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Aircraft Noise and the Market for Residential Housing: Empirical Results for Seven Selected Airports

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16. Abstract

The annoyance due to aircraft noise is capitalized into the value of residential property. Measurement of relationships between aircraft noise levels and property values provides a means by which to calculate the benefits of noise abatement.

This study seeks to obtain a measure of the effect on property values of a decibel change in Noise Exposure Forecast (NEF) levels, other factors remaining constant. The resulting damage cost is interpreted as the amount individuals would be willing to pay for noise abatement, given that the change in noise levels is small. Census block and census tract data are employed for small geographic areas (about two miles radius) near seven selected major U.S. airports.

In each of seven cases, the results indicate that aircraft noise has a negative and statistically significant effect on residential property values. Translating the coefficients into percentages yields a noise depreciation index in the range -0.29 to -0.84 percent per decibel change in NEF level, with a simple average value of -0.55 percent. However, the coefficient estimates for six airports are stable around a weighted-mean value of -0.50 percent. This result is consistent with the average of values obtained in earlier statistical studies of the same relationship.

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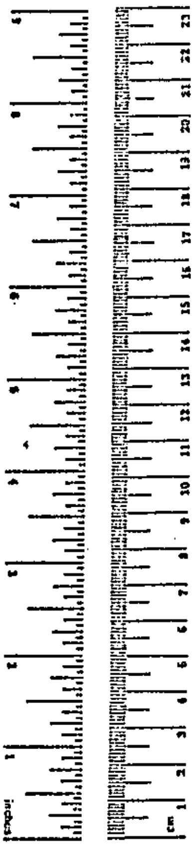
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

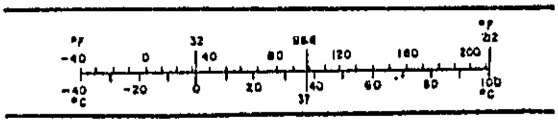
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



EXECUTIVE SUMMARY

E.1 Introduction

The annoyance due to aircraft noise is capitalized into the value of residential property. Measurement of the relationship between aircraft noise levels and property values provides a means by which to calculate the benefits of noise abatement. This report presents empirical estimates of such relationships at seven major U.S. airports.

E.2 Problem Studied

This study seeks to obtain a measure or measures of the effect on property values of a decibel change in noise exposure levels, other factors remaining constant. The resulting damage cost is interpreted as the amount individuals would be willing to pay for a given level of noise abatement, assuming the change in noise exposure levels is small. In the present study, census block and census tract data for 1970 are employed for small geographic areas near seven major U.S. airports. The airports studied are San Francisco, Boston, Cleveland, New Orleans, St. Louis, Buffalo, and San Diego.

While there have been several earlier studies of the noise-property value relationship, most investigators examine only one airport. Differences in data sets and econometric methods make it difficult to compare the results obtained for different areas. For example, empirical studies have been conducted at three levels of aggregation--individual houses, census blocks, and census tracts. In addition, most studies have improperly handled the background noise level and have ignored the possibility that an airport exerts two distinct effects on residential property values--a depreciation effect due to noise and an appreciation effect due to employment accessibility and enhanced commercial value.

The basic objective of the present study is to develop a set of consistent empirical estimates for a number of airports. Data from the 1972 Noise Exposure Forecast (NEF) are combined with census data on residential property values and characteristics. The study areas selected are small geographic areas (approximately two miles radius) situated close to an airport (NEF 20 or 25 to 45). Within these areas, accessibility factors should be constant so that the empirical estimates reflect only the impact of aircraft noise on residential property values. Econometric estimates are obtained using ordinary least-squares and the samples are screened so as to exclude observations located near parks, commercial developments, major streets, highways, and the like. In addition to aircraft noise levels (in 5 NEF increments), variables are included for size of house, housing density, age and housing quality, and neighborhood characteristics. The limited number of explanatory variables reflects, in part, the relative homogeneity of the samples.

E.3 Results Achieved

The final sample sizes range from 113 to 185 census block observations. Mean property values for 1970 range from $16,411 for St. Louis to $32,241 for San Diego. The study area blocks are predominantly residential--the average percent of owner-occupied units is 85 percent--while the average house contains about 5.75 rooms. The mean noise level varies from NEF 27.7 for New Orleans to NEF 33.9 for Cleveland. On average, about 35 percent of the observations are situated in NEF 20-30, 50 percent in NEF 30-40, and 15 percent in NEF 40-50. The samples are selected so as to include a relatively large proportion of households exposed to high noise levels (NEF $\geq$ 35).

For each airport, a regression was selected that seemed to represent the best outcome, taking into account goodness of fit (R^2) and the statistical significance of the NEF coefficient (t-values). In each of seven cases, the results indicate that aircraft noise has a negative and statistically significant effect on residential property values. Translating the regression coefficients into percentages yields a noise depreciation index in the range -0.29 to -0.84 percent per decibel change in NEF level, with a simple average of -0.55 percent. However, the coefficient estimates for six airports (excluding Boston) are stable around a weighted-mean value of -0.50 percent per decibel change in NEF.

In addition to the results for individual airports, a pooled sample was obtained. The pooled sample contained 845 observations from six urban areas (excluding Boston). The regression results with this sample yield an NEF coefficient in the range -0.40 to -0.50 percent per decibel change in NEF. These estimates are slightly less than the simple mean for the individual airports, reflecting the possibility of incomplete controls for interurban sample differences and airport accessibility.

To test for remaining accessibility effects, the pooled sample was partitioned in two ways. The addition of NEF slope and intercept dummy variables produced estimates of -0.53 and -0.55 percent. Further, when the pooled sample was partitioned into two mile intervals, the regression coefficients were stable about weighted means of -0.46 percent and -0.55 percent. When the individual samples were restricted to blocks located one to four miles from the airport terminal, the coefficients were stable around a weighted mean of -0.53 percent. The tests for accessibility influences suggest that the amount of bias is small relative to the range of values for the individual study areas.

E.4 Utilization of Results

A noise depreciation index of -0.50 percent implies that for a given property value (say, $40,000 in 1978 dollars), each decibel reduction in NEF would have a capitalized value of -0.0050 x $40,000 = $200 per decibel per household. On an annualized basis, this is equivalent to about $20 per decibel per household, assuming a nominal interest rate of 10 percent. This amount can be interpreted as the annual amount households would be willing to pay for a decibel reduction in NEF levels, beginning in 1978 and continuing indefinitely. These results can be applied to benefit-cost analyses of noise abatement options in a manner demonstrated by Nelson,[1] if it can be assumed that the changes in noise exposure levels will be small.

E.5 Conclusion

Empirical estimates of the aircraft noise-property value relationship were obtained for seven airports. The results are stable around a weighted-mean value of -0.50 percent per decibel change in NEF. There is little evidence that the noise depreciation index exceeds an upper bound of -1.0 percent.

The evidence presented in the study strongly supports the existence of an implicit market for quiet within which individuals register the amount they are willing to pay for environmental quality in residential areas. The dollar or percentage amounts estimated in this study are revealed by the choices individuals make in this market, rather than by survey techniques that reflect what people say they might be willing to pay for noise abatement. There are reasons to believe that estimates obtained with survey techniques will overstate the expected benefits of noise abatement, since those who pay for noise abatement (air travelers, for example) are not necessarily those individuals who benefit most from such undertakings. The estimates presented herein represent an alternative market-based approach to the question of valuation of noise reductions.

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[1] J. P. Nelson, Economic Analysis of Transportation Noise Abatement (Cambridge: Ballinger Publishing Co., 1978), Chapter 8.

PREFACE

The author wishes to acknowledge the assistance provided by the staff of the Institute for Policy Research and Evaluation. Ronald M. Crandall, project research assistant, collected most of the data and prepared the computer runs. His ability to overcome a number of obstacles in the data was a major factor in the final product presented here. Bonnie Grove, Mary Jane Johnson, and Dorothy Zilly skillfully typed the drafts and final report. Joan Bleikamp provided editorial assistance.

John E. Wesler of the Department of Transportation furnished the noise contour maps and served as technical monitor. Arthur S. De Vany (Texas A&M), Hays B. Gamble (Penn State), John F. Morrall (Council on Wage and Price Stability), and V. Kerry Smith (Resources for the Future) served on the project advisory committee.

This report was prepared under Contract No. DOT-OS-70066 with the Office of University Research, U.S. Department of Transportation. An initial draft of the final report was submitted on June 30, 1978. Revisions were made following review of the draft by Department of Transportation personnel. Views expressed and conclusions reached are, however, those of the author and not necessarily those of the sponsoring agency, the U.S. Government, or any of the above mentioned individuals.

Jon P. Nelson
Senior Research Associate
and Professor of Economics

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Since 1969, a number of empirical studies have examined the relationship between residential property values and aircraft noise levels. These studies have sought to obtain a measure or measures of the effect on property values of a unit change in noise exposure levels, other factors remaining constant. The empirical results obtained have been used both to detail the workings of the real estate market and as a basis for benefit-cost analyses of aircraft noise abatement policy options or proposals. The basic value sought is sometimes referred to as a noise depreciation index.

Because several estimates are available for the depreciation index, policymakers and economists alike are faced with the problem of choosing an appropriate value (or range of values) for this index. Benefit-cost studies, for example, have employed index values that differ by a factor of four and, it can be demonstrated, the results obtained are quite sensitive to the index values employed.[1] Thus, efforts to narrow the range of values for the depreciation index might result in more accurate and reliable quantitative analyses of abatement policy options and proposals. In addition, the study of the noise-property value relationship at a number of airports means that it may be possible to derive individual benefit estimates, rather than relying on the results from a single airport and extrapolating benefits to the nation as a whole.

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[1]See J. P. Nelson, Economic Analysis of Transportation Noise Abatement (Cambridge: Ballinger Publishing Co., 1978), Chapter 8.

Aside from the inherent difficulty of economic measurement of noise effects (nonmarket good, data availability, choice of annoyance index), past empirical studies present several interpretation problems:

1. Due to differences in data sets and econometric methods, it is difficult to compare index values for different airport locations. For example, empirical studies have been conducted at three levels of aggregation--individual houses, census blocks, and census tracts.

2. Some investigators have ignored the notion of a background or residual noise level (a Noise Exposure Forecast of 20 or a Composite Noise Rating of 90), or have employed questionable noise measurement data.

3. Most investigators have ignored the possibility that an airport exerts two distinct effects on residential property values--a depreciation effect due to noise and an appreciation effect due to employment accessibility or enhanced commercial value.

This report is an attempt to resolve these and other issues by applying a consistent set of procedures across a group of airports chosen from the U.S. Department of Transportation's (DOT's) 23-Airport Study.[2] We caution at the beginning that the results obtained are subject to interpretation due to limitations in the data, especially the amount of information available on housing and neighborhood characteristics.

1.2 Statement of the Problem

Previous studies of aircraft noice abatement benefits have attempted to derive a measure representing the marginal capitalized property damage per unit of noise exposure. This measure is typically obtained by selecting a value for the noise depreciation index, multiplying this value by the change in noise exposure levels during a given time period, and then multiplying again by the population exposed to noise. The resulting estimate is interpreted as the amount people

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[2] C. Bartel, L. C. Sutherland, and L. Simpson, Airport Noise Reduction Forecast: Volume 1--Summary Report for 23 Airports, DOT-TST-75-3 (Springfield, Va.: NTIS, October 1974).

would be willing to pay for the given level of noise abatement, assuming the change in noise exposure levels is small.

This aggregative approach is based primarily on numerical and computational simplicity, and does not necessarily reflect the complexity of the actual situations present at various airports. Individual airports differ markedly in terms of the mix of residential and aeronautical activities, including type of aviation services provided and adjacent land usage. Consequently, a less aggregative approach to the measurement of noise abatement benefits is desirable. This improved method would derive abatement benefits from data for a number of individual airports, rather than relying on a single airport and extrapolating the results to the nation as a whole. Barring information on all airports, it should at least be possible to employ more consistent data collection and estimation procedures and thereby narrow the range of possible values for the noise depreciation index.

The present study involves analysis of property values around 10 U.S. airports and employs a consistent data base across all airports. For each airport, linear regression analysis will be used to obtain an estimate of the noise depreciation index. Within the limitations of the data base available and the number of airports analyzed, the results should provide information on the relative consistency of noise exposure effects at a variety of airports. The results should therefore provide a more valid basis for future calculations of the benefits and costs of noise abatement efforts.

Because of difficulties encountered with the sampling procedure, final empirical results are reported in detail for only seven selected airports. Excluded from the analysis are results for Minneapolis-St. Paul, Atlanta, and New York-La Guardia Airports (see Appendix H). The Minneapolis sample contained a number of lakes and a major park which bisected the area under the northwest flight path. The Atlanta sample contained a significant amount of rental housing units which limited the sample sizes. The La Guardia sample included a large number of residential units which did not report property values to the census in 1970. The latter problem was also evident for the Boston sample, although some results have been reported for Boston's Logan Airport.

1.3 Plan of the Study

The remainder of this report is divided into three chapters. The next chapter, Chapter 2, describes the methodology employed in the study of each airport. Chapter 3 summarizes the empirical results, while Chapter 4 contains the conclusions and recommendations. A number of appendices contain descriptions of each study area and detailed tables describing the sample selection procedures, regression estimates, and other empirical results.

CHAPTER 2

METHODOLOGY

This chapter describes the methodology of the study with respect to selection of 10 airports, selection of a study area at each airport, and acquisition of data on aircraft noise levels and residential housing characteristics. Following the description of the methodology, a brief comparison is given of present methods with those employed in census block studies by Paik and De Vany.

2.1 Selection of Airports

The DOT study by Bartel, Sutherland, and Simpson analyzed the impact of noise reduction at the 23 major airports shown in Figure 2.1. Daily jet operations from these airports represented 53 percent of total jet aircraft operations by all principal U.S. air carriers in 1972, while by the year 1987 these airports are expected to account for about 46 percent of total operations.[1]

From the list of 23 airports, 10 were selected for tentative inclusion in the present study (Table 2.1). In 1972, these 10 airports accounted for 45 percent and 36 percent, respectively, of the estimated 23-airport population and total U.S. population residing within the Noise Exposure Forecast 30-unit contour (NEF 30).

Several major airports (O'Hare, JFK, Newark, Los Angeles) are excluded from the list of 10. The size of their noise contours resulted in study areas that extended more than five miles beyond the main terminal. In addition, airports were excluded due to (1) extremely small noise contours or small levels of aviation activity; (2) questionable noise level data from the 23-airport study; and (3) addition of new runways between April 1970 (census period) and October 1972 (noise measurement period).

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[1]C. Bartel, L. C. Sutherland, and L. Simpson, Airport Noise Reduction Forecast: Volume 1--Summary Report for 23 Airports, DOT-TST-75-3 (Springfield, Va.: NTIS, October 1974), p. 1-2.

FIGURE 2.1 LOCATION OF 23 AIRPORTS USED FOR AIRPORT NOISE REDUCTION FORECAST STUDY

TABLE 2.1

SUMMARY CHARACTERISTICS OF THE 23 AIRPORTS

	Airport	10^3 People Exposed to NEF $\geq$ 30	Comments[a]
1.	La Guardia	1,057.0	Included (5)
2.	O'Hare	771.7	Excluded due to large size of noise contours
3.	JFK	507.3	Excluded due to large size of noise contours
4.	Newark	431.9	Excluded due to large size of noise contours
5.	Boston	431.3	Included (10)
6.	Los Angeles	293.4	Excluded due to large size of noise contours
7.	Miami	260.0	Excluded due to large size of noise contours
8.	Denver	180.3	Excluded due to questionable noise contours
9.	Cleveland	128.7	Included (17)
10.	San Francisco	124.4	Included (6)
11.	Seattle	123.2	Excluded due to new runway, 1970-72
12.	Buffalo	113.8	Included (33)
13.	St. Louis	100.0	Included (13)
14.	Atlanta	99.8	Included (2)
15.	Minneapolis	96.7	Included (15)
16.	Philadelphia	76.9	Excluded due to new runway, 1970-72
17.	San Diego	77.3	Included (32)
18.	Midway	38.5	Excluded due to small size of noise contours
19.	New Orleans	32.5	Included (21)
20.	National	24.4	Excluded due to small size of airport
21.	Phoenix	20.5	Excluded due to small size of airport
22.	Dulles	3.5	Excluded due to small size of airport
23.	Portland	1.2	Excluded due to small size of airport
	Total - all 23	4,994.3	
	Total - 10 Inc.	2,261.5	
	Total - U.S.	6,200.0	

[a]Number in parentheses shows 1972 rank in terms of annual average daily air carrier operations.

Source: Noise exposure data from C. Bartel, L. C. Sutherland, and L. Simpson, Airport Noise Reduction Forecast: Volume 1--Summary Report for 23 Airports, DOT-TST-75-3 (Springfield, Va.: NTIS, October 1974), pp. 2-5 and 3-7 through 3-30. U.S. total from DOT information briefs.

The 10 airports include three large, busy airports, five medium-sized airports, and two smaller airports. Annual average daily air carrier operations in 1972 and the land area for each airport are displayed in Table 2.2. Of course, both the activity level of an airport and its location interact to determine the number of people exposed to a given noise level and the severity of the airport noise problem.

2.2 Selection of Study Areas

For each airport, the Department of Transportation provided scaled maps (2.5 inches ≈ 1 mile) of the 1972 NEF contours.[2] These maps included isopleth data, in 5-unit increments, for NEF levels from 25 to 45 (inclusive). Including a background noise level of NEF 20, six data points are possible for any given census block in the samples. No attempt was made to interpolate between the NEF contours, although observations that border on the NEF-25 and NEF-30 contours were excluded from most samples. In addition to the NEF maps, the DOT provided aerial photographs and obstruction charts for each of the airports.

The NEF maps (on vellum) were overlaid on the census block maps for each airport and its surrounding residential area. From this information, a study area was selected that roughly met each of the following criteria:

1. A contiguous geographic area exists within one to five miles from the main terminal. As explained below, this criterion is an attempt to hold accessibility factors constant.
2. The area includes NEF values from 25 to 45. For reasons explained below, NEF 20 values were usually excluded except at two smaller airports (New Orleans and Buffalo).
3. The area contains a relatively homogenous housing stock in terms of housing density, type of housing, and access to major highways. Additional data screening procedures were used to ensure that this criterion was met.

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[2] NEF maps were also provided for four excluded airports--Newark, Seattle, Philadelphia, and Chicago-Midway. The NEF-25 contours were added especially for this study.

TABLE 2.2

SUMMARY CHARACTERISTICS OF
THE 10 AIRPORTS

Airport	1972 Daily Operations[a]	Airport Land Area[b]	10^3 People Exposed to NEF $\geq$ 30
Atlanta	1,136	6.56	99.8
La Guardia	798	0.91	1,057.0
San Francisco	780	8.13	124.4
Boston	590	3.72	431.3
St. Louis	504	2.89	100.0
Minneapolis	338	4.58	96.7
Cleveland	366	2.30	128.7
New Orleans	300	2.34	32.5
San Diego	208	0.76	77.3
Buffalo	204	1.56	113.8

[a]Annual average daily air carrier operations during CY 1972.

[b]Land area inside airport property boundary in square miles.

Source: C. Bartel, L. C. Sutherland, and L. Simpson, Airport Noise Reduction Forecast: Volume 1--Summary Report for 23 Airports, DOT-TST-75-3 (Springfield, Va.: NTIS, October 1974), pp. 2-5 and 3-7 through 3-30.

Figure 2.2 illustrates the selection of a representative study area for Cleveland's Hopkins Airport. Study area maps for all airports are included in the appendices. Each of the selection criteria will now be discussed in greater detail.

Contiguous Geographic Area. In contrast to most earlier studies, relatively small homogeneous study areas were selected for each airport. Within each area, noise levels vary from about NEF 25 to 45. In selecting these areas, it was assumed that an airport has two distinct effects on property values--a depreciation effect due to noise and an appreciation effect due to employment accessibility, air travel accessibility, or the enhanced commercial value of the land.[3]

The noise-accessibility trade-off can be illustrated with the aid of Figures 2.3 (a) and 2.3 (b). The upper curve in each figure, labeled P, shows the value gradient for residential housing with respect to the airport if the airport were nonpolluting. The value gradient decreases at a rate roughly equal to the marginal cost of transportation (operating and time costs) to the airport until it intersects with the underlying value surface, that is, the ambient level of accessibility in the urban area in question. Any point on the P curve thus indicates the total premium associated with increasing accessibility to the airport. A similar model could be used to illustrate the effect of travel accessibility or commercial value on vicinage real estate.

If we now add airport noise to the model, the reduction in residential property values, labeled d, associated with the disutility of noise is drawn below the horizontal line to indicate its negative effect on property values. Any point on the d curve thus indicates the total discount associated with greater and greater amounts of noise as we move in the direction of the airport. The net effect of the airport is now the sum of these two curves which is shown as a heavy line and labeled P + d. In Figure 2.3 (a), the net effect is to reduce absolutely the level of property values, while in Figure 2.3 (b), the net effect is only a relative reduction in property values.

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[3]See A. S. De Vany, "An Economic Model of Airport Noise Pollution in an Urban Environment," in S.A.Y. Lin (ed.), Theory and Measurement of Economic Externalities (New York: Academic Press, 1976), pp. 205-14.

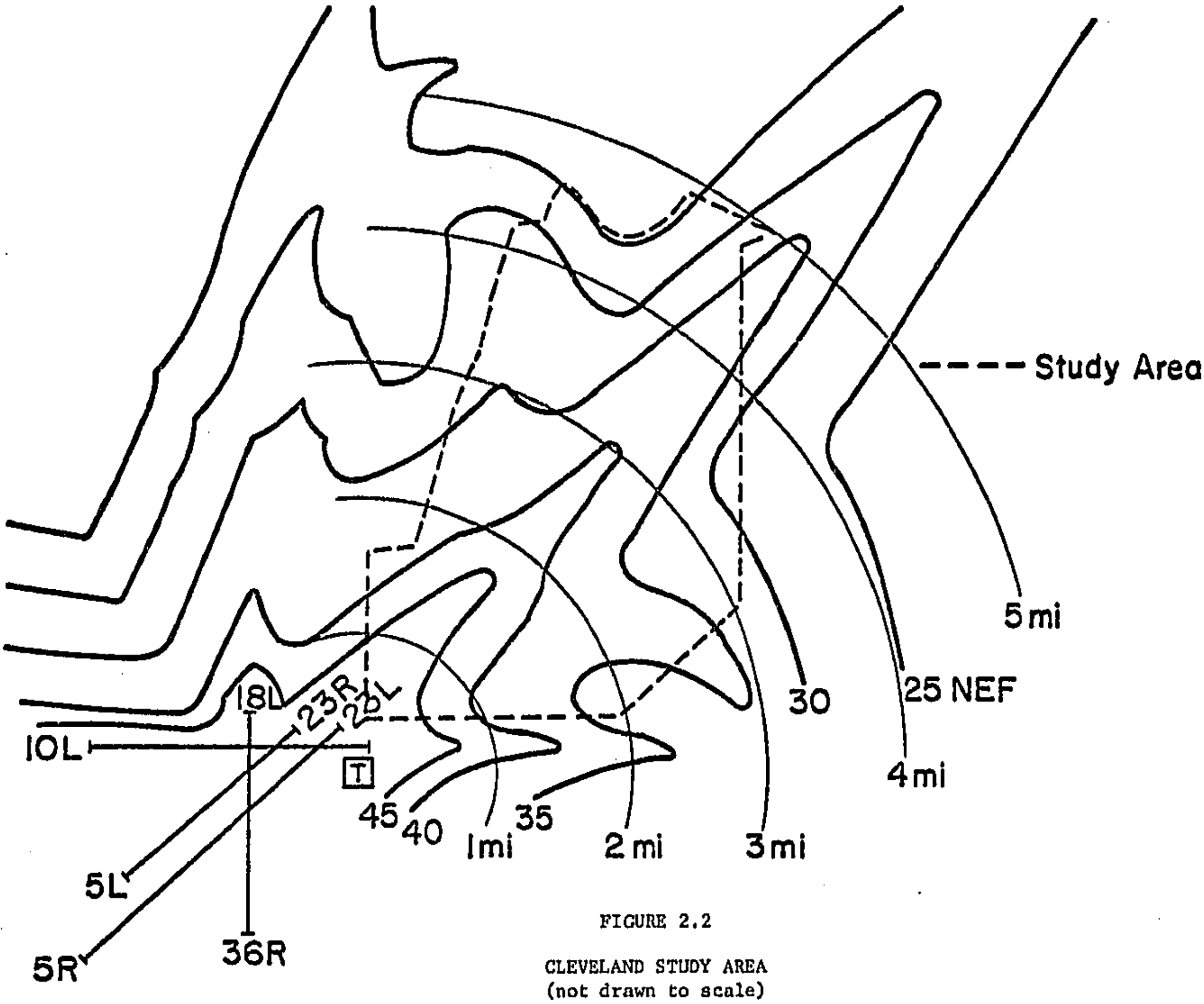

FIGURE 2.2

CLEVELAND STUDY AREA
(not drawn to scale)

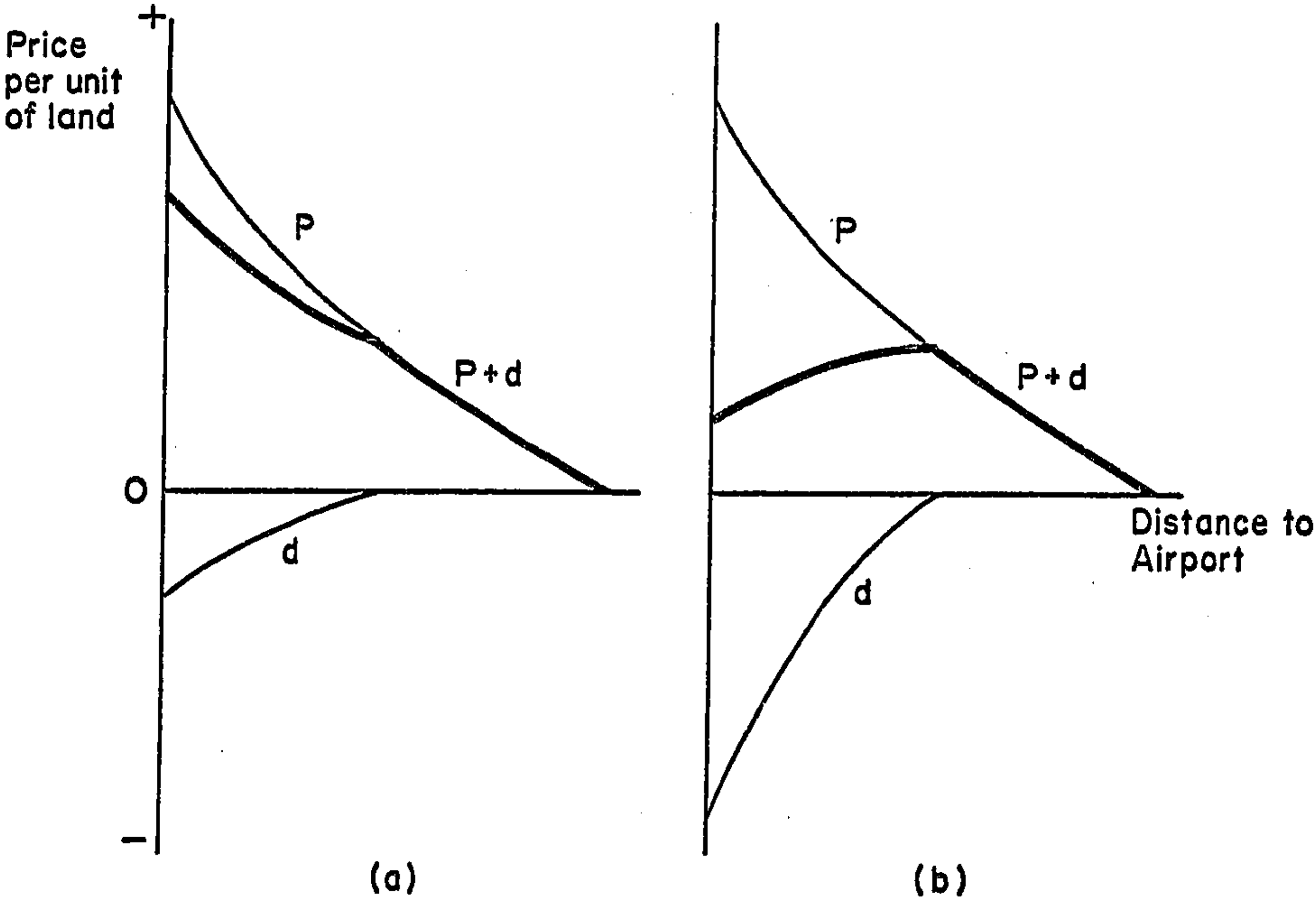

FIGURE 2.3

AIRCRAFT NOISE-AIRPORT ACCESSIBILITY TRADE-OFF

Analytically, the problem is how to separate these two effects from one another. Most earlier studies simply ignore the problem, which will tend to bias the noise regression coefficient toward zero. Some procedures that could be used to separate accessibility and noise effects include

1. Use of an airport accessibility variable, such as linear distance from the airport terminals.[4] However, the high correlation between airport accessibility and airport noise levels will usually result in a multicollinearity problem.

