

Environmental Determinants of Housing Prices: The Impact of Flood Zone Status

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Authors David M. Harrison, Greg T. Smersh and Arthur L. Schwartz, Jr.

Abstract

This article is the winner of the Real Estate Valuation manuscript prize (sponsored by The Appraisal Institute) presented at the 2000 American Real Estate Society Annual Meeting.

This study examines the valuation of homes located within 100-year flood plains. Utilizing a database of 29,887 property transactions in Alachua County, Florida, the results of this investigation suggest that comparable characteristic homes located within a flood zone sell, on average, for less than homes located outside flood zones. Interestingly, the price differential is less than the present value of future flood insurance premiums. In addition, the price differential is shown to have increased since passage of the National Flood Insurance Reform Act of 1994. Finally, it appears that property tax assessors have slightly over-assessed properties located in flood zones relative to those in other areas. The large database and the lengthy period of analysis (1980–1997) are much broader than that of previous research efforts.

Introduction

Efficient housing markets imply that the selling prices of any two properties must converge after controlling for locational and amenity differentials. Extending this theoretical construct to the pricing of environmental attributes, however, has proven somewhat more challenging. For example, selling prices of properties located in governmentally delineated flood zones should clearly be lower than observationally equivalent housing units located outside of these “environmentally sensitive” regions. Logically, the argument continues, this reduction in value should be equal to the present value cost of all future flood insurance premiums. Unfortunately, in practice the answer is not so simple.

Previous researchers investigating flood zone valuation effects have implicitly relied on this insurance cost based valuation assumption and found that properties located in such regions are indeed characterized by lower prices.¹ Interestingly, however, little attention is paid to the potential implications of this implicit

assumption. Specifically, while prices in any economic model are determined by the marginal producer/purchaser, less than half of the estimated 11 million structures currently found in Federal Emergency Management Agency (FEMA) delineated flood zones are covered by catastrophe insurance.² If the marginal purchaser is not forced to acquire hazard insurance of this nature, the negative valuation effect of this environmental attribute may be limited to his/her individual assessment of the risk of loss from flooding. Under this scenario, the present value cost of flood insurance may be viewed as the upper limit, rather than the expected value, of housing value reduction associated with flood risk. Further complicating the valuation of flood zone properties are the limitations on available insurance. Current guidelines limit insurable losses to \$250,000 on one-to-four family residential dwelling units.³ To the extent that property owners desire additional coverage, which is either more costly or unavailable from non-governmental sources, property values for high-end units may be further depressed by this non-insurable component of flood hazard risk.

Interestingly, an additional complication in valuing environmental risks arises out of the traditional property valuation and assessment procedures employed by both financial institutions and local taxing authorities. Specifically, residential property appraisers may not adequately consider the influence of flood zone location on estimated (assessed) property values. To the extent that the selection of comparable units is precise enough to include only properties with matching flood zone characteristics, appraised or assessed values for mortgage loan applications and property tax payments will remain unbiased. However, given the irregular nature of many flood zone boundaries, and the limited exposure of a good many residential appraisers to the valuation effects of environmental hazards, this assumption seems tenuous at best.⁴ Obviously, if mass appraisal techniques employed by tax assessors or third-party appraisers hired by financial institutions simply ignore, or undervalue, the decrease in market value arising from a property being situated in a flood zone, properties in flood plains will be overvalued. As a result, banks may well be more likely to loan money on units in flood prone areas, while purchasers of these units may face disproportionately higher assessments and tax liabilities. Conversely, if appraisal and assessment methodologies attempt to adjust tax liabilities for location-induced hazards using a strict insurance cost based methodology, under-valuation of flood plain properties could result. Such underassessment would effectively subsidize the construction of new units within the designated flood plain, a potentially inefficient outcome from an environmental planning perspective.

With these complications in mind, the current investigation proceeds in two stages. First, using hedonic pricing techniques, this study investigates the direct cost of flood plain location on housing values. Unlike previous models, no implicit reliance on flood insurance premiums is required, rather the current investigation directly measures the differential cost of equivalent housing units across flood plain classifications. Second, the equity of taxation is studied by comparing the ratio of assessed value to market value across flood zone and undesignated

properties. Evidence of systematic differences in this ratio across flood zone boundaries would be consistent with disproportionate locational taxation.

The results of this two-stage investigation represent a significant improvement over the existing literature for at least three reasons. First, this study appears to be the first to empirically address the issue of flood hazard pricing after passage and implementation of the National Flood Insurance Reform Act (NFIR) of 1994. Second, unlike previous studies of environment hazards, this study investigates the property tax equity consequences of such valuation anomalies. Finally, the results should prove more applicable than those offered by previous studies as the dataset employed is significantly richer (both larger, and more complete) than those available to previous researchers.⁵

The remainder of this article is organized as follows. The next section provides a brief background on the history of governmental flood insurance in this country. This is followed by detailed discussions of the specific hypotheses to be examined, the data and methodology employed throughout the investigation, and the empirical results. The final section summarizes the major findings, offers potential avenues for future research, and concludes the study.

