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The Influence of the Threat of Flooding on Housing Values in Fargo, North Dakota and Moorhead, Minnesota

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We would be happy to provide a single copy of this publication free of charge. You can address your inquiry to: Carol Jensen, Department of Agricultural Economics, North Dakota State University, P.O. Box 5636, Fargo, ND, 58105-5636, Ph. 701-231-7441, Fax 701-231-7400, email cjensen@ndsuext.nodak.edu. This publication is also available electronically at the web site: http://agecon.lib.umn.edu/ndsu.html.

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Abstract

The hedonic valuation method (HVM) was used to quantify the impact of the threat of flooding on housing values in Fargo, North Dakota and Moorhead, Minnesota (Fargo-Moorhead). Prices of 3,783 Fargo-Moorhead homes sold between 1995 and 1998 were regressed against structural housing characteristics, neighborhood and environmental indicators, and three flood risk variables. Being located in the 100-year floodplain lowered the sale price of an average home by $8,990 and approximately 81 percent of the price depreciation was associated with required flood insurance premiums. After the extensive 1997 flood, homes in the 100-year floodplain were on average priced $10,241 less than similar homes located outside the floodplain and before the 1997 flood event. The aftermath of publicity of the 1997 flood was specifically responsible for average 100-year floodplain homes being reduced by an additional $1,350. In contrast, homes in the 500-year floodplain on average sold for $3,100 more than similar homes not in the floodplain. It was concluded that homebuyers in Fargo-Moorhead place a value on flooding risk, that more disclosure is needed regarding the location of the 500-year floodplain, and that substantial housing value related benefits are likely to be generated by various flood mitigation projects in the area that result in a re-designation and reduction of the 100-year floodplain.

***Key words**:* Hedonic valuation method, flooding, floodplain, Fargo, Moorhead, Red River of the North, housing values

The Influence of the Threat of Flooding on Housing Values in Fargo, North Dakota and Moorhead, Minnesota

Patrick M. Fridgen and Steven D. Shultz*

Introduction

In the border communities of Fargo, North Dakota and Moorhead, Minnesota, there is regular flooding on both sides of the Red River of the North. Throughout this century, most recently in 1997, there have been several 100+ year flood events. For this reason, a number of flood damage control projects are continuing to be proposed and implemented which include home buyouts, levee systems, and more stringent floodplain management and regulation.

Many of the specific costs and benefits of these projects are not well known, such as how flooding or a reduction in the threat of flooding influences housing values. This uncertainty makes it difficult to assess the cost effectiveness of flood control projects. For example, if a levee is constructed which will protect a housing development from the threat of future flooding, it is fairly easy to estimate its costs, and most direct and indirect benefits such as avoided damage to infrastructure and property. However, it is also important, though more difficult, to quantify the increases in housing values resulting from the levee construction.

In Fargo-Moorhead, it cannot be argued with any certainty how annual flooding events impact housing values. It is possible that consumers in the Fargo-Moorhead housing market may or may not even consider the issue of flooding when making their purchasing decisions. In fact, it is also possible that the benefits of living close to the river simply outweigh the negative effects associated with flooding. The goal of this research is to quantify the influence of the threat of flooding on housing values by estimating a hedonic price model in the Fargo-Moorhead community.

The influence of flooding on residential housing values has been analyzed in various communities throughout the United States using a variety of techniques, the most common of which is the Hedonic Valuation Method (HVM). The HVM is based on the idea that goods with market prices, such as houses, can be thought of as a collection of various characteristics or amenities. It is this combination of characteristics which makes up the value of the good and defines what a prospective buyer is willing to pay for that good. Through the use of the HVM, it is possible to quantify the values of individual characteristics whose aggregate value makes up the value of the good as a whole.

The results of past studies have been site specific as many of the factors that influence housing values (especially non-structural characteristics) vary greatly from one community to the next. For this reason, a study quantifying the influence of flooding specifically in the Fargo-Moorhead community is considered worthwhile.

This present study is the estimation of a Hedonic Valuation Model that incorporates structural, neighborhood, environmental, and flood characteristics of homes sold between January 1995 and August 1998 both outside and within the 100- and 500-

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year floodplains. The 100-year and 500-year floodplain designations represent the threat of flooding. Sale prices and structural characteristics were provided by the Fargo-Moorhead Area Association of Realtors, while the neighborhood, environmental, and flood-related variables were compiled using Metropolitan Council of Governments and city engineering offices' data.

The secondary objective of this study was to apply the results to flood-related policy issues in the Fargo-Moorhead community in various situations. First, it is possible to quantify increases in housing values for housing developments which are no longer located in the 100-year floodplain after the construction of levee projects. Increases in housing values can be considered as potential benefits associated with specific flood control projects and should be considered when such projects are being evaluated. Second, it is important to assess changes in property values associated with the potential modification of the official 100-year floodplain locations by the Federal Emergency Management Agency (FEMA).

The Hedonic Valuation Method and Previous Flooding-Property Value Studies

The Hedonic Valuation Method (HVM) is based on the idea that goods with market prices, such as houses, can be thought of as a collection of various characteristics or amenities. As Andreas (1984) suggests, the term “hedonic” refers to a method in which a complex commodity is dissected into the sum of the values of its various components. It is this combination of characteristics or components which makes up the value of a good and defines what a perspective buyer is willing to pay for that good.

These characteristics do not always have readily accessible values associated with them because they are not sold individually. However, it is possible, through the use of hedonic price models, to quantify the implicit prices of the various characteristics from the observed market value of the good as a whole (Doss and Taff 1993).