2. Use of dummy (binary) variables that attempt to capture the net effect of accessibility and noise.[5] If circular distance rings are used to form the dummy variables, each variable tends to reflect more than one noise exposure level (see Figure 2.2 and the appendices). This implies measurement errors and an interpretation problem for the dummy variable coefficients.

3. Selection of a study area which is small enough so that important accessibility variables are constant, but within which noise levels vary over the full range of possible values. This procedure will also tend to hold constant accessibility to other major points (e.g., central business districts), but the problem is to select a study area that is small enough.

The study areas employed in the present study are all within five miles of the main airport terminals and have a radius of about two miles. In most cases, noise levels ranged from NEF 25 to 45. It is, of course, possible that these areas are too large and accessibility will still vary in an important manner.[6] While this issue cannot be resolved completely within the confines of the present study, some tests are presented in Chapter 4 for possible specification bias due to accessibility influences.

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[4]See P. K. Dygert, "Estimation of the Cost of Aircraft Noise to Residential Activities," Unpublished Ph.D. dissertation, University of Michigan, 1973.

[5]See De Vany, op.cit., p. 212.

[6]See De Vany, op. cit., pp. 211-14, for some empirical evidence on this point.

NEF Values. The second criterion used to select study areas was to confine the range of noise levels to NEF values from 25 to 45. There were several reasons for employing this criterion. First, except for areas directly under flight paths, many NEF-25 contours were within five miles of an airport. This means that sideline noise is noticeable out to about five miles, and beyond this distance noise levels reach background levels. Thus, the accessibility criterion dictated a lower cutoff of NEF 25. This, however, was the case only at the medium-sized airports. At large airports, sideline NEF-25 contours will extend beyond five miles, while at smaller airports, sideline noise may be a problem for only several miles depending on aviation activity levels, flight patterns, residential density, and so on.

A second reason for employing this criterion deals with the pattern of residential housing near an airport. At distances greater than five miles or beyond the NEF-25 contour, residential housing patterns tend to undergo important changes in density or accessibility. A suburban area might, beyond these limits, change to a rural area. Housing density thus might change from high density to low density or access to transportation facilities might be considerably worse. The desire to hold these and other variables constant dictated that noise levels should be no lower than NEF 25. in most cases.

A third and final reason for this criterion deals with the possible use of the empirical results from this study. Our interest is in the effect of aircraft noise on residential property values within an area where noise is a moderate to severe problem. Since noise abatement policy is likely to change aircraft noise levels by modest amounts, we are not interested in a comparison of property values in areas where noise is a severe problem with those areas where it is of little or no consequence. For NEF values greater than 25 or 30, the influence of other transportation or urban sources is likely to be quite small, and aircraft noise will be perceived as a significant intrusion. For NEF values below 25 or 30, the noise environment due to other sources may alter the response of individuals to aircraft noise per se. Since noise measurements are only accurate to within ±5 NEF, a value of NEF 25 seemed to be an appropriate cutoff for a threshold level of noise.

NEF values of 20 are included only for New Orleans and Buffalo, due to the small size of these airports and limited noise exposure areas.

Homogeneous Housing Stock. A final reason for selecting small, contiguous geographic areas was the desire to hold constant many of the determinants of residential property values. These include lot size, neighborhood characteristics such as school district, and environmental aspects other than aircraft noise. To the extent that this is possible, the dominant variable in the study area should be the level of aircraft noise. In addition, because of the limited number of explanatory variables available at the census block level, special procedures were used to limit the amount of variation in the housing stock.

In choosing a study area, the census block maps and aerial photographs were used to limit the study area to housing that appeared to be relatively uniform in terms of type, density, and access to transportation facilities. When collecting the data on noise levels, census blocks were excluded if they were near or adjacent to local environmental features (parks, cemeteries, golf courses), major transportation facilities (freeways, major streets, railroad tracks), major commercial developments (shopping centers, apartment complexes), or other special neighborhood features (sewage treatment plants, canals, naval bases).

Beyond these restrictions, wherever possible, the following constraints were incorporated in the final computer sample used in the regressions:

1. Census blocks were excluded if less than 50 percent of housing units were single-family, owner-occupied units.

2. Census blocks were excluded if there were fewer than 10 single-family, owner-occupied units in a block.

3. Census blocks were excluded if less than 80 percent of the housing units reported property values. This constraint is an attempt to obtain comparable samples for property values and other block variables such as the mean number of rooms per unit.

4. The residuals from the final regressions were screened to detect any extreme positive or negative residuals by census blocks. Given the small samples employed and limited number of explanatory variables, outliers can have a substantial impact on the empirical results.

5. Two explanatory variables (noted below) were specified at the census tract level. The tract variables attempt to capture broad differences in the housing stock that might be correlated with aircraft noise levels.

2.3 Data Acquisition

Having selected a study area, each block was then assigned a value for NEF. In general, if a block was divided between two noise levels and the division was more or less equal, then the block was assigned the lower of the two NEF values. In addition, a second, more restricted sample was obtained by excluding blocks near or adjacent to the actual NEF-25 or -30 contours and blocks within the NEF-30 contour but adjacent to the NEF-35 contour. This procedure was adopted for three reasons. First, the noise data are for October 1972 while census data are for April 1970. Between these dates, the actual contour lines may have shifted due to changes in aviation activity levels. Second, the noise data are in 5 NEF increments. Two blocks that border either side of a contour may differ by as little as one or two NEF units, yet the recorded values must necessarily differ by 5 NEF. Measurement errors such as these will bias the regression coefficient toward zero. Third, the exclusion criterion results in samples that are more heavily weighted toward severe noise levels (NEF 35-50). In general, the final empirical results are based on samples that incorporate the boundary restrictions on the NEF variable.

Data on the remaining variables were obtained from three sources: the 1970 Census Third Count Summary Tapes, the printed census city block reports, and the printed census tract reports.

The Third Count tapes were obtained for each airport from The Pennsylvania State University Computation Center. From these tapes, data were obtained by census block on the following variables:[7]

[7] The variables and data sources are described in greater detail in Table 3.1 in the next chapter.

1. Mean owner-occupied property value (owner estimate).

2. Percent of owner-occupied houses that have more than 1.5 occupants per room.

3. Percent of census block population which is black.

4. Percent of total housing units (rental plus owner-occupied) that are owner-occupied.

5. Absolute number of owner-occupied housing units.

Because of the large number of disclosure suppressions on the second variable, the empirical results do not include information on the density of occupancy. The fifth variable was used only to screen out blocks where statistical reporting errors might be a significant problem.

The printed census block reports, entitled Block Statistics: 1970 Census, were used to obtain data on the following variables:

1. Mean number of rooms per unit for owner-occupied houses.

2. Number of owner-occupied houses with substandard plumbing.

Using information on total owner-occupied housing units and total owner-occupied population in each block (from the Third Count tapes), additional variables were formed on the average number of people per room and percent of owner-occupied housing units with substandard plumbing. The former variable was of limited usefulness due to disclosure suppressions in the population data for most cities.

Finally, the printed census tract reports, entitled Census Tracts: 1970 Census, were used to acquire the following data:

1. Percent of housing units built before 1939.

2. Percent of housing units with central air conditioning.

Since these variables are specified at the tract level, they represent an attempt to capture any broad differences among blocks in the samples.

Because the aircraft noise data also cover broad areas, the tract and NEF variables tend to be highly correlated. It was not possible, in all cases, to include both tract variables in the final regressions. This problem should be kept in mind when interpreting the final empirical results.

2.4 Comparison with Earlier Studies

Two earlier studies by Paik and De Vany employed census block data to study the property value--airport noise relationship. This final section briefly reviews the methodology of these studies.

Paik.[8] This study employed 1960 census block data and 1965 NEF data for three major airports: John F. Kennedy Airport in New York, Los Angeles International, and Love Field Airport in Dallas. A sample of about 100 blocks was obtained for each airport, with noise levels more or less equally divided between NEF 20, 30, and 40. For example, the Los Angeles sample consisted of 30 blocks with an NEF value of 20, 32 blocks with NEF 30, and 30 blocks with NEF 40. Each sample consisted of blocks located within five to six census tracts.[9] Paik also excluded blocks located near the boundaries of the NEF contours and included only those blocks where at least 50 percent of the housing were single-family, owner-occupied units. About 10 percent of the blocks included in each sample had fewer than 10 single-family, owner-occupied units.

Paik's study includes explanatory variables for aircraft noise, population or housing density, percent single-family homes, percent nonwhite homes, percent crowded homes, percent deteriorated homes, and median number of rooms per unit. Most of these variables were not statistically significant and Paik's final regressions incorporate only NEF and median number of rooms as explanatory variables.[10]

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[8] I. K. Paik, "Measurement of Environmental Externality in Particular Reference to Noise," Unpublished Ph.D. dissertation, Georgetown University, 1972.

[9] Ibid., p. 131.

[10] Ibid., p. 141.

The methodology of the present study differs in several respects from Paik's. First, additional procedures were taken to screen out sparsely populated residential blocks and blocks where less than 80 percent of the units have reported values. Second, the NEF data in the present study are generally confined to values from 25 to 45, rather than 20 to 40. Third, the present study uses census and noise data for 1970 and 1972, respectively, rather than 1960 and 1965. These differences suggest that our results should better reflect the effect of noise on property values within those areas where aircraft noise is a significant environmental problem. Paik's study, on the other hand, probably captures an "all-or-nothing" effect, as well as the short-run real estate market effects associated with the introduction of commercial jet aircraft in the early 1960s. The exclusion of tract variables in Paik's study also casts doubt on the empirical results.

De Vany. This study employed 1970 census block data for Love Field Airport in Dallas. De Vany employed a large sample that included information on 1,270 census blocks. He defined five circular distance rings around the airport, resulting in four qualitative dummy variables. When each of these variables was zero, the block lies somewhere beyond four miles distance from the airport; otherwise, it lies in one of the intervals 0-1, 1-2, 2-3, or 3-4 miles as indicated by a value of one for the respective dummy variable.[11] The coefficient on a dummy variable reflects the net effect of airport noise and airport accessibility within the given interval. The four distance rings will include all blocks under the main flight paths with NEF values of 40 or more. However, on the sidelines, the distance rings probably reflect noise levels as low as NEF 20.

De Vany also employed explanatory variables for percent of homes that are owner-occupied, average number of rooms per house, average age of housing, average length of stay of residents, percent of homes with air conditioning, and distance from the central business district. In the final regression, all variables were statistically significant except the variable for average length of stay by residents.

[11] De Vany, op.cit., p. 212.

While the variables employed in the present study are much the same as in De Vany's study, the samples employed are quite different. We use small study areas that include about 200 to 400 blocks, rather than samples drawn from a broader urban area. The various constraints and restrictions placed on the data further reduce our final samples to 113 to 185 observations. Within each study area, we attempt to capture the effect of noise alone on property values, rather than the net aggregate effect of an airport on the market value of real estate. Despite the major differences between the two studies, De Vany's empirical results are quite comparable with those obtained in the present study. This suggests that the methodology adopted herein does control for the effects of airport accessibility.

CHAPTER 3

EMPIRICAL RESULTS

This chapter presents the results for the aircraft noise-property value relationship at seven selected airports. The empirical results are based on the so-called hedonic price equation approach to property values. The chapter summarizes this equation, the choice of explanatory variables and functional form, and the econometric results.

3.1 The Hedonic Price Equation

Because each house and lot represents an almost unique combination of characteristics, the decision to purchase a property is complex. The price that a potential buyer is willing to pay depends on location, attributes of the community and neighborhood, local taxes, and public services, as well as the physical characteristics of the structure and land. Since these characteristics are sold as a package, it is difficult to infer from one sale what the incremental effect of one attribute (one more room or one more decibel of noise) has on the final selling price of a dwelling. A way must be found to disentangle the incremental effect of each attribute on the composite price or value of the property. To the extent that such an unbundling is possible, estimates can be obtained for the implicit price of quiet in dollars per decibel, the price of living space in dollars per room, and so on.

If observations are available on a sample of housing sales or values, then multivariate regression analysis can be used to obtain estimates of the implicit or hedonic prices of housing characteristics. For simplicity, we assume that houses differ only in terms of size (in number of rooms or living space) and aircraft noise exposure (in NEF units). Forming a simple linear econometric relationship, we can write

(1) $V_i = b_o + b_1X_{hi} + b_2X_{ni} + u_i, \quad i = 1, \ldots, N$

where V is the selling price or value of the i-th home in dollars; X_h and X_n are the (variable) amounts of living space and noise exposure, respectively; b_1 and b_2 are the implicit prices to be estimated; b_o is a constant term that captures the effect of all other determinants of property values; and u is a stochastic error term reflecting possibly omitted variables and measurement errors.[1]

Equation (1) thus represents a hedonic price equation from which implicit attribute and characteristic prices may be obtained econometrically. For example, suppose that b_1 has an estimated value of $6,700 in 1970 dollars so that each extra room adds this amount to the final selling price of a dwelling, other factors remaining constant. If the housing market is competitive, then the estimated price will be equal to the marginal (incremental) cost of additional living space.[2]

3.2 Choice of Variables

Potentially, a large number of variables will determine observed differences in property values within a given urban or suburban area. For descriptive purposes, it is useful to divide these characteristics into five more or less mutually exclusive and exhaustive classes:

1. Physical Characteristics--the number of rooms, size and dimensions of the lot, number of stories, age and condition of the structure, availability of central air conditioning, etc.
2. Accessibility Characteristics--access to major places of employment and other agents with whom a homeowner might wish to engage in transactions.

[1]Of course, other variables may be present in the sample and the relationship need not be strictly linear.

[2]For some empirical evidence on this point, see J. P. Nelson, Economic Analysis of Transportation Noise Abatement (Cambridge: Ballinger Publishing Co., 1978), p. 91.

3. Environmental or Neighborhood Characteristics--noise levels, housing density, racial composition, and other major physical or social features of the neighborhood and community in which the house is located.

4. Public Sector Characteristics--real property tax rate, school quality, and the quantity and quality of other major public services to which a property owner is entitled.

5. Alternative Use Characteristics--possible conversion of residential land and dwellings to commercial or industrial uses, except as restricted by zoning ordinances. In equilibrium, the highest valued use is expected to be in place on a given plot of land.

The sample selection procedures described in Chapter 2 attempt to control for (hold constant) many of the possible determinants of residential property values. The actual variables employed in the hedonic price equation are summarized in Table 3.1. The most important of these variables will now be described under six headings.

Mean Property Value. The dependent variable is the mean value of residential housing units in each census block. Census data on value are limited to single-family, owner-occupied houses on less than 10 acres, without a commercial establishment or medical office on the property. Cooperatives, condominiums, mobile homes, and trailers are excluded from the census value tabulations.

Value estimates are obtained by asking each homeowner how much the property (house and lot) would sell for if it were presently for sale (circa April 1970). Housing value is recorded on the census questionnaire in intervals of $2,500 for values less than $25,000 and in intervals of $10-$15,000 for values above $25,000. For computing census block means, the midpoint of each interval is used, except that $3,500 is used for values less than $5,000 and $60,000 is used for values in excess of $50,000.[3]

[3]The use of owner estimates of value and value intervals will introduce measurement errors in the dependent variables. Several empirical investigations of this issue suggest that these measurement problems are not overly serious, see Ibid., pp. 80-81. The data screening procedures employed in the present study also attempt to compensate for this problem, i.e., only those blocks where at least 80 percent of the units reported values are employed in the final regressions.

TABLE 3.1

DESCRIPTION OF VARIABLES

Variable Name	Description, Method of Construction, and Source
1. MPVAL	Mean Owner-Occupied Property Value (Specified Units). Construction: Aggregate owner-occupied property value X 250 / Owner-occupied units reporting value. Source: 1970 Census Third Count Summary Tapes.
2. ROOMS	Mean Number of Rooms per Unit for Owner-Occupied Houses. Construction: None. Source: U.S. Department of Commerce, Bureau of the Census, Block Statistics: 1970 Census, Table 2.
3. NOPLUMB	Percent of Owner-Occupied Houses with Substandard Plumbing. Construction: Number of units lacking some or all plumbing facilities X 100 / Total owner-occupied housing units. Source: Plumbing variable from Block Statistics: 1970 Census, Table 2. Owner-occupied housing units from Third Count Tapes.
4. MORE15	Percent of Owner-Occupied Houses that have More than 1.5 Occupants per Room. Construction: Number of owner-occupied units with more than 1.5 people per room X 100 / Total owner-occupied housing units. Source: 1970 Census Third Count Summary Tapes.
5. BLACKPOP	Percent of Block Population which is Black. Construction: (Black males + Black females) X 100 / Total block population. Source: 1970 Census Third Count Summary Tapes.
6. PCENTOO	Percent of Total Housing Units that are Owner-Occupied. Construction: Total owner-occupied units X 100 / Total housing units. Source: 1970 Census Third Count Summary Tapes.
7. BEFORE39	Percent of Year Round Housing Units Built Before 1939 (Tract Level). Construction: Housing units built before 1939 X 100 / Total year round housing units. Source: U.S. Department of Commerce, Bureau of the Census, Census Tracts: 1970 Census, Table H-2.
8. AIRC	Percent of Year Round Housing Units that have Central Air Conditioning (Tract Level). Construction: Housing units with central air conditioning X 100 / Total year round housing units. Source: U.S. Department of Commerce, Bureau of the Census, Census Tracts: 1970 Census, Table H-2.

TABLE 3.1 (Continued)

Variable Name	Description, Method of Construction, and Source
9. PEOPLEPR	Average Number of Persons Per Room. Construction: (Owner-occupied population X 100)/(Total owner-occupied units X ROOMS) Source: ROOMS from Block Statistics: 1970 Census, Table 2. Other data from Third Count Tapes. Note: Due to extensive confidentiality suppression of the population variable in some cities, PEOPLEPR was of limited usefulness.
10. OOUNITS	Absolute Number of Owner-Occupied Housing Units. Construction: None. Source: 1970 Census Third Count Summary Tapes.
11. NEF-I	Noise Exposure Forecast (without boundary restrictions). Construction and Source: Obtained from census block maps and DOT-NEF contour maps.
12. NEF-II	Noise Exposure Forecast (with boundary restrictions). Construction and Source: Obtained from census block maps and DOT-NEF contour maps. Blocks adjacent to NEF-25 and -30 contours or blocks within NEF 30 but adjacent to NEF 35 are eliminated.

Physical Characteristics. The larger the houses and lots in a census block, the higher the mean property value, other factors remaining constant. In addition, the age and quality of housing would be expected to be important determinants of property values. At the census block level, variables used to capture the effect of physical characteristics include the mean number of rooms per unit and the percent of units with substandard plumbing. Rooms counted include only whole rooms used for living purposes; not counted as rooms are bathrooms, half-rooms, kitchenettes, utility and storage areas, basements, unfinished attics, and the like. Substandard plumbing refers to units that do not have all of three specified facilities--hot and cold piped water, flush toilet, and bathtub or shower inside the structure--or that have toilet and bathing facilities that are shared with occupants of other housing units.

In addition to rooms and plumbing facilities, several other variables capture some of the effects of physical differences among dwelling units. Holding the size of structures constant, the average size of lots will be related to the density of housing. As a proxy for housing density, an explanatory variable is included for the percent of total housing units that are owner-occupied. Broad differences in the age and quality of the housing stock are also reflected in two proxy variables that are specified at the census tract level; these are the percent of housing units built before 1939 and the percent of housing units with central air conditioning. The sample selection procedures attempt to hold constant (or approximately so) many of the other physical characteristics of the housing stock in each study area.

Accessibility Characteristics. The distance of a property from major places of employment, shopping centers, and other commercial or industrial developments affects the real costs of living at that address and, hence, the amount people would be willing to pay for a particular dwelling. In the present study, an attempt is made to hold most accessibility factors constant by selecting relatively small study areas (about two miles radius) and, within each study area, excluding blocks that are near or adjacent to shopping centers, major streets and highways, parks, and the like.

Environmental or Neighborhood Characteristics. The central hypothesis in this study is that a relationship exists between aircraft noise (in NEF units) and the value of single-family residential property. In addition to the Noise Exposure Forecast, environmental variables are included for the proportion of single-family homes in each block, the age and quality of housing at the block and tract level, and the racial composition of each block. The percent of total housing units that are owner-occupied is a proxy for the undesirable effects of multifamily dwelling, such as noise, congestion, and visual blight. The percent of housing units with substandard plumbing (block level) and the percent of housing units built before 1939 (tract level) capture some of the negative external effects associated with less well maintained or older, less modern neighborhoods.

The racial variable is the percent of total block population which is black. The coefficient on this variable could be positive or negative. It will be positive if discrimination in the housing market limits the supply of housing available to blacks or other minorities. It will be negative if there are negative externalities associated with living in a racially mixed neighborhood. To the extent that blacks in the population have lower incomes and spend less on housing, then the racial variable will also capture some of the effect of physical housing characteristics on property values. In most of the study areas, the proportion of blacks in the population is quite small. The one exception to this rule is St. Louis.

Finally, the study design attempts to control for a number of local environmental factors that may cause differences in property value levels. Excluded from the samples are blocks near or adjacent to shopping centers, parks, cemeteries, golf courses, apartment complexes, railroad tracks, highways and major streets, sewage plants, and so on.

Public Sector Characteristics. Wherever feasible, the study areas were selected so as to include only one major political jurisdiction. Thus, important public sector variables (property tax rate, school quality, crime rates, etc.) should be constant in each study area. Since the tract variables cover broad areas, it is possible that these variables capture some public sector effects on residential property values.

Alternative Use Characteristics. Where residential land near an airport is a potential site for commercial or industrial development, its value, during a transition period, may exceed that produced by residential characteristics alone.[4] Commercial or industrial activities are less affected by noise and may be able to offer higher rents to existing landowners. By excluding blocks located near major streets and by restricting the samples to those blocks that are predominantly residential, the sample selection procedures are designed to control for possible conversion (speculative) effects on residential property values. In long-run equilibrium, however, we would expect each plot of land to be occupied by the highest valued use, except where restricted by zoning ordinances.

3.3 Choice of Functional Form

Several functional forms are possible for equation (1), including linear, double-log, and semi-log. The double-log form is especially useful because it allows for multiplicative interactions (tie-ins) among the explanatory variables and because the coefficient estimates can easily be compared for different study areas; that is, the coefficients represent elasticities showing the percentage change in the dependent variable for a given percentage change in an independent variable.[5]

The functional form chosen in the present study, after some initial experimentation, was as follows:

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[4] For analysis of this issue, see R. W. Crowley, "A Case Study of the Effects of an Airport on Land Values," Journal of Transport Economics and Policy, 7 (May 1973), pp. 144-52.

[5] The double-log form represents an application of the Weber-Fechner law of stimulus and response, i.e., the response rate is proportional to the percentage change in the stimulus.

(2) $\ln V = b_o + b_1 \ln X_h + b_2 \ln D + b_3 NEF + b_i X_i + u$

where ln V = natural log of the mean property value in each block,

$\ln X_h$ = natural log of the mean number of rooms per unit,

ln D = natural log of the percent of housing units that are owner-occupied,

NEF = Noise Exposure Forecast, and

X_i = all other explanatory variables such as percent of owner-occupied houses with substandard plumbing, percent of total block population which is black, etc.

The latter variable set, X_i, is made up of various environmental or neighborhood variables that contain a large number of zero observations. This made it desirable to employ the linear form of these variables, rather than, say, add a small constant to the zero observations to facilitate a logarithmic transformation.

The use of a semi-log relationship between property values and the Noise Exposure Forecast is based on the theoretical nature of this index and similar community response indices. For example, based on tests of the annoyance due to aircraft flyover noise, Bishop states that

> We would expect the subjective ratings plotted on a logarithmic scale to have a linear relationship with the perceived noise levels.[6]

To capture this relationship, we let the level of property value be expressed by

(3) $V = b_o Z^{b_1} A^{b_2} u_1$

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[6] D. E. Bishop, "Judgments of the Relative and Absolute Acceptability of Actual and Recorded Aircraft Noise," in Bolt Baranek and Newman, Analysis of Community and Airport Relationships/Noise Abatement, AD-645-945 (Springfield, Va.: NTIS, December 1965), Part II, p. 47. See also D. E. Bishop, "Judgments of the Relative and Absolute Acceptability of Aircraft Noise," Journal of the Acoustical Society of America, 40 (July 1966), pp. 108-22.

where V is the property value, Z is a set of housing characteristics such as number of rooms and housing density, A is subjective annoyance due to aircraft noise, and u_1 is a stochastic error term. Following Bishop, A is expressed by

$$(4) \quad A = c_o e^{c_1 NEF} u_2$$

where NEF is the Noise Exposure Forecast index in decibels, e is the natural log base, and u_2 is a stochastic error term. Taking logarithms yields

$$(5) \quad \ln A = \ln c_o + c_1 NEF + \ln u_2.$$

Taking the log of equation (3) and substituting for ln A allows us to write

$$(6) \quad \ln V = d_o + d_1 \ln Z + d_2 NEF + u_3$$

where $d_2 = b_2 c_1$, etc. Equation (6) is the basic relationship between NEF and residential property values employed in the present study.

Differentiating equation (6) with respect to NEF yields

$$(7) \quad \frac{\partial \ln V}{\partial NEF} = \frac{(\partial V/V)}{\partial NEF} = d_2$$

where $d_2 \cdot 100$ is the percentage change in a given property value associated with a unit change in the Noise Exposure Forecast. Thus, the coefficient d_2 can be interpreted as the relative rate of housing value change associated with each unit increase in aircraft noise exposure. The price of noise, in turn, is given by

$$(8) \quad \frac{\partial V}{\partial NEF} = d_2 V$$

which implies that, other factors remaining constant, the effect of a unit change in NEF will be greater the higher the property value.

Finally, the elasticity of value with respect to aircraft noise is given by

$$(9)\quad \frac{\partial V}{\partial NEF} \cdot \frac{NEF}{V} = d_2 \; V \left(\frac{NEF}{V}\right) = d_2 NEF$$

which implies that a given percentage increase in NEF will have a larger percentage impact the higher the NEF level, other factors remaining constant.

