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Sound effects: Measuring the impact of aircraft noise on residential property values around McCarran International Airport

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SOUND EFFECTS

Measuring the Impact of Aircraft Noise on Residential Property Values around McCarran International Airport

By

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ABSTRACT

The airline industry is investing billions of dollars to adhere to the Airport Noise and Capacity Act of 1990. The Act requires airlines to reconfigure 100% of their fleets with quieter aircraft. This regulation is based in part on studies conducted around airport facilities which indicated a negative impact from noise on residential property values.

The purpose of this paper is to review the issue of aircraft noise and its impact on residential property, specifically single-family homes. It discusses the use of hedonic functional forms in measuring the effect of aircraft noise around a major airport facility. The empirical analysis concludes that a low, negative impact on single-family residences can be expected as a result of aircraft noise exposure around McCarran International Airport.

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CHAPTER I

BACKGROUND and INTRODUCTION

As the airline industry has grown, so too has the amount of noise generated by aircraft over populated and recreational areas. Many public officials and concerned private groups have demanded constraints be placed on noise pollution from commercial aircraft because of the negative environmental and economic impacts. The impact of noise is believed to be so great that Congress passed the Airport Noise and Capacity Act of 1990. The Act mandates the gradual conversion (by the year 2000) of all the nation's air fleets to quieter, more efficient aircraft. The nation's commercial airlines, who are believed to produce greater than 95% of jet engine noise, are currently in the process of investing billions of dollars to replace older, noisier aircraft to meet the mandated deadline. Some local municipalities where major U.S. airports are located have even resorted to placing bans on flight activity during hours when noise is believed to be most intrusive.

The issue of aircraft noise and its effect on nearby communities has been the subject of many scholarly articles and publicly commissioned studies. The research efforts of these groups have resulted in a greater understanding of the effects of noise exposure and provided the basis for noise mitigation programs. However, while jet engine noise is believed to be intrusive, it has not been demonstrated conclusively that it causes sale prices on homes to be lower than normal as a result of exposure.

The debate continues on whether the effect is significant, and if so, how to measure it. In a survey of work completed during the 1970s, Jon P. Nelson (1980) reviewed twelve property value studies which used hedonic pricing models to establish the negative aircraft effects on residential property, concluding that the negative effect ranged from .46 to 1.1 percent. Pennington, Topham, and Ward (1990) studied the effects of aircraft noise around Manchester International Airport in England using a hedonic estimation equation and found "...a low negative, but weak and non-robust relationship between noise and property values." Later work by Uyeno, Hamilton, and Biggs (1993), and T. J. Levesque (1994) suggests a significant negative effect from aircraft noise on property values. A report prepared for the Federal Aviation Administration (FAA) in September 1994 by the consulting firm Booz-Allen & Hamilton Inc. offered the results of noise studies completed at three large airport communities which show varying negative impacts on the housing values from aircraft noise. What is significant about the above studies, which are representative of the vast collection of work on the topic, is that all use similar forms of the hedonic model and home characteristics to present empirical results in demonstrating the noise effects.

The purpose of this paper is to show, using a log-linear hedonic model, that aircraft noise is significant. In Section 2, a review of the theoretical framework of the hedonic pricing method is presented. Section 3 follows with a discussion of the more popular empirical considerations, and presents the basic model used in this study. In Section 4 a brief review of data sources commonly used is provided along with descriptions of the data used in this study. Section 5 provides a brief discussion of the empirical results of the study. Section 6 concludes by summarizing the implications of the results and offers areas for further study.

CHAPTER II

THEORETICAL FRAMEWORK

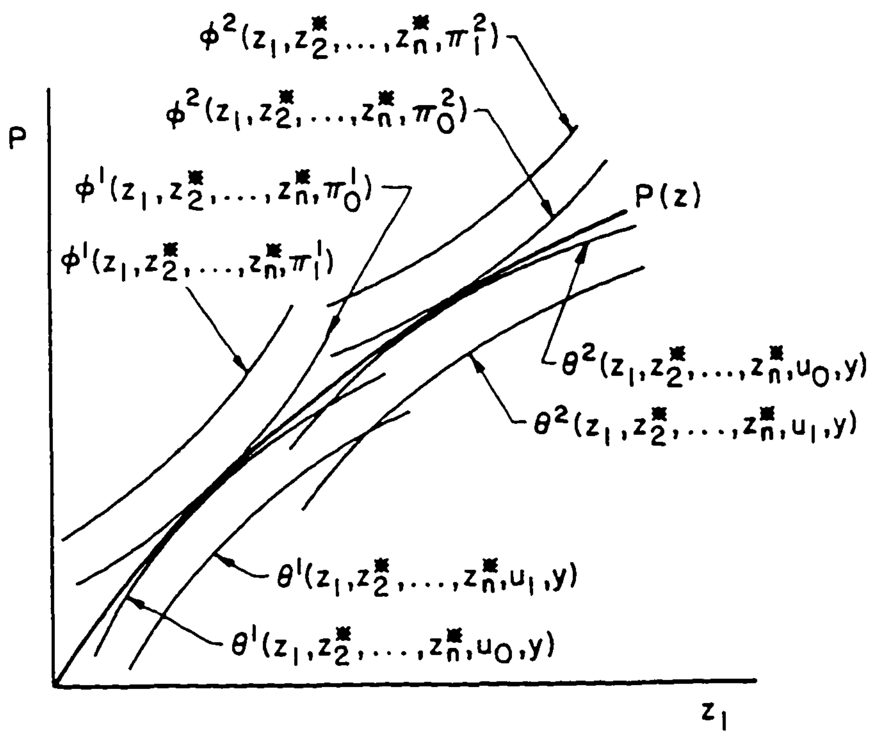
An article published by R. B. Palmquist (1991) offers a clear interpretation of hedonic theory. According to Palmquist there are certain consumer products which are distinct, but yet closely related in the mind of the consumer. Residential property is an example of such a product. The buyer of a home typically looks for the presence. or absence, of certain features which, in their mind, are important in making a purchase decision on a home. Let us assume a situation where a prospective buyer is deciding to purchase one of two or more homes which, to her, are physically and aesthetically identical in nearly every aspect except one. If that one feature is the determining factor in the amount she offers the seller for the home, then that feature has either added to or detracted from the value of the home for the buyer. We can say then that the exceptional feature has added a distinct value to the home. If we extend this analysis to all buyers and every feature of every home, each individual amenity offers a distinct value to the home for the buyer. In this scenario, the buyer demanded certain features of a product supplied. On the other side of this transaction, the producer of the product made a decision concerning what features to provide in the product supplied. The decision mechanisms of the two entities and their interaction in the housing market provide the basis of the *hedonic hypothesis* - certain *like* goods are aggregations of characteristics, and economic behavior is related to the characteristics.

