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Does Small Dam Removal Affect Local Property Values? An Empirical Analysis

By

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Does Small Dam Removal Affect Local Property Values? An Empirical Analysis

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Abstract

This paper uses hedonic analysis to examine the impact of small dam removal on property values in South-central Wiscosin. Data on residential property sales were obtained for three categories of sites: those where a dam is intact, those where a dam was recently removed, and those where the stream has been free-flowing for at least 20 years. The primary conclusions that emerge from the data are that residential property located in the vicinity of a free-flowing stream is more valuable than identical property in the vicinity of a small impoundment, and that shoreline frontage along small impoundments confers no increase in residential property value compared to frontage along free-flowing streams.

I. Introduction

It is estimated that more than 400 dams have been removed from US streams and rivers since the 1920s, with the majority of removals taking place after 1970 (Pohl, 2003). The decision to keep and repair a dam or to remove the structure and restore river habitat is necessarily a complex one that involves engineering, environmental, economic and social considerations. These decisions are frequently contentious, confounded not just by technical concerns but by social ones as well. A growing body of literature examines in detail many of the issues concerning dam removal (River Alliance of Wisconsin and Trout Unlimited, 2000; Gaylord Nelson Institute for Environmental Studies, 2001; American Rivers, 2002; H. John Heinz III Center, 2002; H. John Heinz III Center, 2003).

One of the most vexing issues concerning dam removal is the impact on local property values. Frequently, property owners who view their property as “lake” frontage rather than river frontage fear that the value of their property will decline with the loss of the dam and its associated impoundment (Born et al., 1998). To date, there has been no formal study of the effect of dam removal on local property values, and only a couple of informal examinations of this issue (Sarakinos and Johnson, 2003; Graber et al. 2001).

The most common method for determining the effect on residential property values of a public project such as dam removal is hedonic analysis, which conceives of a residential property as a set of attributes including structural attributes such as square footage and number of bathrooms, and neighborhood characteristics such as crime rates and school quality. In the current context, the presence/absence of a dam, and the distance between a property and the impoundment, are hypothesized to be among the neighborhood attributes affecting property values. Hedonic analysis applies statistical techniques to market data to determine the relative contribution to property values of the various property attributes. This is the approach taken in the study of small dam removal presented here. The analysis includes market sales data over the period 1993-2002 for three types of sites in south-central Wisconsin: those where a small dam remains intact, those where a small dam was recently removed, and those where a river or stream has been free-flowing for more than 20 years. Including all three types of sites allows us to separately identify the relative effect on property values of an intact small dam/impoundment.

II. Data and Estimated Models

Data

Hedonic analysis of residential property requires that all properties used in the analysis are from a single residential market (see, for instance, Haab and McConnell, pg. 253). Defining the geographic boundaries of a housing market is of course a subjective matter. In our study we focus on the “Madison” housing market, defined as that portion of south-central Wisconsin within commuting distance of Madison, Wisconsin. The Madison market has seen a relatively large number of small dams removed since 1990.

Figure 1 presents the locations of the fourteen sites in south-central Wisconsin used in the study. They are located in five counties and for our purposes are grouped into three categories: 1) six sites had dams removed during 1995-2000 (hereafter called “removed” sites, 2) four had intact