3.4 Final Samples

Table 3.2 summarizes the sample means for the final study areas for seven airports.[7] With boundary restrictions on the NEF variable, sample sizes range from 113 to 185 observations. Mean property values range from $16,411 in St. Louis to $32,241 in San Diego. The mean noise level varies from NEF 27.7 for New Orleans to NEF 33.9 for Cleveland. The study area blocks are predominantly residential--the average percent of owner-occupied units is about 85 percent including Boston and 88 percent without Boston. The average house in the final samples has about 5.75 rooms.

The remaining housing characteristic means vary greatly--Boston and Cleveland have the oldest housing stocks, St. Louis and New Orleans have the greatest proportion of central air conditioning units, and St. Louis has the greatest proportion of blacks in the sample population.

Table 3.3 shows the distribution of observations by noise levels, where each observation is assigned to one of three NEF contours. In only two instances do fewer than 10 percent of the observations lie in a given interval (Boston and New Orleans for NEF 40-50). On average, about 35 percent of the observations are situated in NEF 20-30, 50 percent in NEF 30-40, and 15 percent in NEF 40-50.

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[7]For reasons explained in Appendix H, the final results exclude Minneapolis, Atlanta, and La Guardia Airports.

TABLE 3.2

SUMMARY OF MEAN VALUES OF VARIABLES, BY AIRPORT[a]

Variable	(1) San Francisco (N = 153)	(2) Boston (N = 154)	(3) Cleveland (N = 185)	(4) St. Louis (N = 113)	(5) New Orleans (N = 143)	(6) Buffalo (N = 126)	(7) San Diego (N = 125)
Mean Property Value (St. Dev.)	$29,686 (5,198)	$22,857 (3,423)	$20,898 (2,787)	$16,411 (3,684)	$21,975 (5,651)	$20,656 (4,319)	$32,241 (8,335)
NEF-II	31.797	27.955	33.892	30.177	27.657	29.325	32.320
Mean Rooms per Unit	5.753	5.790	5.526	5.487	5.804	5.856	5.990
Percent Owner-Occupied Units	83.354	69.986	89.255	87.620	88.331	91.277	86.250
Percent Black Population	0.717	0.472	0.090	8.479	0.431	0.104	0.108
Percent Substandard Plumbing	0.382	1.872	1.141	0.787	0.280	0.376	0.166
Percent Built Before 1939	9.580	59.251	29.868	15.501	0.963	11.610	19.850
Percent Central Air Conditioning	1.253	0.945	3.689	33.516	38.134	1.935	0.748
Distance to CBD (miles)[b]	11.000	4.000	7.000	11.000	8.500	6.500	5.500

[a]N = sample size in blocks.

[b]Distance from approximate center of study area to city hall, rounded to nearest half mile.

TABLE 3.3

DISTRIBUTION OF OBSERVATIONS, BY NEF INTERVAL[a]
(No. of Blocks)

Airport	NEF Interval 20-30	30-40	40-50	Total
San Francisco	25	109	19	153
(percent)	(16.3)	(71.2)	(12.4)	
Boston	85	69	--	154
(percent)	(55.2)	(44.8)		
Cleveland	24	128	33	185
(percent)	(13.0	(69.2)	(17.8)	
New Orleans[b]	73	58	12	143
(percent)	(51.0)	(40.6)	(8.4)	
St. Louis	56	37	20	113
(percent)	(49.6)	(32.7)	(17.7)	
Buffalo[b]	64	45	17	126
(percent)	(50.8)	(35.7)	(13.5)	
San Diego	47	49	29	125
(percent)	(37.6)	(39.2)	(23.2)	
Total	374	495	130	999
	(37.4)	(49.5)	(13.0)	
Total, excl. Boston	289	426	130	845
	(34.2)	(50.4)	(15.4)	

[a]Distributions do <u>not</u> reflect differences in population per block.

[b]Includes NEF 20 values as well as NEF 25 values.

The most recent U.S. Environmental Protection Agency (EPA) figures suggest that populations in the vicinity of airports are distributed as follows:[8]

NEF	1972 Population (millions)	Percent
25-30	8.5	53.1
30-40	6.0	37.5
40 and over	1.5	9.4
Total	16.0	100.0

Assuming more or less even population density by noise interval, the samples used in the present study contain a relatively greater proportion of the population in the NEF 30 and over intervals.

3.5 Empirical Results: Summary by Airport

Table 3.4 summarizes the empirical results for seven airports. In each case, a regression was selected that seemed to represent the best outcome, taking into account goodness of fit and the significance of the NEF coefficient. The table displays the coefficient estimates and uncorrected R^2s, as well as the possible range of NEF coefficients obtained from alternative specifications of equation (6).

The best NEF coefficients lie in the range -0.0029 to -0.0084, with a simple mean of -0.0055. Results for Cleveland, St. Louis, New Orleans, and Buffalo lie below the mean value. Results for San Francisco, Boston, and San Diego lie above the mean value. The results for Cleveland may be affected by multicollinearity since the next best estimate is -0.0069. The results for Boston reflect the poor sample obtained for this study area. If these two samples were

[8]U.S. Environmental Protection Agency, Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure, NTID 73.4 (Washington, D.C.: EPA, July 1973), p. 37. See Nelson, op. cit., p. 155, for other comparative population estimates.

TABLE 3.4

SUMMARY OF EMPIRICAL RESULTS, BY AIRPORT

Airport[a]	Mean Property Value	NEF Range	Best NEF Coefficient Estimate	Student-t Statistic	Regression R^2	Possible Coefficient Range[b]
San Francisco (N = 153)	$29,686	25-45	-0.0058	3.1549	0.713	-0.0041 to -0.0060
Boston (N = 154)	22,857	25-35	-0.0084	2.1693	0.153	-0.0084 to -0.0129
Cleveland (N = 185)	20,898	25-45	-0.0029	2.2695	0.690	-0.0029 to -0.0069
St. Louis (N = 113)	16,411	25-45	-0.0051	1.9136	0.742	-0.0040 to -0.0053
New Orleans (N = 143)	21,975	20-45	-0.0040	2.0523	0.751	-0.0033 to -0.0050
Buffalo (N = 126)	20,656	20-45	-0.0052	2.6000	0.611	-0.0052 to -0.0064
San Diego (N = 125)	32,241	25-45	-0.0074	3.1795	0.762	-0.0068 to -0.0074

[a]N = sample size.

[b]Coefficient values based on alternative regressions incorporating several explanatory variables. These results reflect the robustness of the coefficients given alternative model specifications.

Study Area	Correlations
San Francisco	-0.459*
Boston	-0.341*
Cleveland	-0.301*
St. Louis	-0.390*
New Orleans	-0.567*
Buffalo	-0.404*
San Diego	-0.108

where the asterisks indicate statistical significance at the 90 percent confidence level. The San Diego results are interesting in that the peak noise contours (NEF 40-50) contain mostly higher valued residential properties adjacent to the San Diego Naval Base. The next lowest correlation is Cleveland, where the sample is drawn largely from the NEF 30-40 contours.

The empirical results for seven individual airports are thus consistent with the basic hypothesis of this study. The range of coefficient estimates obtained may reflect differences in the samples used, income levels of the residents, climate of the study area, and sampling variations due to the stochastic nature of the property value-aircraft noise relationship. The next section of this chapter analyzes a pooled sample, while Chapter 4 considers the distribution of individual coefficients about a weighted-mean value.

3.6 Empirical Results: Pooled Sample

The observations from six airports, excluding Boston, were pooled to form a sample with 845 blocks. This procedure is permissable

the observations are drawn from a
chapter demonstrates that the nois
weighted mean, homogeneity of the e
all regression. For example, there
the level of property values acros
o and St. Louis.

The appropriate test for overall homogeneity of the samples is given by

$$(10)\quad F = \frac{[S^2 - \Sigma S_m^2]/(M - 1)(K + 1)}{\Sigma S_m^2/[\Sigma N_m - M(K + 1)]}$$

where

S^2 = residual sum of squares from the grand (pooled) regression (N = 845),

S_m^2 = residual sum of squares from the individual regressions of sample size N_m (m = 1,...,6),

M = number of airports (subsamples), and

K = number of independent variables.

For the pooled sample,

$$F = \frac{(32.838 - 9.522)/(5)(7)}{(9.522)/(845 - (6)(7))} = 60.545$$

which is statistically significant at the 0.05 level.

To allow for differences in the samples, dummy variables were added for five areas with San Francisco as the reference area; that is, the regression constant pertains to San Francisco. Since this procedure assumes the areas differ only in the constant term, the results for the pooled sample should be interpreted with caution. It is possible that the NEF coefficient reflects, in some important and unknown way, differences that exist among the urban areas.

Table 3.5 presents the regression results for the pooled sample. The NEF-II coefficient is about -0.005 in regressions (1) and (2), Regression Coefficients

	(1)	(2)	(3)	(4)
Constant	7.4625 (49.4098)*	7.5031 (49.0437)*	7.5295 (49.7636)*	7.5614 (49.3988)*
NEF-II	-0.0048 (6.6984)*	-0.0047 (6.5249)*	-0.0041 (5.4999)*	-0.0040 (5.3979)*
Ln Mean Rooms per Unit	1.3624 (31.6072)*	1.3828 (30.7938)*	1.3180 (29.4772)*	1.3365 (28.5900)*
Ln Percent Owner-Occupied	0.1364 (4.2801)*	0.1196 (3.5682)*	0.1330 (4.2008)*	0.1191 (3.5750)*
Percent Black Population	-0.0025 (4.1966)*	-0.0027 (4.4083)*	-0.0026 (4.3327)*	-0.0027 (4.4968)*
Percent Substandard Plumbing	-0.0007 (0.2577)	-0.0002 (0.0915)	-0.0009 (0.3413)	-0.0005 (0.1981)
Percent Built Before 1939	—	-0.0006 (1.6052)*	—	-0.0005 (1.3474)*
Percent Central Air Conditioning	—	—	0.0018 (3.4499)*	0.0017 (3.3349)*
New Orleans Dummy	-0.3573 (24.8744)*	-0.3609 (24.8442)*	-0.4198 (18.1979)*	-0.4209 (18.2434)*
Cleveland Dummy	-0.2948 (21.4865)*	-0.2817 (17.6674)*	-0.3020 (21.8993)*	-0.2908 (18.0824)*
St. Louis Dummy	-0.5346 (33.4484)*	-0.5280 (32.0337)*	-0.5926 (25.6329)*	-0.5853 (24.6643)*
Buffalo Dummy	-0.4222 (28.4876)*	-0.4196 (28.1749)*	-0.4204 (28.5364)*	-0.4183 (28.2490)*
San Diego Dummy	0.0053 (0.3645)	0.0109 (0.7282)	0.0077 (0.5309)	0.0124 (0.8263)
R^2	0.8379	0.8384	0.8402	0.8406
$\bar{R}^2$	0.8360	0.8363	0.8381	0.8383
F	431.1923	392.9683	398.1991	365.5246
SEE	0.1209	0.1201	0.1194	0.1193
Det (X'X)	0.2253	0.1188	0.4299	0.2253
N[a]	845	845	845	845

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

but declines to -0.004 in regressions (3) and (4). The latter regressions include the tract variable for central air conditioning.[9] Four of the five dummy variables are statistically significant.[10] All other coefficients are significant, except that for substandard plumbing. The corrected R^2s are about 0.84.

The mean property value for the pooled sample is $23,713 (Table 3.6), while the simple correlation between property values and NEF levels is -0.176 (Table 3.7). The simple correlation between NEF levels and the tract variable for central air conditioning is statistically significant. The two tract variables are also significantly correlated with each other. These interactions suggest that there may be some multicollinearity present in regressions (2) - (4), but this problem does not appear to be severe enough to cause significant precision losses.

Table 3.8 displays the mean values of the block variables by NEF level. Properties located in the NEF-30+ intervals tend to be somewhat lower in value, smaller, and less residential. These differences suggest that the NEF coefficient might overstate the effect of noise on property values due to incomplete specification of the hedonic price equation. This issue is discussed further in the next chapter.

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[9]The pooled regressions were also run for the NEF variable without boundary conditions. The NEF coefficients were -0.0038, -0.0036, -0.0030, and -0.0029 for regressions (1) - (4), respectively. The sample size was 1,078 observations and the corrected R^2 was 0.84.

[10]The partial F statistic for the dummy variables is 294.861, which is statistically significant at the .05 confidence level. As an alternative to the dummies, the distance to the CBD was used in the pooled regressions (see Table 3.2). However, this variable performed poorly and the $\bar{R}^2$s declined to about 0.56.

Mean Property Value (1)	$23,713	$7,398	$8,422	$54,444
NEF-II (2)	31.047	6.526	20.000	45.000
Mean Rooms per Unit (3)	5.727	0.652	4.300	8.300
Percent Owner-Occupied Units (4)	87.669	11.080	50.000	100.000
Percent Black Population (5)	1.388	7.430	0.000	80.420
Percent Sub-stand. Plumbing (6)	0.552	1.635	0.000	14.286
Percent Built Before 1939 (7)	15.177	15.848	0.000	79.737
Percent Central Air Conditioning (8)	12.369	18.111	0.000	75.923

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

TABLE 3.7

ZERO-ORDER CORRELATIONS
POOLED SAMPLE
(Sample Size N = 845)[a]

Variable[b]	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	-0.176	0.648*	0.100	-0.200	-0.145	0.006	-0.231
(2)	--	-0.325*	-0.196	-0.095	0.040	0.229	-0.377*
(3)		--	0.257*	-0.034	-0.154	0.050	0.122
(4)			--	-0.002	-0.034	-0.169	0.110
(5)				--	0.015	-0.123	0.205
(6)					--	0.162	-0.018
(7)						--	-0.298*

*Significant at the 90 percent confidence level.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]For a listing of the variables, see Table 3.6. Variables (1), (3), and (4) are in natural logs.

Mean of Variable (St. Dev.)	NEF Interval		
	20–30	30–40	40–50
Property Value	$24,957 (8,143)*	$23,153 (6,504)	$22,783 (8,078)[a]
Rooms per Unit	5.939 (0.617)*	5.642 (0.613)	5.532 (0.669)*[a]
Percent Owner-Occupied Units	89.983 (9.281)*	86.984 (10.888)	84.764 (14.082)*[a]
Percent Black Population	2.361 (9.507)*	1.118 (6.862)	0.110 (0.505)*[a]
Percent Substandard Plumbing	0.472 (1.373)	0.581 (1.672)	0.638 (2.009)
NEF-II	23.737 (2.176)*	32.782 (2.487)	41.615 (2.347)*[a]
No. of Obs.	289	426	130

*Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 30–40.

[a]Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 20–30.

CHAPTER 4

DISCUSSION OF THE EMPIRICAL RESULTS

Previous chapters discussed the study methodology and summarized the empirical results for seven airports. In the present chapter, the study's strengths and limitations are considered. Based on this review, it is concluded that the statistical results are robust and consistent with earlier empirical studies for the same time period. The main shortcomings of the study are the problem of specification of a complete empirical model of property values and measurement errors introduced by the use of aggregate census data. The possibility of incomplete control for the effect of airport accessibility on land values should also be considered.

4.1 Confidence Intervals and Stability: Individual Airports

The basic hypothesis in this study holds that a stable, discernable empirical relationship exists between the level of aircraft noise and the level of residential property values. Alternatively, one might hold that no such relationship exists, or that some known relationship exists between differential noise levels and residential property values (based, perhaps, on past empirical studies). These alternative hypotheses are referred to as null hypotheses. This section presents statistical tests of several null hypotheses and, in addition, tests for the stability of the empirical results relative to a weighted-mean coefficient value.

The rule for rejecting or not rejecting a null hypothesis is based on a test statistic computed from the data and empirical results. Typically, the null hypothesis is rejected when a test statistic exceeds a specified value, called the critical value. Table 4.1 presents the best estimates of the NEF coefficients and the 90 percent confidence

TABLE 4.1

90 PERCENT CONFIDENCE INTERVALS
FOR NEF COEFFICIENTS

Airport[a]	Estimated NEF Coefficient	Estimated Standard Error	90 Percent Confidence Interval[b,c]
San Francisco (DF = 145)	-0.0058	0.0018	-0.0058 ± .0030
Boston (DF = 147)	-0.0084	0.0039	-0.0076 ± .0064
Cleveland (DF = 177)	-0.0029	0.0013	-0.0029 ± .0021
St. Louis (DF = 105)	-0.0051	0.0026	-0.0051 ± .0043
New Orleans (DF = 135)	-0.0040	0.0020	-0.0040 ± .0033
Buffalo (DF = 118)	-0.0052	0.0020	-0.0052 ± .0033
San Diego (DF = 117)	-0.0074	0.0023	-0.0074 ± .0038
Pooled Sample[d] (DF = 832)	-0.0040	0.0007	-0.0040 ± .0012

[a]DF = degrees of freedom

[b]Lower bounds are, respectively, -0.0028, -0.0012, -0.0008, -0.0008, -0.0007, -0.0019, -0.0036, and -0.0028.

[c]Upper bounds are, respectively, -0.0088, -0.0140, -0.0050, -0.0094, -0.0073, -0.0085, -0.0112, and -0.0052.

[d]The pooled sample excludes Boston.

intervals for these coefficients. These intervals are based on the following statistical rule

$$(1)\quad \hat{b} \pm t_c \cdot (\hat{s}_b)$$

where $\hat{b}$ denotes the estimated NEF coefficient for a given airport, $\hat{s}_b$ is the estimated standard error of the coefficient, and t_c is the critical value of the Student-t statistic for a given confidence level, e.g., 1.645 for the 90 percent confidence level. This statistic has N - K degrees of freedom, where N is the number of observations and K is the number of parameters estimated (including a constant term).

The interval given by equation (1) allows us to state that in repeated samples for a <u>given</u> airport, the true NEF coefficient (denoted by b) will lie within this interval 90 percent of the time, i.e., the statement $\hat{b} - t_c \cdot (\hat{s}_b) \leq b \leq \hat{b} + t_c \cdot (\hat{s}_b)$ may be made with 90 percent confidence.

Suppose we are interested in testing the null hypothesis which states that no relationship whatsoever exists between aircraft noise and residential property values. This is equivalent to testing whether b = 0 for each airport, that is,

$$(2)\quad H_N : \; b = 0$$

$$H_A : \; H_N \text{ is false}$$

where H_N and H_A are the null and alternative hypotheses, respectively. For the null hypothesis to be rejected, the critical lower bound of the 90 percent confidence interval must include zero. Table 4.1 indicates that the null hypothesis of no relationship can be rejected for all seven airports.[1]

[1] Of course, it might be argued that as a practical matter the lower bound for New Orleans does not differ significantly from zero. Choice of a higher confidence level (say, 99 percent) would also alter this conclusion.

This test procedure may be used for any specific value of the parameter and not necessarily zero as in the above example. To test the null hypothesis that the true NEF coefficient equals -0.0100, the upper bounds of the 90 percent confidence intervals can be used. In only two of seven cases do these critical values exceed -0.0100 and the null hypothesis could not be rejected. To test the null hypothesis that the true NEF coefficient is -0.0030, the lower confidence bounds can be used. In only one of seven cases would we not reject this null hypothesis. The evidence presented in Table 4.1 is therefore consistent with the conclusion that the range of true NEF coefficients is -0.0030 to -0.0100, or a 0.3 to 1.0 percent depreciation per unit increase in NEF.

Rather than view each airport as an individual case, we can treat the empirical results as repeated samples of the same phenomenon using different geographic areas. Repeated cross-sections raise the question of the mean coefficient value and the stability of the individual empirical results around that mean value. It is possible to test for stability of the coefficient estimates without resorting to the cumbersome procedure of pooled-data regression analysis.

To conduct this test, we let b_m^* be the estimated NEF coefficient in the m-th sample $(m = 1,\ldots,6)$ and let $\bar{b}^*$ be a weighted average of the b_m^*s such that

$$(3) \quad \bar{b}^* = \frac{\Sigma\ (b_m^*/p_m^*)}{\Sigma\ (1/p_m^*)}$$

where p_m^* is the corresponding diagonal element in the inverse of the moment matrix of regressors, i.e., the appropriate diagonal element of $(X_m' X_m)^{-1}$, where X_m is the $N_m \times K_m$ matrix of observations on the regressors.

If the null hypothesis that the coefficients are stable holds, then $b_m^* = \bar{b}^*$, and

$$(4)\quad F = \frac{\Sigma \frac{(b_m^* - \bar{b}^*)^2}{p_m^*} \Big/ M - 1}{\Sigma\ S_m^2 / \Sigma\ (N_m - K_m)} < F^{M-1}_{\Sigma(N_m - K_m)}$$

where M is the number of samples, N_m is the number of observations in the m-th sample, K_m is the number of parameters to be estimated, and S_m^2 is the residual sum of squares.[2]

The test statistic given by equation (4) calls for taking M separate regressions, summing their residual sums of squares, and comparing this with a sum of squared deviations of the coefficient estimates. The resulting statistic has an F-distribution with M - 1 and $\Sigma\ (N_m - K_m)$ degrees of freedom. Table 4.2 presents the required computations. The weighted mean value of the NEF coefficients is -0.0050. The test results indicate that the null hypothesis cannot be rejected. Thus, based on six samples, we conclude that the empirical results yield stable coefficients distributed around a weighted-mean value of -0.0050. This value is slightly greater than the coefficient estimate obtained using the pooled sample, at least when both tract variables are included.

4.2 Partitioned Regressions: Pooled Sample

As a further test of robustness, the pooled sample was partitioned in two ways. First, dummy variables were inserted in the regressions, where

[2] See G. C. Tiao and A. S. Goldberger, "Testing Equality of Individual Regression Coefficients," Unpublished paper, University of Wisconsin, Social Systems Research Institute, February 1962.

TABLE 4.2

TEST OF THE STABILITY OF NEF COEFFICIENTS
FOR SIX AIRPORTS

Airport	N_m-K_m	s_m^2	b_m^*	$p_m^* \cdot 10^{-3}$	$(1/p_m^*) \cdot 10^3$	(b_m^*/p_m^*)	$[(b_m^*-\bar{b}^*)^2/p_m^*] \cdot 10^{-3}$
San Francisco	145	1.329	-0.0058	0.367	2.725	-15.804	1.744
Cleveland	177	0.961	-0.0029	0.310	3.226	-9.355	14.226
St. Louis	105	1.507	-0.0051	0.492	2.033	-10.366	0.020
New Orleans	135	1.998	-0.0040	0.262	3.817	-15.267	3.817
Buffalo	118	1.835	-0.0052	0.256	3.906	-20.312	0.156
San Diego	117	1.892	-0.0074	0.337	2.967	-21.958	17.092
Total	797	9.522	--	--	18.674	-93.062	37.055

$$\bar{b}^* = (-93.062)/(18.674 \cdot 10^3) = -0.0050$$

$$F = \frac{(37.055 \cdot 10^{-3})/(5)}{(9.522)/(797)} = 0.620 < 2.21$$

(5) $D1 = 1$ if $NEF = 40$ or 45,

$= 0$ otherwise;

$D2 = 1$ if $NEF = 30$ or 35,

$= 0$ otherwise.

Using Figure 2.3, we expect $D1 > 0$, $D1 \cdot NEF < 0$, $D2 > 0$, and $D2 \cdot NEF < 0$ if any accessibility effects remain in the pooled sample.

The empirical results with these dummies are presented in Table 4.3. The signs on D1 and D2·NEF are consistent with the accessibility hypothesis, but neither coefficient is statistically significant.[3] On the other hand, the NEF coefficients are now closer to the simple and weighted means for the individual samples and partial F-tests indicate that the dummies jointly contribute to the explanation of variation in residential property values. The NEF-property value relationship is possibly more complex than the simple relationship depicted in Table 3.5, although the amount of bias appears to be small relative to the range of values for the individual study areas.

As a second test, the pooled sample was partitioned using the linear distance from the airport terminal. In Table 4.4, the results are summarized for blocks located within 2 miles of the main terminal, 1 to 3 miles, 2 to 4 miles, and 3 to 5 miles, respectively. The mean property values (Y), NEF range, and sample size (N), are also displayed.

While the range of NEF coefficients is now somewhat greater, application of an F-test indicates that the sample estimates are stable. The values -0.0030 and -0.0055 are stable about a weighted mean of -0.0046. The values -0.0061 and -0.0036 are stable about a weighted mean of -0.0055. On the whole, these results are consistent with those presented above, although there is some suggestion of a greater noise discount at about 2 to 3 miles distance from an airport. This result may simply reflect sampling variation, but deserves to be tested further using less aggregate data drawn from a single urban area.[4]

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[3]Due to high intercorrelation ($r = 0.998$ and 0.994), it was not possible to include both slope and intercept dummies in the same regression.

[4]For example, 20.5 percent of the one to three mile sample consists of observations drawn from San Diego, compared to 14.8 percent for the pooled sample.

TABLE 4.3

REGRESSION RESULTS FOR POOLED SAMPLE, WITH DUMMY VARIABLES

Variable	Regression Coefficient (Student-t) (1)	(2)
Constant	7.5917 (45.5622)*	7.5982 (47.0939)*
NEF-II	-0.0053 (2.0864)*	-0.0055 (2.8258)*
D1·NEF-II	0.0008 (0.7451)	—
D2·NEF-II	-0.0008 (1.0117)	—
D1	—	0.0383 (1.0843)
D2	—	-0.0243 (1.2654)
Ln Mean Rooms per Unit	1.3229 (28.3730)*	1.3230 (28.4368)*
Ln Percent Owner-Occupied	0.1293 (3.9166)*	0.1294 (3.9217)*
Percent Black Population	-0.0026 (4.2572)*	-0.0025 (4.2265)*
Percent Substandard Plumbing	-0.0009 (0.3574)	-0.0010 (0.3867)
Percent Built Before 1939	-0.0003 (0.7876)	-0.0003 (0.7612)
Percent Central Air Conditioning	0.0012 (2.3167)*	0.0012 (2.2896)*
St. Louis Dummy	-0.5853 (24.3246)*	-0.5858 (24.6400)*
Cleveland Dummy	-0.2931 (18.1188)*	-0.2940 (18.1788)*
New Orleans Dummy	-0.4118 (17.9477)*	-0.4123 (18.0095)*
San Diego Dummy	0.0003 (0.0194)	-0.0010 (0.0646)
Buffalo Dummy	-0.4308 (28.7315)*	-0.4317 (28.7017)*
R^2	0.8446	0.8449
$\bar{R}^2$	0.8420	0.8423
F	322.2996	322.9932
SEE	0.1180	0.1178
Det (X'X)	0.1081	0.1822
N	845	845

*Signifcant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

TABLE 4.4

PARTITIONED REGRESSION RESULTS FOR POOLED SAMPLE

Variable	Distance to the Airport Terminal in Miles: 0-2	1-3	2-4	3-5
Constant	7.7452 (31.3114)*	7.5771 (40.6833)*	7.2450 (34.5836)*	7.5129 (24.7396)*
NEF-II	-0.0030 (1.9118)*	-0.0061 (6.2330)*	-0.0055 (4.4066)*	-0.0036 (2.1529)*
Ln Mean Rooms per Unit	1.2832 (15.4708)*	1.4238 (23.7166)*	1.3970 (23.4522)*	1.1991 (14.3227)*
Ln Percent Owner-Occupied	0.0904 (1.8664)*	0.0987 (2.5225)*	0.1715 (3.8405)*	0.1766 (2.6623)*
Percent Black Population	0.0002 (0.1962)	-0.0014 (2.1518)*	-0.0038 (5.3915)*	-0.0089 (2.0661)*
Percent Substandard Plumbing	0.0024 (0.4778)	-0.0016 (0.4360)	0.0016 (0.5350)	0.0007 (0.2046)
Percent Built Before 1939	0.0029 (3.2848)*	0.0012 (2.0541)*	-0.0013 (2.9414)*	-0.0013 (2.7049)*
Percent Central Air Conditioning	-0.0051 (2.5252)*	0.0009 (1.3960)	0.0015 (2.4666)*	0.0025 (2.5728)*
St. Louis Dummy	-0.5205 (7.7382)*	-0.6313 (21.4939)*	-0.5364 (19.0175)*	-0.5373 (13.0741)*
Cleveland Dummy	-0.3160 (11.1460)*	-0.3061 (14.9281)*	-0.2448 (11.7504)*	-0.2631 (10.2452)*
New Orleans Dummy	-0.2578 (4.6232)*	-0.4207 (14.5228)*	-0.3973 (10.9389)*	-0.3917 (8.1535)*
San Diego Dummy	-0.0456 (1.6089)	-0.0332 (1.8929)*	0.0322 (1.6616)*	0.0306 (0.7102)
Buffalo Dummy	-0.4626 (21.6426)*	-0.4506 (26.1784)*	-0.3755 (17.1976)*	-0.4079 (4.9984)*
R^2	0.8729	0.8589	0.8483	0.8339
$\bar{R}^2$	0.8674	0.8559	0.8448	0.8252
SEE	0.1099	0.1177	0.1155	0.1105
$\bar{Y}\cdot 10^3$	23.5972	24.0176	23.6023	23.6947
NEF Range	25-45	20-45	20-45	20-40
N	289	572	529	244

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value. Student-t values in parentheses.