These characteristics may be attached to the good through externalities, i.e., schools, freeway access, proximity to an airport, etc. The aggregate effect of these characteristics are reflected in either the appraisal or transaction price of the home.

However, measuring the effects can prove very difficult because typically there is no market for just one of the characteristics. Hedonic regressions were commonly used to measure the effects of amenities on the product price without sound theoretical basis. In 1974, Sherwin Rosen presented a seminal article which modeled the interactions of consumers and producers of a differentiated product in a competitive market. The interactions determined the equilibrium hedonic price schedule. Rosen assumed that a particular variety of a differentiated product could be represented by a vector $z = (z_1, z_2, .. z_n)$ of characteristics of the product. The price of the product is then a function of the combinations of these characteristics $P=P(z)$. The consumer will then maximize utility $U(X, z1, z2, .. z_n)$ by consuming the characteristics of the differentiated product and some composite good, X, subject to a budget constraint, $y = X+P(z_1, z_2, .. z_n)$. The consumers *bid* function for the product can be represented by $\theta(z_1, z_2, .. z_n, U_o, y)$, some combination of the differentiated product characteristics, an initial level of utility, and a budget constraint.

On the other side of the market, the firm will seek to maximize profits, π, by choosing which product-specific amenities and in what quantities to provide in the products, given firm-specific technologies and factor prices. Its revenues will depend upon quantity sold and the price schedule for the product. If the cost function can be represented by $C(M, z; \beta)$, where M is the number of products produced and β the technologies and factor prices of the firm, the profits are then $M*P(z) - C(M,z;\beta)$. The producer's offer function is then represented by $\phi(z,\pi;\beta)$, where z is the choice of characteristics to produce a profit, π, given producer attributes, β. The equilibrium price schedule (Figure 1) is then determined by the tangencies of the utility functions created by the interaction in a competitive market between the consumer's bid functions $\theta_k(z_1,z_2,..z_n,U_o,y)$ and the producer offer functions $\phi_j(z_1,z_2,..z_n,\pi)$, where k and j are the number of consumer bids and producer products offered, respectively.

Figure 1: Graph of hedonic equation



Source: Palmquist, R. B., North Carolina State Univ: "Hedonic Methods". Measuring the Demand for Environmental Quality, John B. Baden & Charles D. Kolstad (Editors), Elsvier Science Publishers B.V. (North Holland), 1991

In the figure, the quantity of one of the characteristics, z_1, is shown on the horizontal axis with other characteristics fixed, and the price, P, on the vertical axis. Consumers will moves to a higher level of utility the lower the bid price, given a budget constraint and the other fixed characteristics. In practice, most studies have estimated the consumer side of the market, with the characteristic in question measured on the horizontal axis. In the case of measuring aircraft noise effects on the price of a home, the measurement would be in the form of noise exposure levels. In an ordinary least squares regression, the coefficient on the characteristic in question is interpreted as the partial derivative of the equilibrium price with respect to noise.

Critics of the hedonic pricing method suggests that, while it models the activities of both consumers and producers, it fails to capture changes in equilibrium prices in factor markets for producers. It also does not model on-going fluctuations in the equilibrium price of the product. Maler (1977) and Freeman (1979) raise similar questions as to the application of the method to a product market with a continuously fluctuating equilibrium. They question whether the differentiated product varies enough that the price, bid, and offer (supply) functions can be assumed to be continuous. While these criticisms are notable, proponents of the model point out that similar criticisms exist for other models of economic behavior, and empirical results are consistent with theory.

CHAPTER III

EMPIRICAL CONSIDERATIONS

There are several functional forms for the estimation of an hedonic equation presented in the literature. A brief examination of three of the more popular forms is in order. Uyeno *et al* (1993) used an exponential form of the hedonic equation to describe the relationship between property values and aircraft noise.

$$\ln H = b_0 + b_1(NEF) + \sum_{i=2}^{n} b_i(\ln X_i) + \mu$$

In their equation, the log of the property value, ***H***, is regressed against the explanatory variable noise, ***NEF***, and the log of other corresponding property characteristics, ***X***. Their study measures the effects of aircraft noise on detached homes, as well as vacant land and condominiums, which until then had not been measured. The coefficient on the noise variable is interpreted as the "...noise elasticity, such that a given percentage increase in the Noise Exposure Forecast level (NEF) will have a greater impact the higher the NEF level...". They concluded that noise effects property values by .65 percent per NEF level.

T. J. Levesque (1994) used a Box-Cox transformed hedonic equation to estimate the model, with the transformation occurring "...on all of the continuous variables, i.e. time, home characteristic (*Z*), and home price (*p*), with the noise variable, β...".

$$\frac{p^{\lambda_1} - 1}{\lambda_1} = \alpha_0 + \alpha_1 \frac{time^{\lambda_2} - 1}{\lambda_2} + \sum_{j=1}^{m} \gamma_j \frac{(Z^{\lambda_2}j - 1)}{\lambda_2} + \sum_{k=1}^{n} \beta_k \delta_k$$

According to the author, this variation will allow "...flexibility general enough to accommodate a range of conditions relating to the curvature of the hedonic price function." Levesque the tranformation equation to show a -1.3 percent change in price per change in noise level.

Pennington, *et al* (1990) used a log-linear form of the hedonic equation to estimate the effects of noise in communities around the Manchester International Airport, in Manchester, England. In addition to the normal home characteristics included in previous models, the authors also tested the suggestion of Nelson (1978), Freeman (1979), and Li and Brown (1980) that "...The influence of local neighborhood characteristics and environmental conditions will be of crucial importance to the determination of the price of a residential property." The test of neighborhood and environmental influences consisted of the inclusion of a neighborhood index variable describing various features of the homes and neighborhoods. Certain aspects of the new variable have been captured in other studies. According to the authors, their variable provides a comprehensive index of neighborhood characteristics. The authors conclude that noise becomes insignificant when considered with neighborhood characteristics, and has an effect of .4 percent per noise level without.

A study commissioned by the Federal Aviation Administration (FAA) presents results from regressions combining a few neighborhood characteristics and individual property characteristics for studies completed at Baltimore-Washington International Airport (BWI), Los Angeles International Airport (LAX), and La Guardia (LGA) and Kennedy (JFK) International Airports in New York City. The study used a linear equation and regressed the characteristics against a "normalized" house value[1]. The authors believe the inclusion of this normalized house price variable combines the "...best objective and subjective estimation techniques avail able." They used a linear hedonic equation to show a 1.35 percent per noise level for higher priced homes and no significant change for homes in the moderate to low price range.