The National Flood Insurance Program

Responding to the “virtual unavailability” of private flood insurance, the National Flood Insurance Program (NFIP) was originally authorized by Congress through the National Flood Insurance Act of 1968. Initially, the program was designed as a voluntary initiative to make affordable flood insurance available to owners of improved real estate and mobile homes located within governmentally delineated Special Flood Hazard Areas (SFHA).⁶ It was quickly discovered, however, following a series of major floods in the early 1970s, that the voluntary nature of the program led to very low participation rates.⁷ According to FEMA estimates, the participation rate among eligible structures was as low as 10% or less in some communities.⁸ Low participation rates, and the mounting cost of disaster relief bills quickly motivated Congress to overhaul the flood insurance program in an attempt to increase participation.⁹ The Flood Disaster Protection Act of 1973 significantly overhauled the existing program and for the first time mandated participation for certain properties. Specifically, the 1973 law required borrowers at federally regulated financial institutions, who wished to finance properties located in a flood zone, to obtain catastrophe insurance for all personal property used as collateral to secure their loan. Institutions were required to monitor compliance with these provisions on all new loans, and were not allowed to extend, renew or increase existing loans unless participation in the NFIP was ensured. The new provisions appeared to increase participation rates, and the NFIP remained largely unchanged for the next twenty years.¹⁰

During the summer of 1993, the Midwestern United States was hit with some of the most devastating flooding ever recorded. Surprisingly, when the floods hit, less

than 20% of eligible structures within FEMA's flood zones were insured. This disaster highlighted key weaknesses in the FDPA of 1973, and once again led Congress to overhaul the NFIP. The NFIP was specifically designed to remedy two underlying causes of low participation: (1) lax enforcement by lenders; and (2) lapsed policies by homeowners. An important loophole in the NFIP, prior to the passage of the NFIR, was that many borrowers would obtain flood insurance when their mortgages were originated, only to subsequently allow their policies to expire. As long as the borrower made timely payments of principal and interest, lenders had little incentive to review individual loan files and monitor the status of insurance payments as few, if any, penalties were imposed for failure to comply. Also contributing to the lax supervision and monitoring of NFIP participation was the development and expansion of the secondary mortgage market. Originating lenders who sold their loans to Fannie Mae, Freddie Mac, or any other secondary market purchaser had their incentives to monitor reduced even further. To overcome these deficiencies, the Reform Act explicitly stated that insurance coverage must be documented throughout the life of the loan, it enhanced the penalties for non-compliance, and it extended the documentation requirements to federally regulated secondary market purchasers and government sponsored enterprises such as Fannie Mae and Freddie Mac. Early indications suggest that the Reform Act may indeed be contributing to increased participation in the NFIP. For example, the number of NFIP policyholders has increased 49.3%, from 2.76 million to 4.12 million, over the past five years, while the total amount of coverage on existing NFIP policies has increased 86.7% to over \$480 billion. Currently, the average NFIP policy covers just over \$117,000 worth of flood related losses. As expected, the increase in NFIP participation by homeowners has generated a substantial increase in premium revenue. Revenue from policy premiums has increased 86.6%, to nearly \$1.6 billion annually, since enactment of the NFIR. Currently, the average annual cost for \$100,000 of NFIP insurance is approximately \$330. Historical comparisons on the size and growth of the National Flood Insurance Program are presented in Exhibit 1.

Exhibit 1 | Growth of the National Flood Insurance Program

	1980	1990	1998
Policies in Force	2,058,601	2,415,883	4,117,936
Flood Loss Claims	47,983	21,176	75,663
Loss Dollars Paid (\$)	219,449,804	186,324,840	569,572,510
Policy Revenue (\$)	155,271,780	655,460,565	1,599,231,132
Total Coverage (\$)	93,963,333,000	210,005,953,000	482,576,897,000
Average Policy Coverage (\$)	45,644	86,927	117,189
Cost per \$1,000 of Coverage (\$)	1.65	3.12	3.31

Valuation Consequences of Flood Zone Location

Homeowners have long been concerned with the adverse valuation effects associated with environmental hazards such as the risk of flooding. Traditional economic theory suggests that the negative valuation effect should be equal in magnitude to the cost of eliminating the problem. In practice, it is impossible to entirely eliminate the risk of loss from flooding, however, the economic impact of such a catastrophe can be greatly reduced via the purchased of flood insurance. While insurance leads to only a mitigation, rather than an elimination of flood risk, valuation experts have used the availability of catastrophe insurance policies, such as those offered through the NFIP, as a foundation for estimating the market value of properties located within governmentally delineated floodplains. Specifically, these experts argue that the market value of a housing unit located within a flood zone should be equal to the value of an observationally equivalent housing unit not situated in such a region, less the discounted value of all future flood insurance premiums.