Study Sites
Southcentral Wisconsin

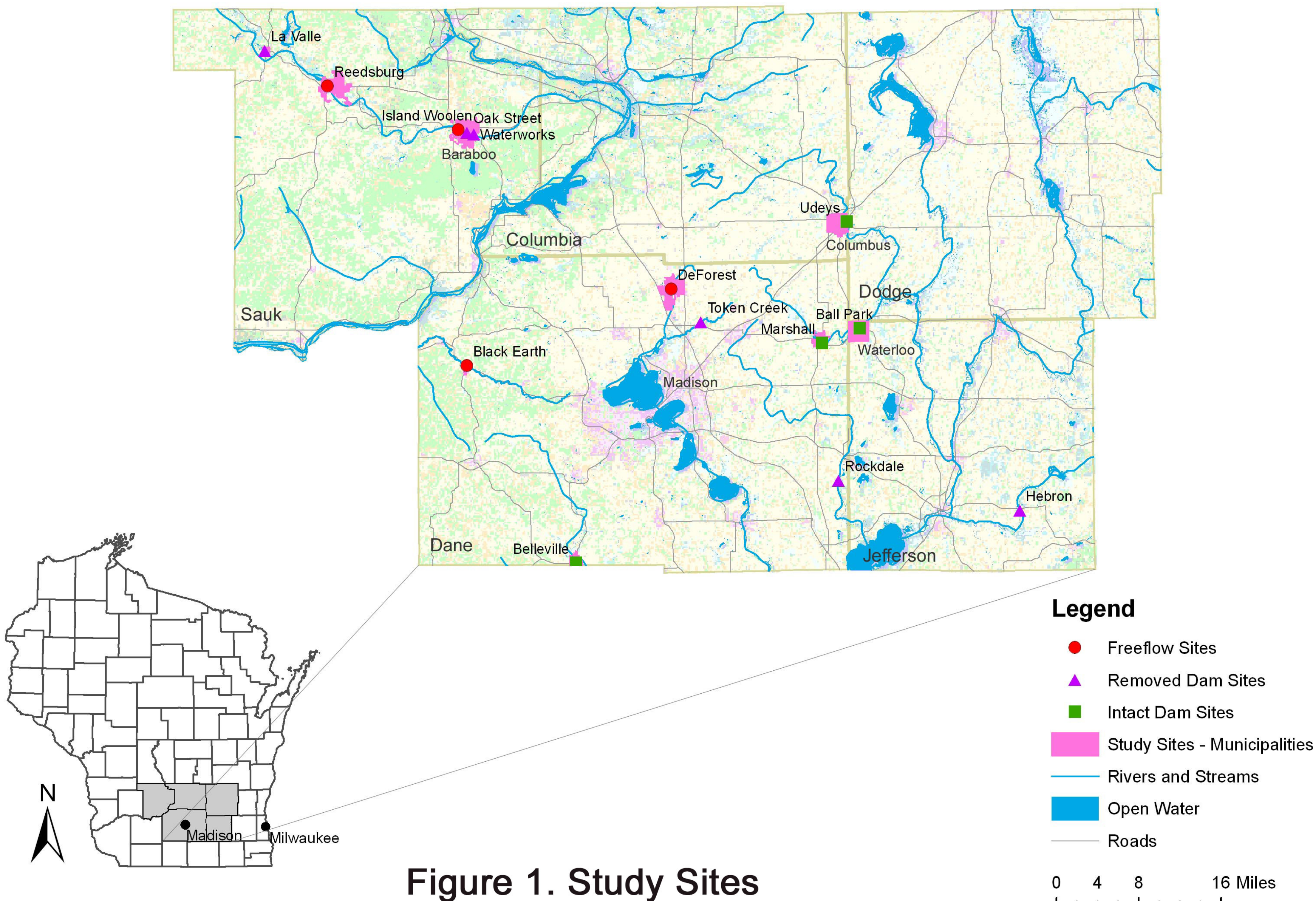

Figure 1. Study Sites

dams during the study period ("intact" sites), and 3) four have free-flowing river sections passing through the municipality ("free-flowing" sites). Free-flowing sites have either never had a dam, or if they did, the dam was removed at least 20 years ago. Table 1 contains a brief overview of the study sites.

All sites are comprised predominantly of year-round residential properties rather than vacation homes. All are located in small municipalities. Six of the sites can be categorized as former mill towns, in the sense that a commercial/industrial district developed along the millpond formed by the dam, with the older residential district typically ¼-mile or more away from the river. At the remaining four removed/intact sites the waterfront is dominated by residential, rather than commercial/industrial, properties. Virtually all of the sites have open space or park lands along some portion of the waterfront. The village of Baraboo has three sites in the study; an upriver free-flowing site, and two downstream removed sites.

Table 2 provides stream and impoundment characteristics. All existing and former impoundments in the study can be categorized as small, given their range of surface areas (8 to 194 acres), and range of maximum depths (5 to 15 feet). In none of the impoundments is the water especially clear in midsummer; secchi depths range from 1.5 to 2.4 feet. The two largest impoundments, Belleville and Marshall, are both intact dam sites.

The unit of observation in the study is a single-family residential property within ¼ mile of a study site water body. For removed and intact sites, observations are within a ¼ mile of the existing or former impoundment, or within ¼ mile of the first mile of stream below the dam. For free-flowing sites, observations are within ¼ mile of a two-mile stretch of the stream. Observations were limited to parcels of one acre or less, to minimize the confounding effects in the hedonic analysis of future development potential.

