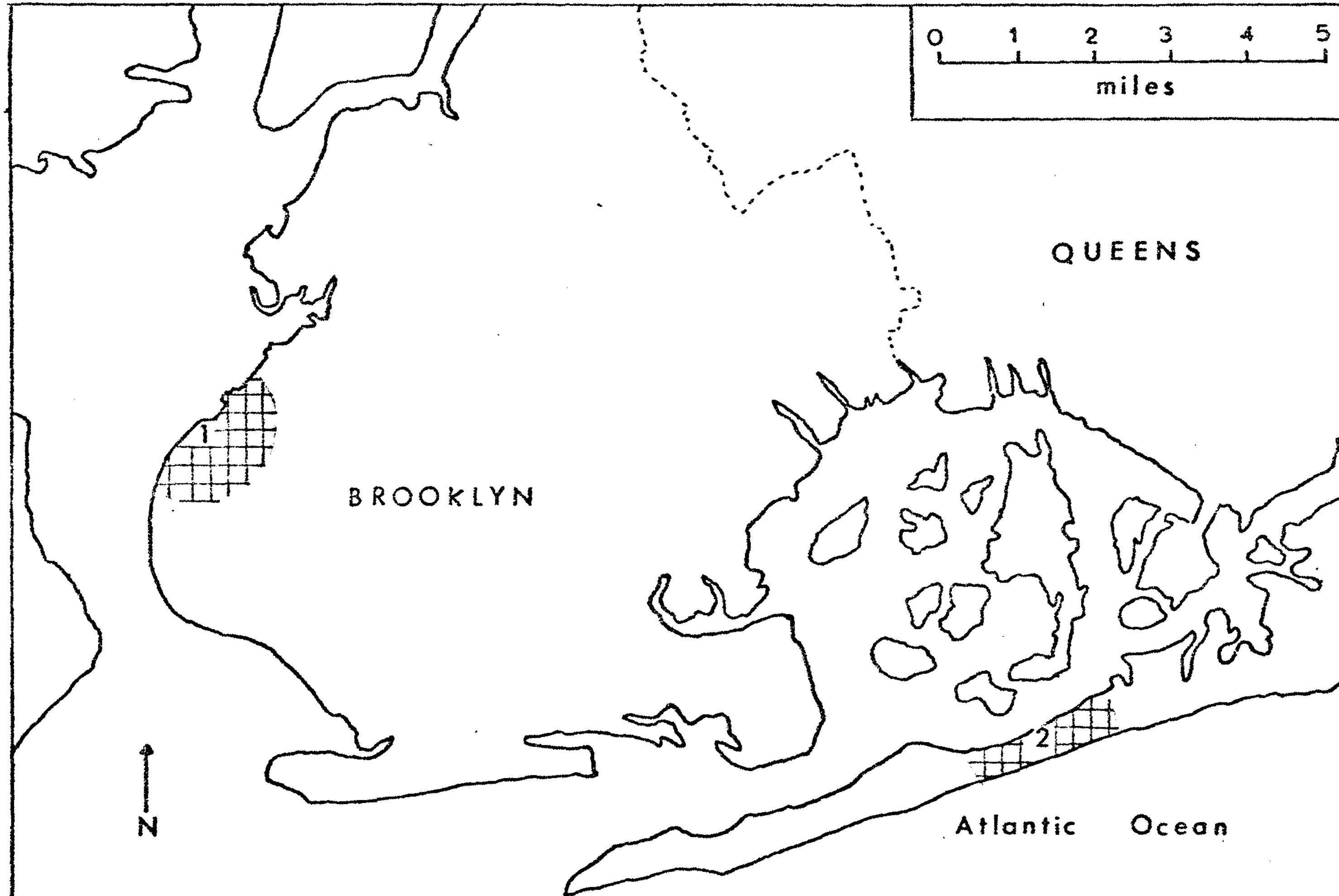
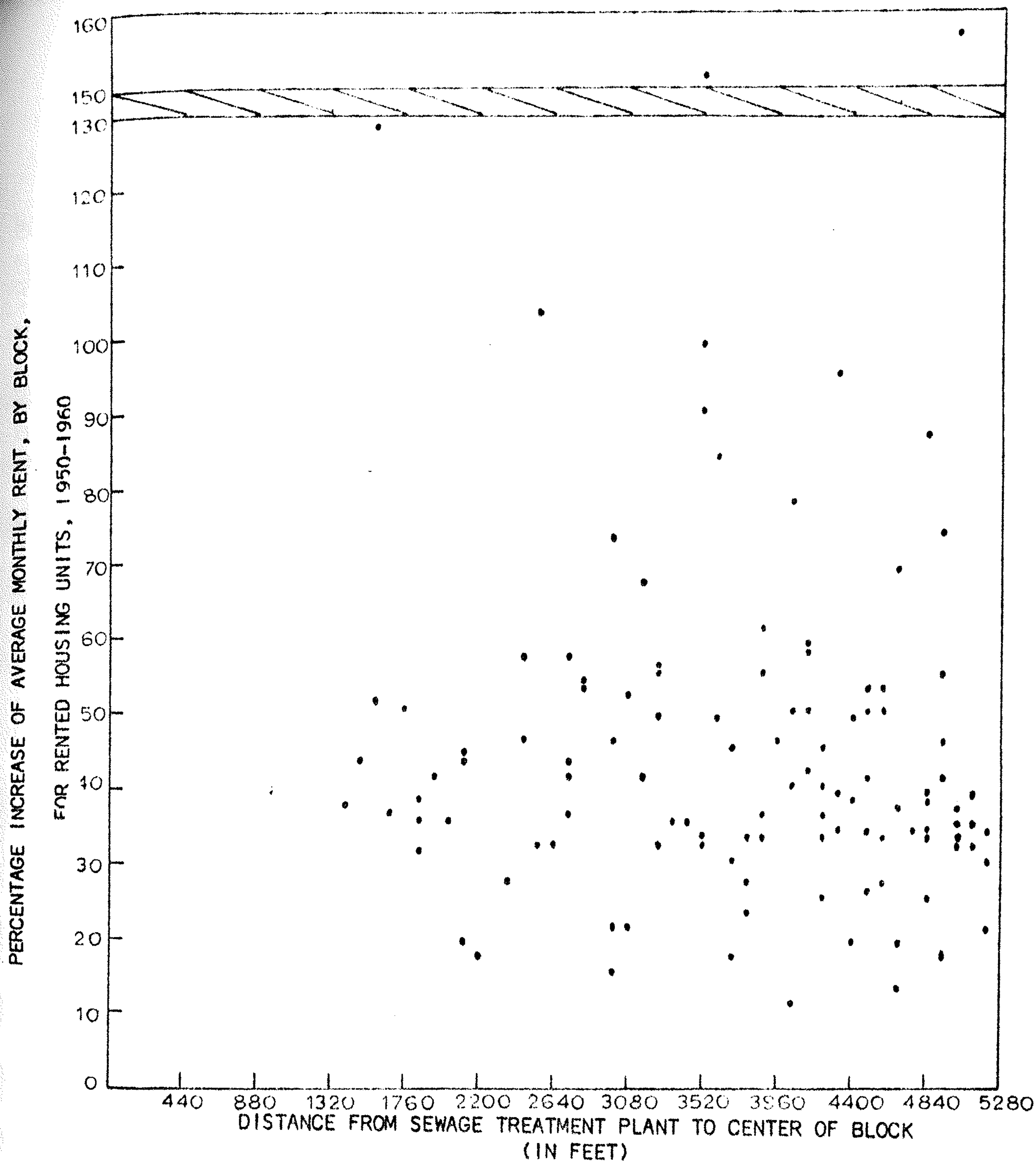