The impacts of flooding on housing values have been analyzed from various perspectives. Some researchers have looked at the influences of floodplain location, designation, and regulation on housing values (Damianos and Shabman 1976, Donnelly 1989, Muckleston 1983, Schaefer 1990, and Zimmerman 1979). Others have studied the impact of actual flood events on housing values (Babcock and Mitchell 1980, and Tobin and Montz 1988). Some of these studies have used a HVM model (Donnelly 1989, Shabman and Damianos 1976, and Schaefer 1990) to estimate the effects of flooding on housing and property values. Others have chosen different methods such as analyzing changes in mean values of homes in affected areas (Babcock and Mitchell 1980, Muckleston 1983, Tobin and Montz 1988, and Zimmerman 1979). Though the focus and objective of these studies were similar, many of their results were either contradictory or inconclusive perhaps due to different study locations (Table 1).

Table 1. Past HVM studies that have analyzed the effects of environmental amenities

Author and Year	Location	Source of Data	Variables & Effect On Housing Values
Ridker & Henning, 1967	St. Louis, MO	Census	Air Pollution (-)
Nelson, 1978	Washington, DC	Unknown	Air Pollution (-), Noise Pollution (-)
Diamond, 1980	Chicago, IL	Savings and Loan Assoc.	Air Pollution (-), Lake Michigan (+), Hills (-/+)
Li & Brown, 1980	Boston, MA	Multiple Listing Service	Air Pollution (-), Noise Pollution (-), Conservation Lands (+/-), Rivers & Oceans (+), Housing Density (-), Scenic Views (+), Highways (-)
Graves et al., 1988	S. California	Market Data Coop.	Air Pollution (-), Beaches (+), Scenic Views (+)
Donnelly, 1989	La Crosse, WI	Multiple Listing Service	Floodplain (-)
Palmquist & Danielson, 1989	North Carolina	Multiple Sources	Soil Erosion (-)
Michaels & Smith, 1990	Boston, MA	Society of Real Estate Appraisers	Toxic Waste Sites (-)
Kulshreshth & Gillies, 1993	Saskatoon, SK	Sask. Real Estate Board	River View (+)
Doss & Taff, 1993	Ramsey County, MN	County Assessor	Lakes (+), Scrub-shrub Wetlands (+), Forested Wetlands (-), Emergent-vegetation Wetlands (-)
Shultz, 1993	Tucson, AZ	U.S. Census	Open Spaces (+), Parks (-), Rivers & Washes (+/-)
Lansford and Jones, 1995	Texas	Travis County Appraisal District	Waterfront (+), Proximity to Lake (+), High Lake Levels (+)
Geoghegan et al., 1997	Washington, DC	U.S. Census	Open Spaces (+/-), Waterfront (+)

Procedures

The first step in quantifying the influence of flooding on housing values involves estimating an hedonic price function similar to equation 1.

$$\text{(1)} \qquad PRICE = f\,(Z_s, Z_n, Z_e, Z_f)$$

where PRICE = Sale price of houses

Z_s = structural variables,
Z_n = neighborhood variables,
Z_e = environmental variables, and
Z_f = flood variables.

The sale prices of homes were regressed against their characteristics, including structural characteristics (Z_s) such as number of bedrooms and square footage; neighborhood characteristics (Z_n) including land uses and market segments; environmental characteristics (Z_e) such as the house's location relative to the river; and flooding characteristics (Z_f) which measure the influence of various flood-related characteristics on housing values.

Marginal Implicit Prices (MIPs)

Marginal Implicit Prices are a function of characteristics in the hedonic price function. They represent the change in the mean value of homes associated with a one-unit change in an explanatory variable. The MIP equation for variables that have a linear relationship is illustrated in equation 2.

$$\text{(2)} \qquad MIP\,(X_i) = \partial P_h / \partial X_i = B_i$$

where Ph = implicit price function,
Xi = ith characteristic being valued, and
Bi = the coefficient for the characteristic.

Elasticities:

Elasticities (E_{YX}) represent the percentage change in the sale price of the house (P_h) for every percentage change in each of the explanatory variables (X_i). The equation representing the calculation of elasticities for linear variables is represented in equation 3.

(3) $$EYX_i = \partial P_h / \partial X_i * X_i / P_h = B_i * X_i / P_h$$

where EYX_i = the housing value elasticity for an amenity
Xi = the quantity level of an amenity
Bi = the coefficient of an amenity
P_h = the mean housing value
X = the mean level of an amenity

The Dependent Variable

The dependent variable in the hedonic model was the prices of homes sold (between January 1995 and August 1998), plus the unpaid special assessments, minus points (up-front interest based costs) paid by seller.

The required real estate transaction data were provided by the Fargo Moorhead Area Association of Realtors (FMAAR). The original FMAAR data set consisted of approximately 4,500 sales between January 1995 and August 1998 (3,300 sales in Fargo, and 1,200 sales in Moorhead). Some of these 4,500 sales from the original data set were removed before the final analyses because they were outside of Fargo or Moorhead city limits or due to missing information and/or inconsistencies in the reported data.

Structural Variables

The structural housing variables (Z_s) were provided in sales data from the FMAAR. The structural housing variables included the number of bathrooms (BATH), square footage of the house (SQFT) and lot (LOTSQFT), the age of the house (AGE), and the number of garage stalls (GARST). All structural variables are represented by a linear specification with the exception of the LOT variable which is represented with the semi-log functional form as it is assumed that once lot sizes become large, their influence on housing price diminishes.