The single-market requirement of hedonic analysis is temporal as well as spatial; a house sold in 1950 is not in the same market as one sold in 2000. Yet as with any statistical analysis, the more observations the better, and this consideration advocates for stretching the time frame of the analysis. Moreover, there is considerable information to be gained form collecting observations before and after dam removal at removed sites. The time frame in our study is 1993-2002, which provided us with both adequate sales data and good temporal bracketing of dam removal at removed sites (see Table 1 for dam removal dates). To accommodate temporal shifts in the residential property market over the study period, we included annual dummy variables in the hedonic analysis. To avoid conflating the immediate effect of dam removal with the longer-term changes in property values associated with the evolution of the riparian zone to a free-flowing stream, observations at removed sites were collected only for the 5-year period centered on the year the dam was removed. So, for instance, data at the Token Creek site were collected only for the period 1997-2001. In total, 773 observations were used in the analysis, of which 116 were frontage parcels and 657 were nonfrontage parcels. Table 3 provides a breakdown of the observations for each study site. The most obvious weakness of the data is the lack of frontage observations at removed sites. As discussed shortly, this impacted the hedonic analysis we were able to conduct.

All variables used in the estimation are for the year of sale. The data were typically found through Geographic Information Systems (GIS), GIS webviewer applications, hard copy maps, deeds, and tax rolls. The set of observations includes only “arm’s length” transactions (sales between unrelated parties). Many waterfront sales were not admissible because they were either family exchanges (non-arm’s length sales), or the grantee was the village or town.[1]

Table 1. Overview of Study Sites

Site No.	Dam Name	Site Type	Removal Date [1]	Municipality	Population [2]	County
1	Rockdale	Removed Dam	June 2000	Rockdale	214	Dane
2	Token Creek	Removed Dam	Dec 1999	N/A [3]	N/A	Dane
3	Oak Street	Removed Dam	Dec 2000	Baraboo	10,711	Sauk
4	Waterworks	Removed Dam	Dec 1998	Baraboo	10,711	Sauk
5	LaValle	Removed Dam	Oct 2000	LaValle	326	Sauk
6	Hebron	Removed Dam	Aug 1996	Hebron [4]	243	Jefferson
7	Belleville	Intact Dam	N/A	Belleville	1,908	Dane
8	Marshall	Intact Dam	N/A	Marshall	3,432	Dane
9	Ball Park	Intact Dam	N/A	Waterloo	3,259	Jefferson
10	Udeys	Intact Dam	N/A	Columbus	4,479	Columbia & Dodge
11	Black Earth	Freeflowing Stream	1957	Black Earth	1,320	Dane
12	Island Woolen Mill	Freeflowing Stream	1972	Baraboo	10,711	Sauk
13	Reedsburg Dam	Freeflowing Stream	1973	Reedsburg	7,827	Sauk
14	N/A	Freeflowing Stream	N/A	DeForest	7,368	Dane

[1] Source: Wisconsin Department of Natural Resources Dams Safety Program Database 01/2006
[2] Source: U.S. Census Bureau, Census 2000
[3] Cluster of residences located within Towns of Burke and Windsor
[4] Per Census 2000, Hebron designated as a statistical entity comprising a densely settled concentration of population that is not within an incorporated place, but is locally identified by a name.

Table 2. River and Impoundment Characteristics

Site No.	Dam Name	Impoundment Surface Area [1] (acres)	Impoundment Normal Storage [1] (acre-ft)	Impoundment Max Depth [1] (ft)	Secchi Depth [2] (ft)	Stream	Watershed Basin	Mean Monthly Discharge (Min-Max) (cfs)
1	Rockdale	104	170	5	2.2	Koshkonog Creek	Lower Rock	45.3 - 169 [3]
2	Token Creek	23	50	6	2.3	Token Creek	Lower Rock	18.5 - 32.8 [4]
3	Oak Street	16	60	7	N/A	Baraboo	Lower	248 - 798 [5]

[1] In this latter case the parcel became tax-exempt, and so court records no longer included data on the value of improvements; such data were necessary for our analysis).

						River	Wisconsin	
4	Waterworks	47	190	12	N/A	Baraboo River	Lower Wisconsin	248 - 798 [5]
5	LaValle	21	60	6	2.2	Baraboo River	Lower Wisconsin	248 - 798 [5]
6	Hebron	28	100	15	2.5	Bark River	Lower Rock	64.9 - 144 [6]
7	Belleville	112	260	7	1.5	Sugar River	Sugar-Pecatonica	85 - 222 [7]
8	Marshall	194	320	15	2.4	Maunesha River	Upper Rock	N/A
9	Ball Park	8	15	5	2.4	Maunesha River	Upper Rock	N/A
10	Udeys	26	90	10	N/A	Crawfish River	Upper Rock	18 - 105 [8]
11	Black Earth	N/A	N/A	N/A	N/A	Black Earth Creek	Lower Wisconsin	29.3 - 47.6 [9]
12	Island Woolen Mill	N/A	N/A	N/A	N/A	Baraboo River	Lower Wisconsin	248 - 798 [5]
13	Reedsburg Dam	N/A	N/A	N/A	N/A	Baraboo River	Lower Wisconsin	248 - 798 [5]
14	N/A	N/A	N/A	N/A	N/A	Yahara River	Lower Rock	15.9 - 37.6 [10]