FIG. F1 Location of sewage treatment plants at Owls Head, Brooklyn (#1), and Rockaway, Queens (#2). The shading indicates areas of property value survey

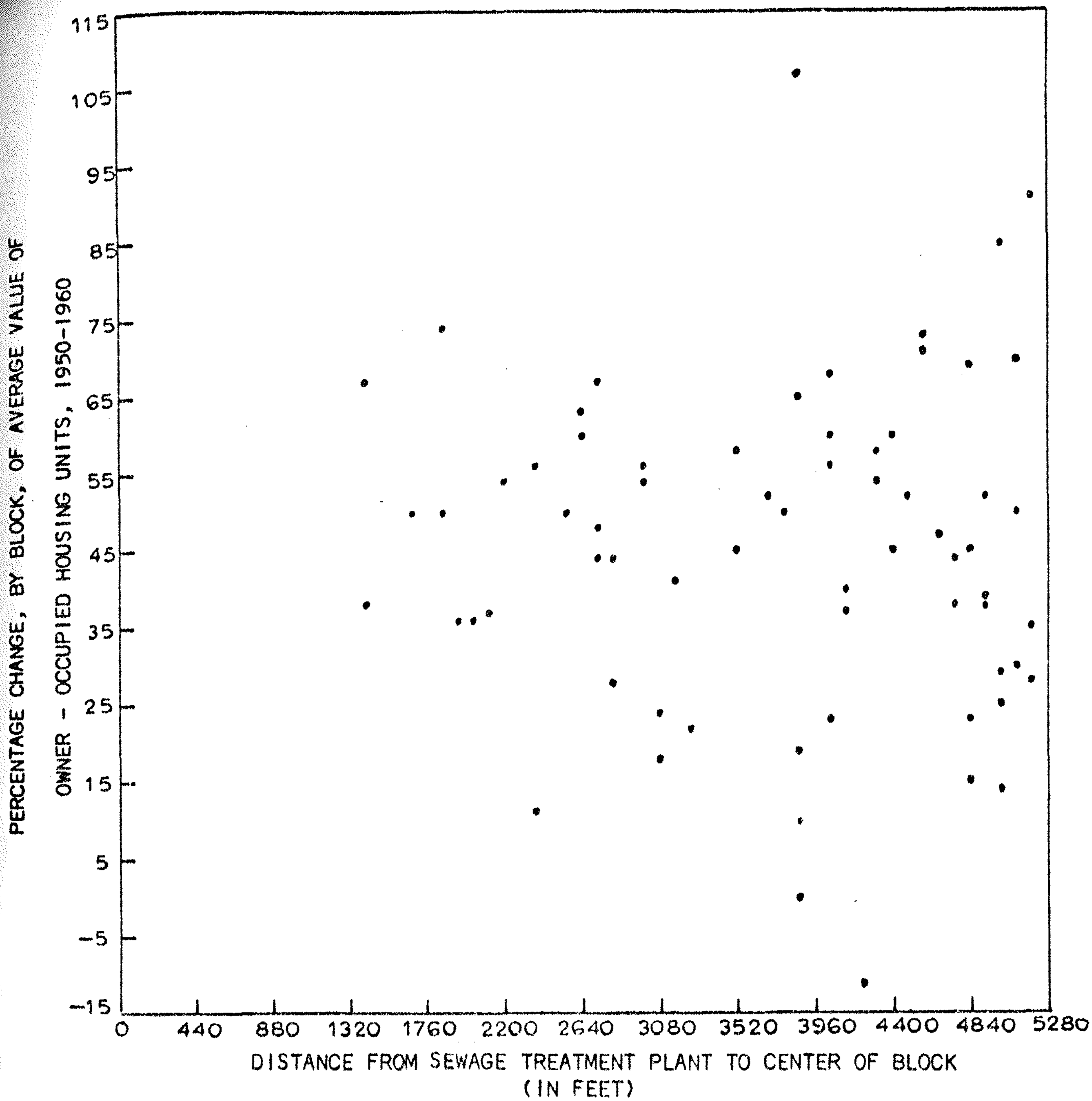


Sources: U.S. Census of Housing 1950, Vol. V, Block Statistics, Part 127.

U.S. Census of Housing 1960, Vol. III, City Blocks, Series HC (3), No. 274.

Note: 1950 average rents based on occupied and vacant units. 1960 average rents based only on occupied units.