A number of the structural variables required dummy variables. For those houses that have central air conditioning, the dummy variable AC = 1 was assigned to represent those homes. Financing was also assumed to be important for consumers in the housing market, so a dummy variable (CLOAN) was assigned for homes purchased though a conventional loan or cash. Finally, houses that have a poured concrete basement were represented by the dummy variable PBASE. Further descriptions of how these variables were used in the regression model are included in Table 2.

Neighborhood and Land Use Variables

The neighborhood variables (Z_n) in the hedonic model included a set of dummy variables that represent which elementary school district a home is located within and nearby land uses.

Table 2. Description and expected signs of variables in the study

Acronym	Description	Expected Sign
BATH	Number of bathrooms in house	(+)
SQFT	Square footage of house (feet)	(+)
LLOTSQFT	Log of square footage of lot (feet)	(+)
AGE	1999 - year built	(-)
GARST	Number of garage stalls	(+)
AC	=1, if house has central air conditioning*	(+)
CLOAN	=1, if financing involved conventional loans of cash*	(+)
PBASE	=1, if basement is poured concrete*	(+)
FPLAIN1	=1, if house is in 100-year floodplain*	(-)
FLD97	=1 if in 100-year floodplain & sold after 1997 flood*	(-)
FPLAIN5	=1, if house is in 500-year floodplain*	(-)
LOGPARK	Log of distance from house to nearest park/recreation area	(-)
GOLF	=1, if house is abutting a golf course*	(+)
RIVER	=1, if house is on lot along Red River*	(+)
%COM	Percentage of surrounding area in commercial land use	(-)
%IND	Percentage of surrounding area in industrial land use	(-)
%MR	Percentage of surrounding area in multiple-family residences	(-)
MCKWASH	=1, if located in MCKWASH market segment	?
LONGF	=1, if located in LONGF market segment	?
MADROOS	=1, if located in MADROOS market segment	?
HAWHOR	=1, if located in HAWHOR market segment	?
JEFCARL	=1, if located in JEFCARL market segment	?
LCCLARA	=1, if located in LCCLARA market segment	?
LINC	=1, if located in LINC market segment	?
MHDNORTH	=1, if located in MHDNORTH market segment	?
MHDSOUTH	=1, if located in MHDSOUTH market segment	?

* Variable takes a value of 0 otherwise.

School districts represent the general neighborhoods and are therefore a proxy for a variety of omitted variables. In Fargo, 13 elementary school districts were combined into 7 districts while in Moorhead, two (North and South) school districts were used.

The land use variables represent the amount of commercial, industrial, and multiple-family residence land uses that occur near individual homes. More specifically, the variables %COM, %IND, and %MR measure the percentage of commercial, industrial, and apartment based land uses in census block groups surrounding individual homes. These land use data were obtained in the form of a GIS database from Metropolitan Council of Governments (MetroCOG) and are portrayed in Figure 1.

Environmental Variables

The environmental variables (Z_e) in the hedonic model include the distance of houses to the nearest park or open area (PARK), a dummy variable representing houses abutting golf courses (GOLF), and a dummy variable representing homes along the Red River (RIVER) (Figure 2).

The PARK variable represents the log of the distance from the housing lots to the perimeter of the nearest recreation area (neighborhood parks, city parks, or general open space areas). These park areas are hypothesized to positively influence housing values due to the various open space amenity opportunities they offer. A semi-logarithmic functional form is adopted with these variables because the relationship between housing values and proximity to recreation areas has been shown to decrease at an increasing rate.

Homes on golf courses or the river are also hypothesized to be valued higher than otherwise similar homes with fewer scenic views and recreational opportunities.

Flood Variables

The model includes three flood-related variables (Z_f): A dummy variable for houses within the 100-year floodplain (FPLAIN1), a dummy variable for houses within the 500-year floodplain (FPLAIN5), and a dummy variable representing whether houses were sold in the 100-year floodplain after the 1997 flood (FLD97).

Whether homes are located in the 100-year floodplain was determined directly from the FMAAR database where it is included due to the fact that 100-year floodplain homes are required by lending institutions to be covered by flood insurance.

Houses within the 500-year floodplain were identified using a GIS coverage of the 500-year flood lines that were provided in Fargo by the City Engineering Department and digitized from hardcopy paper maps for Moorhead. A sample of homes located within the 100-year and 500-year floodplains are illustrated in Figure 3.

Finally, an interaction variable is included in the model to represent houses sold in the 100-year floodplain following the 1997 flood. It is hypothesized that prior to the 1997 flood, 100-year floodplain homes sold for more amounts than similar homes after the flood event. This is expected to be a result of a greater awareness of the threat of flooding in the 100-year floodplain. This variable was estimated in a separate (second) model specification without the other floodplain variables in order to avoid multi-collinearity problems.