The data sources used in the literature on this subject varied. The Federal Aviation Administration study above uses a Multiple Listing Service and Comparison Valuation Method to determine home values. Levesque (1994) used listings from actual market transactions, as did Uyeno *et al* (1993) and Pennington *et al* (1990). In Nelson's (1980) survey of studies on the subject, he suggests that little is to be gained by using census track data instead of owner-estimated prices, if the latter is aggregated to the track level. He, however, suggests that actual sales data tends to include more structural variables and tends to be more accurate in terms of a physical comparison between homes.

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[1] This normalization process involved appraising the home values according to standard appraisal practices for homes in what is considered to be identical neighborhoods with identical characteristics. A reference home is then chosen within both a quiet and noisy neighborhood. The price of each of the remaining homes in the two neighborhood types is then adjusted according to characteristics that exist at each individual home in comparison to the reference home.

The noise variable is generally measured in terms of the noise exposure forecast (NEF), or other similarly measured indices. The forecasts are generally for a geographic area, and homes in the general vicinity are assigned the forecasted value for noise exposure. Levesque (1994) used a decomposed variable for noise which differentiates between the number of noise incidents above a certain level, the loudness of the noise, and the variation in intensity. The decomposition, according to the author, allows one to determine which characteristic of the noise event causes the most adverse effects.

As will be discussed later, the data source in this survey provides information to address many of the above-mentioned considerations, with the exceptions of distance and neighborhood characteristics. However, even though a specific measurement for distance is not provided, it is believed that certain aspects of distance are captured in the noise variable as used in this study. A neighborhood index was not included in the set and is therefore not modeled.

Two important factors in determining home price is the size of the lot and the total number of square feet available in the home. Incremental changes in either of the two measurements effects price in some varying proportion on either side of the transaction. This suggests an exponential relationship between price and these two variables. It is therefore appropriate to estimate the following equation:

$$\mathbf{lnSaleprice} = b_0 + b_1 \mathbf{lnLOTSQFT} + b_2 \mathbf{lnTOTSQFT} + b_3\ \mathbf{DNL} + \sum_{i=4}^{n}(b_i Z_i) + \epsilon$$

where **lnLOTSQFT** and **lnTOTSQFT** are the logs of lot square feet and total building square feet, respectively; ***Z*** is the quantity of the included home characteristics, and **DNL** represents the noise variable which will be discussed further in the next chapter. In the equation, the log is taken on both the square foot of the lot and total home square foot. In doing so, it is presumed that the relationships between the buyer's offer price and these two variables can be better represented by exponential rather than linear functions. The resulting coefficients may then be used to study the effects of proportional changes in each variable on the sale price. The set of home characteristics used in the study include the following:

AGE	= the age of structure in years
BATH	= the number of bathrooms is quarter bath units
BEDROOMS	= the number of bedrooms
FIREPLACE	= an indicator variable for whether the house has a fireplace
GARSQFT	= total garage square feet
LOTSQFT	= total lot square feet
POOL	= an indicator variable for whether the house has a pool
ROOMS	= total number of rooms (excludes baths, closets)
TOTSQFT	= total building square feet
TREND	= the time trend, equal to 1 in 1963 and increases by 1 per year

CHAPTER IV

DATA

Actual home sales transactions data gathered from Clark County, Nevada, Tax Assessor roles for detached, residential parcels is used to estimate the proposed relationships. Using geographical information system software, noise contours for McCarran International Airport were overlaid onto a digitized aerial photo. The Assessor information for individual parcels was then extracted from within each particular contour. Table 1 contains descriptive statistics on the data. In all, over 6000 observations were extracted. Refinement of the data brought the usable number down to 4332 observations[2].

One characteristic not included in the records provided by the Assessor is home age. Although the actual age of each home at the time of sale was not readily available, it was estimated by subtracting the year built from the year of sale. Some of the calculations resulted in negative values. Obviously, homes cannot have negative age. Further research of Assessor recording policies revealed that the sale date in these cases represented the price paid for undeveloped land zoned for residential use with a unit capacity of one, where homes were later constructed.

[2] Certain parcel records included missing entries, foreclosures or other non-market transactions, or parcels grouped as part of purchase agreements. Parcels containing these types of entries were deleted.

Therefore the year built is typically later than the date of sale, resulting in a negative calculation for age. The observations for which the age calculation resulted in a negative value, approximately .04 percent of the total data set, were deleted from the study.

Table 1 ***Descriptive Statistics***

	Mean	Median	Maximum	Minimum	Std. Dev.	Obsevations
AGE	5.705543	1	64	0	8.602883	4332
BATH	2.386952	2.5	7	0.75	0.635178	4332
BEDROOMS	3.467667	3	7	0	0.842668	4332
FIREPLACE	0.819287	1	1	0	0.385653	4332
XDNL	60.94205	60	75	55	4.363836	4332
SALEPRICE	161725.6	135000	3100000	1580	155134.5	4332
ROOMS	6.73418	7	13	1	1.524501	4332
POOL	0.28908	0	1	0	0.453387	4332
LOTSQFT	12065.45	7259.5	285754	0	14509.03	4332
TOTSQFT	2189.815	2042	16936	416	937.6361	4332
TREND	25.78314	28	44	1	5.801071	4332

AGE = the age of structure in years
BATH = the number of bathrooms is quarter bath units
BEDROOMS = the number of bedrooms
XDNL = the corresponding contour measurement
FIREPLACE = an indicator variable for whether the house has a fireplace
GARSQFT = total garage square feet
LOTSQFT = total lot square feet
POOL = an indicator variable for whether the house has a pool
ROOMS = total number of rooms (excludes baths, closets)
TOTSQFT = total home square feet
TREND = the time trend, equal to 1 in 1963 and increases by 1 per year

The noise variable is derived from the noise exposure data contained in the Noise Compatibility Study prepared for McCarran International Airport in 1992, and later updated in 1994. The variable is in the form of a noise contour measurement calculated by taking the annual average Day-Night noise exposure level (DNL) measured at various points around the airport environs using fixed and hand-held acoustical monitors (Appendix 1). The locations of the measuring equipment are based on established flight departure patterns experienced at McCarran. Automated Radar Tracking System (ARTS) software provided visual pictures of aircraft flight patterns which were used to help determine locations of monitoring equipment (Appendix 2). The measurements are then used in the Integrated Noise Model (INM) developed by the consulting firm Brown-Buntin Associates, Inc. for the Federal Aviation Administration. The INM uses algorithms to combine aircraft noise levels and airport operations factors at a series of points within a coordinate system which defines the location of airport runways and generalized aircraft flight tracks. The model then interpolates between measured noise monitoring points to plot contours of equal noise exposure (Appendix 3). While the averaging of noise levels introduces some error into establishing contours magnitudes, Federal officials as well as airport authorities nationwide have accepted the method as the fairest most, comprehensive way to measure noise exposure.