[1] Source: Wisconsin Department of Natural Resources Dams Safety Program Database 01/2006
[2] Source: University of Wisconsin-Madison, Environmental Remote Sensing Center, www.landsat.org
[3] Source: nearest inactive USGS Gaging Station 05427507, Koshkonong Creek, near Rockdale, WI (period of record: 11/01/76-10/21/82)
[4] Source: nearest inactive USGS Gaging Station 05427800, Token Creek near Madison, WI (period of record: 07/28/64-12/31/80)
[5] Source: nearest active USGS Gaging Station 05405000, Baraboo, WI
[6] Source: nearest USGS active Gaging Station 05426250, Rome, WI
[7] Estimated flows at Hwy 69 Bridge in Belleville, WI based on data from active USGS gaging station 05436500 Source: "Definite Project Report with Integrated Environmental Assessment: Public Review Draft", Army Corps of Engineers, June 2003
[8] Source: Inspection and Evaluation Study (Final): Udey Dam, Mead & Hunt, September 2005
[9] Source: nearest active USGS Gaging Station 05406500, Black Earth, WI
[10] Source: nearest active USGS Gaging Station 05427718, Windsor, WI

Table 3. Observations Tally

Site No.	Dam Name	Stream	Site Type	Frontage Observations	Nonfrontage Observations	Total Observations
1	Rockdale	Koshkonog Creek	Removed Dam	2	14	16
2	Token Creek	Token Creek	Removed Dam	0	27	27
3	Oak Street	Baraboo River	Removed Dam	4	42	46
4	Waterworks	Baraboo River	Removed Dam	0	42	42
5	LaValle	Baraboo River	Removed Dam	0	41	41
6	Hebron	Bark River	Removed Dam	0	2	2
7	Belleville	Sugar River	Intact Dam	11	56	67
8	Marshall	Maunesha River	Intact Dam	39	113	152
9	Ball Park	Maunesha River	Intact Dam	5	56	61
10	Udeys	Crawfish River	Intact Dam	12	62	74
11	Black Earth	Black Earth Creek	Freeflowing Stream	0	56	56

12	Island Woolen Mill	Baraboo River	Freeflowing Stream	11	52	63
13	Reedsburg Dam	Baraboo River	Freeflowing Stream	2	29	31
14	N/A	Yahara River	Freeflowing Stream	30	65	95
			Total Observations Used in Analysis	**116**	**657**	**773**

Form of the Hedonic Price Function

The underlying premise of the hedonic price function is that a residential property is a collection of attributes, each with an implicit price. Rosen (1974) is the classic reference, and Freeman (1993) provides a good discussion.

The dependent variable in the hedonic model is the sale price of the property. Following Papenfus and Provencher (2006), we do not include features of the residential structure, such as square footage and the number of bedrooms, as explanatory variables, but instead include as an explanatory variable the assessed value of improvements to the land as a proxy for the value of the residential structure and other improvements. The underlying perspective of this approach is that assessors accurately judge the value of improvements, up to a factor of proportionality to be estimated in the model.

As explicitly assumed in tax assessments, we treat the market value of residential property as the sum of the value of land and improvements. Letting $f(\mathbf{x})$ denote a parcel's land value, where $\mathbf{x}$ is a vector of parcel characteristics, and letting IMPROVE denote the assessed value of improvements on the parcel at the time of sale, we have the hedonic form,

$$P = f(\mathbf{x}) + \alpha \cdot IMPROVE + \varepsilon \qquad (1)$$

where α is the factor of proportionality to be estimated, and ε is a random component accounting for unobserved variability in residential property prices.

In preliminary estimation, we tried several forms for the land value function $f(\mathbf{x})$; all of them gave qualitatively similar results. A simple linear form is problematic, as it assumes that the marginal value of an increase in a property characteristic is constant and unrelated to the values of other characteristics, though quadratic and interaction terms can be added to capture important nonlinearities. An alternative model is one in which $f(\mathbf{x})$ takes an exponential form, ($f(\mathbf{x}) = e^{\beta\mathbf{x}}$). We report results for two models, one where $f(\mathbf{x})$ is linear and the other where it is exponential.

Brief Discussion of Variables Affecting Property Values

Table 4 provides definitions for the vector $\mathbf{x}$ used in estimation. Table 5 provides means and standard deviations for a selected set of these variables. Here we discuss the variables that bear immediately on the question of the effect of dam removal on residential property prices.