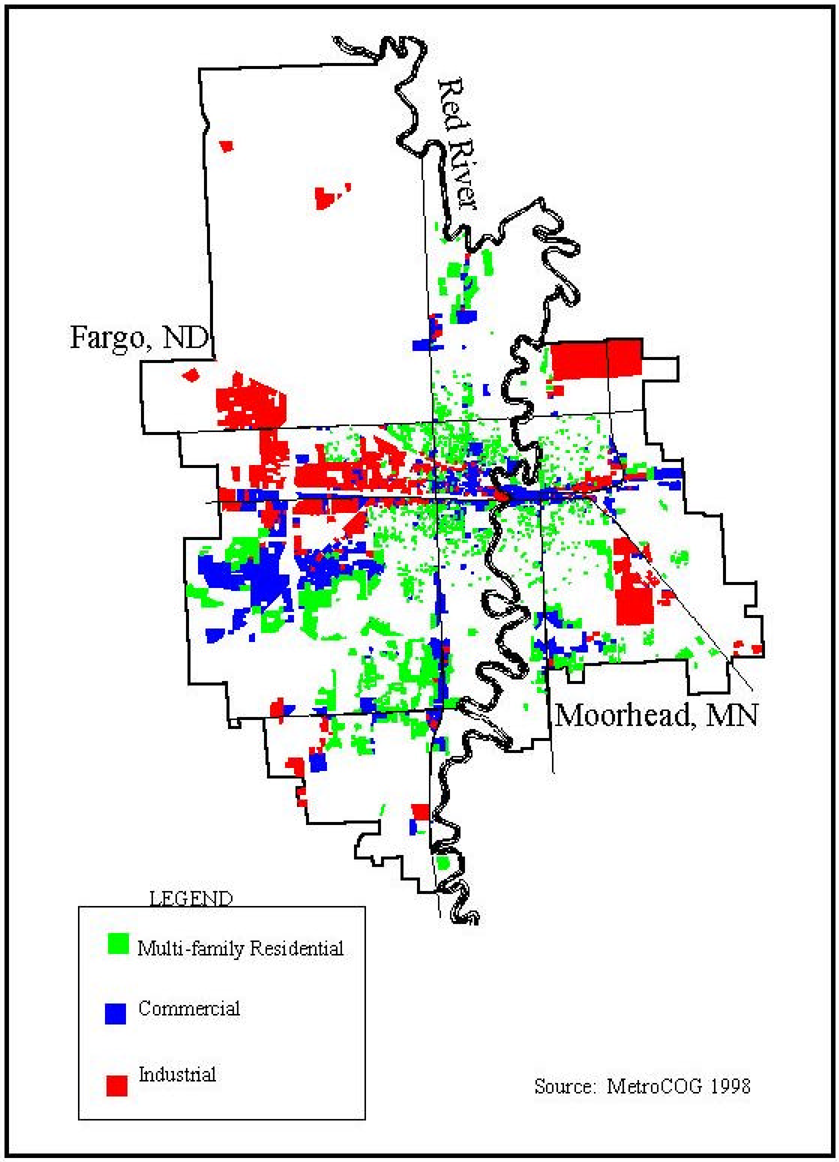

Figure 1. Multi-family residential, commercial, and industrial properties in Fargo-Moorhead.

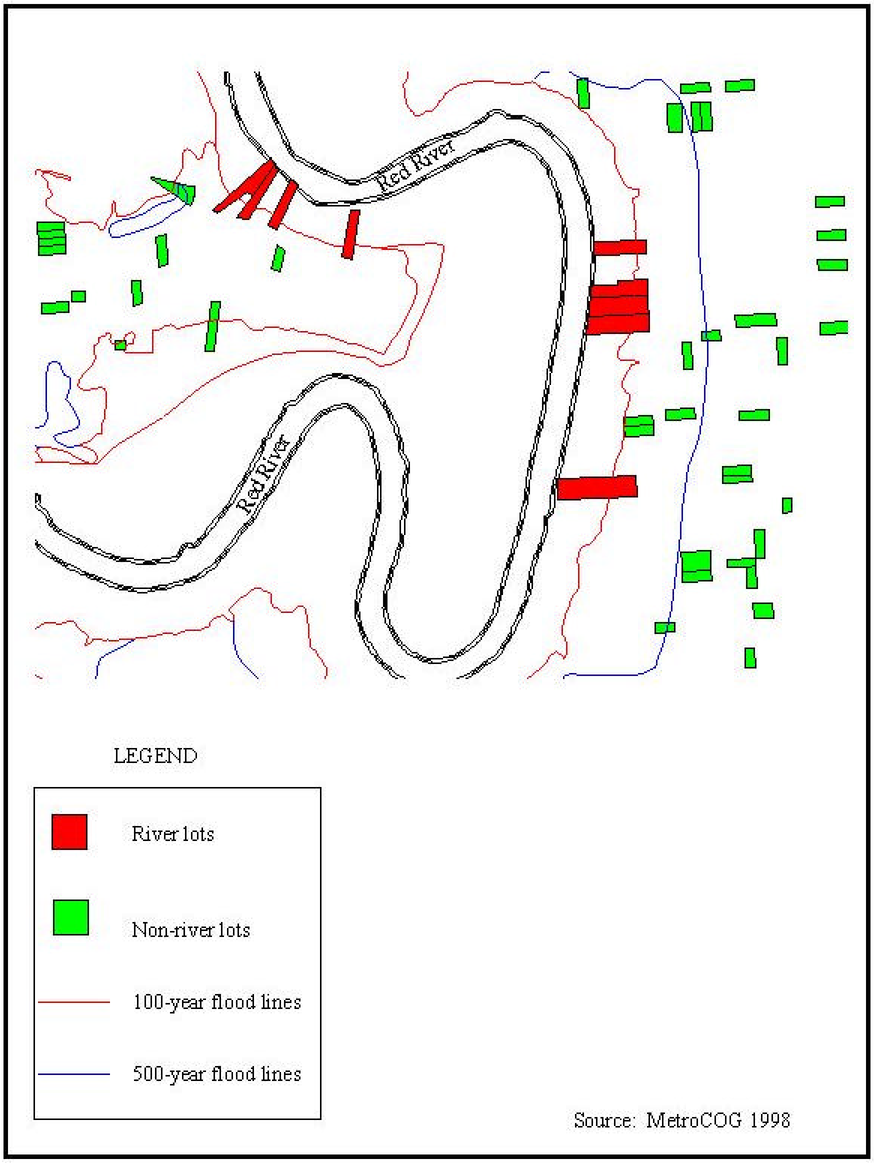

Figure 2. Examples of sold river lots and floodplain designations.