The Day-Night Level of noise (DNL) is calculated by the following equation:

$$\mathbf{DNL = SEL + 10Log\ N_{eq} - 49.4}$$

where SEL (sound exposure level) means the energy average SEL for all noise events which accounts for the duration and level of an aircraft noise event; N_{eq} means the equivalent number of events that occur within an annual average day (determined by adding the actual number of events occurring between 7:00 a.m. and 10:00 p.m. to

10 times the number of events occurring between 10:00 p.m. and 7:00 a.m. This weighting factor is added to account for the additional sensitivity to intrusive noise experienced during these hours); 49.4 is 10 times the logarithm of the number of seconds in a 24-hour day.

A parcel record taken within a contour was assigned the value of the contour for the measured noise exposure. For example, all records taken between the boundaries of McCarran Airport and the 75dnl contour are exposed to 75dnl noise levels and therefore were assigned a value of 75; values between the 75 and the 70 were assigned 70, etc[3]. With a mean age of 5.7 years some concern might be given to the potential for movement of the contour lines during the period of study. In comparing the location of contour lines between the two noise studies conducted during 1992 and 1994, it was determined that very little movement had taken place. However, parcels that appeared in different contours when the 1992 and 1994 noise studies were compared, were eliminated from study.

A group of parcels located 300ft outside and adjacent to the 60 dnl contour is also included in the data set (Appendix 3. See Buffer area). The noise variable in

[3] The contour measurements are averages over time. One could be led to assign an *average* value to parcels located between contour measurements. This too would lead to changes in measurements in increments of five DNL. Other, more precise measurements are possible, but are more labor intensive and more costly.

this group is assigned a value of fifty-five (55).[4] This allows the coefficient on the 60 dnl dummy variable to be interpreted.

As indicated earlier, certain aspects of distance are also captured in the noise variable. In using distance in hedonic modeling, the theory is that proximity to certain neighborhood or community attributes could impact economic decisions. Typically, this is handled by measuring the distance from the attribute to the data point, or a generalized area containing the point. In any case, the distance variable sequences the observations longitudinally from the attribute. In assigning each observation in this study a DNL value corresponding to the contour measurement, longitudinal sequencing has occurred. Therefore, although a specific distance variable is not included, the noise variable could be a proxy for its effect.

One problem with using the measured noise data is that of discontinuity in the noise variable; the measurements are discrete instead of continuous values. If possible, the desired specification of the model would include a continuous measurement for noise. Later, a test called *Lack of Fit* [5] will be employed to determine whether a significant difference in explanatory power exists between to the two specifications.

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[4] Typical ambient noise levels outside the 60 contour measured 55-65 dB DNL, with the average DNL near 60. Assigning the noise variable in these parcels a value of 55 allows a test of significance on the 60 dB DNL dummy variable later and serves as a control group for the study.

[5] "*Lack of Fit Test*", Applied Linear Statistical Models by John Neter, William Wasserman, and Michael H. Kutner; IRWIN, 1990; pg 131-140

CHAPTER V

RESULTS

Starting with the hypothesis of a log-linear relationship between price and home characteristics, the equation is regressed using ordinary least squares. The dependent variable is the log of SALEPRICE. Table 2 lists the results.

Table 2 ***Regression Results***

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.278071	0.16357	20.040812	1.70E-85
AGE	-0.00245	0.000676	-3.617706	0.000301
BATH	0.15301	0.011724	13.051383	3.28E-38
BEDROOMS	-0.04814	0.009371	-5.136605	2.92E-07
ROOMS	-0.05767	0.006641	-8.68459	5.31E-18
XDNL	-0.00199	0.001078	-1.84478	0.065138
FIREPLACE	0.013376	0.012513	1.0689605	0.285147
GARSQFT	0.000252	2.58E-05	9.7984475	1.96E-22
POOL	0.119799	0.011433	10.478565	2.18E-25
LLOTSQFT	0.06414	0.008964	7.1551335	9.78E-13
LTOTSQFT	0.894518	0.027103	33.00393	3.47E-213
TREND	0.049888	0.000881	56.615444	0

R-squared	0.753453	Mean dependent var	11.79732
Adjusted R-squared	0.752824	S.D. dependent var	0.593937
S.E. of regression	0.295286	Akaike info criterion	-2.43685
Sum squared resid	375.9807	Schwarz criterion	-2.41916
Log likelihood	-855.025	F-statistic	1197.959
Durbin-Watson stat	1.537849	Prob(F-statistic)	0

Sample Size: 4331 observations

In reviewing the results, we notice the negative sign on AGE, and the unexpected negative signs on BEDROOMS and ROOMS. One would expect the age of a home to be significant in the mind of the home buyer. As the home ages, one would expect the rational buyer to take into account the remaining life of plumbing and fixtures, the structural integrity including roof and foundation, dated architectural features, etc., when making an offer. The value of these features in most cases will decrease with age. On the other hand, the estimated equation does not include characteristics such as neighborhood indices, mature landscapes, etc. So age may, to some degree, pick up these effects if the buyer associates them with age. Therefore, age could enter the buying decision both positively and negatively, suggestive of a possible curved linear relationship, which will be tested using an AGE polynomial.

As mentioned the negative coefficients on ROOMS and BEDROOMS are unexpected. One would expect a six bedroom home in most cases to be worth more than a home with three, all other amenities being equal. A probable reason for the apparent negative effect is the potential multicollinearity between ROOMS, BEDROOMS, and LTOTSQFT. All three variables are a measure of living space in the home. The *E-Views* software used in this study contains a Redundant Variables test, a residuals test used to determine if the inclusion of a variable adds significant explanatory power to an equation. In the case of multicollinearity, the test provides information in the form of an F-statistic that will aid in making the choice between variables. The results of the Redundant Variables test run for all three variables shown on the next page in Table 3 indicate that the model can be best estimated with LTOTSQFT.