As a final test for accessibility effects, the six individual samples were partitioned to include only observations located from one to four miles from the airport terminal. Thus, these samples exclude observations within one mile of the terminal (0-1 miles) or greater than four miles from the airport terminal (4-5 miles). The resulting samples are now consistent with one another insofar as each sample includes observations which are the same distances from the terminal. The major changes occur in the San Francisco, Cleveland, and New Orleans samples, where 13, 19, and 20 observations are excluded, respectively. Only four observations are excluded from Buffalo and there are no changes in either the St. Louis or San Diego sample sizes.

The regression results are summarized in Table 4.5. The coefficient range is now -0.39 percent to -0.74 percent. The Cleveland coefficient increases from -0.29 percent to -0.51 percent and the San Francisco coefficient declines from -0.58 percent to -0.47 percent. The New Orleans and Buffalo coefficients are basically unchanged. Application of the Tiao-Goldberger F-test to these coefficients resulted in a weighted mean of -0.53 percent. The six individual coefficients were stable about this mean, with a calculated F-value of 0.333. The results using these samples are therefore consistent with the earlier results for the individual and pooled samples. The major change occurs in the results for Cleveland, suggesting that some accessibility bias may have been present in the earlier results for this area. Insofar as these samples are more homogeneous or control better for accessibility effects, the bias due to accessibility is quite small, with the possible exception of Cleveland.

TABLE 4.5

SUMMARY OF REGRESSION RESULTS--RESTRICTED SAMPLES[a]

	San Francisco	St. Louis	Cleveland	New Orleans	San Diego	Buffalo
NEF-II Coefficient (Student-t)	-0.0047 (2.3866)	-0.0051 (1.9136)	-0.0051 (3.5054)	-0.0039 (1.7931)	-0.0074 (3.1795)	-0.0052 (2.5413)
R^2	0.6990	0.7420	0.7010	0.7540	0.7620	0.6100
Sample Size	140	113	166	123	125	122
Mean Property Value $\cdot 10^3$ (S.D.)	29.2980 (5.1860)	16.4110 (3.6840)	20.9700 (2.7150)	22.6460 (5.6870)	32.2410 (8.3350)	20.7730 (4.3380)
Mean NEF Level (S.D.)	32.2 (5.0)	30.2 (6.1)	34.2 (4.4)	26.1 (6.6)	32.3 (6.7)	29.1 (6.9)
NEF Range	25-45	25-45	25-45	20-45	25-45	20-45
Percent of Observations NEF $\geq$ 40	13.6	17.7	16.9	2.4	23.2	12.3

[a]Restricted samples for observations located one to four miles from the airport terminal. Regressions have the same specification as regression (4) in Table 3.5, except the airport dummy variables are excluded.

4.3 Functional Form: Pooled Sample

As a final test for robustness, the pooled sample was applied to two additional functional forms. First, the model was re-estimated with all explanatory variables in linear form and a logged dependent variable. The R^2 declined slightly from 0.841 to 0.839 and the NEF coefficient increased slightly from -0.0040 to -0.0043. There seems to be no significant advantage to using this model.

Second, the model was re-estimated in complete linear form, and the results are displayed in Table 4.6. Regression (1) yields an NEF coefficient of -$85.71. Evaluated at the sample mean, this implies a noise discount of -$85.71/$23,713.19 = -0.0036, compared to -0.0040 from Chapter 3. Addition of a quadratic term produced inconclusive results due to multicollinearity--the results in regression (2) imply that the size of the noise discount would <u>decline</u> as noise levels increase. In addition to this problem, both regressions (1) and (2) seemed to be subject to greater residual variance at higher property value levels. These considerations suggest that our earlier results are more reliable than those produced by the complete linear model.

4.4. Comparison with Earlier Studies

This section summarizes the results obtained in seven earlier studies of the airport noise-property value relationship for the period 1967-1973. Most earlier studies investigate noise levels in the vicinity of only one airport. The study by Dygert considers both San Francisco and San Jose Airports. Two studies (Mieszkowski and Saper; Maser, Riker, and Rosett) look at separate residential areas within the urban areas of Toronto and Rochester, respectively.[5]

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[5]Table 4.7 does not include Paik's study of 1960 census block data for New York JFK, Dallas Love Field, and Los Angeles International Airport; see I. K. Paik, "Measurement of Environmental Externality in Particular Reference to Noise," Unpublished Ph.D. dissertation, Georgetown University, 1972. The results of this study are not representative due to (1) introduction of commercial jets as a significant new noise source; (2) use of 1965 noise data; (3) use of a background noise level of NEF 20; (4) omission of residential quality variables such as the age of housing or the use of central air conditioning; and (5) omission of controls for residential units that do not report property values.

TABLE 4.6

POOLED REGRESSIONS WITH LINEAR FORM
(Dependent Variable is Mean Property Value)

	Regression Coefficient (Student-t)	
Variable	(1)	(2)
Constant	-5,046.62 (3.10)*	5,833.81 (1.83)*
NEF-II	-85.71 (4.23)*	-770.98 (4.41)*
$(NEF-II)^2$	—	10.49 (3.95)*
Ln Mean Rooms per Unit	5,830.73 (26.96)*	5,759.09 (26.76)*
Ln Percent Owner-Occupied	48.18 (4.19)*	53.47 (4.66)*
Percent Black Population	-48.63 (2.93)*	-44.19 (2.68)*
Percent Substandard Plumbing	8.47 (0.12)	2.11 (0.03)
Percent Built Before 1939	-9.04 (0.93)	-5.59 (0.57)
Percent Central Air Conditioning	12.71 (0.89)	-9.29 (0.61)
New Orleans Dummy	-9,164.23 (14.53)*	-8,905.14 (14.17)*
Cleveland Dummy	-7,453.94 (16.99)*	-7,515.96 (17.27)*
St. Louis Dummy	-12,049.71 (18.62)*	-11,614.23 (17.84)*
Buffalo Dummy	-10,242.09 (25.30)*	-10,605.41 (25.76)*
San Diego Dummy	1,147.37 (2.81)*	908.40 (2.22)*
R^2	0.81	0.81
$\bar{R}^2$	0.81	0.81
F	293.08	276.48
SEE	3,258.90	3,230.70
Det (X'X)	0.23	0.002
N	845	845

*Significant at the 90 percent confidence level, one-tailed t-test.

In order to compare these earlier studies with the present work, it will help to develop the notion of a noise depreciation index. For two residential properties that differ only in their level of noise exposure, the absolute amount of depreciation per decibel (the price of quiet) can be defined as

$$(6)\quad D = \frac{\text{difference in total noise discount}}{\text{difference in noise exposure}}$$

Dividing D by the price of the basic house, the percentage rate of depreciation or noise depreciation index (NDI) is defined as[6]

$$(7)\quad NDI = \frac{D}{\text{Property Value}} \cdot 100$$

$$= \frac{\text{difference in total percentage depreciation}}{\text{difference in noise exposure}} .$$

The NDI is a measure of the noise sensitivity of the housing market expressed in terms of the marginal rate of depreciation per decibel over some given interval of noise exposure. It is also equal to the ratio of the price of quiet to the price of the basic house. For example, suppose that two properties differ in value by $1,000 and the difference in noise exposure is 10 decibels. If the price of the basic house is $20,000, then the NDI would be

$$NDI = \frac{\$1,000/10}{\$20,000} \cdot 100 = 0.5 \text{ percent}$$

or a one-half percent discount (premium) for each decibel increase (decrease) in noise exposure.

The range of noise depreciation indices in Table 4.7 is about 0.50 to 1.10 percent. Taking a simple average of eight estimates yields a mean noise depreciation index of about 0.67 percent:

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[6] See A. A. Walters, Noise and Prices (London: Oxford University Press, 1975), pp. 102-05.

TABLE 4.7

TABULAR SUMMARY OF SELECTED AIRCRAFT NOISE-PROPERTY VALUE STUDIES

Author	Area(s) Studied & Year	Noise Pollution Measure	Type of Data	Model Characteristics	Major Findings
Emerson (1969, 1972)	Minneapolis, 1967 Mean property value is $19,683.	Composite Noise Rating (CNR) from 90 to 125 (NEF 25-45) for Summer 1967; threshold CNR of 90 or 100 units used.	Individual housing data, actual sales prices from Multiple Listing Service sheets for July 15 to September 30, 1967 (sample size N=222). Dependent variable is log of sales price.	Significant explanatory variables include square feet in house, square feet in lot, age, garage space, no. of baths, no. of floors, stucco or stone exterior, no. of ranges, etc., no. of fireplaces, distance to school, location within two lots of freeway, location near parks or open green space, percent nonwhite population in elementary schools, and freedom from aircraft noise nuisance. The noise variable is significant at 90 percent level, one-tailed test; $R^2 = 0.798$.	Emerson (1972, p. 275) concluded that the reduction in prices for residences exposed to a CNR of 125 was 9.8 percent, or $1,929, for a mean $19,683 residence. The implied marginal damage is about $115 per NEF, or a noise depreciation index of 0.58 percent per NEF. The CNR-NEF relationship is approximately CNR = 53 + 1.5 NEF (Dygert 1973, p. 19). Final regressions use a threshold CNR of 100 (NEF 30).
Dygert (1973)	San Francisco, 1970 San Jose, 1970 Mean property values are about $27,600 and $21,000, respectively.	NEF 25 to 45 for 1970. Some estimates for CNR also employed. No adjustment for noise thresholds in full sample regressions.	Census tract data and assessed land values aggregated to the tract level. Sample size of 128 observations for San Mateo County in the vicinity of San Francisco International Airport and 198 observations for Santa Clara County near San Jose Municipal Airport and Moffett Field, a naval air station. Dependent variable is log of mean assessed site value per square foot.	Explanatory variables include accessibility (shopping centers, industrial sites, airport terminals, public schools, and the central business districts), median no. of people per unit, percent nonwhite units, characteristics of the terrain, dwelling units per acre, and the property tax rate. Regressions presented for full sample and partitioned samples based on noise levels, proportion of single-family dwellings, and total property value.	Significant (90 percent level) San Mateo County noise coefficients tend to cluster around -0.005, but range from -0.004 to -0.034. Santa Clara County coefficients range from -0.007 to -0.015, but do not cluster around a central value. Suggested noise depreciation indexes are 0.5 and 0.7 percent, respectively, but could be greater. Typical R^2 is in range 0.60 to 0.70.

TABLE 4.2 (Continued)

Author	Area(s) Studied & Year	Noise Pollution Measure	Type of Data	Model Characteristics	Major Findings
Price (1974)	Boston, 1960 to 1970 Mean apartment rental is about $100 per month for 1970.	NEF 25 to 45 for 1970. NEF values for each tract are interpolated to the nearest NEF unit. No adjustment for threshold noise levels.	Census tract data screened so that at least 25 percent of the total housing units are rental units (sample size N= 270). Dependent variable is the percent change in median contract rent from 1960 to 1970 for tract.	Explanatory variables include the change in the percent of nonwhite population from 1960 to 1970, percent of nonwhites in 1960, percent of people over 65 in 1960, log of median contract rent in 1960, distance to the Boston central business district, percent increase in property tax rate, percent of housing units built before 1930, percent of housing units built since 1960, and the percent of housing units that are public housing units.	Price concluded that, for 1970, the differences in rents between a quiet residence (NEF 25) and a comparably noisy one (NEF 35) would be about $8.33 per month. The average monthly rent was about $100 per month in 1970. This implies a noise depreciation of about 0.83 percent, or slightly less for more costly rental properties. Corrected R^2 is 0.50 or less and the noise coefficient is significant at 95 percent or better.
Mieszkowski and Saper (1975)	Toronto, 1969-73 Mean property values are about $30,000 and $35,000 for Mississauga and Etobicoke, respectively.	NEF 25 to 35 for 1971 and CNR 95 to 115 forecasts for 1975-76. No adjustment for thresholds in full sample regressions, but noise-free regressions can be used to calculate implied discounts in noisy areas.	Individual housing data, actual sales for January 1969 through June 1973. Data are deflated to 1969 using a time dummy. Sample sizes vary depending on control group, but 611 observations are available for the borough of Mississauga and 509 observations for Etobicoke. Dependent variable is either linear or log of sales price.	Explanatory variables include square feet in lot, average room size, lot size, square of both house size and lot size, no. of bedrooms, no. of utility rooms, no. of basement rooms, and dummy variables for 25 additional characteristics such as number of stories, garage size, fireplaces, type of siding, etc. No accessibility measures are included.	Final results are difficult to interpret due to use of control groups. For Etobicoke, the total noise discount relative to the control group (NEF 20) is -6.4 percent for NEF 25, -4.6 percent for NEF 30, and -7.8 percent for NEF 35. This implies noise depreciation rates of 1.3, 0.5, and 0.5 percent per NEF, respectively. The R^2 is about 0.90 when all observations are used.

TABLE 4.7 (Continued)

Author	Area(s) Studied & Year	Noise Pollution Measure	Type of Data	Model Characteristics	Major Findings
Nelson (1975, 1978)	Washington, D.C., 1970 Mean property values is $27,455.	NEF 20 to 35 for 1970. Background noise level of NEF 20 assigned to 42 tracts in vicinity of Washington National Airport.	Census tract data screened to exclude tracts with less than 110 single-family, owner-occupied units (sample size N= 52). Dependent variable is log of median property value for tract.	Explanatory variables included for no. of rooms, lot size in square feet, age of housing, central air conditioning, dummy for riverside locations, and accessibility to employment. Tests conducted for 18 other variables that proved to be insignificant.	The noise depreciation index is about 1.1 percent. The R^2 is 0.863. Noise coefficient is significant at the 90 percent level, one-tailed test.
De Vany (1976, 1977)	Dallas, 1970 Mean property value is about $22,000.	NEF 20 to 50, represented by four qualitative (dummy) variables.	Census block data for 1,270 observations in the vicinity of Love Field. The model is linear and the dependent variable is the mean property value for block.	Explanatory variables included for no. of rooms, percent of homes that are owner-occupied, age of housing, average length of occupancy, percent of homes with air conditioning, and distance to the CBD. The R^2 is about 0.82. The total noise discount for a property bordering on the airport would be about -$5,300, or $177 per NEF. Using the mean value of housing of $22,000 yields a noise depreciation index of about 0.8 percent per NEF.	The dummy variables capture the net effect of an airport on property values. Within one mile of the airport (NEF 50) there is a sizeable net reduction in value; for one to two miles the net effect is inconsequential; for two to three miles the net effect is positive; and beyond three miles there is no net effect on value. DeVany (1977, p. 139) estimates that the noise depreciation index is 0.58 percent within two to three miles (NEF 20-45) from the airport.

TABLE 4.7 (Continued)

Author	Area(s) Studied & Year	Noise Pollution Measure	Type of Data	Model Characteristics	Major Findings
Maser, Riker, and Rosett (1977) Thaler (1978)	Rochester, 1971 Mean property values are about $15,200 and $22,000 for city and suburban samples, respectively.	100 PNdB contour (NEF 30) for 1967. There is a large discrepancy between the FAA 100 PNdB contour and the estimates used. The actual noise levels might be greater than 100 PNdB.	Individual housing sales and census tract data. For 1971, city and suburban observations were analyzed separately for samples of 398 and 990 observations, respectively. The model is linear and the dependent variable is the sales price per acre of land plus structure for each individual parcel. The noise variable is in dummy form.	Significant variables include no. of rooms, percent nonwhite population, property crime rate, condition of property, adjacent or visible land use characteristics such as apartments, industrial sites, and public buildings, type of street, access to central business district, and access to bodies of water or parks. The R^2 is about 0.60 for the city sample and 0.80 for the suburban sample.	The reported results plus communication with the authors suggest that city properties within NEF 30 are discounted by $2,500-2,900, or a noise depreciation of about 0.82 to 0.95 percent per NEF on an average $15,200 property. The suburban discount is $2,400-3,000 on an average $22,000 property, or a noise depreciation of about 0.55 to 0.68 percent per NEF.

Sources: F. C. Emerson, "The Determinants of Residential Value with Special Reference to the Effects of Aircraft Nuisance and Other Environmental Features," Unpublished Ph.D. dissertation, University of Minnesota, 1969. F. C. Emerson, "Evaluation of Residential Amenities: An Econometric Approach," Appraisal Journal, 40 (April 1972), pp. 268-78. P. K. Dygert, "Estimation of the Cost of Aircraft Noise to Residential Activities," Unpublished Ph.D. dissertation, University of Michigan, 1973. I. Price, "The Social Cost of Airport Noise as Measured by Rental Changes: The Case of Logan Airport," Unpublished Ph.D. dissertation, Boston University, 1974. P. Mieszkowski and A. M. Saper, "An Estimate of the Effects of Airport Noise on Property Values," Unpublished paper, University of Houston, 1975. J. P. Nelson, The Effects of Mobile-Source Air and Noise Pollution on Residential Property Values, DOT-TST-75-76 (Springfield, Va.: NTIS, April 1975). J. P. Nelson, Economic Analysis of Transportation Noise Abatement (Cambridge: Ballinger, 1978). A. S. De Vany, "An Economic Model of Airport Noise Pollution in an Urban Environment," in S.A.Y. Lin (ed.), Theory and Measurement of Economic Externalities (New York: Academic Press, 1976), pp. 205-14. A. S. De Vany, "Monetary Measures of the Benefits of Abatement: Property-Value Analysis," in National Academy of Sciences, Noise Abatement: Policy Alternatives for Transportation (Washington, D.C.: 1977), Chapter 7. S. M. Maser, W. H. Riker, and R. N. Rosett, "The Effects of Zoning and Externalities on the Price of Land: An Empirical Analysis of Monroe County, New York," Journal of Law and Economics, 20 (April 1977), pp. 111-32. R. Thaler, "A Note on the Value of Crime Control: Evidence from the Property Market," Journal of Urban Economics, 5 (January 1978), pp. 137-45.

Study Area	NDI
Minneapolis	0.58
San Francisco	0.50
San Jose	0.70
Boston	0.83
Toronto	0.50
Washington, DC	1.10
Dallas	0.58
Rochester	0.55
Average	0.6675

This estimate compares favorably with the simple average of 0.55 percent derived in the previous chapter. The fact that most earlier studies do not control for accessibility effects does not appear to have created significant bias toward zero in the NDI estimates. Indeed, if anything, the results from earlier studies may reflect a negative bias due to omitted variables for age and neighborhood (density) effects.

4.5 Comparison with Court Awards

The cost of an airspace easement is another indicator of the effect of aircraft noise on property values. McClure surveyed the data available on five airports and concluded that a hypothetical $24,000 house (1,200 sq. ft., seven rooms, stucco) exposed to 100 PNdB or more would be reduced in value by about $3,432.[7] Assuming that the easement award is the estimated market value of the property right for 15-25 decibels,[8] then the NDI is 0.57 to 0.95 percent.

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[7] P. T. McClure, Indicators of the Effect of Jet Noise on the Value of Real Estate, P-4117 (Santa Monica, Ca.: Rand Corporation, July 1969), pp. 24-29. The five airports are Columbus, Ohio; Denver, Colorado; Des Moines, Iowa; Seattle, Washington; and Jacksonville, Florida.

[8] Courts typically award damages only for noise exposure levels of NEF 40 or more.

A more recent EPA report determined an average easement cost of $201.40 per unit change in NEF.[9] Assuming in 1972 average property value of $22,000 to $26,000 yields an NDI of 0.77 to 0.92 percent. The easement cost data presented in McClure and the EPA report are broadly consistent with the regression estimates developed in both present and past statistical studies of residential property values. The slightly higher NDI suggested by the easement cost data might be due to inclusion of moving expenses, legal fees, or unwarranted compensation for pain and suffering,[10] as well as the possibility of a higher NDI at peak noise levels.

4.6 Specification Bias

The empirical results obtained in the present study are based on models that contain a handful of variables. The final regressions contain no more than six significant variables. Studies based on individual housing data (Emerson; Mieszkowski and Saper) typically employ models with a dozen or more variables. The coefficients of determination in the present study are also slightly lower than expected.[11] The average R^2 is 0.711 (excluding Boston), while the range was 0.611 to 0.762. Both the limited number of variables and low R^2s suggest that the regression estimates may be subject to specification bias.

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[9] U.S. Environmental Protection Agency, Noise Source Abatement Technology and Cost Analysis Including Retrofitting, NTID 73.5 (Washington, D.C.: EPA, July 27, 1973), p. 4-6.

[10] Many lawyers and some courts seem to believe that losses in residential market value and noise nuisance (pain and suffering) are different types of damages. This is incorrect. Market value represents the discounted present value of the future stream of net benefits associated with a given property, including amenity services. There is no basis for counting damages twice through separate awards for taking and for personal-injury claims.

[11] The coefficient of determination (R^2) is the proportion of variation in the dependent variable that can be attributed to (explained by) variations in the set of explanatory variables. An R^2 of 0.70 means that 70 percent of the variation in property values is explained by the independent variables.

In a narrow sense, specification errors occur when the formulation of the regression equation is incorrect. If, for example, a relevant explanatory variable is omitted, then the remaining coefficient estimates may be biased. The direction of the bias depends on the sign of the omitted variable and the correlation between the omitted and included explanatory variables. If the excluded variable is not correlated with (orthogonal to) an included variable, then the coefficient estimate for the included variable will be unbiased. However, the coefficient's standard error estimate will contain an upward bias and the usual tests of significance and confidence intervals will be unduly conservative, i.e., the null hypothesis that $b = 0$ will not be rejected often enough.

The data and empirical results indicated that housing located in higher noise intervals (NEF 40-50) tends to be smaller and lower in value (Table 4.8). The housing stock in noisy areas (NEF 30+) also contains a greater proportion of rental units. Thus, it is possible that the empirical results do not adequately reflect the value differentials associated with older, more crowded neighborhoods. The implication is that the noise coefficient is biased away from zero (more negative) due to a positive correlation between the NEF variable and omitted housing characteristics. If anything, therefore, the empirical results tend to overstate the true effect of noise on residential values.

There are, however, no consistent patterns among the mean values of the block variables. For example, in three cases (San Francisco, Cleveland, San Diego), housing is significantly smaller in the NEF 20-30 contours when compared with either NEF 30-40 or NEF 40-50. In one case (Cleveland), housing located at NEF 40-50 is significantly more residential. A number of cases exist where there are no significant differences among the mean values. These comparisons, while admittedly simple, suggest that specification bias is not of major importance. The diverse pattern of property values and housing conditions suggests that the stability of the NEF coefficients is not due solely to change alone. Nevertheless, the possibility of some specification bias is surely present.

TABLE 4.8

COMPARISON OF MEAN VALUES OF VARIABLES, BY NEF INTERVAL[a,b]

Mean of Variable	NEF 20-30 Compared to NEF 30-40	NEF 20-30 Compared to NEF 40-50	NEF 30-40 Compared to NEF 40-50
<u>Property Value</u>			
Sign. greater	4	5	3
Sign. lower	1	0	1
No difference	1	1	2
<u>Rooms per Unit</u>			
Sign. greater	3	5	3
Sign. lower	2	1	2
No difference	1	0	1
<u>Percent Owner-Occupied</u>			
Sign. greater	4	3	3
Sign. lower	1	1	1
No difference	1	2	2
<u>Percent Black Population</u>			
Sign. greater	0	2	2
Sign. lower	0	0	0
No difference	6	4	4
<u>Percent Substandard Plumbing</u>			
Sign. greater	2	1	2
Sign. lower	1	0	1
No difference	3	5	3

[a]See the last table in each appendix for the actual mean values and standard deviations. Entries in Table 4.7 indicate the number of mean values that are significantly greater or lesser for, say, the NEF 20-25 contour compared to NEF 30-40 contour.

[b]Empirical results for Boston have been excluded from this table.

4.7 Heteroskedasticity and Aggregation

Regression models of the sort presented in this study assume that the variance of the disturbance term is constant (homoskedastic). When dealing with cross-sectional microeconomic data, the assumption of homoskedasticity is not very plausible on a priori grounds. For example, it seems reasonable that there would be less variation in property values at high noise levels than at low noise levels. At high noise levels, the possibility of annoyance is perceived more accurately by homeowners, and the random variation of property values about the average level is therefore lower.

A nonuniform or heteroskedastic disturbance term does not bias the coefficient estimates. However, the standard error estimates are biased downward. This means that the usual tests of significance and confidence will be unduly optimistic, i.e., the probability of rejecting the null hypothesis that $b = 0$ will be greater than that indicated by the chosen confidence level.

Grouping the data (aggregation) might reduce the amount of variation present at lower noise levels. Unless the number of observations is the same in every group, however, the disturbance term will still be heteroskedastic. Moreover, information contained in the sample is discarded due to aggregation. That is, estimation based on group means discards the information about the variation of the observations within each group. Aggregation, therefore, does not necessarily solve a heteroskedasticity problem and may result in a further loss of information.

The data employed in the present study are grouped according to census blocks. While these blocks are fairly small observational units, the number of residential properties in each block is not constant. As a rather simple check on heteroskedasticity, we plotted the <u>estimated</u> value of the dependent variable against the <u>estimated</u> value of the disturbance term for all final regressions. Although the estimated residual is not the same as the true residual, they can be used as proxies, especially if the sample size is sufficiently large.

In general, the graphical tests did not suggest the presence of heteroskedasticity, but the small number of observations at very high and very low property values makes any conclusion on this issue somewhat tentative. Moreover, since we do not know the true disturbance variance, there is no obvious way to transform the data so that the disturbances in the transformed data are more nearly homoskedastic.

4.8 Conclusion

The empirical analysis in this study addressed the problem of measuring the effect of aircraft noise on residential property values. In an attempt to hold airport accessibility constant, the sampling procedures exploited the elongated shape of aircraft noise contours in the vicinity of seven major U.S. airports. We found that aircraft noise is capitalized in housing prices and the coefficient for six individual airports (excluding Boston due to census measurement errors) are stable about a weighted mean of -0.50 percent per decibel change in NEF. Thus, a 5-decibel increase (decrease) in NEF would reduce (increase) the value of a $24,000 home by $600, other factors remaining constant. This estimate is robust, stable, and consistent with earlier empirical investigations. The range of noise depreciation coefficients in the present study was about -0.3 to -1.0 percent per decibel change in NEF.