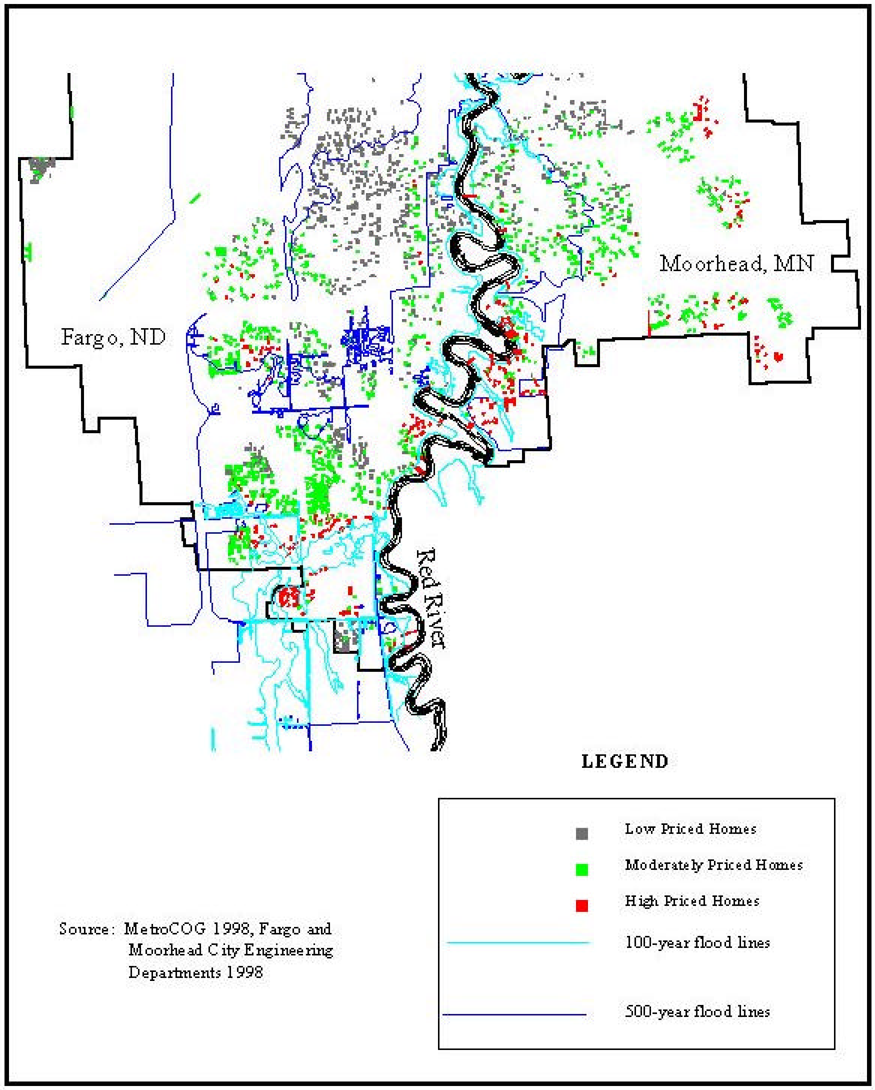

Figure 3. Values of homes sold in a section of south Fargo and Moorhead with floodplain designations.

Results

The mean sale price of the 3,783 Fargo-Moorhead homes in this study sold between January 1995 and August 1998 is $100,139 (Table 3). The average home is 36 years old, has 1,562 square feet of living space on a 9,472 square foot lot, has two bathrooms, and has a two-stall garage. In addition, over 50 percent of the sales had a poured concrete basement or central air conditioning. Forty-two percent of the sales were within the 500-year floodplain while 1 percent were within the 100-year floodplain. Summary statistics for Fargo-Moorhead homes sold between 1995 and 1998 are presented in Tables 3 and 4.

Table 3. Summary statistics for housing sales in Fargo-Moorhead

Variable *(units)*	Mean	S.E.
PRICE *($)*	100,139	50,728
AGE *(years)*	37	27
BATH *(# / home)*	2	0.8
BUFCOM *(%)*	3.5	5.4
BUFIND *(%)*	1.5	5.5
BUFMR *(%)*	10.2	9.8
SQFT *(ft^2)*	1,562	626
GARST *(# / home)*	1.8	0.8
LOTSQFT *(ft^2)*	9,472	4,865
AC *(1/0)*	.56	.49
CLOAN *(1/0)*	.53	.49
GOLF *(1/0)*	.06	.24
BASEP *(1/0)*	.61	.48
FPLAIN1 *(1/0)*	.01	.1
FLD97 *(1/0)*	.01	.07
FPLAIN5 *(1/0)*	.42	.49
RIVER *(1/0)*	.02	.14

Table 4. Relationship between price, size, and characteristics of homes

Characteristic of Interest	$ / ft^2
All Fargo-Moorhead homes	64
Homes in 100-year floodplain	63
Homes in 500-year floodplain	67
All homes before 1997 flood	63
All homes after 1997 flood	67
Homes in 100-year floodplain before 1997 flood	64
Homes in 100-year floodplain after 1997 flood	63

On average, homes in the 100-year floodplain have a lower price per square foot (\$64/ ft^2) than homes in the 500-year floodplain (\$67 ft^2).

Most homes sold after the 1997 flood were worth more per square foot than those sold before the 1997 flood. This is thought to be a result of both inflation and a booming real estate market resulting from relatively low interest rates and a robust economy in the Fargo-Moorhead area .