Table 3 ***Redundant Variable Test***

Variable	*F-Stat*	*R2 w/o variable*	*F-Stat w/o variable*
ROOMS	28.31	0.75	1090.464
BEDROOMS	28.00	0.75	1090.584
LTOTSQFT	819.14	0.697	831.528

Logic suggests that the best fit will be obtained by including the variable that generates the least error. Clearly, when a comparison is made between the test F-statistics, and the resulting R^2 and F-statistics of the equations when the variables are removed, the results in Table 3 indicate that the best fit can be obtained by using LTOTSQFT.

As suggested earlier, the relationship between age and saleprice is most likely curved linear. The regression results shown in Table 4 on the next page seem to indicate a polynomial relationship with AGE moving from positive to negative, and then positive again. Although AGE is rendered insignificant with the inclusion of its exponential extensions, it is included in the final equation to complete the polynomial relationship between age and price.

Table 4 ***Regression Results***

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.568297	0.143448	31.84637	4.54E-200
AGE	0.003137	0.002657	1.1802691	0.237958
AGESQ	-0.00043	0.00017	-2.5164776	0.011889
AGECU	7.34E-06	2.89E-06	2.5441987	0.010987
BATH	0.127949	0.012027	10.638274	4.16E-26
XDNL	-0.00369	0.001112	-3.3180847	0.000914
FIREPLACE	0.026428	0.012916	2.0460955	0.040807
GARSQFT	0.000277	2.66E-05	10.395571	5.12E-25
POOL	0.130613	0.011851	11.020972	7.11E-28
LLOTSQFT	0.086022	0.009257	9.2928328	2.32E-20
LTOTSQFT	0.641536	0.022901	28.013569	8.54E-159
TREND	0.05052	0.000924	54.654083	0

R-squared	0.736985	Mean dependent var	11.79732
Adjusted R-squared	0.736314	S.D. dependent var	0.593937
S.E. of regression	0.304989	Akaike info criterion	-2.37219
Sum squared resid	401.0938	Schwarz criterion	-2.35451
Log likelihood	-994.814	F-statistic	1098.409
Durbin-Watson stat	1.45698	Prob(F-statistic)	0

Sample Size: 4331 observations

The results of the initial regression in Table 2 show an insignificant t-statistic for the noise variable, DNL. However, in the results shown above in Table 4, when the multicollinearity between ROOMS, LTOTSQFT, and BEDROOMS is addressed, and the AGE variable extended, the noise variable becomes significant, with a negative relationship with price. Also, the fireplace dummy, insignificant in the initial regression, becomes significant when the multicollinearity is addrssed. The log-linear specification allows one to interpret the noise coefficients as the percentage change in the price as a result of a change in DNL level. Taking the inverse log of the coefficient for DNL and subtracting 1, we obtain

$$e^{0.00369} - 1 = .00369$$

which can be interpreted as a .369 percent change in price per change in DNL. Compared to the results of other studies, this measure effect is consistent.

Up to this point the noise variable, **DNL,** has been entered into the equation as a *continuous* variable, However, the value of the noise variable is measured in five decibel increments, resulting in a discontinuity. If it were entered as *discontinuous*, using dummy variables for each contour measurement, the equation could be estimated so that the slope coefficients for each measurement could be determined. The results are shown for this new equation on the next page in Table 5.

In this equation, the noise is entered as dummy variables represented by D60, D65, D70, and D75. The control group noise variable value is now changed to zero. The t-statistics indicate only the D65 and D70 dummies are significant. An explanation for the insignificant coefficient on the D75 variable may be the small number of observations (15) found in this contour. The insignificant coefficient on the D60 variable can be explained by comparing it to ambient noise. Measurements of background noise in the absence of aircraft noise at the monitoring locations shown in Appendix 1 ranged from 55 dB DNL to 65 dB DNL[6]. This means that the average home in the 60 contour has a measured aircraft noise exposure no greater than that of one presumed to have relatively no exposure. These results show no statistical difference between the two groups.

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[6] Brown-Buntin Associates: FAR Part 150 Update, McCarran International Airport, January 1994; pg. 14

Table 5 Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.396353	0.139053	31.61648	1.74E-197
AGE	0.003957	0.002701	1.4648382	0.143038
AGESQ	-0.00047	0.000171	-2.7370616	0.006225
AGECU	7.91E-06	2.90E-06	2.7294913	0.006369
BATH	0.128161	0.012024	10.658709	3.36E-26
POOL	0.13008	0.011871	10.958204	1.40E-27
D60	-0.00485	0.013006	-0.3732828	0.708956
D65	-0.02807	0.012918	-2.1726752	0.029859
D70	-0.08039	0.023057	-3.4866623	0.000494
D75	0.079751	0.102515	0.7779382	0.436648
FIREPLACE	0.026458	0.012929	2.0463536	0.040782
GARSQFT	0.000281	2.68E-05	10.505526	1.65E-25
LLOTSQFT	0.085044	0.009579	8.8778871	9.82E-19
LTOTSQFT	0.638639	0.023079	27.671875	2.79E-155
TREND	0.050086	0.000969	51.695497	0

R-squared	0.737326	Mean dependent var	11.79732
Adjusted R-squared	0.736473	S.D. dependent var	0.593937
S.E. of regression	0.304897	Akaike info criterion	-2.3721
Sum squared resid	400.5739	Schwarz criterion	-2.35
Log likelihood	-992.01	F-statistic	863.9544
Durbin-Watson stat	1.457921	Prob(F-statistic)	0

Sample Size: 4331 observations

The results show a small difference in the explanatory power between this, the *discontinuous* equation, and the previous, *continuous* equation shown in Table 4(The R^2s differ by 0.000341). The interpretation of the noise effect in this case is of a change in the effect as one moves between contours. In this case, a movement from D65 to D70 represents and 5.37 percent change in the amount aircraft noise effects the saleprice.

The two models can be compared further by employing the *Lack of Fit* test described by Neter, Wasserman, and Kutner (1990) in their text. The test uses residuals from the two fitted regression lines to compare restricted (continuous) and unrestricted (discontinuous) dummy variable specifications. The test requires repeat observations, called *replicates*, on one or more levels of an independent variable. The difference between the continuous and discontinuous sums of squared residuals is called the *lack of fit sum of squares*. The test statistic is the *lack of fit mean square* divided by the *unrestricted mean square*. It is distributed as an F distribution with *c*-2 and *n-c* degrees of freedom, where *c* is the number of independent variables in the unrestricted equation, and *n* is the number of replicates. To proceed, the test is applied to the sum of squared residuals from the following equations and alternative hypotheses:

Continuous: $\textbf{LSaleprice} = b_0 + b_1\textbf{DNL} + \Sigma\, b_i\textbf{Z}_i + \epsilon$

Discontinuous: $\textbf{LSaleprice} = b_0 + b_1\textbf{D60} + b_2\textbf{D65} + b_3\textbf{D70} + b_4\textbf{D75} + \Sigma\, b_i\textbf{Z}_i + \epsilon$

H_0 : Noise is Continuous

H_a : Noise is not Continuous

Here, the null hypothesis is that the variation in saleprice due to noise can be explained with one continuous variable just as well as four non-continuous ones. The alternative hypothesis suggests that the lower error associated with the dummy variable specification is significantly different from the continuous (restricted) specification and is the better model.