While intuitively appealing, an insurance cost based valuation proposition has limited applicability to the real world for numerous reasons. First, not all structures within flood zones require catastrophe insurance. Only properties with mortgages falling under the auspices of federally regulated financial institutions, or those acquired by government sponsored enterprises (GSEs) in the secondary market, are required to participate in the NFIP. Even under the stricter participation guidelines set forth via the NFIR, less than one-half of all structures located in 100-year flood plains are insured against flooding. From a highest and best use perspective, the lack of mandatory participation may have significant valuation implications. Consider, for example, the case of two prospective homebuyers, A & B, illustrated in Exhibit 2. Suppose buyers A & B are both evaluating a housing unit, which each would value at \$150,000 if it were located outside a floodplain. Furthermore, suppose that the structure is located within a FEMA designated high flood risk area (100-year flood plain) and that flood insurance is available to either borrower, in perpetuity, at a present value cost of \$5,000. Buyer A, believing that

Exhibit 2 | Comparison of Offer Prices for Differentially Informed Buyers Within a SFHA

	Buyer A	Buyer B
Value of unit in flood-free area (\$)	150,000	150,000
Present value cost of flood insurance (\$)	5,000	5,000
Personal expectation of the present value of flood losses (\$)	7,500	2,000
Does this buyer wish to purchase flood hazard insurance?	Yes	No
Expected offer price (\$)	145,000	148,000

expected losses from flooding will exceed the present value cost of insurance, is only willing to pay up to \$145,000 for the structure.¹¹ Buyer B, on the other hand, believes the present value of all future losses associated with flooding will total only \$2,000. If Buyer B is able to pay cash, or obtain financing outside the jurisdiction of the NFIR of 1994, he/she might be willing to pay up to \$148,000 for the structure. Clearly, sellers would prefer to transact with Buyer B, and the negative valuation effect of flood zone location would be less than the present value cost of catastrophe insurance. Without mandatory purchase requirements for all property owners of floodplain structures, the cost of flood insurance serves as only a limit, not a basis, for the negative valuation effect of the environmental hazard.

A second problem with the insurance cost paradigm is that not all structures within flood zones are fully insurable. Private flood insurance is difficult, if not impossible, to obtain; and the National Flood Insurance Program currently limits the amount of available coverage to \$250,000 for structures and \$100,000 for contents. If prospective purchasers of high-end properties cannot obtain adequate insurance, they will rationally reduce their offering price to account for this uninsurable component of flood risk. If the prospective buyer is risk averse, this offer price reduction will exceed the uninsurable expected loss from flooding as an uncertainty premium will be imputed into the calculation. Alternatively, if prospective buyers are sufficiently risk-averse, they may leave the market entirely, lowering the liquidity of properties, and expected value of future transactions, in environmentally sensitive regions.

Third, the insurance cost paradigm assumes both taxational efficiency and equality with regard to locational variations in selling prices. An evaluation of traditional assessment procedures questions the validity of this assumption. State and local taxing authorities typically rely on property value estimates, or assessments, as a foundation for determining property tax liabilities. For residential properties, assessors typically base their valuation estimates on mass appraisal techniques. While such methodologies may well call for a determination of whether each property is located within a FEMA special flood hazard area, it is unclear to what degree local municipalities actually do account for differential flood risk. To the extent that assessment methodologies are able to accurately gauge the valuation consequence of flood plain location, assessed values for property tax determination will remain unbiased. Unfortunately, given the irregular nature of many flood zone boundaries and uncertainty regarding the accuracy and flexibility of mass appraisal techniques, this assumption seems tenuous at best.

The implications of systematically inaccurate tax assessments, both overassessments and underassessments, are extremely relevant to the valuation question. Consider the scenario under which no adjustments are made for flood zone location. In this case, properties located in flood plains would be overassessed and their tax liabilities will be higher than that justified by their actual market values. This implies that purchasers of housing units located within the 100-year floodplain face the two-fold penalty of bearing flood risk and facing inequitably higher property taxes.

Now, consider the scenario under which adjustments reflecting differential flood zone locations are made to assessed property values based on the insurance cost model. As noted, the insurance cost should reflect the limit, not expected value, of the market value reduction from insurable flood losses. Therefore, adjustments using this methodology will overstate the true valuation effects, and property tax assessments for structures located within the floodplain will be disproportionately low. An unintended consequence of such a policy is that the construction and purchase of housing units within environmentally sensitive areas would effectively be subsidized. Shilling, Sirmans and Benjamin (1989) argue this is an undesirable outcome as societal flood costs are not limited to the insurable property damage, but also include the increased cost of providing emergency services in flooded areas, lost business or property tax revenue associated with flood events, and most importantly, the increased potential for the loss of human lives.

Finally, the identification of flood zone location is often a post contractual discovery. Many homeowners do not discover that the property they have already agreed to purchase is in a flood zone until after the appraisal or subsequent land survey. In the event that one or both parties to the transaction are unable, or unwilling, to recontract, transaction prices may not be fully representative of the intrinsic value of a given unit of housing. Even if recontracting is possible, adjustments may take the form of direct cash payments from sellers to buyers to facilitate the purchase of flood insurance. Again, such wealth transfers may not be reflected in readily observable transaction prices, but nonetheless represent a potentially important component of property valuation. Clearly, the valuation of structures located within the 100-year floodplain is a complex undertaking.