However, not all homes were worth more per square foot after the 1997 flood. Homes sold within the 100-year floodplain following the 1997 flood were worth approximately \$4 less per square foot than all other homes sold during this period. This may be an indication of a negative relationship between the threat of flooding and housing values; however, these variations in value per square foot are not statistically significant.

Though these preliminary analyses may give some insight to the relationship between flood-related variables and housing values, it is recommended that further analyses, such as the estimation of multiple regression based hedonic valuation model be conducted.

The Hedonic Regression Models

Two separate hedonic models were estimated. The first quantified the influence of the 100-year and 500-year floodplains on housing values in Fargo-Moorhead. The second model focussed on the influence that the 1997 flood event had on housing values within the 100-year floodplain. For both models, the R^2 and adjusted R^2 were 0.78, meaning that the regression models explained 78 percent of the variability in housing values in Fargo-Moorhead.

Model 1: Quantifying the Influence of the 100-year and 500-year Floodplains

All of the variables in Model 1 were found to have a significant influence on housing values at a 95 percent confidence level with the exception of the river variable (RIVER) and the commercial land use variable (%COM). More detailed regression results for this model are summarized in Appendix A..

Neither the RIVER variable, which measures the influence of being located on a river lot, or the %COM variable are significant even at a 90 percent confidence level.

The marginal implicit prices (MIPs) and elasticities for Model 1 are found in Table 5. MIPs represent how much the value of a home increases or decreases with the increase or decrease of an additional unit of the characteristic of interest. For example, a MIP for the variable (AC) indicates that the presence of central air conditioning increases the mean value of an average Fargo-Moorhead home by \$5,414, while the MIP for (BATH) indicates an increase in price by \$12,415 for each additional bathroom.

Table 5. Marginal Implicit Prices (MIPs) and Elasticities (EYX)

Variable (*units*)	MIPs ($)	EYX / Rank
AC *(1/0)*	5,414	0.030 (9)
AGE *(years)*	-198	-0.073 (5)
BATH *(# / home)*	12,145	0.243 (3)
CLOAN *(1/0)*	4,553	0.024 (10)
GARST *(# / home)*	7,448	0.134 (4)
LOTSQFT *(ft^2)*	5.2	0.495 (1)
BASEP *(1/0)*	5,343	0.033 (8)
SQFT (ft^2)	27	0.421 (2)
LOGPARK (distance in feet)	-2.5	-0.022 (11)
GOLF *(1/0)*	9,613	0.006 (16)
RIVER *(1/0)*	2,520	0.0005 (20)
FPLAIN1 *(1/0)*	-8,890	-0.001 (19)
FLD97 *(1/0)*	-10,241	-0.0005 (20)
FPLAIN5 *(1/0)*	3,123	0.013 (13)
%COM *(% of commercial land use in vicinity)*	106	0.004 (17)
%IND *(% of industrial land use in vicinity)*	-552	-0.008 (15)
%MR *(% multi-family residence land use in vicinity)*	-443	-0.045 (7)
MCKWASH *(1/0) (2 Fargo School Districts)*	-9,891	-0.008 (15)
LONGF *(1/0) (1 Fargo School District)*	-8,158	-0.003 (18)
MADROOS *(1/0) (2 Fargo School Districts)*	-6,841	-0.004 (17)
HAWHOR *(1/0) (1 Fargo School District)*	-5,060	-0.003 (18)
JEFCARL *(1/0) (2 Fargo School Districts)*	-9,958	-0.009 (14)
LCCLARA *(1/0) (2 Fargo School Districts)*	-9,899	-0.013 (13)
LINC *(1/0) (1 Fargo School District)*	-11,775	-0.008 (15)
MHDNORTH *(1/0) (N. Moorhead School District)*	-23,687	-0.015 (12)
MHDSOUTH *(1/0) (S. Moorhead School District)*	-25,642	-0.055 (6)

Rank: Order of relative influence: 1-20 (greatest to least)

Of particular relevance to this study, the presence of a house in the 100-year floodplain decreased housing values by $8,890. This is expected because houses in the 100-year floodplain are required to be covered by flood insurance which makes the risk of flooding explicitly known to potential homebuyers. Rational consumers will take this into account when purchasing a home, meaning the total amount of flood insurance which the prospective buyers will pay over the time span of their ownership should be reflected in the purchase price. Variations in this dollar amount could be a result of either positive satisfaction gained by the consumer from living next to a river, or the anxiety and stress associated with the possibility of being flooded could further *negatively* influence this value.

The MIP for the 500-year floodplain variable (FPLAIN5) was positive. This is hypothesized to be a result of the fact that homeowners are not aware of the 500-year flood designation lines, are not required to purchase flood insurance, and/or they do not consider flooding to be a serious risk in these areas. Also, a number of these homes are either located along the river with desirable views or are in newly developed areas with relatively higher values (the average home in the 500-year floodplain is 27 years old and worth $142,000 versus homes outside the 500-year floodplain which are on average 43 years old and worth $87,000).

From the elasticities summarized in Table 6, which rank the variables from least to most important in terms of their influence on housing values, it is apparent that structural variables had the greatest relative influence on housing values. In contrast, the market segments and land use variables appeared to have little influence on housing values, while the RIVER and FLD97 variables also appeared to have less of an influence on housing values than the structural variables. In conclusion, flood-related variables do influence housing values; however, they are less important to homebuyers than the structural characteristics of homes.

Model 2: Quantifying the Influence of the 100-year Floodplain after the 1997 Flood

Most of the variables in Model 2 have a significant influence on housing values at a 95 percent confidence level (only the river variable and the commercial land use variable were insignificant). The variable (FLD97), which measures the influence of the 100-year floodplain on housing values after the 1997 flood event, was significant at a 90 percent confidence level. The regression output for Model 2 is also summarized in Appendix A.