When the observations for six individual airports were pooled to form a sample of 845 observations, the regressions yielded noise coefficients of -0.40 and -0.48 percent. The addition of NEF slope and intercept dummies produced estimates of -0.53 and -0.55 percent. Further, when the pooled sample was partitioned into two mile intervals, the regression coefficients were stable about weighted means of -0.46 percent and -0.55 percent. When the individual samples were restricted to blocks located one to four miles from the airport terminal, the coefficients were stable around a weighted mean of -0.53 percent. The tests for accessibility effects therefore suggest that some additional controls may be necessary if bias is to be avoided in the estimation of noise effects alone. The aggregate nature of the data and limited number of explanatory variables should also be borne in mind.

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[12] Comparison of the double-log and linear models suggests that the logarithmic transformation of the dependent variable does reduce heteroskedasticity.

In spite of some qualifications, the amount of bias in the present study is relatively small, especially when compared to the range of values for the individual study areas. Both present and past empirical studies have frequently produced coefficient estimates in the range -0.50 to -1.0 percent. Apparently, much depends on the particular combination of housing characteristics and noise levels employed, so the tests for accessibility effects may reflect sampling variations or incomplete controls for interurban differences. While the results from this and earlier studies should be interpreted with caution, there is little evidence that the noise coefficient exceeds -1.0 percent in most areas and considerable evidence that suggests a lower value as representative of most aircraft noise-residential housing relationships.

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APPENDICES

APPENDIX A

SAN FRANCISCO EMPIRICAL RESULTS

San Francisco is a relatively large, busy airport, ranking sixth in annual average daily air carrier operations in 1972. Total land area inside the airport boundary is 8.13 square miles.

Location. The San Francisco sample includes census blocks in San Mateo County, but excludes blocks that border on the state fish and game refuge and the Bay. Some blocks were also included from the South San Francisco Division southeast to Millbrae. The study area is west and northwest of the main terminal and is under the noise contours from runways 10R and 10L. The most remote areas are about five miles from the main terminal (Figure A.1).

Sample Size. Data were collected for blocks contained in 11 census tracts (Table A.1). Blocks were excluded if they were near or adjacent to special environmental features, such as parks, cemeteries, or golf courses. For San Francisco, a total of 393 observations were recorded. The net sample, with boundary restrictions on the NEF variable, consisted of 333 blocks. Observations were then deleted if information was missing, the block contained less than 50 percent single-family residential units, or the blocks contained fewer than 10 single-family residential units. The maximum sample sizes are 197 observations without the NEF boundary restrictions and 159 observations with the boundary restrictions.

Empirical Results. Initial empirical results for San Francisco are presented in Tables A.2 and A.3; the results indicate that aircraft noise has a negative effect on residential property values. Moreover, the results are not sensitive to the model specification. When the tract variables are added (before 1939, central air conditioning), there are only slight changes in the NEF-II coefficient value. This result suggests that it should be possible to include both tract variables in the final regressions.

The simple correlations in Table A.3 are

	NEF-II	Before 1939	Cent. Air. Cond.
LMPVAL	-0.448*	0.053	0.165
NEF-II	--	-0.104	0.188
Before 1939	--	--	-0.229

where LMPVAL is the natural log of the mean property value and the asterisk indicates statistical significance at the 90 percent confidence level.

The final regressions in Table A.4 incorporate the sampling restriction on the rooms and property value variables. The final sample size is 153 observations compared to 159 in Table A.3. When both tract variables are employed, the NEF coefficient is -0.0058 and the corrected $\bar{R}^2$ is 0.6994. While this estimate is robust, the air conditioning variable has an incorrect sign, suggesting that it may be capturing some of the effect of aircraft noise. Six of the seven coefficients in this regression are statistically significant. The scatter plot of estimated residuals contained no more than three outliers, which were located close to the mean of the estimated dependent variable.

The mean property value for this sample is $29,686 (Table A.5), while the simple correlation between property values and NEF levels is -0.459 (Table A.6). Housing located in the intervals NEF 40-50 tends on average to be smaller, less residential, and lower in value (Table A.7).

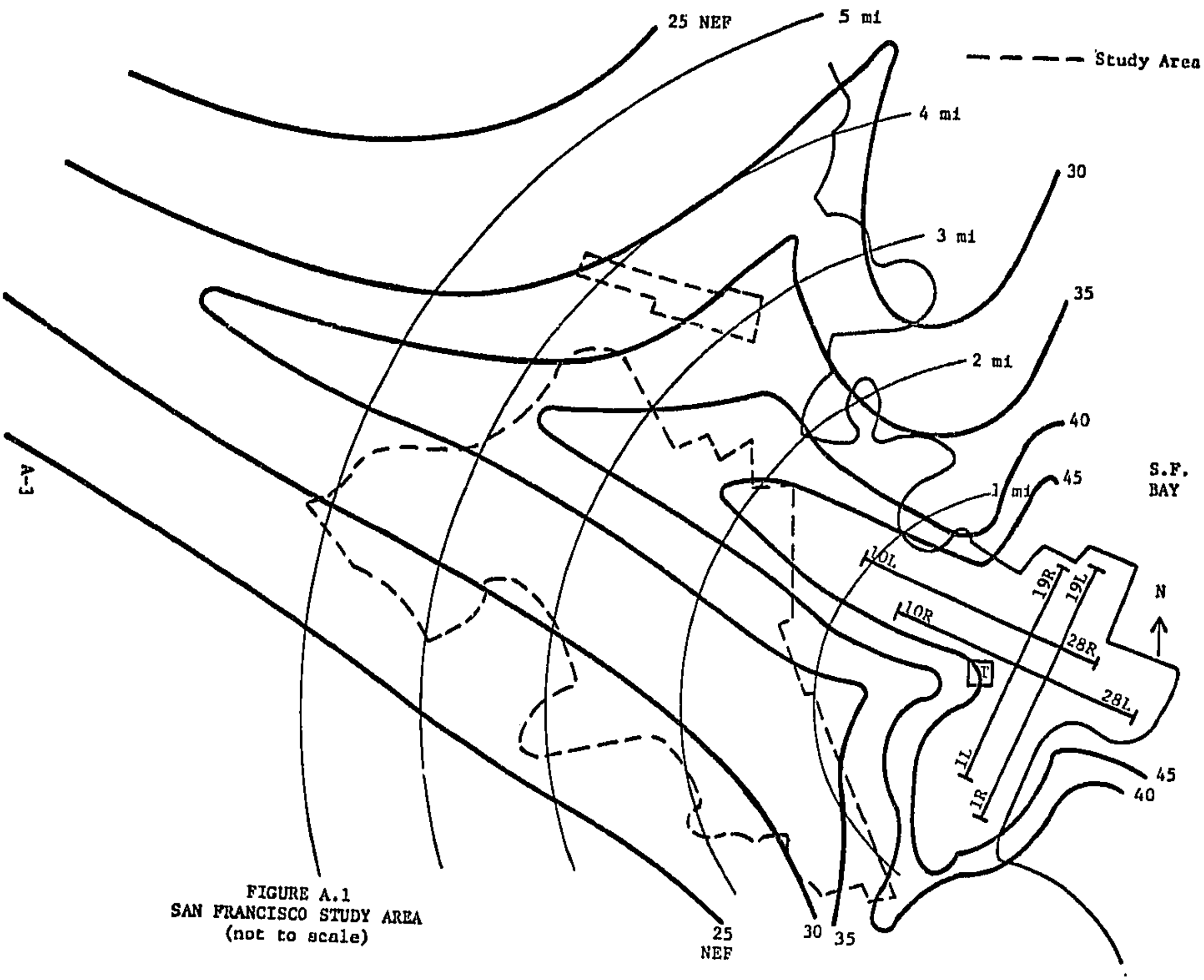

FIGURE A.1
SAN FRANCISCO STUDY AREA
(not to scale)

TABLE A.1

SAN FRANCISCO SAMPLE SIZE

Census Tract No.	Total Blocks Included	Boundary Exclusions[a]	Net Sample
6022	65	8	57
6024	39	6	33
6025	19	4	15
6037	38	8	30
6039	30	3	27
6040	27	8	19
6041	61	8	53
6042	36	1	35
6044	25	1	24
6045	14	3	11
6048	39	10	29
Total	393	60	333

[a]Blocks near or adjacent to the actual NEF-25 or-30 contour lines or within NEF 30 but adjacent to NEF 35.

TABLE A.2

SAN FRANCISCO REGRESSIONS, WITHOUT BOUNDARY RESTRICTIONS ON NEF VARIABLE

	Regression Coefficient (Student-t)			
Variable	(1)	(2)	(3)	(4)
Constant	8.4785 (51.6258)*	8.5928 (35.4049)*	8.3996 (33.5456)*	7.9298 (30.6497)*
NEF-I	-0.0038 (2.1100)*	-0.0041 (2.1986)*	-0.0037 (2.0237)*	-0.0050 (2.8910)*
Ln Mean Rooms per Unit	1.1093 (14.6311)*	1.1305 (13.6492)*	1.2648 (13.1007)*	1.1713 (12.7462)*
Ln Percent Owner-Occupied	--	-0.0323 (0.6406)	-0.0426 (0.8545)	0.1041 (1.8711)*
Percent Black Population	--	--	-0.0085 (2.6035)*	-0.0053 (1.7110)*
Percent Sub-stand. Plumbing	--	--	--	--
Percent Built Before 1939	--	--	--	0.0036 (5.3888)*
Percent Central Air Conditioning	--	--	--	-0.0084 (1.0154)
$\bar{R}^2$	0.5981	0.5969	0.6086	0.6590
F	146.8615	97.7468	77.1994	64.1339
SEE	0.1103	0.1104	0.1088	0.1016
Det (X'X)	0.8305	0.5908	0.4019	0.2267
N[a]	197	197	197	197

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE A.3

SAN FRANCISCO REGRESSIONS,
WITH BOUNDARY RESTRICTIONS ON NEF VARIABLE

Variable	Regression Coefficient (Student-t) (1)	(2)	(3)	(4)
Constant	8.4538 (29.2400)*	8.1871 (29.6056)*	8.3444 (27.3029)*	8.1092 (27.8636)*
NEF-II	-0.0050 (2.4903)*	-0.0066 (3.4605)*	-0.0048 (2.4093)*	-0.0064 (3.3770)*
Ln Mean Rooms per Unit	1.1730 (11.1328)*	1.0864 (10.8262)*	1.1788 (11.1814)*	1.0917 (10.8500)*
Ln Percent Owner-Occupied	-0.0105 (0.1797)	0.0864 (1.4992)*	0.0140 (0.2227)	0.1051 (1.6951)*
Percent Black Population	-0.0096 (2.0867)*	-0.0061 (1.3999)*	-0.0093 (2.0245)*	-0.0060 (1.3598)*
Percent Sub-stand. Plumbing	0.0051 (0.9074)	0.0005 (0.0920)	0.0050 (0.8923)	0.0005 (0.0899)
Percent Built Before 1939	--	0.0034 (4.7390)*	--	0.0034 (4.6691)*
Percent Central Air Conditioning	--	--	-0.0109 (1.0978)	-0.0081 (0.8657)
$\bar{R}^2$	0.6083	0.6564	0.6088	0.6559
F	50.0671	51.3171	41.9794	44.0207
SEE	0.1082	0.1013	0.1081	0.1014
Det (X'X)	0.3784	0.2860	0.3027	0.2278
N[a]	159	159	159	159

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE A.4

SAN FRANCISCO REGRESSIONS,
WITH NEF AND SAMPLING RESTRICTIONS

Variable	Regression Coefficient (Student-t) (1)	(2)	(3)	(4)
Constant	8.1376 (27.5459)*	7.8747 (28.1774)*	7.9727 (25.3280)*	7.7402 (26.0961)*
NEF-II	-0.0044 (2.2548)*	-0.0060 (3.2957)*	-0.0041 (2.1187)*	-0.0058 (3.1549)*
Ln Mean Rooms per Unit	1.1824 (11.5385)*	1.0910 (11.2529)*	1.1871 (11.6248)*	1.0962 (11.3268)*
Ln Percent Owner-Occupied	0.0518 (0.8457)	0.1518 (2.5130)*	0.0894 (1.3518)*	0.1819 (2.8258)*
Percent Black Population	-0.0100 (2.2335)*	-0.0063 (1.5031)*	-0.0095 (2.1450)*	-0.0060 (1.4344)*
Percent Sub-stand. Plumbing	0.0068 (1.2711)	0.0020 (0.3925)	0.0068 (1.2743)	0.0021 (0.4052)
Percent Built Before 1939	--	0.0035 (4.9422)*	--	0.0035 (4.8789)*
Percent Central Air Conditioning	--	--	-0.0142 (1.4738)*	-0.0119 (1.3276)*
$\bar{R}^2$	0.6497	0.6978	0.6524	0.6994
F	57.3740	59.5015	48.5549	51.5194
SEE	0.1034	0.0960	0.1030	0.0958
Det (X'X)	0.3637	0.2758	0.2843	0.2150
N[a]	153	153	153	153

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

TABLE A.5

DESCRIPTION OF SAN FRANCISCO VARIABLES
(Sample Size N = 153)[a]

Variable	Mean	Standard Deviation	Minimum	Maximum
Mean Property Value (1)	$29,686[b]	$5,198	$19,323	$41,250
NEF-II (2)	31.797	5.053	25.000	45.000
Mean Rooms per Unit (3)	5.753	0.711	4.500	8.300
Percent Owner-Occupied Units (4)	83.354	12.973	50.000	100.000
Percent Black Population (5)	0.717	2.274	0.000	15.951
Percent Sub-stand. Plumbing (6)	0.382	1.584	0.000	11.111
Percent Built Before 1939 (7)	9.580	12.603	0.313	46.192
Percent Central Air Conditioning (8)	1.253	0.978	0.000	3.451

[a] Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b] The mean property value for 356 blocks in the 10 tracts listed in Table A.1 was $28,014 (based on printed block statistics).

TABLE A.6

ZERO-ORDER CORRELATIONS FOR
SAN FRANCISCO VARIABLES
(Sample Size N = 153)[a]

Variable[b]	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	-0.459*	0.789*	0.489*	0.317*	-0.023	0.042	0.172
(2)	--	-0.412*	-0.459*	-0.126	-0.023	0.288*	-0.141
(3)		--	0.526*	0.539*	-0.116	-0.162	0.279*
(4)			--	0.204	-0.132	-0.408*	0.453*
(5)				--	-0.075	-0.172	0.171
(6)					--	0.206	-0.074
(7)						--	-0.220

*Significant at the 90 percent confidence level.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]For a listing of the variables, see Table A.5. Variables (1), (3), and (4) are in natural logs.

TABLE A.7

MEAN VALUES OF SAN FRANCISCO VARIABLES, BY NEF INTERVAL

Mean of Variable (St. Dev.)	NEF Interval 25-30	30-40	40-50
Property Value	$29,629 (2,232)*	$30,845 (5,029)	$23,109 (3,995)*[a]
Rooms per Unit	5.728 (0.151)*	5.899 (0.742)	4.947 (0.342)*[a]
Percent Owner-Occupied Units	88.132 (7.080)*	84.880 (12.269)	68.312 (12.910)*[a]
Percent Black Population	0.814 (1.304)	0.786 (2.611)	0.192 (0.398)*[a]
Percent Substandard Plumbing	0.000 (--)*	0.525 (1.856)	0.067 (0.290)*
NEF-II	25.000	31.560	42.105
No. of Obs.	25	109	19

*Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 30-40.

[a]Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 25-30.

APPENDIX B

BOSTON EMPIRICAL RESULTS

Boston (Logan) is a relatively large, busy airport, ranking tenth in annual average daily air carrier operations in 1972. Total land area inside the airport boundary is 3.72 square miles.

Location. The Boston sample includes census blocks in the areas known as Chelsea, Revere, Everett, and Malden, but excludes blocks near the rivers and Boston harbor. The study area is northwest of the main terminal and is under the noise contours from runways 15L and 22R. The most remote areas are about five miles from the main terminal (Figure B.1)

Sample Size. Data were collected for blocks contained in 12 census tracts (Table B.1). Blocks were excluded if they were near or adjacent to special environmental features such as parks, apartment complexes, railroad tracks, highways, and rivers. For Boston, a total of 393 observations were recorded. The net sample, with boundary restrictions on the NEF variable, consisted of 312 blocks. Observations were then deleted if information was missing, the block contained less than 50 percent single-family residential units, or the blocks contained fewer than 10 single-family residential units. The maximum sample sizes are 185 observations without the boundary restrictions and 154 observations with the boundary restrictions. These restrictions also reduced the noise levels in the Boston sample to only three possible values, NEF 25, 30, and 35.

Empirical Results. The best empirical results for Boston are presented in Table B.2; the results indicate that aircraft noise has a negative effect on residential property values. The regression fits the data very poorly, although three of the six variables in regression (4) are statistically significant. The poor fit is due to the insignificant effect of the rooms variable; indeed, the simple correlation between the rooms variable and property values is negative. When the sampling restriction on property values was added, the sample size fell from 154 observations to only 50 observations. This suggests that measurement errors are present for the rooms variable.

In addition to this problem, the tract variable for the age of housing (before 1939) was highly correlated with the NEF variable and the other independent variable. It was necessary to omit this tract variable from the final regressions due to a collinearity problem. The Boston sample apparently is made up of older, larger houses which are situated close to the airport. Because of these problems, the empirical results in Table B.2 should be used with caution.

The mean property value for this sample is $22,857 (Table B.3), while the simple correlation between property values and NEF levels is -0.341 (Table B.4). Housing located in the intervals NEF 30-40 tends on average to be larger, less residential, and lower in value (Table B.5).

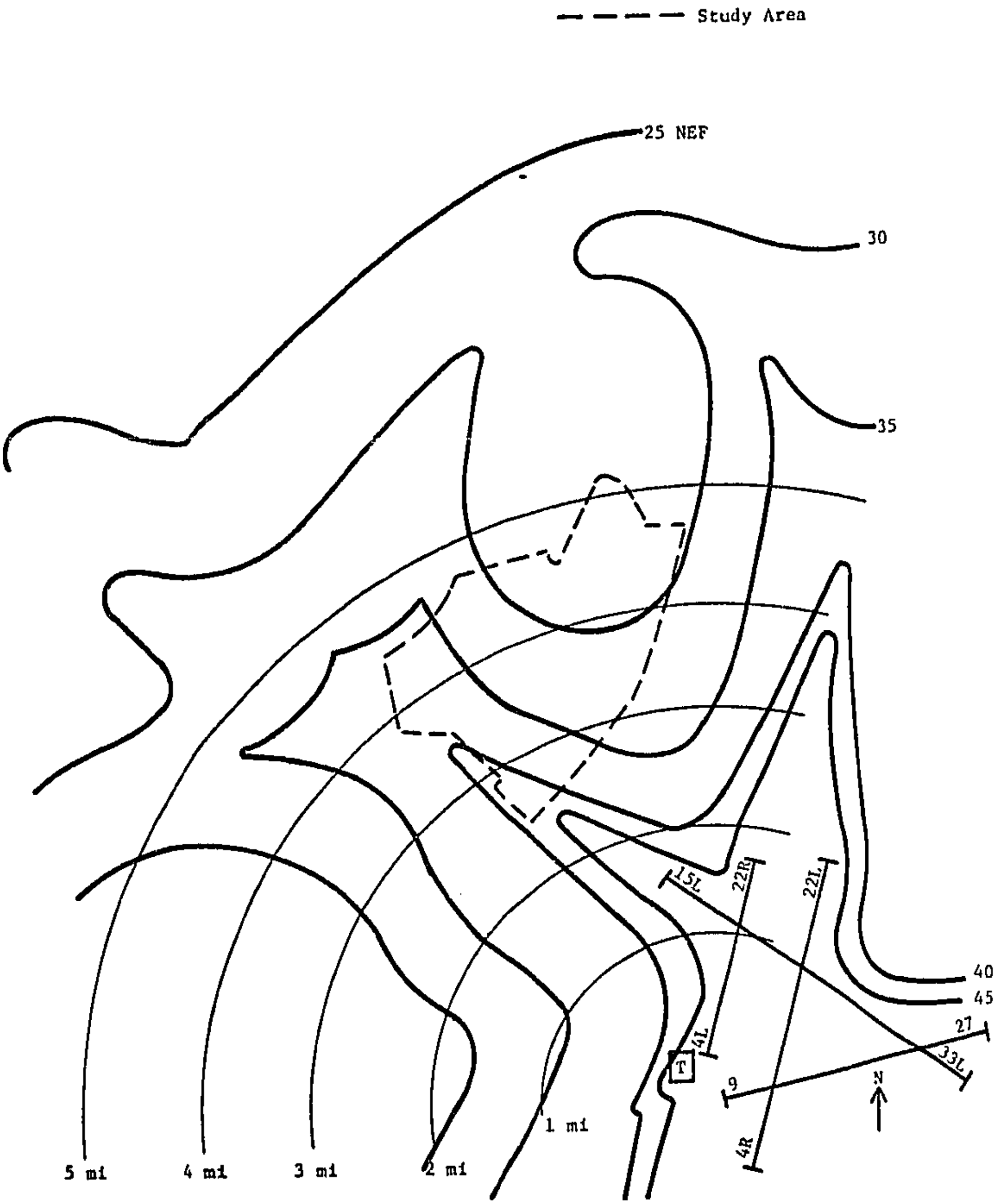

FIGURE B.1
BOSTON STUDY AREA
(not to scale)

TABLE B.1

BOSTON SAMPLE SIZE

Census Tract No.	Total Blocks Included	Boundary Exclusions[a]	Net Sample
3421	50	7	43
3422	72	20	52
3423	25	0	25
3424	12	0	12
3425	40	10	30
3426	19	13	6
1604	8	0	8
1605	31	17	14
1606	38	5	33
1701	37	6	31
1702	17	3	14
1703	44	0	44
Total	393	81	312

[a]Blocks near or adjacent to the actual NEF-25 or-30 contour lines or within NEF 30 but adjacent to NEF 35.

TABLE B.2

BOSTON REGRESSIONS, WITH
BOUNDARY RESTRICTIONS ON NEF VARIABLE

	Regression Coefficient (Student-t)			
Variable	(1)	(2)	(3)	(4)
Constant	10.6354 (38.9848)*	10.0671 (23.9505)*	10.0647 (23.6447)*	9.9912 (23.3327)*
NEF-II	-0.0129 (3.8622)*	-0.0110 (3.0000)*	-0.0095 (2.5158)*	-0.0084 (2.1693)*
Ln Mean Rooms per Unit	-0.1416 (0.8505)	-0.1210 (0.7300)	-0.1389 (0.8286)	-0.1097 (0.6504)
Ln Percent Owner-Occupied	--	0.1110 (1.7684)*	0.1127 (1.7640)*	0.1057 (1.6531)*
Percent Black Population	--	--	-0.0042 (0.7302)	-0.0029 (0.5082)
Percent Sub-stand. Plumbing	--	--	-0.0017 (0.4532)	-0.0013 (0.3551)
Percent Built Before 1939	--	--	--	--
Percent Central Air Conditioning	--	--	--	0.0202 (1.3233)*
$\bar{R}^2$	0.1089	0.1213	0.1143	0.1187
F	10.3510	8.0402	4.9478	4.4359
SEE	0.1406	0.1396	0.1401	0.1398
Det (X'X)	0.8699	0.7270	0.6073	0.4913
N[a]	154	154	154	154

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE B.3

DESCRIPTION OF BOSTON VARIABLES
(Sample Size N = 154)[a]

Variable	Mean	Standard Deviation	Minimum	Maximum
Mean Property Value (1)	$22,857[b]	$3,423	$15,000	$33,281
NEF-II (2)	27.955	3.643	25.000	35.000
Mean Rooms per Unit (3)	5.790	0.432	4.900	7.400
Percent Owner-Occupied Units (4)	69.986	13.860	50.000	100.000
Percent Black Population (5)	0.472	2.091	0.000	18.841
Percent Sub-stand. Plumbing (6)	1.872	3.180	0.000	13.636
Percent Built Before 1939 (7)	59.251	20.364	32.263	94.326
Percent Central Air Conditioning (8)	0.945	0.824	0.000	2.122

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

[b]The mean property value for the 393 blocks in the 12 tracts listed in Table B.1 was $21,556 (based on printed block statistics).

TABLE B.4

ZERO-ORDER CORRELATIONS FOR BOSTON VARIABLES (Sample Size N = 154)[a]

Variable[b]	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	-0.341*	-0.182	0.264*	-0.124	-0.131	-0.426*	0.248*
(2)	--	0.361*	-0.400*	0.256*	0.245*	0.798*	-0.383*
(3)		--	-0.204	0.006	0.013	0.348*	-0.236
(4)			--	-0.002	-0.194	-0.369*	0.222
(5)				--	0.147	0.255*	-0.229
(6)					--	0.321*	-0.171
(7)						--	-0.601*

*Significant at the 90 percent confidence level.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

[b]For a listing of the variables, see Table B.3. Variables (1), (3), and (4) are in natural logs.

TABLE B.5

MEAN VALUES OF BOSTON VARIABLES,
BY NEF INTERVAL

Mean of Variable (St. Dev.)	NEF Interval		
	25-30	30-40	40-50
Property Value	$23,876 (3,435)*	$21,602 (2,980)	--
Rooms per Unit	5.655 (0.374)*	5.957 (0.442)	--
Percent Owner-Occupied Units	74.139 (13.494)*	64.871 (12.617)	--
Percent Black Population	0.045 (0.417)*	0.998 (3.019)	--
Percent Substandard Plumbing	1.179 (2.575)*	2.726 (3.637)	--
NEF-II	25.000	31.594	--
No. of Obs.	85	69	--

*Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 30-40.

APPENDIX C

CLEVELAND EMPIRICAL RESULTS

Cleveland is a medium-sized airport, ranking seventeenth in annual average daily air carrier operations in 1972. Total land area inside the airport boundary is 2.30 square miles.

Location. The Cleveland sample includes census blocks in the areas known as River Edge and Linndale. The study area is bisected by Interstate Highway I-71 in the south and by State Highway 10 in the north. Special care was taken to exclude blocks near these highways and other important transportation facilities (major streets, railroad tracks). Blocks located near parks and playgrounds were also excluded. The study area is northeast of the main terminal and is under the noise contours from runways 23R and 23L. The most remote areas are about five miles from the main terminal (Figure C.1).

Sample Size. Data were collected for blocks contained in 11 census tracts (Table C.1). For Cleveland, a total of 267 observations were included. The net sample, with boundary restrictions on the NEF variable, consisted of 207 blocks. Observations were then deleted if information was missing, the block contained less than 50 percent single-family residential units, or the block contained fewer than 10 single-family residential units. The maximum sample sizes are 246 observations without the NEF boundary restrictions and 197 observations with the boundary restrictions.

Empirical Results. Initial empirical results for Cleveland are presented in Tables C.2 and C.3; the results indicate that aircraft noise has a negative effect on residential property values. However, the empirical results are sensitive to the model specification. When the tract variables are added (before 1939, central air conditioning), the NEF-II coefficient is no longer statistically significant. This result appears to be due to the amount of correlation among the tract variables and the NEF variable. The simple correlations in Table C.3 are

	NEF-II	Before 1939	Cent. Air Cond.
LMPVAL	-0.204	0.598*	0.102
NEF-II	--	-0.347*	-0.387*
Before 1939	--	--	0.038

where LMPVAL is the natural log of the mean property value and the asterisks indicate statistical significance at the 90 percent confidence level.