FIG. F2 Owls Head Sewage Treatment Plant, Brooklyn, N.Y. Relationship between distance of block from plant and percentage increase of block's average monthly rent for rented housing units, 1950-1960



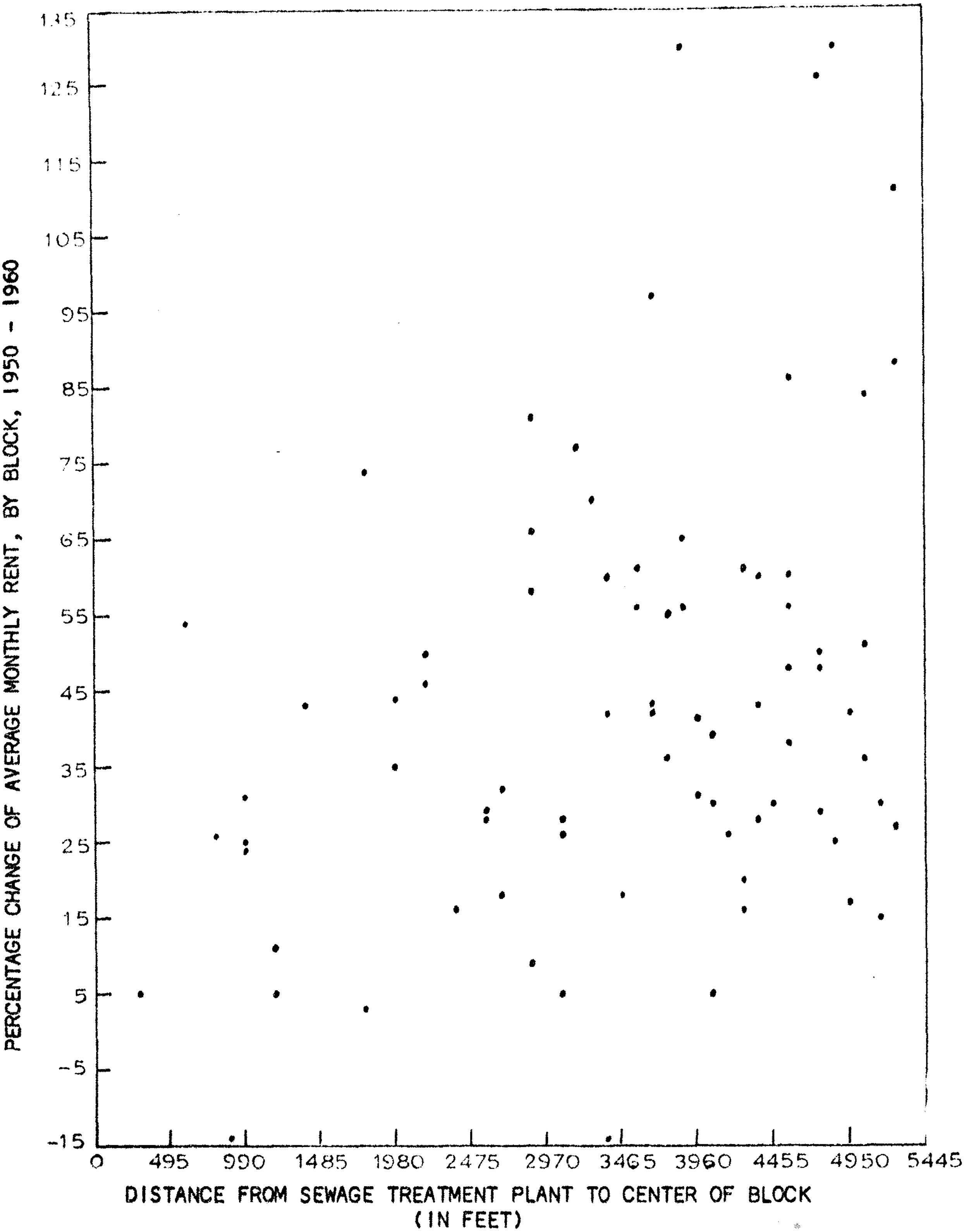
Sources: U.S. Census of Housing 1950, Vol. V, Block Statistics, Part 127.

U.S. Census of Housing 1960, Vol. III, City Blocks, Series HC(3), No. 274.

Note: 1950 average values based on occupied and vacant units. 1960 average values based only on occupied units.

FIG. F3. Owls Head Sewage Treatment Plant, Brooklyn, N.Y. Relationship between distance of block from plant and percentage change of average value of block's owner-occupied housing units, 1950-1960.

• (148)



Sources: U.S. Census of Housing 1950, Vol. V, Block Statistics, Part 129.

U.S. Census of Housing 1960, Vol III, City Blocks, Series HC(3), No. 276.

Note: 1950 average rents based on occupied and vacant units. 1960 average rents based only on occupied untis.

FIG. F4. Rockaway Sewage Treatment Plant, Queens, N.Y. Relationship between distance of block from plant and percentage change of block's average monthly rent for rented housing units, 1950-1960.

CONSUMER TOWN SELECTION[1]

Richard A. Mitchell

S.U.N.Y. at Buffalo

Introduction

Problems of determining the places in which people spend their money and why they choose some places in preference to others have long been of concern to students of geography. The history of geographic thought is marked by a great deal of speculation and a large volume of research that is designed to establish the characteristics of the relationships between customers and the places they patronize. Out of these efforts has arisen a considerable body of inter-related principles that has come to be known as "central place theory." One part or aspect of that theory has received little emphasis, however, and that is the individual and his movements in space. This fact has been noted by several researchers in recent years. Marble, for example states that:

> "Turning to general location theory, as exemplified by the works of Isard, Lefeber, and others, we find that only a small amount of attention has been given to the spatial problems of the individual consumer. Most of the attention of workers in the field has been directed toward problems of a broader scale than those encountered by the individuals moving in space."[2]

Huff makes a similar point:

> "One of the most potent agents shaping the spatial structure of society is the individual consuming unit and his movements in space. The complex patterns of movement manifested by the consumer not only affect the location of most tertiary activities but they also have a strong bearing on nearly all forms of land uses. Yet, despite the significance of the individual consumer in spatial analysis, very few analysts have focused their research efforts at this level."[3]

This paper is directed toward learning more about how consumers, particularly rural consumers, move in space.

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[1]This paper represents part of the research which was conducted under a Faculty Research Fellowship during the Summer of 1968. The writer wishes to express his gratitude to the State University of New York - Research Foundation for that support.

[2]Duane F. Marble, "Transport Inputs at Urban Residential Sites," Papers and Proceedings of the Regional Science Association, V (1959), p. 254.

[3]David L. Huff, "Toward a General Theory of Consumer Travel Behavior" (unpublished Ph.D. Dissertation, Department of Marketing, Transportation and Foreign Trade, University of Washington, 1959), p. 1.