Data

To evaluate the valuation consequences of flood zone location on the market values of housing units and the locational equality of taxation with respect to environmental hazards, data were collected on every parcel of property in Alachua County (Gainesville) Florida from the Florida Department of Revenue's property tax master file. These files contain information regarding the location, lot size, structural characteristics, and two most recent selling prices and dates for every land parcel in the state. Each owner-occupied property in Alachua County that sold via an arms-length transaction between January 1, 1980 and December 31, 1997 was then geocoded and mapped against FEMA flood zone maps for the region to determine whether each parcel was within the 100-year floodplain. Descriptive statistics for each property characteristic, delineated by flood zone status, are provided in Exhibit 3.

An examination of the information reported in Exhibit 3 reveals that the typical SFHA property exhibits a slightly lower selling price (\$69,900 vs. \$73,600), is more likely to be located within the city limits of Gainesville (91% vs. 85%), is of a slightly newer vintage (10.6 years vs. 12.7 years), and is slightly smaller (70 sq. ft.) than its non-SFHA located counterparts. Differences in the average number

Exhibit 3 | Comparisons of Property Characteristics by Flood Zone Status

Variable	All Parcels		SFHA Parcels		Non-SFHA Parcels		t difference SFHA vs. Non-SFHA
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Selling price (\$)	73,114.95	45,592.53	69,878.29	37,154.33	73,571.94	46,643.68	-4.61***
Gainesville (%)	85.76	34.95	91.15	28.40	84.99	35.71	10.05***
Age (years)	12.45	11.69	10.58	9.07	12.72	11.99	-10.41***
Living area (sq. ft.)	1,633.57	570.00	1,571.61	528.82	1,642.32	575.05	-7.07***
Additional area (sq. ft.)	521.15	303.75	515.45	273.44	521.96	307.78	-1.21
Bedrooms (#)	3.02	0.62	2.96	0.61	3.02	0.62	-5.83***
Bathrooms (#)	1.96	0.52	2.00	0.43	1.95	0.53	5.16***
Lot size (acres)	0.33	1.49	0.20	1.31	0.34	1.51	-5.34***
Inside SFHA (%)	12.37	32.93	1.00	—	0.00	—	—

* Significant at the 90% confidence level.
 ** Significant at the 95% confidence level.
 *** Significant at the 99% confidence level.

Selling price = The selling price, in dollars, of the specified parcel of property;
Gainesville = A dummy variable equal to 1 if the parcel is located within the city limits of Gainesville (the county's primary metropolitan area), 0 otherwise;
Age = The age of the structure at the time of the transaction;
Living area = The primary living area of the structure in square feet;
Additional area = The additional improved area of the structure in square feet;
Bedrooms = The number of bedrooms contained in the unit;
Bathrooms = The number of bathrooms contained in the unit;
Lot size = The size of the lot in acres (0 if missing); and
Inside SFHA = A dummy variable equal to 1 if the parcel is located within a FEMA delineated Special Flood Hazard Area (100-year floodplain), 0 otherwise.

of bedrooms and bathrooms across flood zone status also appear statistically significant due to the size of our dataset, however, the typical unit in both locations contains approximately three bedrooms and two bathrooms, suggesting this statistical result is of questionable economic importance. In total, 12.37% (3,697 out of 29,881) of all arms-length property transactions in Alachua County Florida during our sample period involved properties located in FEMA delineated special flood hazard areas.

Methodology and Analysis

The analysis begins by examining the impact of flood zone location on housing values. Specifically, the structural characteristic determinants of housing prices in Alachua County are estimated using a standard hedonic pricing model of the following form:¹²

$$SP_i = f(YR_{t,i}, AGE_i, LOT_i, ZOL_i, LA_i, AA_i, BEDS_i, BATHS_i, CITY_i, FZ_i, FZX_i).$$

where:

- SP_i = Selling price of the i^{th} house;
- $YR_{t,i}$ = A series of dummy variables for each year between 1981 and 1997 taking on the value of 1 if the i^{th} transaction occurred in that particular year, 0 otherwise;
- AGE_i = The age of the i^{th} structure at the time of the transaction;
- LOT_i = The size of the i^{th} lot in acres (0 if missing);
- ZOL_i = A zero-order coefficient designed to control for missing values of lot size, the variable takes on the value of 1 if lot size is missing, 0 otherwise;
- LA_i = The primary living area, in square feet, of the i^{th} structure;
- AA_i = The additional improved area, in square feet, of the i^{th} structure;
- $BEDS_i$ = The number of bedrooms contained in the i^{th} structure;
- $BATHS_i$ = The number of bathrooms contained in the i^{th} structure;
- $CITY_i$ = A dummy variable equal to 1 if the i^{th} parcel is located within the city limits of Gainesville (the county's primary metropolitan area), 0 otherwise;
- FZ_i = A dummy variable equal to 1 if the i^{th} parcel is located within a FEMA delineated Special Flood Hazard Area (100-year floodplain), 0 otherwise; and
- FZX_i = A dummy variable equal to 1 if the i^{th} transaction took place after implementation of the National Flood Insurance Reform Act of 1994 and the i^{th} parcel is located within a FEMA delineated SFHA, 0 otherwise.