The final regressions in Table C.4 incorporate the sampling restrictions on the rooms and property value variables. The final sample size is 185 observations compared to 197 in Table C.3. The NEF coefficient is still sensitive to the model specification which incorporates the tract variable for central air conditioning. The NEF coefficient for regression (4) is only -0.0029 compared to -0.0069 in regression (2). While the former regression has been chosen as the final result, it should be recognized that the Cleveland estimate may be subject to multicollinearity problems. Six of the seven coefficients in regression (4) are statistically significant. The scatter plot of estimated residuals contained no more than two outliers, which were located close to the mean of the estimated dependent variable.

The mean property value for this sample is $20,898 (Table C.5), while the simple correlation between property values and NEF levels is -0.301 (Table C.6). Housing located in the intervals NEF 40-50 tends on average to be smaller, less residential, and lower in value (Table C.7).

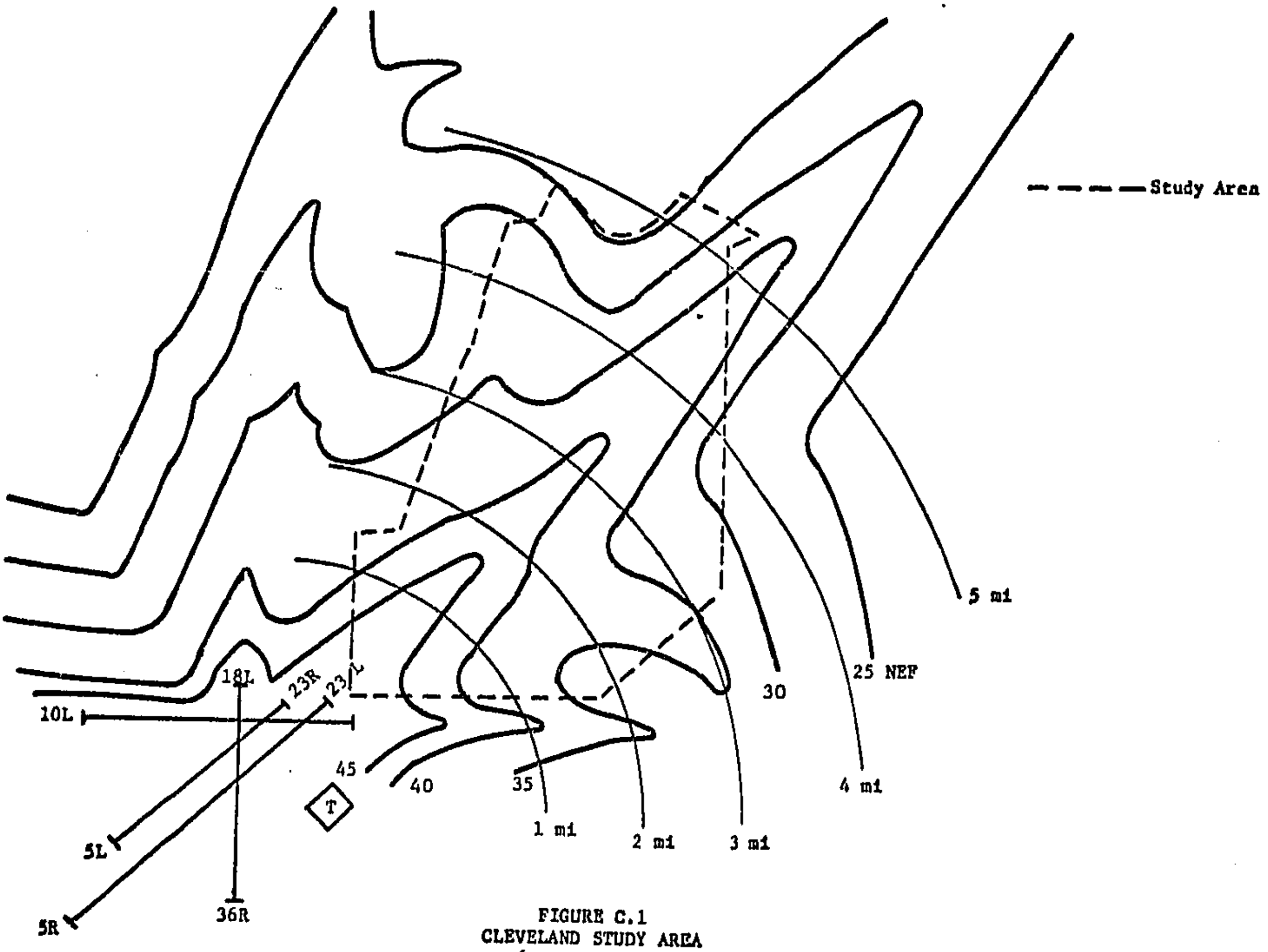

FIGURE C.1
CLEVELAND STUDY AREA
(not to scale)

TABLE C.1

CLEVELAND SAMPLE SIZE

Census Tract No.	Total Blocks Included	Boundary Exclusions[a]	Net Sample
1231	16	12	4
1232	19	7	12
1234	19	0	19
1235	38	20	18
1236	27	1	26
1237	26	0	26
1238	12	0	12
1239	24	6	18
1242	30	4	26
1243	35	8	27
1245	21	2	19
Total	267	60	207

[a]Blocks near or adjacent to the actual NEF-25 or-30 contour lines or within NEF 30 but adjacent to NEF 35.

TABLE C.2

CLEVELAND REGRESSIONS, WITHOUT
BOUNDARY RESTRICTIONS ON NEF VARIABLE

	Regression Coefficient (Student-t)			
Variable	(1)	(2)	(3)	(4)
Constant	8.1195 (48.9447)*	6.6087 (24.1106)*	6.6678 (24.7520)*	7.4739 (36.0430)*
NEF-I	-0.0007 (0.4844)	-0.0035 (2.4460)*	-0.0036 (2.5814)*	0.0008 (0.6888)
Ln Mean Rooms per Unit	1.0751 (12.4134)*	1.1589 (14.3416)*	1.1515 (14.4993)*	1.0390 (13.6742)*
Ln Percent Owner-Occupied	--	0.3273 (6.6406)*	0.3210 (6.6296)*	0.1351 (3.4387)*
Percent Black Population	--	--	-0.0058 (0.7710)	0.0003 (0.0428)
Percent Sub-stand. Plumbing	--	--	-0.0119 (3.3640)*	-0.0101 (3.8314)*
Percent Built Before 1939	--	--	--	-0.0014 (4.2110)*
Percent Central Air Conditioning	--	--	--	0.0294 (10.9697)*
$\bar{R}^2$	0.4002	0.4906	0.5100	0.7319
F	82.7383	79.6409	52.0032	96.5693
SEE	0.1182	0.1089	0.1068	0.0790
Det (X'X)	0.9490	0.8266	0.8162	0.2797
N[a]	246	246	246	246

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE C.3

CLEVELAND REGRESSIONS, WITH
BOUNDARY RESTRICTIONS ON NEF VARIABLE

Variable	Regression Coefficient (Student-t) (1)	(2)	(3)	(4)
Constant	8.3776 (51.8887)*	7.5668 (23.7791)*	7.6267 (24.5899)*	7.8545 (31.4133)*
NEF-II	-0.0022 (1.4645)*	-0.0033 (2.2253)*	-0.0034 (2.3553)*	-0.0010 (0.7727)
Ln Mean Rooms per Unit	0.9547 (11.3055)*	1.0058 (11.8834)*	1.0033 (12.1734)*	1.0054 (12.0240)*
Ln Percent Owner-Occupied	--	0.1708 (2.9377)*	0.1625 (2.8682)*	0.0821 (1.7197)*
Percent Black Population	--	--	-0.0030 (0.3286)	0.0007 (0.0970)
Percent Sub-stand. Plumbing	--	--	-0.0127 (3.5707)*	-0.0118 (4.1106)*
Percent Built Before 1939	--	--	--	-0.0015 (4.0875)*
Percent Central Air Conditioning	--	--	--	0.0249 (7.6069)*
$\bar{R}^2$	0.4163	0.4384	0.4681	0.6572
F	70.8892	51.9948	35.4958	54.6691
SEE	0.1032	0.1012	0.0985	0.0791
Det (X'X)	0.9621	0.8368	0.8302	0.3246
N[a]	197	197	197	197

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE C.4

CLEVELAND REGRESSIONS, WITH
NEF AND SAMPLING RESTRICTIONS

	Regression Coefficient (Student-t)			
Variable	(1)	(2)	(3)	(4)
Constant	7.7647 (23.5724)*	7.8496 (25.8506)*	7.8081 (27.6168)*	7.8565 (28.8873)*
NEF-II	-0.0053 (3.8568)*	-0.0069 (5.2962)*	-0.0013 (1.0169)	-0.0029 (2.2695)*
Ln Mean Rooms per Unit	0.9698 (12.6341)*	1.2111 (14.7380)*	0.8194 (11.9686)*	1.0003 (12.4970)*
Ln Percent Owner-Occupied	0.1591 (2.5960)*	0.0741 (1.2706)	0.1555 (2.9568)*	0.1007 (1.9229)*
Percent Black Population	0.0041 (0.4981)	-0.0069 (0.0914)	0.0021 (0.2984)	0.0007 (0.1041)
Percent Sub-stand. Plumbing	-0.0114 (3.4624)*	-0.0098 (3.2095)*	-0.0121 (4.2776)*	-0.0109 (3.9973)*
Percent Built Before 1939	--	-0.0022 (5.7563)*	--	-0.0014 (3.9684)*
Percent Central Air Conditioning	--	--	0.0254 (8.0658)*	0.0214 (6.7001)*
$\bar{R}^2$	0.5260	0.5982	0.6510	0.6777
F	41.8445	46.5629	58.1921	56.2614
SEE	0.0894	0.0823	0.0767	0.0737
Det (X'X)	0.8313	0.4816	0.6181	0.3220
N[a]	185	185	185	185

*Significant at the 90 percent confidence level, one-tailed t-test.
Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

TABLE C.5

DESCRIPTION OF CLEVELAND VARIABLES
(Sample Size N = 185)[a]

Variable	Mean	Standard Deviation	Minimum	Maximum
Mean Property Value (1)	$20,898[b]	$2,787	$15,703	$30,125
NEF-II (2)	33.892	5.026	25.000	45.000
Mean Rooms per Unit (3)	5.526	0.510	4.500	7.200
Percent Owner-Occupied Units (4)	89.255	9.418	51.923	100.000
Percent Black Population (5)	0.090	0.803	0.000	10.000
Percent Sub-stand. Plumbing (6)	1.141	2.007	0.000	8.333
Percent Built Before 1939 (7)	29.868	21.296	12.476	79.737
Percent Central Air Conditioning (8)	3.689	2.081	1.383	9.816

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]The mean property value for 338 blocks in the nine tracts listed in Table C.1 was $21,603 (based on printed block statistics).

TABLE C.6

ZERO-ORDER CORRELATIONS FOR CLEVELAND VARIABLES (Sample Size N = 185)[a]

Variable[b]	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	-0.301*	0.679*	-0.091	-0.028	-0.177	0.177	0.589*
(2)	--	-0.205	0.264*	-0.050	-0.026	-0.324*	-0.427*
(3)		--	-0.280*	-0.028	0.003	0.572*	0.336*
(4)			--	-0.006	-0.063	-0.395*	-0.166
(5)				--	-0.042	-0.057	-0.084
(6)					--	0.092	0.041
(7)						--	0.066

*Significant at the 90 percent confidence level.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]For a listing of the variables, see Table C.5. Variables (1), (3), and (4) are in natural logs.

TABLE C.7

MEAN VALUES OF CLEVELAND VARIABLES, BY NEF INTERVAL

Mean of Variable (St. Dev.)	NEF Interval 25-30	30-40	40-50
Property Value	\$21,702 (3,448)	\$21,150 (2,747)	\$19,335 (1,706) *a
Rooms per Unit	5.450 (0.383) *	5.611 (0.538)	5.252 (0.357) *a
Percent Owner-Occupied Units	84.683 (10.094) *	88.922 (9.767)	93.875 (4.482) *a
Percent Black Population	0.022 (0.107)	0.126 (0.963)	0.000 (--)
Percent Substandard Plumbing	1.423 (2.265)	1.129 (2.000)	0.980 (1.874) *
NEF-II	25.000	33.594	41.515
No. of Obs.	24	128	33

*Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 30-40 (large sample test).

[a] Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 25-30 (large sample test).

APPENDIX D

ST. LOUIS EMPIRICAL RESULTS

St. Louis is a medium-sized airport, ranking thirteenth in annual average daily air carrier operations in 1972. Total land area inside the airport boundary is 2.89 square miles.

Location. The St. Louis sample includes census blocks in the areas known as Berkeley, Ferguson, and Kinloch. The study area is east of the main terminal and is affected by noise from runways 30R, 30L, and 24. The most remote areas are about four miles from the main terminal (Figure D.1).

Sample Size. Data were collected for blocks located in five census tracts (Table D.1). Blocks were excluded if they were near or adjacent to major environmental features, major transportation facilities, or commercial developments. For St. Louis, a total of 258 observations were recorded. The net sample, with boundary restrictions on the NEF variable, consisted of 207 blocks. Observations were then deleted if information was missing, the blocks contained less than 50 percent single-family residential units, or the block contained fewer than 10 single-family residential units. The maximum sample sizes are 197 observations without NEF boundary restrictions and 149 observations with the boundary restrictions.

Empirical Results. Initial empirical results for St. Louis are presented in Tables D.2 and D.3; the results indicate that aircraft noise has a negative effect on property values. However, the empirical results are sensitive to the model specification. When the tract variables are added (before 1939, central air conditioning), the NEF-II coefficient declines in value or is no longer statistically significant. This result appears to be due to the amount of correlation among the tract variables and the NEF variable. The simple correlations in Table D.3 are

	NEF-II	Before 1939	Cent. Air. Cond.
LMPVAL	-0.511*	-0.615*	0.799*
NEF-II	--	0.675*	-0.617*
Before 1939	--	--	-0.844*

where LMPVAL is the natural log of the mean property value and the asterisks indicate statistical significance at the 90 percent confidence level.

In addition to this collinearity problem, the results reflect the very low property values observed in tract 2128, a tract which is adjacent to the airport. The average property value in this tract was only $9,950 and the average number of rooms is only 4.8. The minimum property value in Table D.3 is $4,400 and the minimum number of rooms is 3.9.

Table D.4 presents the regressions which incorporate the sampling restrictions on the rooms and property value variables. The sample size is 149 observations compared to 185 in Table D.3. When both tract variables are employed, the NEF coefficient is -0.0044 and the corrected R^2 is 0.8638. The results with this sample are still not very robust as the NEF coefficient is only weakly significant or insignificant when the tract variables are employed.

Table D.5 presents the regressions which incorporate the sampling restrictions and also exclude all observations from tract 2128. The sample size is now reduced to 113 observations compared to 149 observations in Table D.4. When both tract variables are included, the NEF coefficient is -0.0051 and the corrected R^2 is 0.7247. This estimate is still sensitive to the model specification, but only when air conditioning is the only tract variable included. We therefore choose regression (4) as the final result and employ an NEF coefficient of -0.0051 for St. Louis. Six of the seven coefficients in this regression are statistically significant. The scatter plot of estimated residuals contained two outliers, one toward each end of the range of estimated values for the dependent variable.

The mean property value for this sample is $16,411 (Table D.6), while the simple correlation between property values and NEF levels is -0.390 (Table D.7). Housing located in the intervals NEF 30-40 and 40-50 tends on average to be smaller and lower in value (Table D.8).

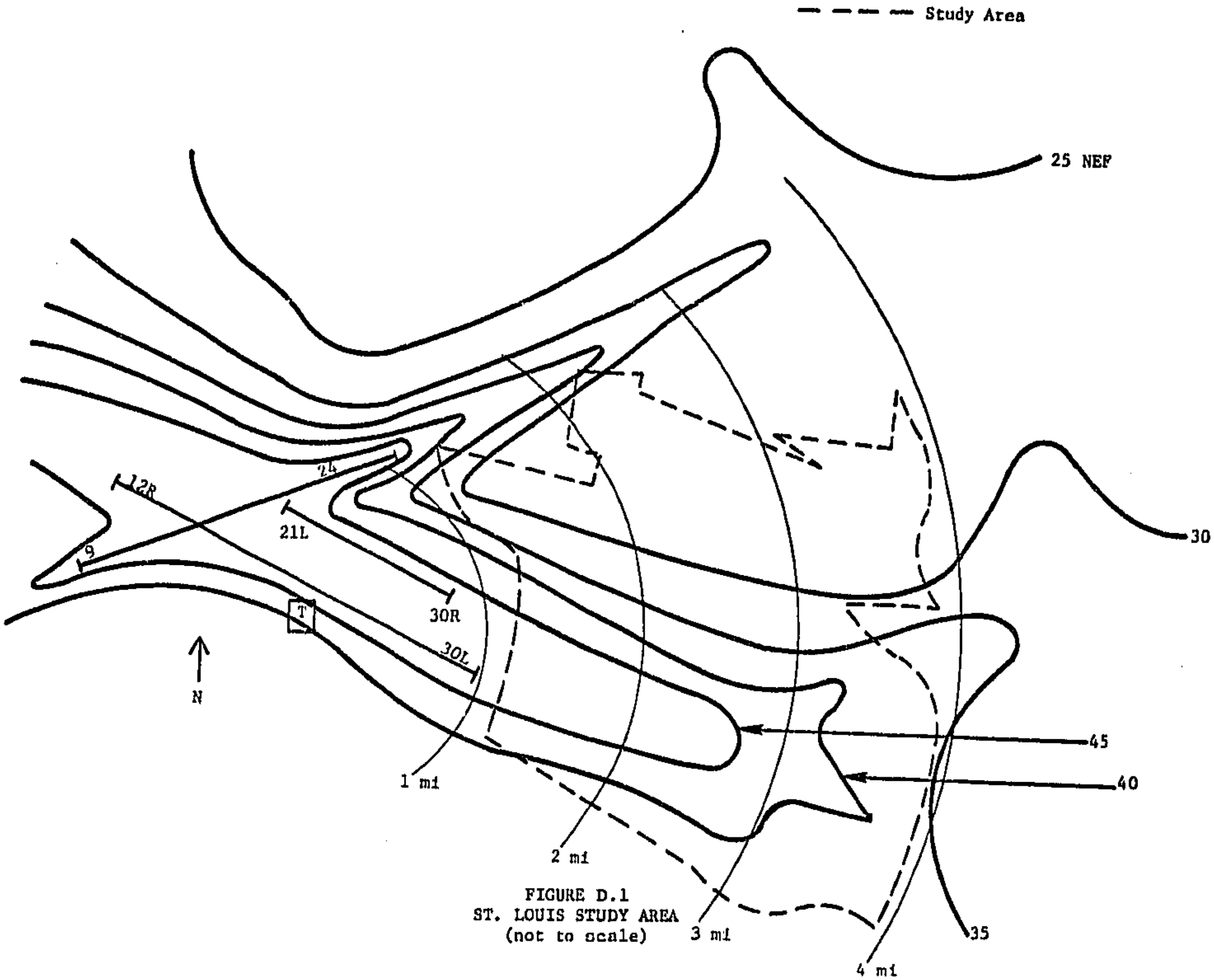

FIGURE D.1
ST. LOUIS STUDY AREA
(not to scale)

TABLE D.1

ST. LOUIS SAMPLE SIZE

Census Tract No.	Total Blocks Included	Boundary Exclusions[a]	Net Sample
2115	27	2	25
2126	47	16	31
2127	68	6	62
2128	72	10	62
2129	44	17	27
Total	258	51	207

[a]Blocks near or adjacent to the actual NEF-25 or-30 contour lines or within NEF 30 but adjacent to NEF 35.

TABLE D.2

ST. LOUIS REGRESSIONS, WITHOUT
BOUNDARY RESTRICTIONS ON NEF VARIABLE

	Regression Coefficient (Student-t)			
Variable	(1)	(2)	(3)	(4)
Constant	6.2813 (20.2115)*	3.7072 (8.2638)*	5.8592 (16.5688)*	5.9334 (17.1284)*
NEF-I	-0.0097 (3.2559)*	-0.0066 (2.4634)*	-0.0047 (2.4711)*	-0.0006 (0.2726)
Ln Mean Rooms per Unit	2.1323 (13.7358)*	1.6963 (11.2850)*	1.3956 (12.9144)*	1.3130 (10.8214)*
Ln Percent Owner-Occupied	--	0.7255 (7.2784)*	0.3607 (4.8545)*	0.3190 (4.3434)*
Percent Black Population	--	--	-0.0037 (11.3311)*	-0.0029 (7.5751)*
Percent Sub-stand. Plumbing	--	--	-0.0036 (2.8896)*	-0.0031 (2.4404)*
Percent Built Before 1939	--	--	--	-0.0015 (0.8977)
Percent Central Air Conditioning	--	--	--	0.0046 (2.2352)*
$\bar{R}^2$	0.6045	0.6881	0.8490	0.8566
F	150.7897	145.1174	221.4113	168.2086
SEE	0.2266	0.2012	0.1400	0.1364
Det (X'X)	0.7950	0.5891	0.2690	0.0193
N[a]	197	197	197	197

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE D.3

ST. LOUIS REGRESSIONS, WITH
BOUNDARY RESTRICTIONS ON NEF VARIABLE

	Regression Coefficient (Student-t)			
Variable	(1)	(2)	(3)	(4)
Constant	6.1356 (16.4501)*	3.5046 (6.6967)*	5.8223 (13.3694)*	5.8497 (13.6292)*
NEF-II	-0.0087 (2.5242)*	-0.0065 (2.1361)*	-0.0063 (2.8650)*	-0.0042 (1.4806)*
Ln Mean Rooms per Unit	2.2000 (12.0236)*	1.6946 (9.4367)*	1.3371 (10.0835)*	1.2046 (8.0301)*
Ln Percent Owner-Occupied	--	0.7710 (6.4729)*	0.4048 (4.4382)*	0.3813 (4.1780)*
Percent Black Population	--	--	-0.0036 (9.3046)*	-0.0029 (6.2453)*
Percent Sub-stand. Plumbing	--	--	-0.0037 (2.5549)*	-0.0036 (2.4250)*
Percent Built Before 1939	--	--	--	0.0017 (0.7775)
Percent Central Air Conditioning	--	--	--	0.0063 (2.2938)*
$\bar{R}^2$	0.6234	0.7058	0.8527	0.8570
F	123.4999	119.3633	172.3028	127.7307
SEE	0.2361	0.2086	0.1477	0.1455
Det (X'X)	0.7371	0.5243	0.2147	0.0182
N[a]	149	149	149	149

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE D.4

ST. LOUIS REGRESSIONS, WITH
NEF AND SAMPLING RESTRICTIONS

Variable	Regression Coefficient (Student-t) (1)	(2)	(3)	(4)
Constant	5.8223 (13.3694)*	5.8207 (13.3684)*	5.8421 (13.6341)*	5.8497 (13.6292)*
NEF-II	-0.0063 (2.8630)*	-0.0044 (1.5150)*	-0.0032 (1.2664)	-0.0042 (1.4806)*
Ln Mean Rooms per Unit	1.3371 (10.0835)*	1.3636 (10.0978)*	1.2555 (9.3144)*	1.2046 (8.0301)*
Ln Percent Owner-Occupied	0.4048 (4.4382)*	0.3883 (4.1941)*	0.3739 (4.1249)*	0.3813 (4.1780)*
Percent Black Population	-0.0036 (9.3046)*	-0.0034 (8.6211)*	-0.0030 (6.4894)*	-0.0029 (6.2453)*
Percent Sub-stand. Plumbing	-0.0037 (2.5549)*	-0.0033 (2.1728)*	-0.0033 (2.3037)*	-0.0036 (2.4250)*
Percent Built Before 1939	--	-0.0017 (1.0310)	--	0.0017 (0.7775)
Percent Central Air Conditioning	--	--	0.0048 (2.4016)*	0.0063 (2.2938)*
$\bar{R}^2$	0.8527	0.8527	0.8574	0.8638
F	172.3028	143.8261	149.3343	127.7307
SEE	0.1477	0.1476	0.1453	0.1455
Det (X'X)	0.2147	0.0770	0.0555	0.0108
N[a]	149	149	149	149

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) exlcudes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

TABLE D.5

ST. LOUIS REGRESSIONS, WITH NEF AND SAMPLING RESTRICTIONS

	Regression Coefficient (Student-t)			
Variable	(1)	(2)	(3)	(4)
Constant	5.6170 (12.8923)*	5.6253 (12.8852)*	5.6110 (13.0276)*	5.6264 (13.1531)*
NEF-II	-0.0040 (1.8648)*	-0.0053 (1.9654)*	-0.0028 (1.2414)	-0.0051 (1.9136)*
Ln Mean Rooms per Unit	1.3647 (11.3879)*	1.3375 (10.7120)*	1.2791 (10.0699)*	1.1943 (8.7205)*
Ln Percent Owner-Occupied	0.4224 (4.4311)*	0.4328 (4.4903)*	u.4150 (4.4006)*	0.4346 (4.6009)*
Percent Black Population	-0.0023 (3.5062)*	-0.0019 (2.3313)*	-0.0026 (3.8959)*	-0.0019 (2.3499)*
Percent Sub-stand. Plumbing	0.0052 (0.9577)	0.0050 (0.9216)	0.0055 (1.0321)	0.0052 (0.9877)
Percent Built Before 1939	--	0.0017 (0.7933)	--	0.0037 (1.5866)*
Percent Central Air Conditioning	--	--	0.0044 (1.8698)*	0.0059 (2.3255)*
$\bar{R}^2$	0.7143	0.7133	0.7208	0.7247
F	57.0004	47.4407	49.1911	43.1270
SEE	0.1221	0.1223	0.1207	0.1198
Det (X´X)	0.6318	0.2460	0.3891	0.1322
N[a]	113	113	113	113

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Blocks from census tract number 2128 are excluded. Only those blocks are included where at least 80 percent of the units reported values.

TABLE D.6

DESCRIPTION OF ST. LOUIS VARIABLES
(Sample Size N = 113)[a]

Variable	Mean	Standard Deviation	Minimum	Maximum
Mean Property Value (1)	$16,411[b]	$3,684	$ 8,422	$25,990
NEF-II (2)	30.177	6.121	25.000	45.000
Mean Rooms per Unit (3)	5.487	0.631	4.300	7.000
Percent Owner-Occupied Units (4)	87.620	10.468	53.571	100.00C
Percent Black Population (5)	8.479	18.250	0.000	80.420
Percent Sub-stand. Plumbing (6)	0.787	2.203	0.000	14.286
Percent Built Before 1939 (7)	15.501	8.409	1.316	23.030
Percent Central Air Conditioning (8)	33.516	6.125	24.282	43.034

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Blocks from census tract number 2128 are excluded. Only those blocks are included where at least 80 percent of the units reported values.

[b]The mean property value for 224 blocks in the four tracts listed in Table D.1 was $15,984, excluding tract 2128 (based on printed block statistics).

TABLE D.7

ZERO-ORDER CORRELATIONS FOR
ST. LOUIS VARIABLES
(Sample Size N = 113[a]

Variable[b]	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	-0.390*	0.797*	0.494*	-0.164	-0.119	0.015	0.457*
(2)	--	-0.422*	-0.190	-0.240*	0.138	0.585*	-0.493*
(3)		--	0.339*	-0.004	-0.226	-0.051	0.496*
(4)			--	-0.015	0.005	-0.115	0.207
(5)				--	0.009	-0.611*	0.270*
(6)					--	0.049	-0.146
(7)						--	-0.489*

*Significant at the 90 percent confidence level.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Blocks from census tract 2128 are excluded. Only those blocks are included where at least 80 percent of the units reported values.