Data

We might begin by noting that the movement of consumers in space is, indeed, complex, This can best be shown by taking a brief look at the data that this paper is based on.[4]

The data consists of a random sample of 115 rural nonfarm residents in the state of Iowa. Collected from the sample respondents was information for the 1960 calendar year as to type of expenditure and the urban places at which the expenditures were made. The number places that the respondents traveled to, to make purchases from, ranged from one to fifteen, with the median number being five. Sixteen percent of the respondents purchased goods and services from nine places or more, Thus, it would appear that we are faced with a fairly complex situation.

Rule I

The second thing we might note is that the explanation of the expenditure pattern of a rural population is implicit in central place theory. That is if we take some of the assumptions that are often made in central place work, we may develop a simple rule which designates the set of towns that should be patronized by a rural consumer. For example, let us assume that:

(1) a consumer will purchase a good or service from the closest place offering that good or service

(2) each town has the same set of goods and services as all smaller towns plus an additional set.

(3) the needs of the consumers are such that they require the complete set of goods and services offered by the towns.[5]

Under the above assumptions the following rule should completely specify the towns which a consumer will patronize.

Rule I: The consumer will purchase from the town which is closest to him and then progressively from the next largest place at an increased distance.

Rule I was applied to the 115 consumers previously described and the results can best be described by the Venn diagram displayed in Fig. MI. The diagram shows the three possible results in this situation i.e. the relative number of places that were predicted to be visited but were not; the places that were visited but not predicted; and finally the places that were both predicted and visited.

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[4]A more detailed description of the data and sample design can be found in: Richard A. Mitchell, "An Explanation of the Expenditure Pattern of a Dispersed Population" (unpublished Ph D. dissertation, Department of Geography, University of Iowa, 1964).

[5]This assumption is troublesome as it is doubtless not true for the one year period for which the data were collected.

The 42% predicted and visited does not appear to be an exceptional result but there is no base against which to measure the figure and thus if nothing else it can stand as a benchmark against which to ascess future results.

The 25% visited but not predicted, at first blush is a rather vexing result. This result only occurs when a consumer purchases from a town that is smaller than some closer town. A different view of consumer expenditure patterns reduces the magnitude of this problem but does not eliminate it. It should be noted that the percentages presented in Fig. MI refer to number of towns; a different picture emerges if we look at dollars as opposed to number of towns. In terms of dollar amounts the predicted and visited towns account for approximately 86% of the total dollars spent while the visited and not predicted account for 14%. Thus even though large numbers of towns are involved in this seemingly "irrational" behavior, a somewhat smaller relative amount of money is involved.

In addition many of the expenditures are composed of such things as travel expenses (e.g. food and gas on a trip) i.e. items which might not be considered as a part of a regular shopping pattern. Unfortunately in the questionaire that was used in collecting the data upon which this paper is based, there was no attempt at identifying what were "regular" or "usual" shopping patterns.

Rule 2

The predicted but not patronized towns also present a problem, especially since they constitute 33% of the total places either specified by Rule I or visited by the consumers. The problem is the overspecification of towns by the rule. Many explanations for this overspecification are possible. One explanation might be that the consumers recognize a hierarchy of places in terms of their purchasing behavior. If this is the case, then it is possible that two or more of the towns predicted for a particular consumer belong to the same town-size class. In this situation it would be necessary to visit only one of the towns to purchase a set of goods and services, as they would, presumably, all offer the same set of goods and services. Rule I would, in this situation, tend to overpredict the number of places visited and a more realistic rule might be:

> Rule 2: The consumer will purchase from the town which is closest to him and then progressively from the next closest place in a town-size class larger than the preceding class.

The only problem with this line of reasoning is that a technique is needed to determine the town-size classes recognized by the rural consumers. Although the hierarchy of places is frequently mentioned in work in central place theory there have been few attempts to actually determine the population ranges of the town-size classes. One such attempt, utilizing data used in the present study, was made by this writer.[6]

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[6]Richard A. Mitchell, "Determining the Population Sizes in the Hierarchy of Central Places," presented at the Annual Meeting of the Association of American Geographers, St. Louis, Mo., April, 1967.

Space does not permit a detailed description of the method for determining the population ranges for the classes in the hierarchy but a brief description follows.

(1) The consumers who, it was assumed, purchased from a town in each town-size class in the hierarchy, were identified. There were eleven such consumers and they each purchased from six different places, hence a six-place hierarchy.

(2) The populations for the towns were grouped according to the town-size classes they represented and plotted as six frequency distributions; each distribution thus being an estimate of one of the classes in the hierarchy.

(3) The distributions overlapped and the dividing lines between adjacent distributions were taken as the population ranges for the classes in the hierarchy.

(4) The dividing lines between distributions were determined by the formula

$$D_{i,i+1} = \frac{\bar{X}_i \quad \sigma_{i+1} + \bar{X}_{i+1} \quad \sigma_i}{\sigma_i \quad + \quad \sigma_{i+1}}$$

where $D_{i,\ i+1}$ is the dividing line between the ith and the next higher order class; $\bar{X}_i$, $\bar{X}_{i+1}$ and σ_i , σ_{i+1} are the means and standard deviations of the ith and next higher order class; and $i = 1,2,3,4,5,6$.

The hierarchy identified by the technique described above is presented in Table I.

The Test of Rule 2

Rule,2, utilizing the classes identified in Table I, was applied to the sample of rural consumers. The results are displayed in the Venn diagram of Fig. M2.

The use of Rule 2 had the expected result of lowering the number of places that the consumers were predicted to purchase from. Unfortunately, some of the places correctly assigned by Rule I, were now incorrectly assigned by Rule 2. The net result is that Rule 2 is no better than Rule I.

The poorness of the result of Rule 2, upon a little reflection, is not surprising. The fault however, may not lie with the notion of a hierarchy per se, but with the notion that the hierarchy is a set of rigidly defined classes. In the hierarchy described in Table I, for example, a town of 7,653 people is viewed as the same size as a town of 2,500 people while a town of 7,654 is viewed as larger than a town of 7653. That this situation is untenable is self-evident.

What is needed is a rule such that, when given that a consumer purchases from a place of a particular size, it will specify the size of the next most viable place to purchase from. Such a rule would, in effect, define a "variable hierarchy" which is dependent upon point of entry into the hierarchial system. The problem is to find an approach for the development of such a rule. A possible approach is a slight modification of a technique used by Professor Gerard Rushton in approaching a similar problem of consumer behavior.