The results of three alternative model specifications following the above format

are presented in Exhibit 4. First, Column 1 is a presentation of the estimated model parameters using only transactions occurring before the passage of the National Flood Insurance Reform Act of 1994. The results are generally consistent with a priori expectations with respect to both the signs and magnitudes of the regression coefficients. Specifically, homes located within the city limits of Gainesville, and presumably better access to municipal services, command a premium of roughly \$10,000. Newer homes also command a premium, while an increase in the size of unit (both with respect to the primary living area and additional square footage) increases the market value of the structure. Additional bedrooms and bathrooms both increase transaction prices, while large lots also add to a parcel's value. With respect to environmental hazards, properties located within the 100-year floodplain are priced nearly \$1,000 lower than observationally equivalent housing units located outside an SFHA. This result, while only marginally significant, is consistent with expectations that the risk of loss from flooding will reduce the market value of properties susceptible to such hazards, but by an amount less than the present value cost of all future catastrophe insurance premiums. Column 2 is a listing of results for the post-Reform Act period of analysis. Interestingly, the regression results appear to be very consistent within this alternative time interval. Once again, it appears that buyers are willing to pay a premium for properties located within the city limits of Gainesville, for newer homes and for larger lots. Larger units, as well as those with more bedrooms and bathrooms, also command higher prices. Interestingly, the economic impact of flood zone location is significantly more pronounced during this post-Reform Act period. Constant quality housing units within FEMA delineated special flood hazard areas exhibit more than a \$2,000 discount, relative to their non-SFHA peers, in the post-1994 era. In sum, the results in the first two columns of Exhibit 4 suggest that the hedonic model study is relatively robust across estimation intervals and are consistent with the belief that the negative valuation consequences of being located within an SFHA are increasing.

Column 3 of Exhibit 4 contains estimates of this study's hedonic model, over the entire seventeen-year sample period. An interaction term is added to the specification to directly assess whether the valuation consequences of flood zone location have changed since passage of the NFIR. This additional variable, $SFHA*P94$, uniquely identifies those properties that are located within FEMA's 100-year floodplain *and* have transacted since 1994. This coefficient should pick up the additional importance, if any, of flood zone location on property valuations appearing subsequent to the regulatory revisions. Not surprisingly, the results for the individual property characteristics mirror those presented for each previously reported subsample. Homes within the city limits of Gainesville remain higher priced than those in greater Alachua County. Age remains inversely related to market value, while size (both lot size and structure size) remains a strongly positive determinant of housing values. Interestingly, the interactive term identifying recent flood zone transactions, $SFHA*P94$, is consistent with the hypothesis that the negative valuation consequences of flood zone location are more pronounced after the passage of the 1994 NFIR. Specifically, the results in

Exhibit 4 | Determinants of Residential Housing Prices

Variable	Pre-1994 NFIR	Post-1994 NFIR	Entire Sample Period
<i>Gainesville</i>	10,523.20 (17.55)***	13,730.26 (10.46)***	11,446.57 (19.57)***
<i>Age</i>	-546.34 (-26.64)***	-663.01 (-18.78)***	-612.91 (-33.58)***
<i>Living area</i>	34.15 (45.62)***	45.87 (29.07)***	37.50 (54.00)***
<i>Additional area</i>	18.74 (19.61)***	26.62 (13.88)***	21.20 (24.23)***
<i>Bedrooms</i>	701.61 (1.39)	1,119.75 (1.17)	830.19 (1.83)*
<i>Bathrooms</i>	3,436.75 (5.19)***	4,590.97 (3.67)***	3,757.34 (6.22)***
<i>Lot size</i>	936.27 (3.22)***	1,156.30 (1.80)*	1,067.17 (3.78)***
<i>SFHA</i>	-985.80 (-1.83)*	-2,126.60 (-2.09)**	-1,034.38 (-1.93)*
<i>SFHA*P94</i>	-	-	-1,858.92 (-1.61)
# of Observations	21,208	8,673	29,881
R ²	0.4802	0.4916	0.4934
F-Statistic	333.38***	318.90***	425.08***

Notes: The values in parenthesis are *t*-Statistics.
 * Significant at the 90% confidence level.
 ** Significant at the 95% confidence level.
 *** Significant at the 99% confidence level.

Independent Variables
Gainesville = A dummy variable equal to 1 if the parcel is located within the city limits of Gainesville (the county's primary metropolitan area), 0 otherwise;
Age = The age of the structure at the time of the transaction;
Living area = The primary living area of the structure in square feet;
Additional area = The additional improved area of the structure in square feet;
Bedrooms = The number of bedrooms contained in the unit;
Bathrooms = The number of bathrooms contained in the unit;
Lot size = The size of the lot in acres (0 if missing);
SFHA = A dummy variable equal to 1 if the parcel is located within a FEMA delineated SFHA (100-year floodplain), 0 otherwise; and
*SFHA*P94* = A dummy variable equal to 1 if the transaction took place after implementation of NFIR and the parcel is located within a FEMA delineated SFHA, 0 otherwise.