The MIP for FLD97 is -$10,241, which means that housing values for houses located in the 100-year floodplain after the 1997 flood were $10,241 less than similar houses located outside of the 100-year floodplain after the 1997 flood, *ceteris paribus*.

This decrease in housing values is expected because a flood event such as the one that occurred in 1997 brings about an increased awareness of the risk of flooding. This increased awareness of the risks associated with living in the 100-year floodplain following the flood of 1997 is assumed to be a result of people's understanding of the potential threat of flooding in the Fargo-Moorhead area.

Separating Out the Effect of Required Flood Insurance

It is possible to identify how much the impact of the 100-year floodplain on housing prices is a result of required flood insurance premiums for homes located in the 100-year floodplain in contrast to price premiums associated with fear and anxiety associated with living in high risk flood areas. For example, the coefficient for the variable measuring the influence of the 100-year floodplain (i.e., the threat of flooding) in Fargo-Moorhead is -$8,890. However, flood insurance premiums for average homes in the 100-year floodplain in Fargo over a 15-year period are approximately $7,200 (based on a flood insurance rate of 0.73 per $100 of coverage and a 6% discount rate).

The difference between average flood insurance payments ($7,247) and the overall influence of flooding on housing values ($8,890) is approximately $1,643. This difference of about 19 percent is assumed to be the additional value of the anxiety or fear associated with living in flood threatened areas.

Using the Hedonic Results for Evaluating Flood Control Projects

The results of the hedonic models can be used to answer two related questions facing policymakers in Fargo-Moorhead: What are the housing value related benefits associated with specific mitigation measures? And, how will property values be influenced by a possible re-designation of the 100-year floodplain?

In both Fargo and Moorhead, various levees have recently been constructed while many others have been proposed in order to protect public and private property from flooding. For example, in Moorhead the Woodlawn and Horn Park levees are estimated to provide protection for up to 90 homes in the 100-year floodplain at a total cost of $595,000. In Fargo, the 4th Street (9th Ave. to 13th Ave.) levee project will provide protection for 43 Fargo homes in the 100-year floodplain at a cost of $650,000. The 4th Street levee was constructed to a height which met FEMA standards; however, the Horn and Woodlawn Park levees in Moorhead were not built high enough to meet FEMA standards to initiate a re-designation of the flood lines in these Moorhead neighborhoods.

There would be two ramifications if homes are removed from the 100-year floodplain after the construction of these levee structures. First, houses designated outside the 100-year floodplain would no longer require flood insurance. The present value of flood insurance premiums over a 15-year period that would no longer need to be paid by these 90 homes in Moorhead neighborhoods (provided the levee structures are raised to FEMA standards) is approximately $612,000 while the value of flood insurance premiums for the 43 homes in Fargo neighborhoods being protected by levee structures is estimated to be $340,000.

A second consequence of levee construction would be an increase in housing values for the 43 Fargo and 90 Moorhead homes taken out of the 100-year floodplain classification. From the results of this study, these values are estimated to total $70,649 for the 43 Fargo homes and $147,870 for the 90 Moorhead homes. These values are the difference between the FPLAIN1 coefficient ($8,890) and the average total amount of flood insurance paid over 15 years ($7,247), multiplied by the number of homes affected. By inputting the coefficients and actual characteristics of individual homes into the hedonic price function, it is possible to get more accurate results for specific homes.

These insurance and housing value related benefits associated with flood control measures can be compared to their construction costs ($650,000 in Fargo and $595,000 in Moorhead). However, there are also likely to be additional benefits of these flood control projects including reductions in structural damages to roads, houses, and commercial buildings, as well as reductions in insurance premiums and increases in commercial building values located in flood threatened areas. Studies similar to this could be used in cost-benefit analyses for flood mitigation decision making by policymakers. This may give further justification to additional flood mitigation efforts or to improving those already in place (i.e., raising existing levee structures to levels that comply with FEMA standards).

A second policy related issue that can be addressed with the results of this study is the issue of how housing values will increase or decrease with the potential re-classification of 100-year floodplain lines in the Fargo-Moorhead area. As a result of flood damages incurred during the 1997 flood, FEMA is planning to re-study and possibly re-classify the 100-year floodplain maps in the Fargo-Moorhead area (FEMA FIRM Revision Document 1998). From the results of this study, average homes added to the 100-year floodplain would see a reduction in their housing values by approximately $8,890 (or 9 percent) as a result of required flood insurance premiums and increased levels of stress and uncertainty associated with flooding risks. In contrast, if homes have their 100-year floodplain designations removed, they are expected to increase by about $8,890.

Conclusions

The Hedonic Valuation Method (HVM) was used to quantify the influence of the threat of flooding on housing values in Fargo-Moorhead by regressing values of homes sold between January 1995 and August 1998 with their various characteristics. These characteristics included structural, neighborhood, environmental, and flood-related amenities. Table 6 contains a summary of the main results of the modeling exercise.

The 100-year floodplain was shown to have a statistically significant and negative influence on housing values (houses in the 100-year floodplain are on average expected to be worth $8,890 less than similar houses outside the 100-year floodplain). About 81 percent of this price reduction is a result of FEMA flood insurance requirements for homes in the 100-year floodplain. The remaining 19 percent price reduction is expected to be a result of fear or anxiety associated with flooding risks.