Lack of Fit Test

$$F^* = \frac{401.094 - 400.574}{4-1} \div \frac{400.574}{4324-4}$$

$$= \frac{0.1733}{0.0927} = 1.8695; \quad F_c = F(.99;3,4320) = 3.78$$

Since $F^* = 1.8695 < F_c = 3.78$, the null hypothesis can not be rejected at the 99 percent level of significance[7]. In terms of the choice between models. the test indicates no significant explanatory power will be lost by entering the noise measurements as one variable. Intuitively, this result seems illogical since one is less likely to encounter measurement error with four fitted lines than with one. The selection of specifications notwithstanding, aircraft noise itself is significant.

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[7] Source of statistical table: Economic Models & Economic Forecasts by Robert S.Pindyck and Daniel L. Rubinfeld, 3rd ed.(McGraw Hill 1991); pg. 564, Table 4a

CHAPTER VI

CONCLUSION

The airline industry has grown significantly over the past two decades. Much of the growth is due to the increased competition generated by high frequency carriers like Southwest Airlines. In order to keep up, more carriers are moving towards a high frequency operations in addition to the standard hub terminal structure. Unfortunately, high frequency means more jets, and more jets means more frequent noise events. This translates into larger measured contour values.

The Airport Noise and Capacity Act of 1990 sought to mitigate the expected increased noise impact by requiring quieter aircraft. Proponents of the Act argue that the higher noise levels are creating negative economic impacts on property values around airports. The FAA however, does not recognize impacts in areas exposed to less than 65 dB DNL. So one might question where the actual impact begins. As one of the fastest growing airports in an area that boasts one of the highest growth rates in the country, McCarran International Airport provides excellent conditions for the study of this and other questions regarding the effect of aircraft noise.

This study clearly demonstrates that the effect of aircraft noise around McCarran International Airport is low and negative, but nevertheless significant. Homes in the study were affected by aircraft noise by as much as .37 percent per

DNL which is low compared to most studies in the literature. With an average price of $135,000 for homes included in the data set, the impact amounted to $4,995.00 difference in price between home in the 65 DNL contour and the threshhold of relative quiet, 55 DNL. In the dummy variable specification, as one moves closer to the airport, the noise impact on sale price can be expected to rise by as much as 5.37 percent. This result was found by measuring the difference between coefficients on the significant dummy variables. This does necessarily hold true for the 60 dB DNL contour because it was found to have not been impacted significantly by aircraft noise. Therefore, the line between homes that are affected by aircraft noise and those with no perceptable difference is somewhat blurry.

Sellers of homes in the proximity of McCarran have not all, with certainty, had their home values diminished by aircraft noise. On the contrary, Clark County which owns and operates McCarran International Airport has undertaken a land acquisition program which includes a large number of homes around the airport. In establishing sale price, owners were required to obtain comparison method appraisals which were used as the asking price. Therefore, some measure of the effect may be mitigated by the program. However, the results show that the vast majority of the recorded transactions since 1963 were significantly affected negatively by aircraft noise.

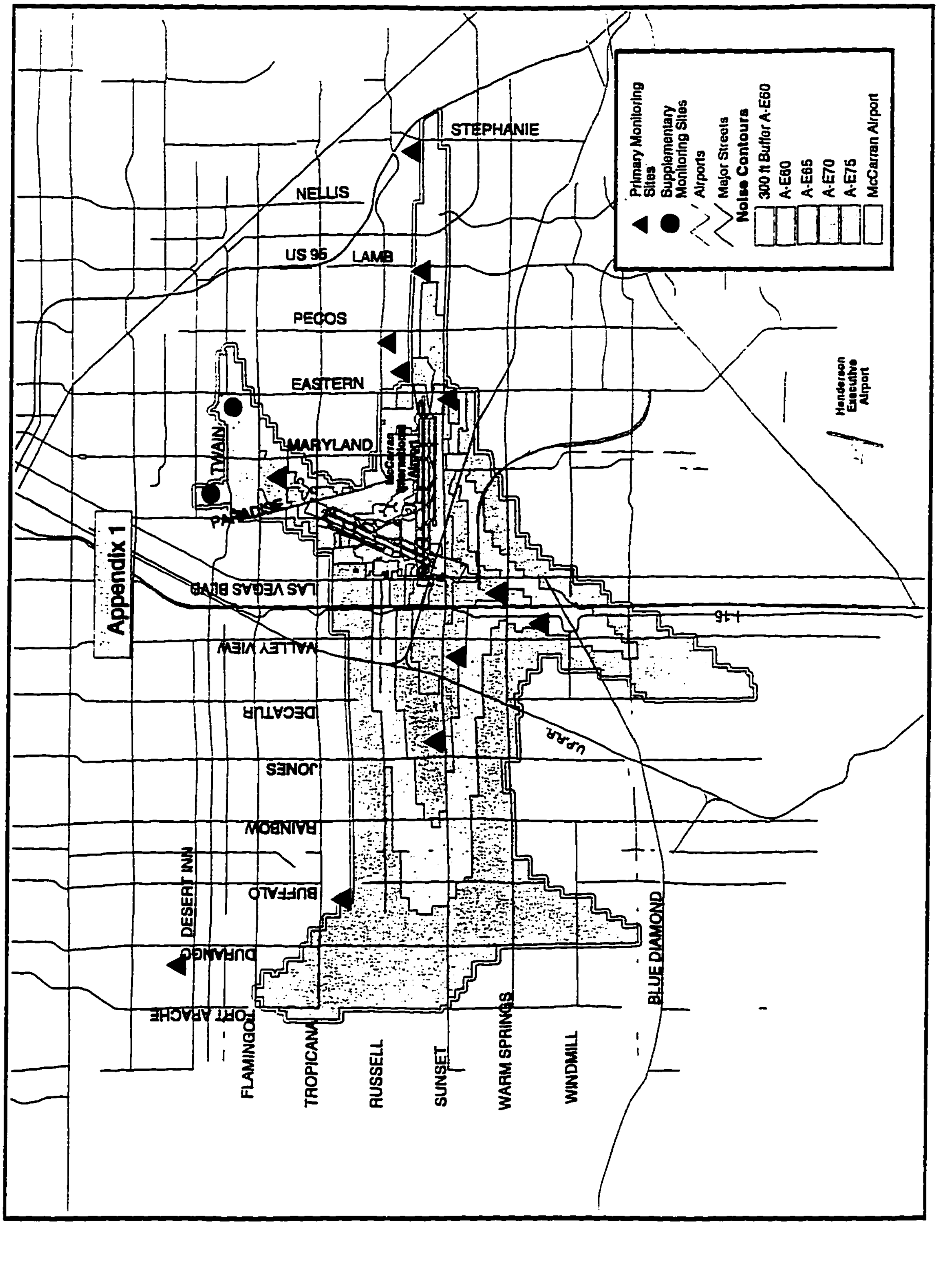
It has also been shown that no significant difference exists between continuous and discontinuous specifications of the model when the data is measured in large increments (5 DNL's in this case). Even though some authors of other studies have assumed this difference, it has been clearly shown here using a residuals test that the difference is not significant.