[b]For a listing of the variables, see Table D.6. Variables (1), (3), and (4) are in natural logs.

TABLE D.8

MEAN VALUES OF ST. LOUIS VARIABLES,
BY NEF INTERVAL

Mean of Variable (St. Dev.)	NEF Interval 25-30	30-40	40-50
Property Value	$18,080 (3,474)*	$14,221 (2,480)	$15,788 (3,934)[a]
Rooms per Unit	5.746 (0.611)*	5.273 (0.593)	5.155 (0.444)[a]
Percent Owner-Occupied Units	89.822 (8.472)*	84.623 (11.084)	86.998 (13.160)
Percent Black Population	11.756 (18.993)	8.093 (20.699)	0.016 (0.072)*[a]
Percent Substandard Plumbing	0.672 (1.642)	0.315 (1.090)	1.982 (4.071)*
NEF-II	25.000	32.297	40.750
No. of Obs.	56	37	20

*Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 30-40 (large sample test).

[a]Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 25-30 (large sample test).

APPENDIX E

NEW ORLEANS EMPIRICAL RESULTS

New Orleans is a medium-sized airport, ranking twenty-first in annual average daily air carrier operations in 1972. Total land area inside the airport boundary is 2.34 square miles.

Location. The New Orleans sample includes census blocks in the area known as Metairie. The study area is east and northeast of the main terminal and is affected by noise from runways 1, 19, and 28. The study area is bounded by Interstate Highway I-10 on the north, Transcontinental Drive on the east, and railroad tracts on the south. Special effort was made to exclude blocks located near or adjacent to these transportation facilities. Blocks located near commercial developments (shopping centers) or environmental features (parks, canals) were also excluded from the sample. The most remote areas are about four miles from the main terminal (Figure E.1).

Sample Size. Data were collected for blocks located in eight census tracts (Table E.1). For New Orleans, a total of 258 observations were recorded. The net sample, including boundary restrictions on the NEF variable, consisted of 184 blocks. Observations were then deleted if information was missing, the block contained less than 50 percent single-family residential units, or the block contained fewer than 10 single-family residential units. The maximum sample sizes are 187 observations without the NEF boundary restrictions and 145 observations with the boundary restrictions.

Empirical Results. Initial empirical results for New Orleans are presented in Tables E.2 and E.3; the results indicate that aircraft noise has a negative effect on residential property values. Moreover, the empirical results are not sensitive to the model specification.

When the tract variables are added (before 1939, central air conditioning), the NEF-II coefficient declines only slightly in value.

The simple correlations in Table E.3 are

	NEF-II	Before 1939	Cent. Air Cond.
LMPVAL	-0.571*	-0.360*	0.684*
NEF-II	--	0.519*	-0.640*
Before 1939	--	--	-0.500*

where LMPVAL is the natural log of the mean property value and the asterisks indicate statistical significance at the 90 percent confidence level.

The final regressions in Table E.4 incorporate the sampling restrictions on the rooms and property value variables. The final sample size is 143 observations compared to 145 observations in Table E.3. When both tract variables are employed, the NEF coefficient is -0.0040 and the corrected R^2 is 0.7376. This estimate is robust and the tract variable for air conditioning has the correct sign. Four of seven variables in regression (4) are statistically significant. The scatter plot of estimated residuals suggests the presence of two positive residuals located near the upper end of the range of estimated values for the dependent variable.

The mean property value for this sample is $21,975 (Table E.5), while the simple correlation between property values and NEF levels is -0.567 (Table E.6). Housing located in the intervals NEF 30-40 and 40-50 tends on average to be smaller, less residential, and lower in value (Table E.7).

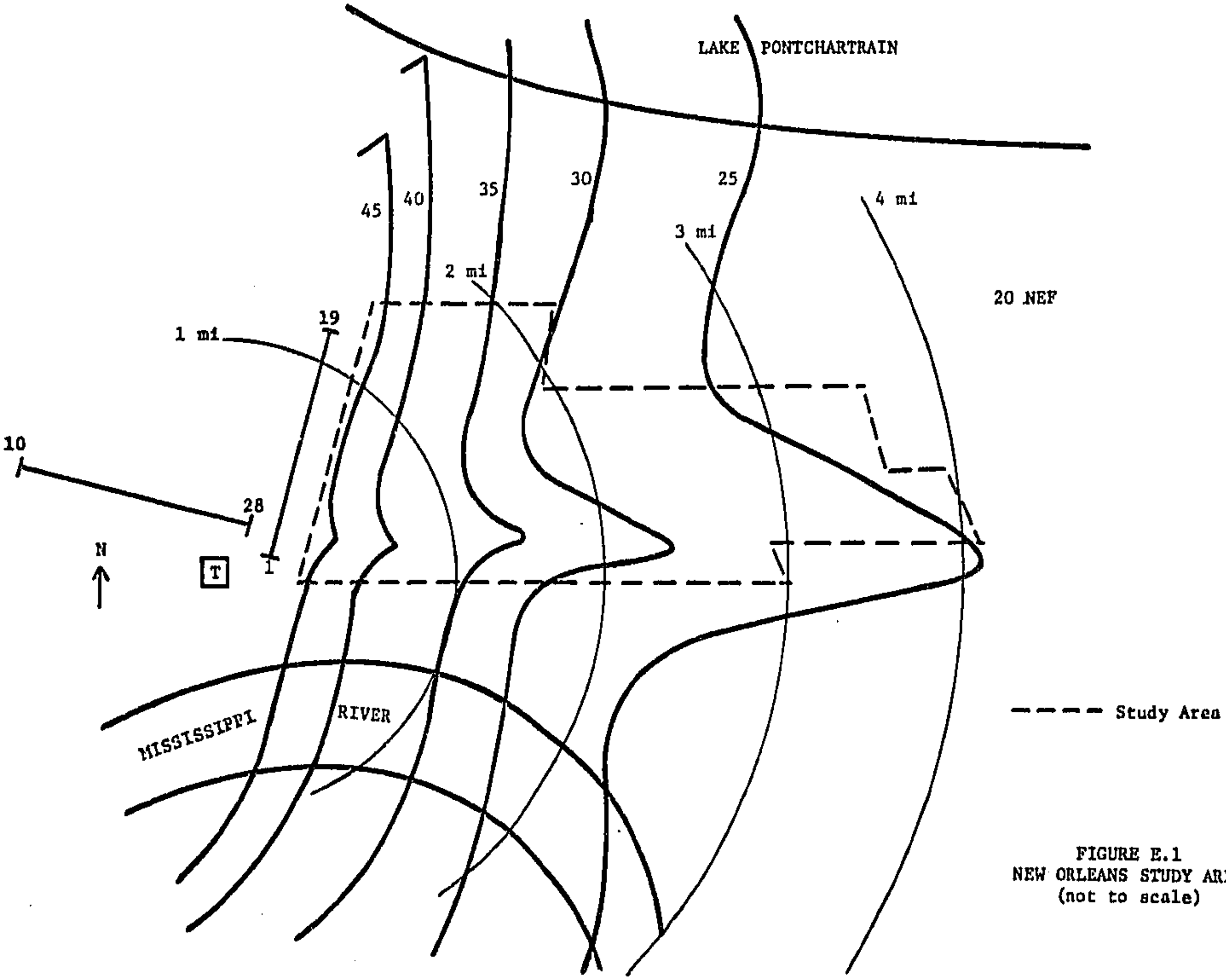

FIGURE E.1
NEW ORLEANS STUDY AREA
(not to scale)

TABLE E.1

NEW ORLEANS SAMPLE SIZE

Census Tract No.	Total Blocks Included	Boundary Exclusions[a]	Net Sample
210	51	3	48
211	38	8	30
212	21	7	14
232	20	6	14
233	23	1	22
234	33	0	33
235	8	2	6
236	39	22	17
Total	233	49	184

[a]Blocks near or adjacent to the actual NEF-25 or -30 contour lines or within NEF 30 but adjacent to NEF 35.

TABLE E.2

NEW ORLEANS REGRESSIONS, WITHOUT BOUNDARY RESTRICTIONS ON NEF VARIABLE

	Regression Coefficient (Student-t)			
Variable	(1)	(2)	(3)	(4)
Constant	7.2720 (37.9978)*	7.6818 (20.8468)*	7.6412 (20.4810)*	7.7731 (20.4160)*
NEF-I	-0.0047 (2.9640)*	-0.0051 (3.1548)*	-0.0048 (2.9388)*	-0.0040 (2.1678)*
Ln Mean Rooms per Unit	1.6113 (17.0055)*	1.6363 (16.9542)*	1.6428 (16.8926)*	1.5280 (13.5031)*
Ln Percent Owner-Occupied	--	-0.0990 (1.3005)*	-0.0943 (1.2310)	-0.0989 (1.2911)*
Percent Black Population	--	--	0.0012 (0.4059)	0.0012 (0.4056)
Percent Sub-stand. Plumbing	--	--	0.0057 (0.7329)	0.0056 (0.7361)
Percent Built Before 1939	--	--	--	0.0096 (1.2283)
Percent Central Air Conditioning	--	--	--	0.0015 (2.0750)*
$\bar{R}^2$	0.7207	0.7217	0.7197	0.7242
F	240.9401	161.7938	96.5175	70.7702
SEE	0.1221	0.1218	0.1223	0.1213
Det (X'X)	0.7275	0.6293	0.6013	0.1837
N[a]	187	187	187	187

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE E.3

NEW ORLEANS REGRESSIONS, WITH
BOUNDARY RESTRICTIONS ON NEF VARIABLE

Variable	Regression Coefficient (Student-t) (1)	(2)	(3)	(4)
Constant	7.3014 (33.7644)*	7.4559 (17.5367)*	7.4308 (17.3019)*	7.6220 (17.2204)*
NEF-II	-0.0044 (2.6718)*	-0.0046 (2.6879)*	-0.0044 (2.5233)*	-0.0038 (1.9049)*
Ln Mean Rooms per Unit	1.5933 (14.9253)*	1.6008 (14.7494)*	1.6076 (14.6466)*	1.4920 (11.5510)*
Ln Percent Owner-Occupied	---	-0.0364 (0.4225)	-0.0350 (0.4027)	-0.0513 (0.5908)
Percent Black Population	---	---	0.0011 (0.3672)	0.0011 (0.3706)
Percent Sub-stand. Plumbing	---	---	0.0052 (0.5204)	0.0058 (0.5856)
Percent Built Before 1939	---	---	---	0.0091 (1.0549)
Percent Central Air Conditioning	---	---	---	0.0015 (1.8894)*
$\bar{R}^2$	0.7341	0.7326	0.7295	0.7334
F	199.7912	132.4831	78.6637	57.6013
SEE	0.1225	0.1229	0.1236	0.1227
Det (X'X)	0.6870	0.5748	0.5488	0.1497
N[a]	145	145	145	145

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE E.4

NEW ORLEANS REGRESSIONS, WITH
NEF AND SAMPLING RESTRICTIONS

Variable	Regression Coefficient (Student-t) (1)	(2)	(3)	(4)
Constant	7.4089 (16.7218)*	7.3531 (16.4943)*	7.5839 (16.5319)*	7.5427 (16.4546)*
NEF-II	-0.0043 (2.4581)*	-0.0050 (2.6850)*	-0.0033 (1.7296)*	-0.0040 (2.0523)*
Ln Mean Rooms per Unit	1.6698 (14.7778)*	1.6923 (14.7378)*	1.5655 (11.6070)*	1.5766 (11.7022)*
Ln Percent Owner-Occupied	-0.0559 (0.6076)	-0.0495 (0.5383)	-0.0700 (0.7579)	-0.0642 (0.6983)
Percent Black Population	0.0012 (0.4106)	0.0013 (0.4530)	0.0011 (0.3820)	0.0013 (0.4316)
Percent Sub-stand. Plumbing	0.0059 (0.6003)	0.0055 (0.5611)	0.0066 (0.6729)	0.0063 (0.6370)
Percent Built Before 1939	--	0.0093 (1.0810)	--	0.0117 (1.3475)*
Percent Central Air Conditioning	--	--	0.0011 (1.4044)*	0.0013 (1.6178)*
$\bar{R}^2$	0.7341	0.7344	0.7360	0.7376
F	79.4163	66.4565	66.9786	58.0140
SEE	0.1225	0.1224	0.1220	0.1217
Det (X'X)	0.5415	0.3694	0.2124	0.1407
N[a]	143	143	143	143

*Significant at the 90 percent confidence level, one-tailed t-test.
Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

TABLE E.5

DESCRIPTION OF NEW ORLEANS VARIABLES
(Sample Size N = 143)[a]

Variable	Mean	Standard Deviation	Minimum	Maximum
Mean Property Value (1)	$21,975[b]	$5,651	$13,938	$47,404
NEF-II (2)	27.657	7.407	20.000	45.000
Mean Rooms per Unit (3)	5.804	0.664	4.300	7.800
Percent Owner-Occupied Units (4)	88.331	9.902	50.000	100.000
Percent Black Population (5)	0.431	3.468	0.000	33.906
Percent Sub-stand. Plumbing (6)	0.280	1.062	0.000	6.667
Percent Built Before 1939 (7)	0.963	1.447	0.000	3.758
Percent Central Air Conditioning (8)	38.134	20.974	19.707	75.923

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]The mean property value for 294 blocks in the eight tracts in Table E.1 was $20,816 (based on printed block statistics).

TABLE E.6

ZERO-ORDER CORRELATIONS FOR
NEW ORLEANS VARIABLES
(Sample Size N = 143)[a]

Variable[b]	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	-0.567*	0.854*	0.311*	-0.029	0.053	-0.372*	0.684*
(2)	--	-0.557*	-0.376*	0.041	-0.169	0.533*	-0.638*
(3)		--	0.366*	-0.054	0.007	-0.438*	0.722*
(4)			--	-0.072	0.049	-0.278*	0.384*
(5)				--	-0.033	-0.002	-0.032
(6)					--	0.042	0.030
(7)						--	-0.508*

*Significant at the 90 percent confidence level.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]For a listing of the variables, see Table E.5. Variables (1), (3), and (4) are in natural logs.

TABLE E.7

MEAN VALUES OF NEW ORLEANS VARIABLES,
BY NEF INTERVAL

Mean of Variable (St. Dev.)	NEF Interval		
	20-30	30-40	40-50
Property Value	$24,783 (6,198)*	$18,876 (2,960)	$19,870 (2,754)[a]
Rooms per Unit	6.149 (0.676)*	5.414 (0.429)	5.592 (0.318)*[a]
Percent Owner-Occupied Units	91.247 (8.353)*	87.002 (9.185)	77.010 (12.900)*[a]
Percent Black Population	0.000 (--)	1.064 (5.411)	0.000 (--)
Percent Substandard Plumbing	0.457 (1.245)*	0.115 (0.875)	0.000 (--)[a]
NEF-II	21.027	33.276	40.833
No. of Obs.	73	58	12

*Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 30-40 (large sample test).

[a]Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 20-30 (large sample test).

APPENDIX F

BUFFALO EMPIRICAL RESULTS

Buffalo is one of the smaller airports in the sample, ranking thirty-third in annual average daily air carrier operations in 1972. Total land area inside the airport boundary is 1.56 square miles.

Location. The Buffalo sample includes census blocks in Cheektowago Township. The study area is bordered by State Highway 5 on the north, Harlem Avenue on the west, and railroad tracks on the south. Special efforts were made to exclude blocks located adjacent to these facilities and other major streets or highways. Excluded also were blocks located near cemeteries, railroad yards, and a sewage treatment plant. The study area is west of the main terminal and is under the noise contours from runways 5 and 14. The most remote areas are about three miles from the main terminal (Figure F.1).

Sample Size. Data were collected for blocks located in seven census tracts (Table F.1). For Buffalo, a total of 213 observations were recorded. The net sample, with boundary restrictions on the NEF variable, consisted of 160 blocks. Observations were then deleted if information was missing, the block contained less than 50 percent single-family residential units, or the block contained fewer than 10 single-family residential units. The maximum sample sizes are 183 observations without the NEF boundary restrictions and 138 observations with the boundary restrictions.

Empirical Results. Initial empirical results for Buffalo are presented in Tables F.2 and F.3; the results indicate that aircraft noise has a negative effect on residential property values. Moreover, the empirical results are not sensitive to the model specification. When the tract variables are added (before 1939, central air conditioning), there are only slight changes in the NEF-II coefficient value.

The simple correlations in Table F.3 are

	NEF-II	Before 1939	Cent. Air Cond.
LMPVAL	-0.501*	0.175	0.556*
NEF-II	--	-0.108	-0.371*
Before 1939	--	--	0.326*

where LMPVAL is the natural log of the mean property value and the asterisks indicate statistical significance at the 90 percent confidence level.

The final regressions in Table F.4 incorporate the sampling restrictions on the rooms and property value variables. The final sample size is 126 observations compared to 138 in Table F.3. When both tract variables are employed, the NEF coefficient is -0.0052 and the corrected R^2 is 0.5881. This estimate is quite robust, although only three of the seven coefficients in regression (4) are statistically significant. The scatter plot of estimated residuals contained two outliers, which were located close to the mean of the estimated dependent variable.

The mean property value for this sample is $20,656 (Table F.5), while the simple correlation between property values and NEF levels is -0.404 (Table F.6). Housing located in the intervals NEF 40-50 tends on average to be smaller, less residential, and lower in value (Table F.7).

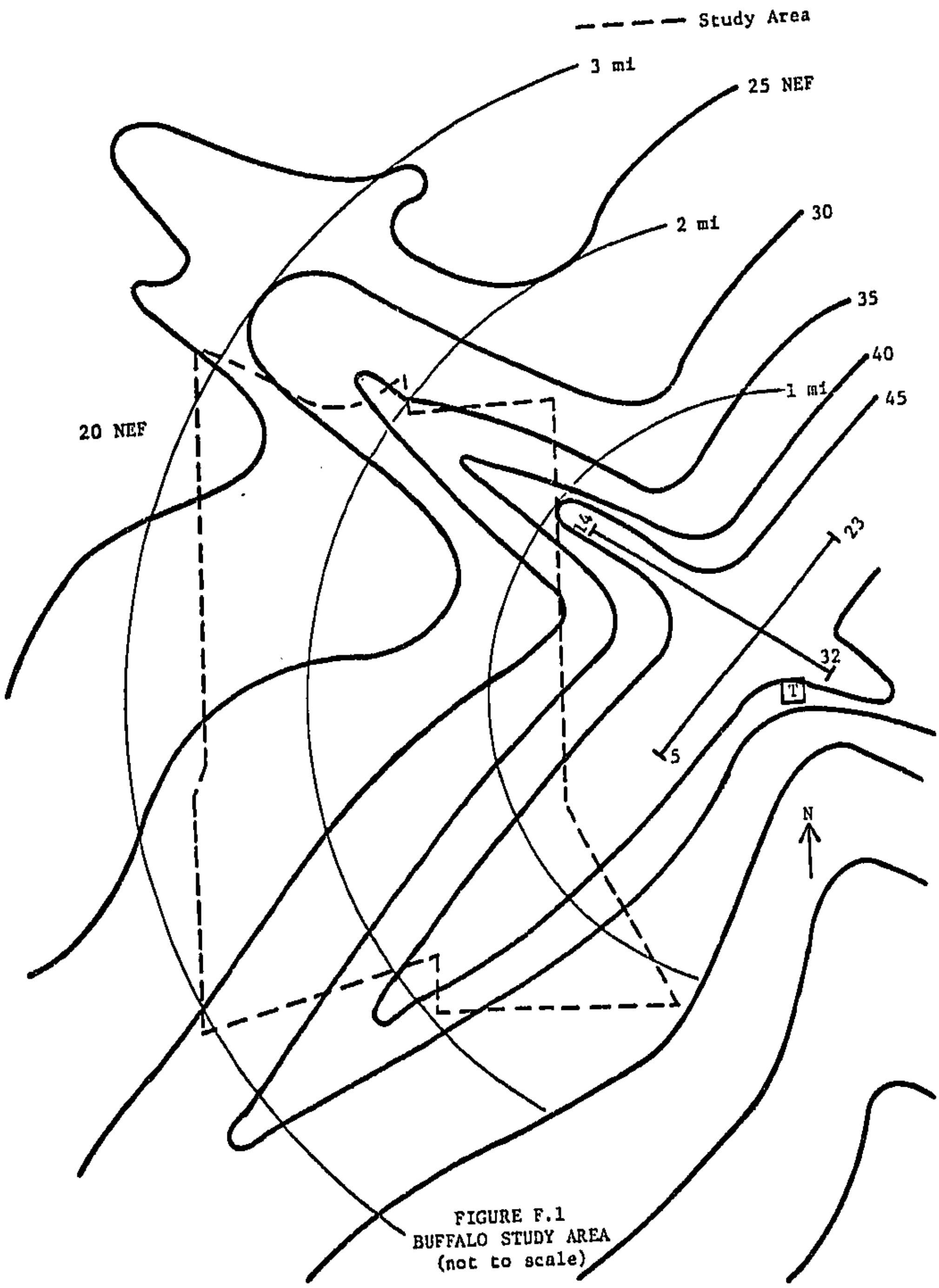

FIGURE F.1
BUFFALO STUDY AREA
(not to scale)

Tract No.	Blocks Included	Boundary Exclusions[a]	Net Sample
95.02	50	17	33
100.01	20	4	16
100.02	30	5	25
101.01	75	21	54
101.02	5	0	5
105	10	0	10
106	23	6	17
Total	213	53	160

[a]Blocks near or adjacent to the actual NEF-25 or -30 contour lines or within NEF 30 but adjacent to NEF 35.

TABLE F.2

BUFFALO REGRESSIONS, WITHOI
BOUNDARY RESTRICTIONS ON NEF V/

Variable	Regression Coeffic..... (Student-t) (1)	(2)	(3)	(4)
Constant	7.2855 (33.3112)*	7.7575 (19.1048)*	7.7293 (18.8901)*	8.1719 (20.1499)*
NEF-I	-0.0042 (2.5699)*	-0.0047 (2.8194)*	-0.0044 (2.6165)*	-0.0028 (1.7033)*
Ln Mean Rooms per Unit	1.5604 (13.9359)*	1.5719 (14.0345)*	1.5843 (13.7591)*	1.3454 (11.0065)*
Ln Percent Owner-Occupied	--	-0.1061 (1.3781)*	-0.1063 (1.3736)*	-0.1369 (1.8441)*
Percent Black Population	--	--	-0.0137 (0.6417)	-0.0238 (1.1568)
Percent Sub-stand. Plumbing	--	--	0.0047 (0.5101)	0.0041 (0.4575)
Percent Built Before 1939	--	--	--	0.0009 (0.7303)
Percent Central Air Conditioning	--	--	--	0.0304 (3.8843)*
$\bar{R}^2$	0.5836	0.5857	0.5827	0.6221
F	128.5323	86.7493	51.8181	43.8094
SEE	0.1310	0.1306	0.1311	0.1248
Det (X'X)	0.8784	0.8133	0.7457	0.4017
N[a]	183	183	183	183

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

Variable	Regression Coefficient (Student-t) (1)	(2)	(3)	(4)
Constant	7.7676 (28.4856)*	8.1249 (16.6373)*	8.1045 (16.2734)*	8.5169 (17.0123)*
NEF-I I	-0.0062 (3.4536)*	-0.0066 (3.5616)*	-0.0065 (3.3255)*	-0.0054 (2.8315)*
Ln Mean Rooms per Unit	1.3243 (9.5446)*	1.3296 (9.5661)*	1.3379 (9.2381)*	1.1234 (7.3460)*
Ln Percent Owner-Occupied	--	-0.0791 (0.8823)	-0.0787 (0.8642)	-0.1067 (1.1986)
Percent Black Population	--	--	-0.0037 (0.1514)	-0.0097 (0.4065)
Percent Sub-stand. Plumbing	--	--	0.0020 (0.2154)	0.0013 (0.1401)
Percent Built Before 1939	--	--	--	0.0004 (0.3272)
Percent Central Air Conditioning	--	--	--	0.0291 (3.1728)*
$\bar{R}^2$	0.5460	0.5453	0.5386	0.5711
F	83.3834	55.7572	32.9881	27.0656
SEE	0.1294	0.1295	0.1304	0.1258
Det (X'X)	0.7962	0.7305	0.6208	0.3602
N[a]	138	138	138	138

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied units.

TABLE F.4

BUFFALO REGRESSIONS, WITH
NEF AND SAMPLING RESTRICTIONS

Variable	Regression Coefficient (Student-t) (1)	(2)	(3)	(4)
Constant	7.7592 (12.7326)*	7.6719 (12.7619)*	8.1855 (13.6836)*	8.0845 (13.3759)*
NEF-II	-0.0064 (3.1205)*	-0.0059 (2.8929)*	-0.0053 (2.6683)*	-0.0052 (2.6000)*
Ln Mean Rooms per Unit	1.3904 (9.1930)*	1.3382 (8.8770)*	1.1553 (7.1747)*	1.1579 (7.1976)*
Ln Percent Owner-Occupied	-0.0243 (0.2166)	0.0043 (0.0382)	-0.0466 (0.4318)	-0.0286 (0.2626)
Percent Black Population	-0.0010 (0.0405)	-0.0119 (0.4851)	-0.0061 (0.2603)	-0.0112 (0.6446)
Percent Sub-stand. Plumbing	0.0063 (0.6266)	0.0042 (0.4215)	0.0060 (0.6188)	0.0049 (0.6202)
Percent Built Before 1939	--	0.0032 (2.2027)*	--	0.0017 (1.1151)
Percent Central Air Conditioning	--	--	0.0299 (3.3706)*	0.0261 (2.7405)*
$\bar{R}^2$	0.5516	0.5655	0.5872	0.5881
F	31.7542	28.1199	30.6401	26.4943
SEE	0.1301	0.1281	0.1248	0.1247
Det (X'X)	0.6173	0.5637	0.4266	0.3384
N[a]	126	126	126	126

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

TABLE F.5

DESCRIPTION OF BUFFALO VARIABLES
(Sample Size N = 126)[a]

Variable	Mean	Standard Deviation	Minimum	Maximum
Mean Property Value (1)	$20,656[b]	$4,319	$14,700	$36,136
NEF-II (2)	29.325	6.910	20.000	45.000
Mean Rooms per Unit (3)	5.856	0.539	5.000	7.700
Percent Owner-Occupied Units (4)	91.277	9.285	62.500	100.000
Percent Black Population (5)	0.104	0.503	0.000	4.651
Percent Sub-stand. Plumbing (6)	0.376	1.195	0.000	8.333
Percent Built Before 1939 (7)	11.610	8.204	4.933	45.297
Percent Central Air Conditioning (8)	1.935	1.514	0.000	4.663

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]The mean property value for 321 blocks in the seven tracts listed in Table F.1 was $20,350 (based on printed block statistics).

TABLE F.6

ZERO-ORDER CORRELATIONS FOR
BUFFALO VARIABLES
(Sample Size N = 126)[a]

Variable[b]	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	-0.404*	0.725*	0.118	-0.148	-0.099	0.266*	0.575*
(2)	--	-0.441*	-0.301*	0.291*	-0.010	-0.118	-0.368*
(3)		--	0.095	-0.122	-0.221	0.178	0.529*
(4)			--	-0.002	0.050	-0.056	-0.148
(5)				--	-0.066	0.140	-0.048
(6)					--	0.039	-0.092
(7)						--	0.395*

*Significant at the 90 percent confidence level.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]For a listing of the variables, see Table F.5. Variables (1), (3), and (4) are in natural logs.