The Rushton Approach

The problem approached by Rushton is that of predicting the town in which a member of a rural population will make his major grocery purchase.[7] The procedure he followed was to develop a subjective preference function for a set of rural residents, utilizing a scaling technique developed in psychology. Briefly the technique involves the categorization of possible choices available to a consumer for the purchase of groceries. These choices or "locational types" are based on the population size and the distance a town is from the consumer. Any given consumer will have many locational types available to him and one of them is the type from which he makes his grocery purchase. Information from many such consumers yields a set of data which are operated on via a method for making paired comparison and the final outcome is a ranking of the original locational types. (Study Table 2).

In order to define the variable hierarchy, it may be possible to utilize the technique employed by Rushton in the following way. First of all, the alternatives in the way of possible places of purchase facing a sample of rural consumers would be categorized on the basis of distance and town-size combinations. The actual places of purchase would also be designated. Then, given the consumers who purchase at a particular location type, all other locational types, for that set of consumers, composed of larger and more distant towns would be treated as a set of data and operated on via scaling or ranking techniques. The result would be a ranking of the locational types that are the next most preferred over the original type. Upon performing the operation on all the locational types, the result would be a set of rankings that would designate the next most preferred town in all situations. This procedure will be the subject of future research.

Further Comments on the Rushton Approach

The technique and approach utilized is interesting to say the least and will doubtless prove extremely useful in analysing certain spatial problems. The application of the technique at the present time is not without its problems, however, and one cannot help but wonder whether or not there might

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[7]Gerard Rushton, "The Scaling of Locational Preferences," presented at the Annual Meeting of the Association of American Geographers, Washington, D.C., Aug., 1968.

be an alternate approach to the problem in question. It might be possible, for example, to use a gravity model for the selection of a town for a particular type of purchase. What is being suggested is that the rural consumers weigh the alternatives facing them and that relative weights of the alternatives have the same ranking as the familiar $\frac{P}{D^{\alpha}}$ index assigned to each town. It should also be noted that it would be reasonable to compute the index for only those towns with a population equal to or in excess of the threshold population of the good or service in question. This kind of approach is, of course, not new in geography, as the gravity model does have a long history. Further, one could easily argue that the approach used by Rushton is essentially a gravity concept and indeed, in a previous work he developed a different model for determining the town of maximum grocery purchase, which likewise contains the elements of a gravity model.[8]

In order to test the hypothesis suggested above, two things are required, data and a procedure for establishing the proper exponent on distance. One way to approach both of these problems is to operate on the "set of data" presented in Table 2. Clearly each of the locational types presented can be converted to P over D ratios by letting the midpoints of the population and distance intervals represent the entire interval. The proper exponent can then be found by:

(1) assuming that the ranking of locational types developed by Rushton is a "good" ranking,

(2) creating a number of rankings for the locational types based on the P over D^{α} ratios when α is assigned a variety of values, and

(3) then comparing the various gravity model rankings with the Rushton ranking.

The best exponent will, of course, be the one which yields the best results when the comparisons are made.

Table 3 displays the results of the procedure described above with rank correlations employed to facilitate the comparisons. These results illicit several comments:

(1) The relationships between the various gravity rankings and the Rushton ranking are high with most of the variability found within the first four locational types and types 14 and 19.

(2) Locational types 14 and 19 are especially interesting in that they point up a rather peculiar situation in the Rushton ranking. Type 14 identifies a town of between 1,000 and 2,000 people and is between 16 and 20 miles from the consumer. It has a rank on the preference scale of 24. Type 15 has a population between 1,000 and

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[8]Gerard Rushton, Spatial Pattern of Grocery Purchases by the Iowa Rural Population, University of Iowa, Bureau of Business and Economic Research, Monograph No. 9, 1966.

2,000 people and is 21 to 25 miles from the consumer. It has a rank of 22. What this in essence says is that a town of say 1,500 people, 22.5 miles from a consumer, is a more desirable place to purchase groceries than a town of 1,500 people, 17.5 miles from the consumer. A similar situation exists between locational types 19 and 20. These results would seem to be untenable on logical grounds and it should be noted that the gravity approach cannot yield such results.

(3) There is little difference between the various gravity rankings; i.e. it appears that any exponent from 1.5 through 4 yields basically the same results.

After analysing Table 3 a question still remains, and that question pertains to just how well the towns for grocery purchases can be predicted. Thus far it has only been established that various pairs of rankings are similar. To get at this question, the gravity technique was applied to the same sample of Iowa rural non-farm residents discussed earlier in this paper. That is, the gravity ranking of towns, using , was caluclated for each consumer in the sample and the town with the largest index was the predicted town for the major grocery purchase. This procedure correctly predicted 60% of the cases in question.

Now the question still remains as to whether 60% prediction is a "good" figure or not. To have some base against which to judge this, we note that applying rule "purchase groceries from the closest town", yields only 35% prediction. The writer is therefore somewhat encouraged by the results, especially in light of the crudeness of the approach.

Many refinements in the approach are feasible, ranging from more sophisticated techniques for deriving the optinum exponent for distance, to better ways for measuring the size of a town and distance to it. Two of the households incorrectly predicted, for example, have their major wage earner employed in the town in which groceries are purchased. Clearly the definition of distance is not adequate in these cases.

Another problem area appears to be county-seat town. County-seats attract a disproportionate share of the consumers (approximately 58%) in regard to grocery purchases. This is no doubt in part due to the fact that county-seats are larger, on average, than non county-seats but this does not entirely explain their popularity. There were eleven instances in the sample when households purchased groceries from a particular town when a larger town was at a closer distance. Of the eleven, four are county-seats. This suggests tha population may not be an adequate surrogate for measuring the "size" or attractive power of a county-seat.

On the basis of the above results it would appear that the gravity model approach might also warrant further research.

RESULTS OF RULE 1*

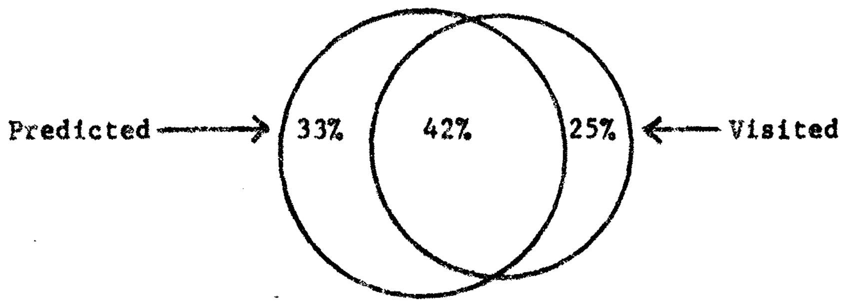

FIGURE M1.