The noise data used in this study allowed for the direct comparison of the two specifications, while maintaining the integrity of the measurements. More conclusive evidence of the effect of aircraft noise could be produced if the monitoring stations measuring aircraft noise could be set at specific intervals so that smaller measurements are obtained to approximate a continuous variable. Until such data is available, the discontinuity in the noise data should be entered into the regression equation as dummy variables.

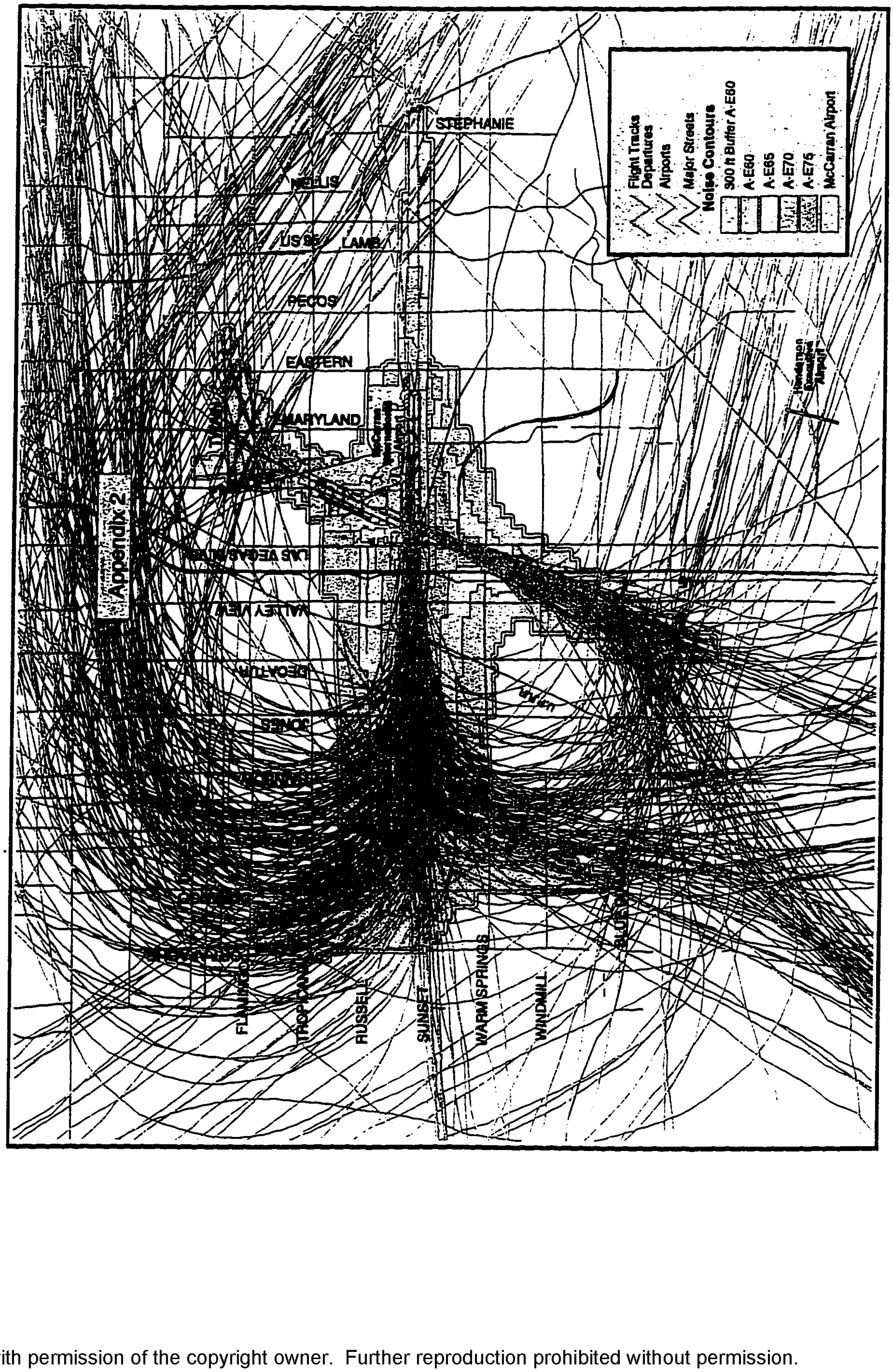
A further test of the appropriateness of the hedonic model in addressing this issue would be to gather data in an area where the noise exposure has diminished or increased significantly over time. A comparison between the change in noise levels and the change in home prices could be made to determine if the change in noise levels is the cause of price changes.

Certainly, evidence exists in the literature that other considerations should be counted when measuring the level of the effects of aircraft noise, such as distance and neighborhood characteristics. However, what has been shown in this study, and the collection of work in favor of significant noise impacts is *sound* evidence of aircraft noise *effects*!