Unreported Independent Variables
Year 19XX = A series of dummy variables for each year between 1981 and 1997 taking on the value of 1 if the transaction occurred in that particular year, 0 otherwise;
ZOL = A zero-order coefficient designed to control for missing values of lot size, the variable takes on the value of 1 if lot size is missing, 0 otherwise; and
 Constant = A standard OLS intercept term equal to 1 for all observations.

Column three suggest that the negative valuation effects of flood zone location have nearly tripled in magnitude (from approximately \$1,000 to nearly \$3,000) since the Act's passage.

One potential explanation for the increased importance of flood zone status since 1994 is that increases in nominal housing prices have led to an increase in the nominal cost of insurance. While the hedonic regression models utilized here do control for differential sale years, and hence differential mean housing prices (appreciation) over time, they are potentially limited as they do not allow the magnitudes of individual parameter estimates to vary over time. Even a cursory glance at Exhibit 4 reveals that component costs for nearly every housing stock attribute increase in absolute volume between the pre- and post-1994 intervals. Theory suggests that as nominal house prices rise, the cost of flood insurance will rise commensurately, and hence the negative valuation effect, which the insurance cost model views as simply the present value of all future flood insurance premiums, will also increase over time.

Exhibit 5 contains estimates of the approximate change in flood insurance costs over the alternative time intervals. First, using previously estimated hedonic pricing models, the nominal cost of an equivalent unit of housing for each alternative time period is calculated, and then, an estimate of the associated flood insurance premium is calculated. The standard unit of housing for estimation purposes is a 10-year old structure, located on a 1/3 acre lot, within the city limits of Gainesville. The structure is assumed to have 2,000 square feet of primary living area, an additional 500 square feet of enclosed usable space, three bedrooms and two bathrooms. Substituting these attributes into the pricing model generates a cost estimate for equivalent housing units across alternative time intervals. As shown in Exhibit 5, the "standard" housing unit would have cost approximately \$75,000 prior to the 1994 Reform Act, and \$97,000 since that time. The contents of each unit are also insurable, and assuming a desired contents coverage ratio of forty cents contents coverage for every dollar of structure coverage, it is estimated that the total flood insurance coverage is approximately \$84,000 and \$109,000, respectively, for the two time periods. To arrive at an estimated annual insurance cost, the desired coverage amount is multiplied by the average cost per dollar of flood insurance.¹³ As indicated above, insurance costs have increased along with housing values over time. Next, the estimated present value of all future insurance premiums is calculated assuming a discount rate, in perpetuity, of 8%. It is important to note that, according to the insurance cost approach, this estimated present value of all future insurance premiums should equal the required adjustment to market value for our standard housing unit. Using this approach suggests that roughly 70% of the post-1994 increased valuation significance of flood zone location can be attributed to increased insurance costs resulting from higher nominal housing values. Examining the data more closely, it is noted that the hedonic adjustment for flood zone location as a percentage of the estimated present value cost of all future catastrophe insurance premiums has increased markedly (from 31.89% to 47.95%) since the passage of the NFIR.¹⁴ This finding

Exhibit 5 | Insurance Costs Estimates

Variable	Pre-1994 NFIR	Post-1994 NFIR
<i>Year built adjustment^a (\$)</i>	18,869.20	-9,974.75
<i>Gainesville (\$)</i>	10,523.20	13,730.26
<i>Age (\$)</i>	-5,463.41	-6,630.11
<i>Living area (\$)</i>	68,293.96	91,735.30
<i>Additional area (\$)</i>	9,372.58	13,310.81
<i>Bedrooms (\$)</i>	2,104.82	3,359.26
<i>Bathrooms (\$)</i>	6,873.50	9,181.94
<i>Lot size (\$)</i>	312.09	385.43
<i>SFHA adjustment (\$)</i>	-985.80	-2,126.60
<i>Regression constant (\$)</i>	-34,535.17	-15,593.23
<i>Average improved parcel cost (\$)</i>	75,364.97	97,378.31
<i>Less: value of land (\$)</i>	15,072.99	19,475.66
<i>Structural coverage desired (\$)</i>	60,291.98	77,902.65
<i>Contents coverage desired^b (\$)</i>	24,116.79	31,161.06
<i>Total catastrophe insurance desired (\$)</i>	84,408.77	109,063.71
<i>Average cost per \$1,000 of NFIP (\$)</i>	2.93	3.25
<i>Estimated annual insurance cost (\$)</i>	247.28	354.82
<i>Estimated present value @ 8% (\$)</i>	3,091.05	4,435.21
<i>SFHA adjustment as a % of present value cost of catastrophe insurance (%)</i>	31.89	47.95

^aYear built adjustment is equal to the average coefficient on each of the transaction year dummy variables for the designated time period.
^bDesired contents coverage is set at 40% of the structural coverage desired.

is consistent with a tightening of NFIP participation guidelines, bringing the housing market more into alignment with the insurance cost view, but also strongly suggesting that flood insurance premiums remain far from a binding constraint with respect to residential amenity valuation. While a sizable portion of the increased valuation effect of flood hazards on residential housing values may be attributable to an increase in nominal house prices, and thus the nominal cost of flood insurance/avoidance, the evidence suggests the NFIR had an important economic effect as well.