RESULTS OF RULE 2*

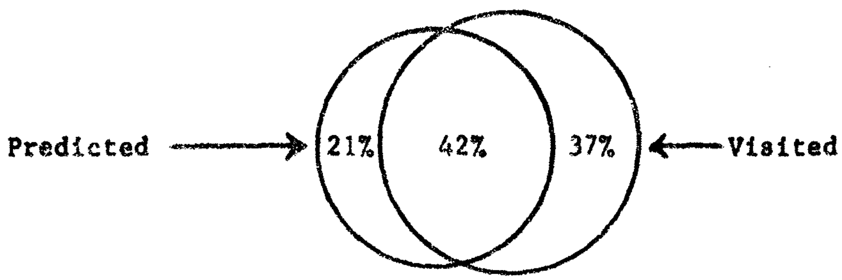

FIGURE M2.

*Predicted $\cup$ Visited = 100%

Table 1

POPULATION RANGES OF THE TOWN-SIZE CLASSES

		Population Range
Order in the Hierarchy	1	1 - 550
	2	551 - 2,197
	3	2,198 - 7,653
	4	7,654 - 34,739
	5	34,740 - 137,143
	6	137,144 - ?

TABLE 2

DEFINITION AND RANK OF LOCATIONAL TYPES*

Locational Types	Distance Groups (Miles)	Town Size Groups (Population)	Rank of Locational Type
1	1-5	0- 500	11
2	6-10	0- 500	16
3	11-15	0- 500	19
4	16-20	0- 500	20
5	21-25	0- 500	25
6	1-5	500-1000	5
7	6-10	500-1000	12
8	11-15	500-1000	17
9	16-20	500-1000	21
10	21-25	500-1000	23
11	1-5	1000-2000	4
12	6-10	1000-2000	8
13	11-15	1000-2000	10
14	16-20	1000-2000	24
15	21-25	1000-2000	22
16	1-5	2000-4000	1
17	6-10	2000-4000	6
18	11-15	2000-4000	9
19	16-20	2000-4000	18
20	21-25	2000-4000	15
21	1-5	4000-8000	2
22	6-10	4000-8000	3
23	11-15	4000-8000	7
24	16-20	4000-8000	13
25	21-25	4000-8000	14

*This table is constructed from a ranking (presented in Fig. 2) and Table 1 in the paper by Rushton identified in footnote 7. The table and ranking have been modified, as 5 locational types, involving the town size group, 8,000-208,980, are not presented here. It was felt that the midpoint of that group could not adequately represent the group and it would thus be useless for making comparisons between the rankings of Table 2 and Table 3.

TABLE 3

RANK OF LOCATIONAL TYPES DEFINED BY $\frac{P^*}{D^\alpha}$

$\frac{P}{D^1}$	$\frac{P}{D^{1.5}}$	$\frac{P}{D^2}$	$\frac{P}{D^{2.5}}$	$\frac{P}{D^3}$	$\frac{P}{D^{3.5}}$	$\frac{P}{D^4}$
15.5	11	7	6	5	5	5
21.5	20	19	16	14	14	12
23	23	22	22	22	20	20
24	24	24	24	24	24	24
25	25	25	25	25	25	25
8	5	4	4	4	4	4
15.5	14	12	11	10	10	10
19	18	18	17	17	17	16
20	21	21	21	20	21	21
21.5	22	23	23	23	23	23
3	3	3	3	3	3	3
11	9	9	9	8	8	8
14	15	14	13	13	13	14
17	17	17	19	18	18	18
18	19	20	20	21	22	22
2	2	2	2	2	2	2
6	6	6	7	7	7	7
10	10	11	10	11	11	11
12	13	13	15	15	15	15
13	16	16	18	19	19	19
1	1	1	1	1	1	1
4	4	5	5	6	6	6
5	7	7	8	9	9	9
7	8	10	12	12	12	13
9	12	15	14	16	16	17
.89	.92	.93	.95	.93	.94	.93

The numbers above are Spearman rank correlation coefficients between the various rankings of Table 3 and the ranking in Table 2.

*See text for explanation.

GROWTH POTENTIAL OF THE PRIMARY METALS AND ENGINEERING INDUSTRIES OF THE BUFFALO AREA

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Introduction

This paper is a report of a research project undertaken by the author and the Greater Buffalo Development Foundation of Buffalo, New York. The objective of the project was to evaluate the employment growth potential of the primary metals and engineering industries of the Buffalo Metropolitan Area. The composition of these industries and their employment for selected years is presented as Table I. These five industries are related such that in most cases, each is a principal intermediate purchaser of the others' output. Consequently, there are strong linkages among tham and they may be said to form an industrial group.

Table I

EMPLOYMENT IN THE PRIMARY METALS AND ENGINEERING INDUSTRIES OF THE BUFFALO AREA FOR SELECTED YEARS (000)

SIC	INDUSTRY	1954	1957	1958	1962	1965	1968
33	Primary Metals	37.1	42.5	31.9	29.6	33.3	32.0
34	Fabricated Metals	8.7	9.0	8.8	9.7	10.3	13.5
35	Non-electrical Machinery	15.0	16.7	13.2	12.7	14.3	14.2
36	Electrical Machinery	14.9	13.6	11.6	12.9	15.9	13.6
37	Transportation Equipment	46.2	44.9	33.4	26.7	30.5	33.9
	Total	121.9	126.7	98.8	91.7	104.3	107.2

Sources: 1954 and 1958 data from the respective Census of Manufactures; all other data from the appropriate Annual Survey of Manufacturers

In part, this report is based upon a survey of 113 establishments conducted in the summer of 1968. Though this represented only about 20 percent of all such establishments, it represented nearly 90 percent of all employment in the group.

The paper is organized into three parts. The first is an analysis of supply factors, the second an analysis of demand factors, and the third an analysis of trends in the growth of productivity.