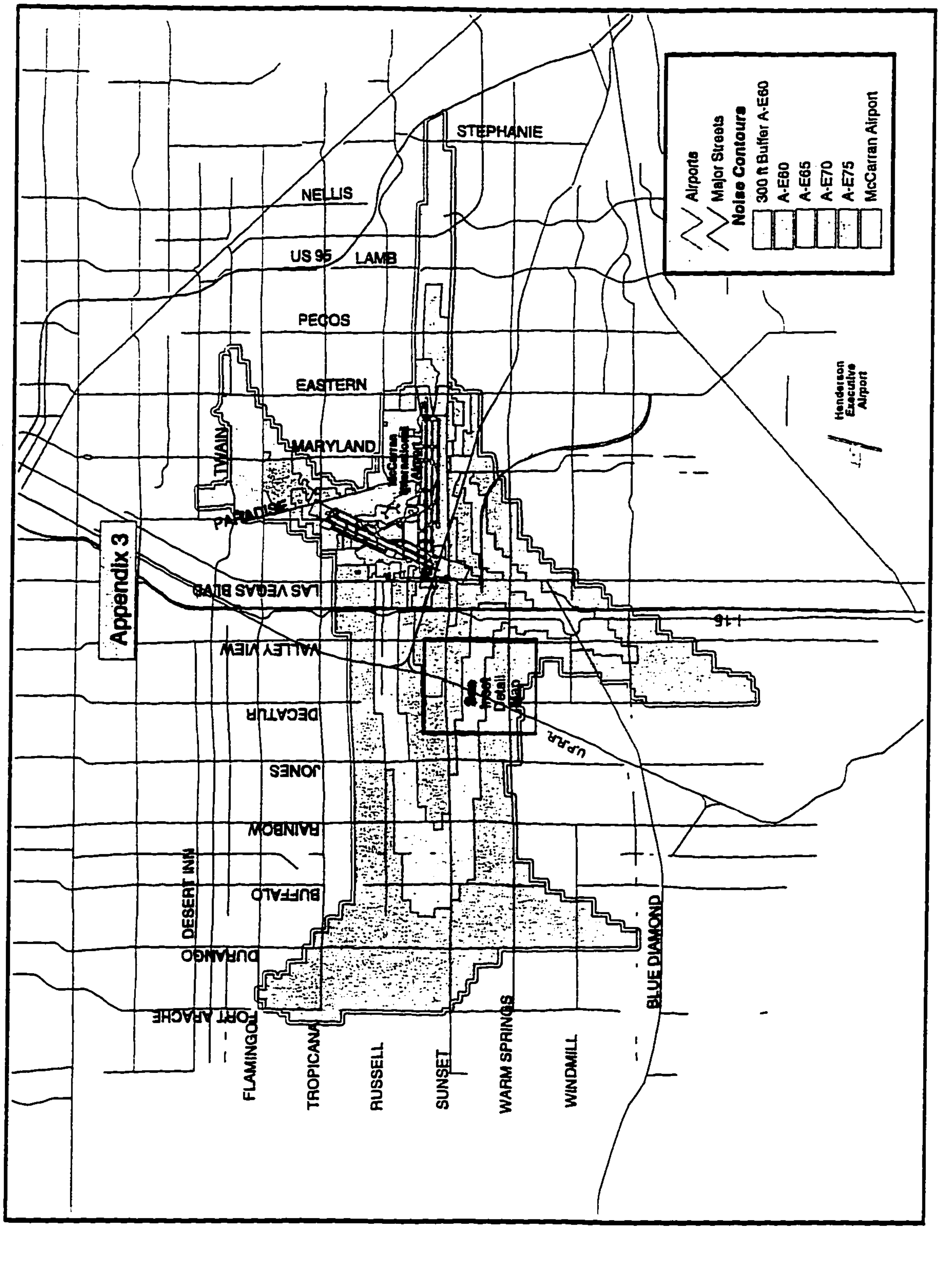
APPENDIX 1
NOISE MONITORING SITES



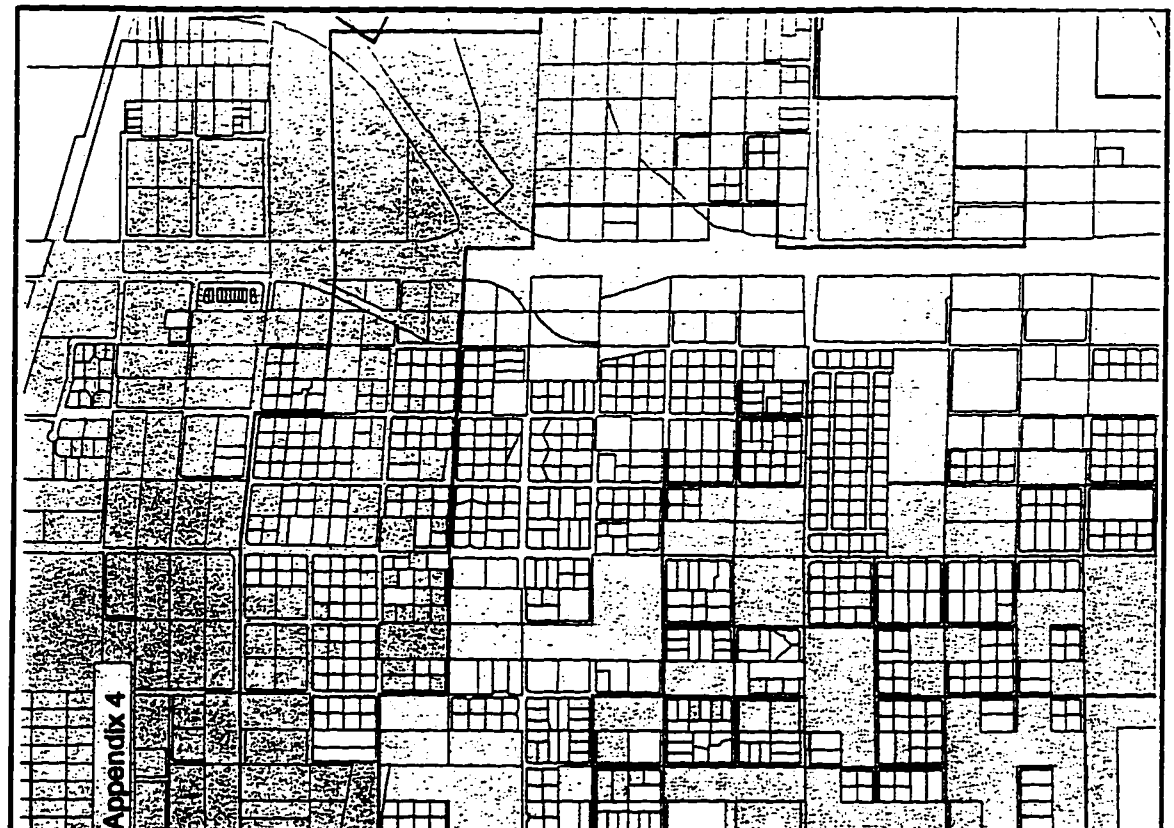
APPENDIX 2
DEPARTURE FLIGHT TRACKS for 1 DAY



APPENDIX 3
NOISE CONTOURS



APPENDIX 4
RESIDENTIAL PARCEL DETAIL MAP



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