TABLE F.7

MEAN VALUES OF BUFFALO VARIABLES, BY NEF INTERVAL

Mean of Variable (St. Dev.)	NEF Interval		
	20-30	30-40	40-50
Property Value	$22,212 (4,816)*	$19,745 (3,163)	$17,210 (1,507) *a
Rooms per Unit	5.986 (0.581)	5.818 (0.484)	5.465 (0.250) *a
Percent Owner-Occupied Units	92.736 (8.796)	91.968 (8.178)	83.957 (10.866) *a
Percent Black Population	0.028 (0.161)	0.078 (0.366)	0.458 (1.161)
Percent Substandard Plumbing	0.488 (1.410)*	0.142 (0.682)	0.572 (1.345)
NEF-II	23.828	32.111	42.647
No. of Obs.	64	45	17

*Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 30-40 (large sample test).

[a]Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 20-30 (large sample test).

APPENDIX G

SAN DIEGO EMPIRICAL RESULTS

San Diego is one of the smaller airports in the sample, ranking thirty-second in annual average daily air carrier operations in 1972. Total land area inside the airport boundary is only 0.76 square miles.

Location. The San Diego sample includes census blocks from a peninsula area known as Ocean Beach. The study area is west of the main terminal and is affected by noise from runways 9 and 13. The most remote areas are about three miles from the main terminal (Figure G.1).

Sample Size. Data were collected for blocks located in eight census tracts (Table G.1). Blocks were excluded if they were near or adjacent to parks, major streets, or naval facilities. For San Diego, a total of 226 observations were recorded. The net sample, with boundary restrictions on the NEF variable, consisted of 187 blocks. Observations were then deleted if information was missing, the block contained less than 50 percent single-family residential units, or the block contained fewer than 10 single-family residential units. The maximum sample sizes are 156 observations without the NEF boundary restrictions and 125 observations with the boundary restrictions.

Empirical Results. The initial empirical results for San Diego are presented in Table G.2 and G.3; the results indicate that aircraft noise has a negative effect on residential property values. Moreover, the results are not sensitive to the model specification. When the tract variables are added (before 1939, central air conditioning), there are only slight changes in the NEF-II coefficient value.

The simple correlations in Table F.3 are

	NEF-II	Before 1939	Cent. Air Cond.
LMPVAL	-0.108	-0.018	0.251*
NEF-II	--	0.649*	-0.261*
Before 1939	--	--	-0.164

where LMPVAL is the natural log of the mean property value and the asterisks indicate statistical significance at the 90 percent confidence level.

When the sampling restriction on the rooms and property value variables was added, there was no change in the sample size. When both tract variables are included, the NEF coefficient is -0.0074 and the corrected R^2 is 0.7482. This estimate is quite robust, although only two of seven coefficients in regression (4) are statistically significant. The scatter plot of estimated residuals contained one negative outlier located near the upper end of the range of estimated values for the dependent variable.

The mean property value for this sample is $32,241 (Table G.4), while the simple correlation between property values and NEF levels is only -0.108 (Table G.5). Housing located in the intervals NEF 40-50 tends on average to be larger and higher in value (Table G.6).

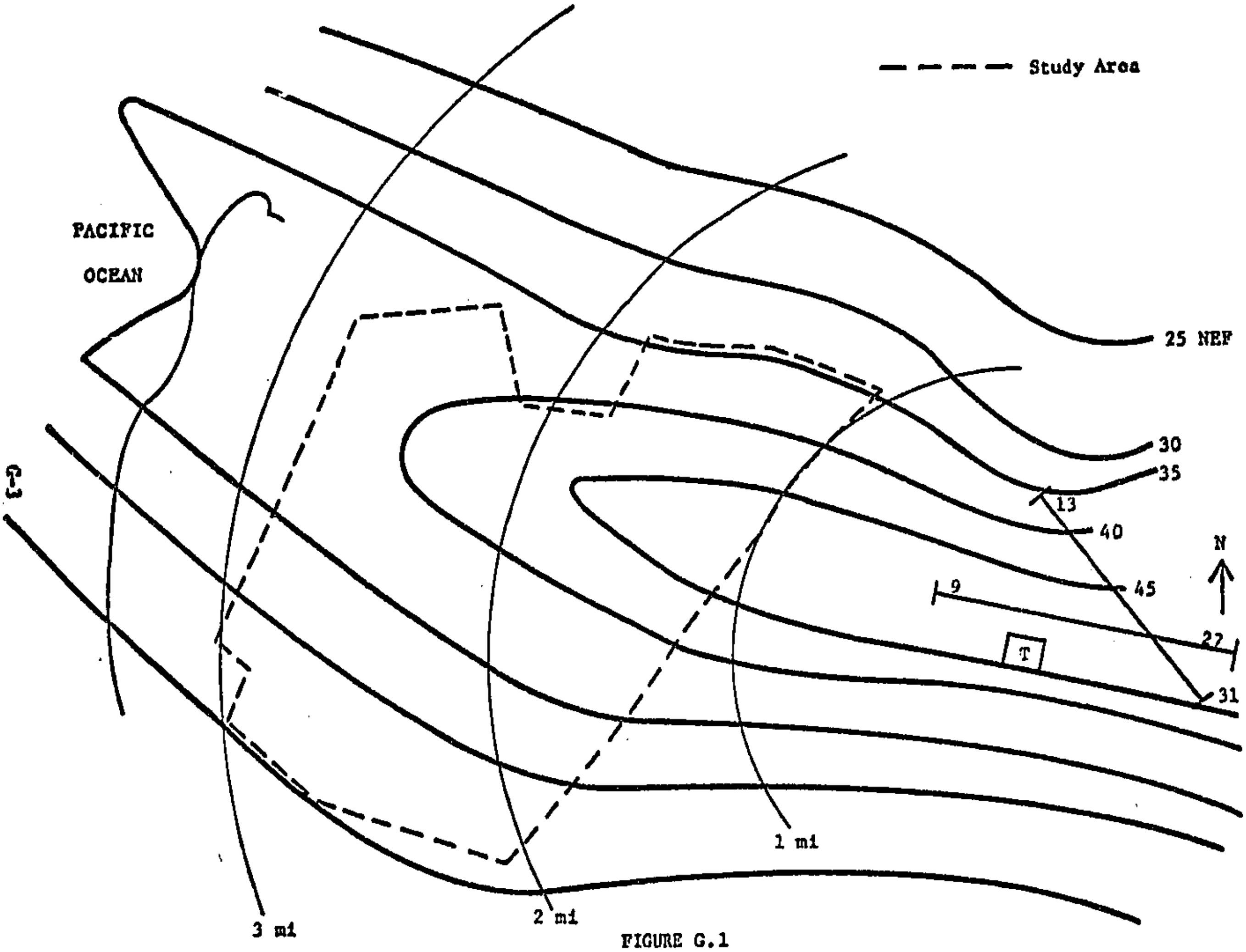

FIGURE G.1
SAN DIEGO STUDY AREA
(not to scale)

TABLE G.1

SAN DIEGO SAMPLE SIZE

Census Tract No.	Total Blocks Included	Boundary Exclusions[a]	Net Sample
68	7	1	6
69	66	0	66
70.01	34	10	24
70.02	33	11	22
71	7	0	7
72	15	3	12
73.02	32	11	21
74	32	3	29
Total	226	39	187

[a]Blocks near or adjacent to the actual NEF-25 or -30 contour lines or within NEF 30 but adjacent to NEF 35.

TABLE G.2

SAN DIEGO REGRESSIONS, WITHOUT BOUNDARY RESTRICTIONS ON NEF VARIABLE

	Regression Coefficient (Student-t)			
Variable	(1)	(2)	(3)	(4)
Constant	6.9461 (39.6919)*	6.8406 (20.7216)*	6.8370 (20.1450)*	6.8479 (19.9096)*
NEF-I	-0.0067 (4.0573)*	-0.0066 (3.9109)*	-0.0066 (3.8836)*	-0.0062 (2.7505)*
Ln Mean Rooms per Unit	2.0234 (20.9485)*	2.0068 (18.8497)*	2.0092 (18.5943)*	2.0070 (18.3584)*
Ln Percent Owner-Occupied	--	0.0295 (0.3771)	0.0295 (0.3685)	0.0256 (0.3128)
Percent Black Population	--	--	-0.0021 (0.0988)	-0.0019 (0.0870)
Percent Sub-stand. Plumbing	--	--	0.0016 (0.1362	0.0011 (0.0932)
Percent Built Before 1939	--	--	--	-0.0003 (0.1842)
Percent Central Air Conditioning	--	--	--	0.0065 (0.2554)
$\bar{R}^2$	0.7401	0.7386	0.7352	0.7318
F	221.6376	146.9775	87.0492	61.4039
SEE	0.1321	0.1325	0.1333	0.1342
Det (X'X)	0.9912	0.8071	0.7532	0.3832
N[a]	156	156	156	156

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE G.3

SAN DIEGO REGRESSIONS, WITH
BOUNDARY RESTRICTIONS ON NEF VARIABLE

Variable	Regression Coefficient (Student-t) (1)	(2)	(3)	(4)
Constant	7.0498 (38.0358)*	6.7311 (20.9718)*	6.7587 (20.4089)*	6.7479 (19.9828)*
NEF-II	-0.0071 (4.2222)*	-0.0068 (4.0109)*	-0.0068 (3.9621)*	-0.0074 (3.1795)*
Ln Mean Rooms per Unit	1.9785 (19.4044)*	1.9156 (16.7764)*	1.9173 (16.5204)*	1.9043 (15.8682)*
Ln Percent Owner-Occupied	--	0.0948 (1.2149)	0.0881 (1.1063)	0.0951 (1.1550)
Percent Black Population	--	--	-0.0128 (0.6091)	-0.0129 (0.6101)
Percent Sub-stand. Plumbing	--	--	-0.0003 (0.0244)	0.0007 (0.0634)
Percent Built Before 1939	--	--	--	0.0009 (0.4962)
Percent Central Air Conditioning	--	--	--	0.0064 (0.2411)
$\bar{R}^2$	0.7542	0.7551	0.7518	0.7482
F	191.2176	128.4677	76.1172	53.6406
SEE	0.1256	0.1254	0.1263	0.1272
Det (X'X)	0.9914	0.7814	0.7266	0.3344
N[a]	125	125	125	125

*Significant at the 90 percent confidence level, one-tailed t-test. Dependent variable is Ln mean property value.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units.

TABLE G.4

DESCRIPTION OF SAN DIEGO VARIABLES
(Sample Size N = 125)[a]

Variable	Mean	Standard Deviation	Minimum	Maximum
Mean Property Value (1)	$32,241[b]	$8,335	$16,471	$54,444
NEF-II (2)	32.320	6.707	25.000	45.000
Mean Rooms per Unit (3)	5.990	0.661	4.600	7.600
Percent Owner-Occupied Units (4)	86.250	12.534	50.000	100.000
Percent Black Population (5)	0.108	0.545	0.000	4.348
Percent Sub-stand. Plumbing (6)	0.166	1.073	0.000	10.000
Percent Built Before 1939 (7)	19.850	8.895	1.662	30.864
Percent Central Air Conditioning (8)	0.748	0.463	0.000	1.881

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]The mean property value for 375 blocks in the seven tracts listed in Table G.1 was $34,535 (based on printed block statistics).

TABLE G.5

ZERO-ORDER CORRELATIONS FOR
SAN DIEGO VARIABLES
(Sample Size N = 125)[a]

Variable[b]	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	-0.108	0.850*	0.448*	-0.069	-0.177	-0.018	0.251*
(2)	--	0.093	-0.088	0.033	0.062	0.649*	-0.261*
(3)		--	0.442*	-0.033	-0.186	0.112	0.215
(4)			--	-0.139	-0.167	-0.168	0.201
(5)				--	-0.031	0.062	-0.048
(6)					--	-0.101	-0.028
(7)						--	-0.164

*Significant at the 90 percent confidence level.

[a]Sample size (N) excludes blocks with less than 50 percent and fewer than 10 single-family, owner-occupied housing units. Only those blocks are included where at least 80 percent of the units reported values.

[b]For a listing of the variables, see Table G.4. Variables (1), (3), and (4) are in natural logs.

TABLE G.6

MEAN VALUES OF SAN DIEGO VARIABLES, BY NEF INTERVAL

Mean of Variable (St. Dev.)	NEF Interval 25-30	30-40	40-50
Property Value	$36,338 (9,080)*	$26,210 (4,942)	$35,792 (5,047)*
Rooms per Unit	6.140 (0.601)*	5.541 (0.518)	6.507 (0.464) *a
Percent Owner-Occupied Units	88.153 (11.325)*	83.795 (12.125)	87.314 (14.669)
Percent Black Population	0.028 (0.192)	0.197 (0.777)	0.086 (0.442)
Percent Substandard Plumbing	0.000 (--)	0.424 (1.693)	0.000 (--)
NEF-II	25.000	33.775	41.724
No. of Obs.	47	49	29

*Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 30-40 (large sample test).

[a]Mean value for this interval is significantly different at the 90 percent confidence level from the mean value for the interval NEF 25-30 (large sample test).

APPENDIX H

MINNEAPOLIS, ATLANTA, AND LA GUARDIA EMPIRICAL RESULTS

In the course of this study, some empirical results were prepared for three additional airports. These are Minneapolis-St. Paul, Atlanta, and New York's La Guardia Airport. This appendix comments on the results obtained for each of these airports and the reasons for their exclusion from the final empirical results in Chapter Four.

Minneapolis-St. Paul. Figure H.1 shows the study area selected for the Minneapolis-St. Paul Airport. The study area includes a number of lakes and a major park (Minnehaha Park) which bisects the area under the northwest flight path. This made it difficult to collect a sample that did not include blocks near at least some of these features. In addition, there is a limit on nighttime operations at the airport which may also influence property values in the surrounding residential area.

Despite a number of experiments, the Minneapolis-St. Paul regressions never yielded a significant, negative NEF coefficient. Rather than deleting sufficient observations so as to produce the desired result, we shall report this case as interesting in its own right. Apparently, accessibility to lakes and parks in this area more than outweighs the disamenities associated with noise. This suggests that a "finer" approach than that taken in the present study would be necessary to capture the effect of noise on property values, e.g., use of individual housing data, detailed site visits, and questionnaires. In addition, it suggests that attempts at exclusionary zoning around airports can deny households access to scarce amenities, the value of which may exceed the disamenities associated with noise.

Atlanta. Figure H.2 shows the study area selected for Atlanta. The study area contained a significant amount of rental housing units. When the sample was restricted to blocks with more than 50 percent

CORRECTION!

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RESHOOT FOLLOWS!

TABLE G.6

MEAN VALUES OF SAN DIEGO VARIABLES,
BY NEF INTERVAL

Mean of Variable (St. Dev.)	NEF Interval 25-30	30-40	40-50
Property Value	\$36,338 (9,080)*	\$26,210 (4,942)	\$35,792 (5,047)*
Rooms per Unit	6.140 (0.601)*	5.541 (0.518)	6.507 (0.464)*a
Percent Owner-Occupied Units	88.153 (11.325)*	83.795 (12.125)	87.314 (14.669)
Percent Black Population	0.028 (0.192)	0.197 (0.777)	0.086 (0.442)
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Atlanta. Figure H.2 shows the study area selected for Atlanta. The study area contained a significant amount of rental housing units. When the sample was restricted to blocks with more than 50 percent residential units, only 54 observations were obtained with NEF-I and 45 with NEF-II. While the noise coefficient was occasionally negative, the small sample size and the effects of rental housing on residential property values made the results suspect. For these reasons, the Atlanta results have not been reported

<u>New York La Guardia</u>. Figure H.3 shows the study area for New York's La Guardia Airport. Recorded noise levels ranged from NEF 25 to 40, but the diverse nature of the area and census sampling errors produced unreliable results. It was impossible to determine if the noise coefficient was negative or not. The results are in several respects similar to those obtained for Boston's Logan Airport. The methodology adopted in the present study is applicable to suburban airports, but not to urban airports like Logan and La Guardia. In these latter areas, a more sophisticated methodology is required, with access to less aggregate data containing more accurate measures of residential property value levels.

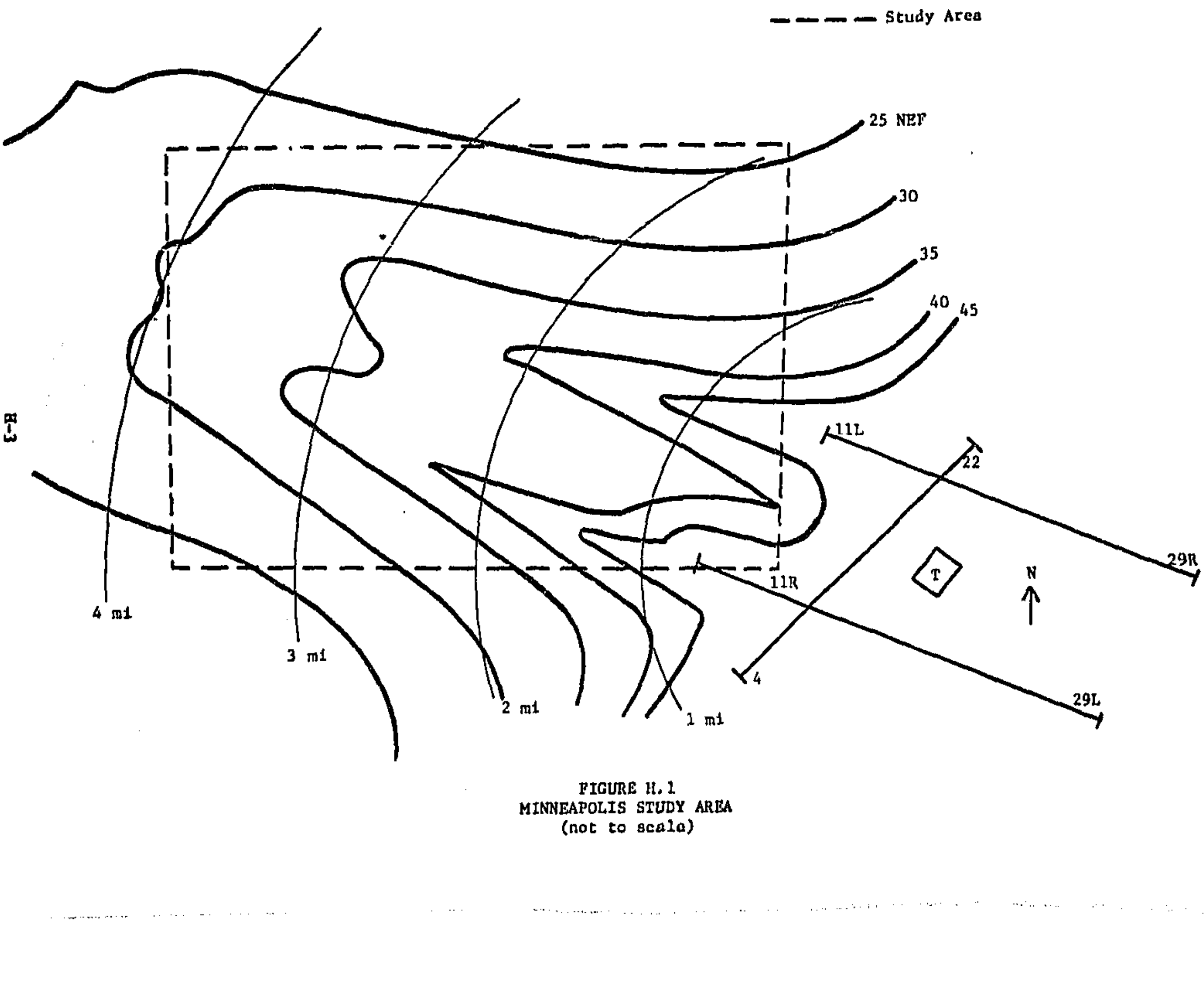

FIGURE H.1
MINNEAPOLIS STUDY AREA
(not to scale)

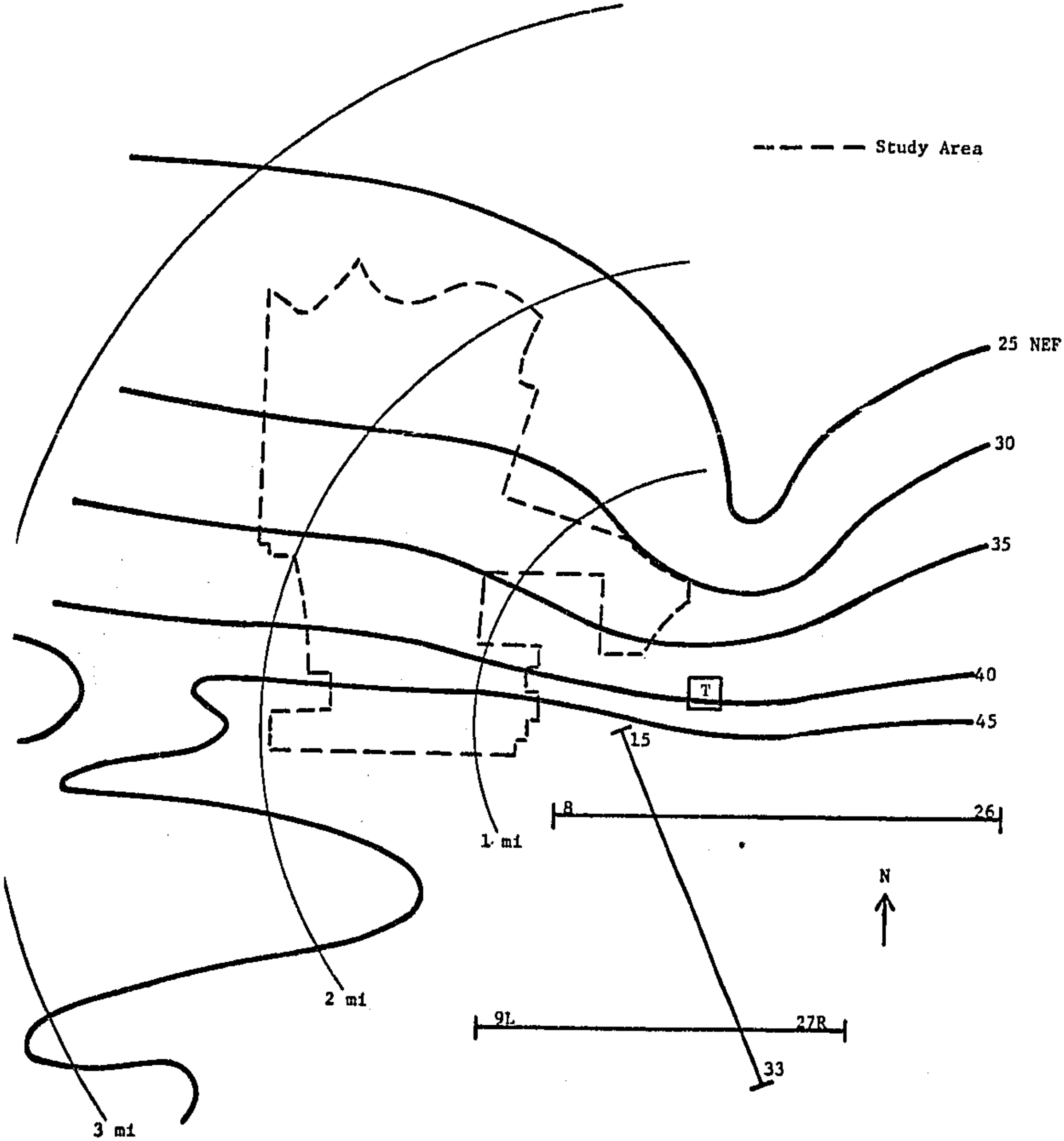

FIGURE H.2
ATLANTA STUDY AREA
(not to scale)

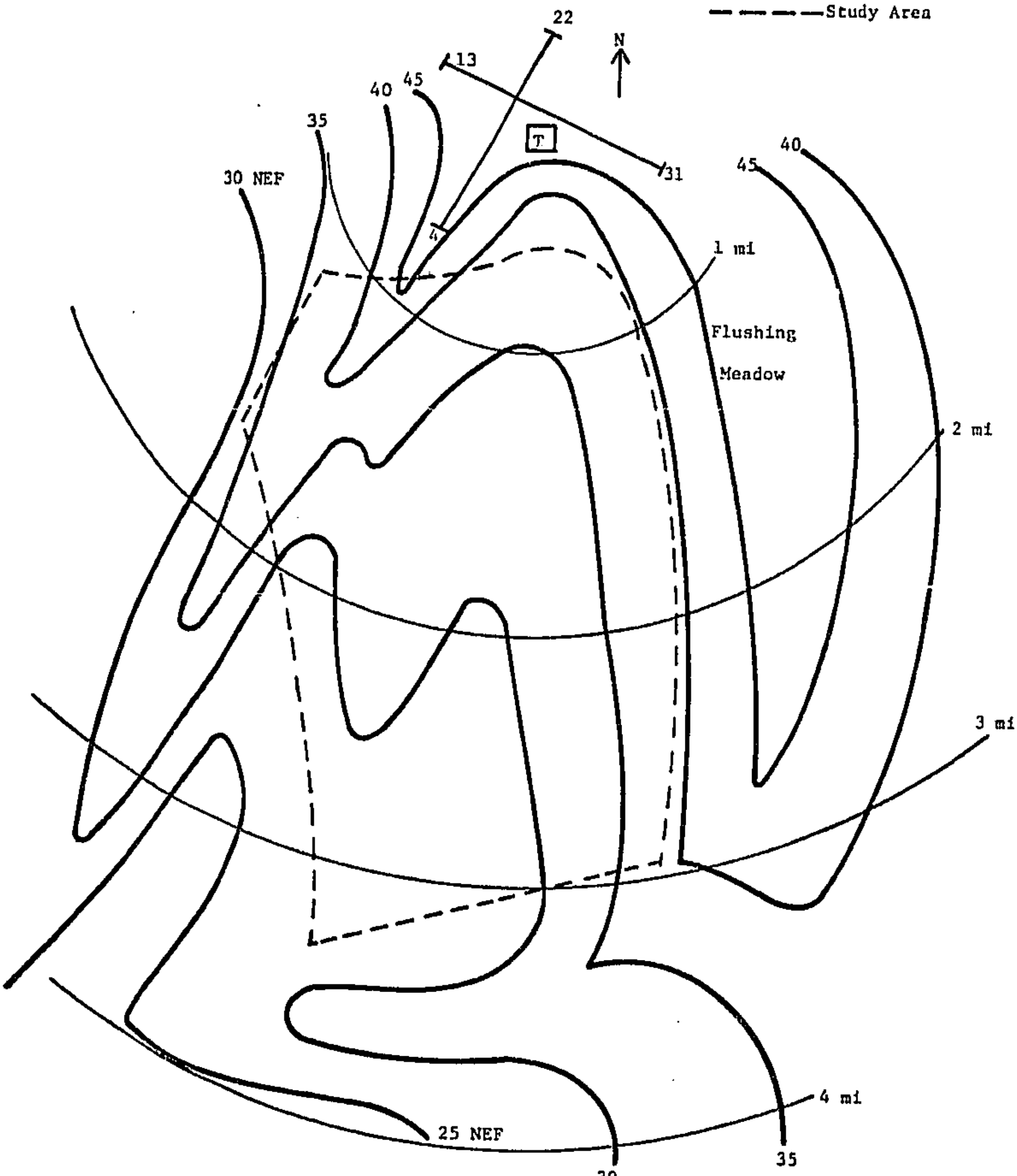

FIGURE H.3
LA GUARDIA STUDY AREA
(not to scale)

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