In the first part, three economic variables are considered: wages, productivity, and the two related subjects of age of plant and equipment, and investment. In each case, the performance of the Buffalo area is judged against that of the nation as a whole and against four similar industrial centers located within the so-called manufacturing belt of the nation. These centers are Milwaukee, Cleveland, Detroit, and Pittsburgh. In each of these, the primary metals and engineering industries are a major component of the manufacturing base.

In the second part, attention is focused upon the determination of the major market area served by these Buffalo industries, and also, upon their major functional markets. These two subjects are then integrated into an assessment of future demand for the products of these Buffalo industries.

In the third part, an assessment of projected growth of productivity is incorporated in order to evaluate the employment growth potential of these industries.

Table 2

WAGES OF PRODUCTION WORKERS IN 1966 (Dollars per Hour)

Industry	Buffalo	Pittsburgh	Milwaukee	Detroit	Cleveland	All U.S.
Primary Metals	3.72	3.77	3.62	3.94	3.68	3.49
Fabricated Metal Products	2.95	3.24	3.10	3.01	2.97	2.77
Machinery, except Electrical	3.69	3.50	3.46	3.89	3.41	3.16
Electrical Machinery	2.95	3.17	3.36	3.08	3.03	2.74
Transportation Equipment	3.80	3.78	3.83	3.79	3.93	3.40
All Metals & Related Industries	3.60	3.61	3.45	3.72	3.47	3.13

Source: 1966 Annual Survey of Manufacturers.

Supply Factors

The first economic variable to be considered is wages, data for which is presented as Table 2. Note in the first place, that the average wage rate of all industries in all five communities was higher than the corresponding national average rate. Though this is not surprising, it is notable as it will subsequently affect the statistics on productivity.

An examination of Table 2 indicates that the wages of these industries in Buffalo compare favorably with those of the four other areas. In particular such an examination shows that:

Milwaukee has the lowest wages in primary metals,
Buffalo has the lowest wages in fabricated metals,
Cleveland has the lowest wages in non-electrical machinery,
Buffalo has the lowest wages in electrical machinery, and
Pittsburgh has the lowest wages in the transportation equipment industry.

It is evident that Buffalo had the lowest wages of the five communities in two industries, and the it was the only one of the five to have two lowest wage industries. If one were to look for the community with the highest wage rates in each industry, he would discover that Buffalo was the only area not having the highest rate in any industry.

The second economic variable to be examined is productivity, which may be defined as the ratio of output per unit of input. Two measures of productivity which are widely used are value added per production worker and value added per dollar of wages of production workers. In each case the higher the value of the measure, the more productive is the industry. It should be noted that while the denominator of each measure is a measure of labor inputs, it is not the productivity of labor which is being measured; it simply is productivity measured in terms of labor.

Statistics of value added per production worker are presented as Table 3. An examination of this table indicates that Detroit is the most productive community in all industries except electrical machinery, in which Milwaukee is the most productive. In terms of the weighted average of the entire group, Buffalo's performance is next to last, being only slightly better than that of Pittsburgh.

A somewhat similar, but basically a more discouraging pattern, emerges from the table of value added per dollar of wages of production workers, Table 4. Note that with respect to the entire industrial group, all five communities have a productivity figure below that of the nation as a whole. This reflects the fact that metropolitan areas characteristically have a higher than average wage structure. Buffalo itself, is still next to the bottom, above Pittsburgh again, but its average productivity is far below the national average. It is also the only one of the five communities to be consistantly below the national average in all industries.

Table 3

VALUE ADDED PER PRODUCTION WORKER IN 1966 (Dollars)

Industry	Buffalo	Pittsburgh	Milwaukee	Detroit	Cleveland	All U.S.
Primary Metals	$17,697	$19,810	$16,980	$23,450	$21,320	$19,618
Fabricated Metal Products	15,978	13,180	17,040	18,760	17,110	16,049
Machinery, except Electrical	20,321	22,770	20,420	23,770	22,690	20,638
Electrical Machinery	19,270	20,810	24,830	17,660	20,060	18,134
Transportation Equipment	21,265	15,000	13,990	23,020	20,510	20,804
All Metals & Related Industries	$19,180	$19,110	$19,700	$22,570	$20,490	$19,210

Table 4

VALUE ADDED PER DOLLAR OF WAGES OF PRODUCTION WORKERS IN 1966 (Dollars)

Industry	Buffalo	Pittsburgh	Milwaukee	Detroit	Cleveland	All U.S.
Primary Metals	$2.38	$2.68	$2.22	$2.79	$2.81	$2.74
Fabricated Metal Products	2.64	2.10	2.66	2.76	2.70	2.74
Machinery, except Electrical	2.56	3.07	2.81	2.68	2.92	3.06
Electrical Machinery	3.11	3.29	3.58	2.73	3.22	3.24
Transportation Equipment	2.64	2.02	2.02	2.80	2.40	2.84
All Metals & Related Industries	$2.59	$2.38	$2.78	$2.76	$2.75	$2.92

Sources: 1966 Annual Survey of Manufacturers

Hence, the general conclusion is that the productivity of this industrial group in the Buffalo area is less than desired. In part, and not necessarily dominantly, this is due to the somewhat high wages of the area. It is also due to the fact that the level of output, that is the value of products produced, is too low. If wages are only a portion of the problem, what is the rest of it? Part of the rest lies in the third economic variable to be discussed, capital investment and age of plant and equipment.

The amount of capital invested in an industry is positively correlated with the level of output produced. Unfortunately, virtually no data are available on the amount of capital invested in an industry on a regional basis. One possible way around this lack is to measure the age of plant and equipment, the assumption being that the older the plant and equipment, the less efficient it is and the lower will be the level of output. The problem here is that if one does this for a specific area, there is no norm to compare against as this data is not available on a national or subnational level. What is available, however, are periodic surveys of the age of metalworking machinery.[1] Since the industries we are concerned with here are dominantly metalworking industries, this survey data becomes the basis for estimating the age of plant and equipment, and thus for making inferences on the level of capital invested.

In addition to the published survey data, the survey conducted in conjunction with this study developed some additional data. But the usable data was fragmentary; in this case representing about 30 percent of the number of firms interviewed. This fragmentary data indicated, however, that on the average 53 percent of the equipment of the surveyed firms was over ten years of age. The published survey results, fortunately for the same year, 1968, was that 66 percent of the metalworking machinery in the Buffalo-Rochester-Syracuse areas was over ten years of age. The latter statistic placed this area next to the top of the list of all areas surveyed, being only slightly better off than Pittsburgh. As is beginning to be fairly obvious, being ahead of Pittsburgh is a dubious honor at best.