Houses in the 100-year floodplain sold after the 1997 flood also had a statistically significant and negative influence on housing values. Such homes on average sold for $10,241 less than similar homes outside the 100-year floodplain and sold before the 1997 flood. The influence of the 100-year floodplain decreased housing values by $8,890, while the specific impact of the 1997 flood event was derived to be $1,351. This is the difference between the threat of flooding after the 1997 flood, which is $10,241, and the overall threat of flooding, $8,890. This additional depreciation is probably the result of homebuyers' increased awareness for the risks associated with flooding following this major flood event.

Table 6. Summary statistics of flood-related variables

	Mean Value ($)	$ / Ft^2	Marginal Implicit Price ($)
All Fargo-Moorhead	100,139	64	
100-year floodplain	102,332	63	-8,890
500-year floodplain	142,117	67	3,123
100-year floodplain, Pre-97 flood	115,577	64	-----
100-year floodplain, Post-1997 flood	86,298	63	-10,241
All homes Pre-97 flood	98,090	63	-----
All homes Post-97 flood	102,767	67	-----
Influence of Post-1997 flood on values of 100-year floodplain homes	-----	-----	-1,351

In contrast, the 500-year floodplain had a significant and positive influence on housing values. Houses in the 500-year floodplain are expected to sell for $3,123 more than similar homes outside the 500-year floodplain. This may be due to the fact that a majority of these homes are in newly developed and relatively expensive areas of Fargo-Moorhead. As well, homeowners in the 500-year floodplain are not required by law to purchase flood insurance and may be unaware that their homes are in the 500-year floodplain.

The results of the hedonic models were also shown to be useful in evaluating the costs and benefits of flood control projects in Fargo-Moorhead. By knowing the marginal implicit price associated with being in the 100-year floodplain and the cost of required flood insurance, one can easily estimate several economic benefits of specific flood mitigation projects and/or a legal re-designation of the 100-year floodplain.

Future Research Needs

Because the results of HVM studies are site specific, the results of this study may not be transferable to other flood prone areas. Also, future researchers need to take a closer look at homebuyers' perceptions and knowledge of the 100-year and 500-year flood lines in Fargo-Moorhead. This should include an analysis of both recent homebuyers and long-term residents.

To further understand the perceptions of these individuals related to flooding, a survey would be required asking homeowners about their knowledge and perceptions of the risks associated with flooding. In addition, the survey could inquire about their knowledge of flood insurance and how they perceive the influence of flood insurance as affecting the value of their homes.

Finally, future research should lengthen the time period of analysis in order to determine how the 1997 flood influences housing prices in the 100-year floodplain in Fargo-Moorhead over time.

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Appendix A: Regression Results for Models 1 and 2

Table A-1. Model 1 (Includes 100- and 500-year Floodplain Variables)

Variable	Coefficient	Std. Error	T-statistic	p-value
AC	5,414	864	6.3	0.00
AGE	-198	25	-8	0.00
BATH	12,145	671	18.1	0.00
CLOAN	4,553	920	5	0.00
GARST	7,448	676	11	0.00
LOGLOT	49,564	3,581	13.8	0.00
BASEP	5,343	985	5.4	0.00
SQFT	27	1	27.4	0.00
LOGPARK	-2,189	1,013	-2.2	0.00
GOLF	9,613	1,717	5.6	0.00
RIVER	2,520	3,137	0.8	0.42
FPLAIN1	-8,890	3,863	-2.3	0.02
FPLAIN5	3,123	1,047	3	0.00
%COM	106	77	1.4	0.17
%IND	-552	85	-6.5	0.00
%MR	-443	48	-9.2	0.00
MCKWASH	-9,891	2,065	-4.8	0.00
LONGF	-8,158	2,295	-3.6	0.00
MADROOS	-6,841	2,778	-2.5	0.01
HAWHOR	-5,060	2,490	-2	0.04
JEFCARL	-9,958	2,090	-4.8	0.00
LCCLARA	-9,899	1,767	-5.6	0.00
LINC	-11,775	1,894	-6.2	0.00
MHDNORTH	-23,687	2,307	-10.3	0.00
MHDSOUTH	-25,642	1,623	-15.8	0.00

F-stat = 539.1, R^2 = 0.78, Adjusted R^2 = 0.78

Table A-2. Model 2 (Includes the Pre/Post 1997 and 100-year Floodplain Variables)

Variable	Coefficient	Std. Error	T-statistic	p-value
AC	5,416	864	6.3	0.00
AGE	-198	25	-8	0.00
BATH	12,146	671	18.1	0.00
CLOAN	4,531	920	4.9	0.00
GARST	7,467	677	11	0.00
LLOTSQFT	49,378	3,581	13.8	0.00
POURD	5,291	985	5.4	0.00
SQFT	27	1	27.4	0.00
LOGPARK	-2,174	1,013	-2.1	0.03
GOLF	9,608	1,717	5.6	0.00
RIVER	2,010	3,117	0.6	0.51
FLD97	-10,241	5,642	-1.8	0.07
FPLAIN5	3,020	1,045	2.9	0.00
%COM	106	77	1.4	0.17
%IND	-552	85	-6.5	0.00
%MR	-442	48	-9.1	0.00
MCKWASH	-9,994	2,065	-4.8	0.00
LONGF	-8,143	2,295	-3.5	0.00
MADROOS	-6,898	2,779	-2.4	0.01
HAWHOR	-5,143	2,491	-2.1	0.03
JEFCARL	-10,021	2,090	-4.7	0.00
LCCLARA	-9,935	1,767	-5.6	0.00
LINC	-11,857	1,895	-6.3	0.00
MHDNORTH	-23,736	2,308	-10.3	0.00
MHDSOUTH	-25,698	1,623	-15.8	0.00

F-model = 538.8, R^2 = 0.78, Adjusted R^2 = 0.78