Finally, to examine the potential for disproportionate locational taxation due to the misvaluation of environmental hazards, the ratio of selling prices to assessed values is compared across flood zone classifications. In the state of Florida, as in

Exhibit 6 | Taxational Assessment Equity

Time Period	Price-Assessed Value Ratio	t difference SFHA vs. Non-SFHA
January 1, 1980 through December 31, 1997		
SFHAs (26,184 sales)	1.017	
Non-SFHAs (3,697 sales)	1.041	3.71*
Pre-NFIR		
SFHAs (18,420 sales)	0.984	
Non-SFHAs (2,788 sales)	1.003	2.70*
Post-NFIR		
SFHAs (7,764 sales)	1.117	
Non-SFHAs (909 sales)	1.129	0.88

Notes: The price-assessed value ratio data are means.
 *Significant at the 99% confidence level.

most states, property tax assessments are based on a linear function of a property’s estimated market value. Real property in Florida is supposed to be assessed at 100% of its true market value. As indicated by the results presented in Exhibit 6, flood zone properties appear to be overassessed relative to non-flood zone properties. This result is consistent across all three alternative estimation intervals, though the result is not statistically significant for the post-1994 interval, and suggests that tax assessors (and their agents) may not adequately adjust appraisal estimates to reflect the reduction in the market value associated with flood risk. The failure of such taxing authorities to properly recognize the true valuation implications of such environmental amenities may lead to a disproportionately high tax burden for owner-occupants of units within high flood risk areas. However, the statistical insignificance of this result in the post-1994 period may suggest that such differential taxation is becoming less pervasive over time, as presumably more local valuation experts are exposed to, and recognize, the valuation importance of environmental risk factors.¹⁵

Conclusion

What is the true impact of flood risk on residential land values? The evidence presented suggests that the market value discount applied to property transactions in flood prone areas is less than the present value cost of all future flood insurance premiums. This finding is consistent with the view that real estate transactions are based on a highest and best use value estimate, and stands in contrast to the insurance cost based view of flood hazard pricing. Interestingly, the relative importance of flood zone location appears to be increasing over time, particularly since the inception of the NFIR. While a substantial portion of the increased

market value discount in recent years may be attributable to corresponding increases in the nominal values of housing units, their contents, and thus flood insurance premiums, such factors are unable to account for the entire change in market dynamics. Specifically, it appears that increasingly stringent participation guidelines bring more potential buyers under the auspices of the NFIP, thereby increasing the probability that the highest bidder for a unit of housing located within a FEMA delineated SFHA will find the mandatory purchase of catastrophe insurance to be a binding valuation constraint. Finally, when examining the ratio of transaction prices to assessed values across flood zone classifications, it appears that owner occupants of floodplain locations may face slightly higher property taxes.

Clearly, the current investigation represents only the first step toward a complete understanding of the full implications of flood and other catastrophic risks on residential housing and mortgage markets. For example, the current investigation examines only one source of environmental hazard, that is, catastrophic flooding. Other environmental hazards, such as wind, drought, hail and other acts of nature could generate similar valuation consequences. In addition, the current investigation focused exclusively on housing prices and not appreciation rates. It is possible that the pattern of house price appreciation could vary systematically along environmental dimensions. It is quite plausible that, as market participants become increasingly aware of the valuation implications of environmental amenities, appreciation patterns across flood zone classifications may rationally, and systematically, differ. Finally, to the extent that existing mass appraisal techniques employed by local taxing authorities do not adequately capture the valuation consequences of environmental hazards, more accurate and flexible techniques must be developed. While each of the above issues is beyond the scope of the current investigation, they are indicative of the many potentially fruitful research dimensions remaining in this area. A more complete understanding of the environmental aspects of real estate valuation should ultimately enhance the efficiency of residential housing markets.

Endnotes

- ¹ See Shilling, Benjamin and Sirmans (1985), Shilling, Sirmans and Benjamin (1989), and MacDonald, White, Taube and Huth (1990) for examples of studies relating housing prices to the cost of obtaining hazard insurance. Skrantz and Strickland (1987) offer a unique twist on the insurance cost paradigm and test the efficiency of housing markets using a flood event. Interestingly, housing prices do not appear to decline after a flood event, however, when hazard insurance premiums rise, the higher costs do appear to be capitalized into housing values. Note, to the best of our knowledge, no major flood events were experienced in Alachua County during the sample period.
- ² See www.fema.gov and the authors' personal calculations.
- ³ An additional \$100,000 of coverage for the building's contents may also be purchased.
- ⁴ Conversations with residential appraisers suggest flood zone location is clearly recognized as a significant determinant of valuation estimates. Indeed, when asked the

relevance of flood risk, appraisers are quick to point out that the Uniform Residential Appraisal Report requires the identification of the parcel's flood zone classification. Interestingly, less uniformity is observed with respect to collection of corresponding information for comparable units. Specifically, while some argue that flood risk is an integral component of differential "location" value, others indicate that flood risk information is not collected for all comparable units used in the analysis. In the event that such information is not collected, subject property value estimates are based exclusively on the subject property's absolute flood risk and relative attribute bundles.