Subjective judgements of the age of plant and equipment of an individual community as large as Buffalo are perhaps unreliable. But the concensus of opinion of knowledgeable persons supports the inference that much of Buffalo's manufacturing plant is too old for most efficient operation and that as a result, Buffalo suffers in comparison to other areas.

Statistics of new capital expenditures for plant and equipment in the Buffalo area for recent years provides another insight into the problem. In 1965, for example, 74 percent of the new capital expenditures went into the primary metals and transportation equipment industries and another 18 percent went into the electrical machinery industry.[2] Thus, these three industries absorbed 92 percent of the new capital expenditures while accounting for only 74 percent of the employment of the group. Quite apparently, recent capital expentitures have been heavily concentrated in two or three industries which have a heavy requirement for such expenditures.

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[1] American Machinist, June 10, 1963 and Novermber 18, 1968.

[2] 1965 Annual Survey of Manufacturers

The general conclusion of this examination of the supply side is somewhat unfavorable for Buffalo. It appears that the competitive position of the primary metals and engineering industries of the Buffalo area is less than desired. This in itself indicates that probably the growth of these industries in Buffalo will not be as rapid as that of Milwaukee, Cleveland and Detroit.

Markets

Having examined the supply side, we will now turn to an examination of the demand side. First we will examine the dominant geographic market area served by these Buffalo industries.

In an attempt to identify the dominant market area served, a question was inserted in the basic questionnaire requesting such data. Unfortunately, the usable information obtained in this manner was quite meager, primarily due to the reluctance, or more accurately, refusal of medium - and large - size corporations to disclose this data. For this reason it was necessary to use data on tons of commodities shipped by distance of shipment from the 1963 Census of Transportation. This data is presented as Table 5.

The generalized pattern of shipments is that of a small market demand within 100 miles and a larger, but also somewhat small market demand beyond 500 miles. Quite obviously, the dominant market area is that situated between 100 and 500 miles. Further analysis of the census data reveals that this includes areas both east and west of Buffalo. This dominant market area is hereafter referred to as the Northeast.

The relatively small size of the local market area, as reflected in the small proportion of shipments shipped less than 100 miles, is surprising. To determine whether this is a characteristic of these industries in Buffalo or a national characteristic of the group, the proportion of shipments shipped less than 100 miles from Buffalo has been compared with the same for the U.S. as a whole (Table 6). Quite obviously, it is a unique characteristic of the Buffalo area. Only in the case of electrical machinery does the nation ship as small a percentage within 100 miles as does Buffalo.

The relatively small local market demand for the products of the primary metals and engineering industries of Buffalo is a disadvantage of the area. On the other hand, the unusually high percentage of shipments to an area of 100 to 500 miles, is an advantage and reflects the favorable location of Buffalo in the largest market area of the nation, the Northeastern United States.

Having ascertained that the dominant geographic market is the Northeastern U.S., we may now turn to the problem of identifying the functional markets, or purchasing sectors. Unfortunately, this cannot be explicitly done for a local area unless there exists an input-output analysis of the local economy. While the Foundation and the author are preparing an elementary input-output analysis of the Buffalo economy, the results of it are not yet available. Thus, it is necessary to use the national pattern of reason why the Buffalo pattern of sales should differ drastically from the national pattern.

Table 5

DISTRIBUTION OF SHIPMENTS FROM THE BUFFALO AREA

Percent Distribution

Industry	Less Than 100 mi.	100 to 499 mi.	500 miles & over	Percent Total
Primary Metals	6.4	88.3	5.3	100.0
Fabricated Metal Products	10.3	71.7	18.0	100.0
Machinery, except Electrical	4.5	53.6	41.9	100.0
Electrical Machinery	11.9	41.7	46.4	100.0
Transportation Equipment	.4	69.0	30.6	100.0
Weighted Total of All Metals & Related Industries	6.0	79.1	14.9	100.0

Source: 1963 Census of Transportation

Table 6

PROPORTION OF SHIPMENTS SHIPPED LESS THAN 100 MILES (PERCENT)

Industry	Buffalo	All U.S.
Primary Metals	6.4	28.4
Fabricated Metal Products	10.3	28.9
Machinery, except Electrical	4.5	17.7
Electrical Machinery	11.9	11.7
Transportation Equipment	.4	17.2
Weighted Total of all Primary Metals and Engineering Industries	6.0	4.7

Source: 1963 Census of Transportation

Table 7 shows the principal functional markets, or purchasing sectors, of the major industries of the group. Each industry presented consists of one or more related three or four digit industries present in the Buffalo area: together the six account for three-quarters of all employment in the group.

Table 7

AGGREGATE SHARE OF MARKET IN 1975 FOR THE MOST PROMINENT SECTORS OF THE PRIMARY METALS AND ENGINEERING INDUSTRIES OF THE BUFFALO AREA

PERCENT

	Intermediate Demands	Investment	Ultimate Use	Total 1/
Primary Iron & Steel	82.8	13.5	3.1	99.4
Stampings, Screw Machine Products & Bolts	87.4	2.2	9.3	98.9
General Industrial Machinery	46.0	38.9	13.1	98.0
Electrical Industrial Equipment & Apparatus	48.8	39.3	10.7	98.8
Motor Vehicles & Equipment	12.0	18.5	68.3	98.8
Aircraft & Parts	18.2	6.1	75.7	100.0

1/ The sum of the percentage of Intermediate Demands, Investment, and Ultimate Use should equal 100 percent. The failure to do so is due to statistical errors.

Source: Almond, Clopper. The American Economy to 1975.

Intermediate demand refers to the purchase of products by producers who further process those products for sale as a finished product. As such, it may be considered to be a form of industrial consumption by manafacturers. Ultimate use refers to production which is sold to, and directly used by, final consumers, technically by final consuming sectors of the economy. There is no further sale of a product by ultimate users. Investment refers to production which is purchased for use in the construction of physical facilities, whether they be manufacturing plants, machinery, homes, etc. As such, investment may be considered as being a form of consumer consumption and as a form of industrial consumption. In the case of the general industrial machinery, and electrical industrial equipment and apparatus, it is probable that most investment is a form of industrial consumption by manufacturers.