- ⁵ For example, Shilling, Benjamin and Sirmans (1985) use observations from only 114 properties (57 inside the 100-year floodplain, 57 outside the 100-year floodplain) located in Baton Rouge, Louisiana. Furthermore, Skrantz and Strickland (1987) examine only 133 homes within a flooded subdivision, and 50 additional units in a non-flooded control group (*i.e.*, 183 total observations are used). Similarly, Shilling, Sirmans, and Benjamin (1989) utilize a sample of only 114 transactions obtained from their local (*i.e.*, Baton Rouge, Louisiana) multiple listing service, while MacDonald, White, Taube, and Huth (1990) employ a sample of 301 observations obtained from property transactions in Monroe, Louisiana, during the first half of 1988. The 29,881 observations available in the current dataset clearly represent the largest dataset, to date, used to examine the valuation consequences of flood hazard risk.
- ⁶ SFHAs are commonly referred to as being in the 100-year flood plain, and are defined as those areas exhibiting a 1% (or greater) chance of flood occurrence in any particular year.
- ⁷ For further details regarding the early development, successes and failures of the NFIP see Felton, Ghee and Stinton (1971), Anderson (1974), Pritchett and Rubin (1975) and Power and Shows (1979).
- ⁸ See www.fema.gov.
- ⁹ Over the past twenty years, the NFIP has processed nearly 1 million flood insurance claims and paid out approximately \$8.7 billion (www.fema.gov).
- ¹⁰ The program was modified slightly in 1989 to allow, but not require, NFIP participation for structures located outside of SFHAs. Today, as a general rule, flood insurance is available on all structures, regardless of flood zone status, in participating communities.
- ¹¹ Financing constraints on Buyer A, in which they are only able to obtain credit if flood insurance is purchased, would lead to this same result.
- ¹² For examples of how similar hedonic regression models have been implemented, see Gatzlaff and Ling (1994). Note, dozens of empirical investigations document the importance of a wide-array of additional transaction-specific value determinants such as selling time, school quality/choice, water views, etc. For example, recent evidence by Glower, Haurin and Hendershott (1998) suggests that time on the market and seller motivation are significant determinants of observed transactions prices. Similarly, Benson, Hansen, Schwartz and Smersh (1998) find water views enhance property values, while Woolf, Ramagopal and Harrison (2000), report homes in areas characterized by school choice (*i.e.*, voucher programs) exhibit higher prices. To the extent that flood zone location is correlated with omitted value determinants such as, but not limited to, those mentioned above, estimates of the valuation consequences of flood hazard risk may suffer from an omitted variables bias. As with most hedonic pricing models, multicollinearity is also of potential concern in the current investigation. Specifically, the correlation coefficients on four pairs of independent variables exceed 0.3 in absolute value (LA & $BATHS = 0.65$, LA & $AA = 0.62$, AA & $BATHS = 0.54$, and $BATHS$ &

$AGE = -0.31$). Fortunately, while little can be done to explicitly correct for multicollinearity within the dataset, the regression results appear robust to both the exclusion of the number of bathrooms within the unit, as well as the use of only one (*i.e.*, AA , LA or $AA + LA$) square footage metric. In addition, White's correction is employed to provide consistent standard errors in the presence of possible heteroskedasticity. Finally, due to NFIP insurance limitations, properties located within the 100-year flood plain and characterized by assessed values in excess of \$250,000 have been eliminated from the analysis. This criterion led to the elimination of six observations.

- ¹³ The average cost per dollar of flood insurance was calculated directly from FEMA files on insurance coverage and policy premiums. It is defined as the total coverage offered by all existing NFIP policies divided by the total annual policy premium revenues. This ratio is calculated separately for each estimation interval.
- ¹⁴ It is also of interest to note that the percentage of all arms-length property transactions in Alachua County Florida involving parcels located within SFHAs has dropped from 12.15% before passage of the NFIR to 9.82% in the post-1994 era. This change is statistically, as well as economically, significant.
- ¹⁵ As noted by an anonymous referee, a series of judicial rulings in the early 1990s increased pressure on local tax assessors within Florida to comply with state laws mandating assessment at 100% of fair market values. To the extent that the distribution of properties (across flood zone classifications) that were reassessed to comply with these rulings differs from the underlying distribution of all structures, the increased "equality" of assessments may well be attributable to the general increase in assessment rates rather than a changing recognition of flood risk valuation consequences. Unfortunately, the existing dataset does not contain information regarding historical assessed values, thereby leaving us unable to empirically differentiate between alternative explanations for the observable increase in assessment equality.

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*David M. Harrison, University of Vermont, Burlington, VT 05405–0157
harrison@bsadpo.emba.uvm.edu.*

*Greg T. Smersh, University of South Florida, St. Petersburg, FL 33701
smersh@bayflash.stpt.usf.edu.*

*Arthur L. Schwartz, Jr., University of South Florida, St. Petersburg, FL 33701
schwartz@bayflash.stpt.usf.edu.*