Dummy variables distinguish the state of sites at the time of a property sale. FREEFLOW takes a value of 1 if a site is a free-flowing site, and 0 otherwise. INTACT takes a value of 1 if a dam was intact at the site at the time of sale, and 0 otherwise. Clearly, all observations at intact sites take a value of 1 for this variable, and importantly, so too do observations at removed sites *if* the sale took place before the dam was removed (recall that the set of observations at removed sites includes sales made both before and after dam removal). This leaves a third category of observations –those made at removed sites in the two years following dam removal –that serves as a baseline reference category in the estimation of the hedonic price function.

We include two variables used to capture the effect of shoreline frontage across all sites (FRONTDUM, LNFRONT), and two dummy variables to examine the particular effect of frontage in the presence of a dam: INTACT-FRONT applies to the subset of INTACT properties with shoreline frontage, and INTACTUP applies to the subset of such properties with shoreline frontage *upstream* from the dam.[2] Note that we do not include a dummy variable analogous to INTACT for shoreline frontage at free-flowing sites. If we included such a variable, the baseline for comparison among shoreline properties would be shoreline properties sold after removal of a dam, yet we have only six such properties in our sample –far too few to provide a reliable point of comparison.[3] Consequently, the coefficients on INTACT-FRONT and INTACTUP are effectively the premiums fetched by shoreline frontage in the presence of an intact dam compared to shoreline frontage along a free-flowing stream.

Table 4. Variables Used in the Hedonic Models

Variable	Definition
PRICE	Sale price in 2005 dollars
C	Intercept term
H2ODIST	Distance from the property to the water body, in feet
FRONTDUM	Dummy variable taking a value of 1 if the property has water frontage
LNFRONT	Natural Log of frontage, in feet
DISTMSN	Distance from the site to Madison, in miles
DISTMKE	Distance from the site to Milwaukee, in miles
LNLOTSIZE	Natural log of the lot (parcel) size, in acres
INTACT	Dummy variable taking a value of 1 if the site had an intact dam at the time of sale
INTACT-FRONT	Interaction between FRONTDUM and INTACT
INTACTUP	Dummy interaction between INTACT-FRONT and a dummy variable taking a value of 1 if the property is located upstream of the dam
FREEFLOW	Dummy variable taking a value of 1 if the site is a free-flowing site (see text)
TSALE	Year of sale index, with 1992=0, 1993=1, etc.
IMPROVE	Assessed value of the improvement in the year of sale, in 2005 dollars

Table 5. Descriptive Statistics for Selected Variables

Variable	Mean	Standard Deviation
PRICE	112,247	59,093
H2ODIST	642.1	463.5
FRONTDUM	0.1500	.3574
FRONT (conditional on >0)	114.9	50.60
DISTMSN	29.14	15.63
DISTMKE	93.16	25.71
LOTSIZE	0.3251	0.1857

[2] Recall that the sample includes sales downstream of the dam.
[3] By comparison, our sample includes 65 frontage properties where the dam is intact at the time of sale, and 45 frontage properties at free-flowing sites.

INTACT	0.5783	0.4942
IMPROVE	69,399	46,218

III. Estimation results

Estimation results are presented in Table 6. The first model is linear in parameters, and the second model, which hereafter we refer to as the exponential model, is separable in land and improvements, with the value of land captured by an exponential term, as described previously. We initially focus on results for the linear model, and then turn to the question of whether results from the exponential model are substantially different than those from the linear model.

Linear Model

The coefficient on IMPROVE is the factor of proportionality that corrects for systematic bias in assessments of residential structures (Equation (1)). When this factor equals 1, the assessment accurately captures the value of improvements, on average. A value greater than 1 indicates a systematic underassessment, and a value less than 1 indicates a systematic overassessment. Estimation results indicate that on average structural improvements are over-assessed by about 22%, though this does *not* imply that the property itself is over-assessed (the land may be typically under-assessed). The coefficient on TSALE indicates that each year the value of land in the study increased by $1947 on average. Distance to Madison reduces the value of property at the rate of $823 per mile, and distance to Milwaukee reduces the value of property at a rate of $233 per mile. Together, these results indicate that all else equal, a property that lies 30 miles outside of Madison, but directly towards Milwaukee, has a value $17,700 less than an identical property in Madison, while a property that lies 30 miles outside of Madison, and directly away from Milwaukee, has a value $31,680 less than an identical property in Madison. The coefficient on LNLOTSIZE indicates that increasing lot size from ¼ acre to ½ acre increases the value of a property by $12,580.

The positive sign on H2ODIST, and the nonsignificance of FRONTDUM and LNFRONT, conflict with the intuition of most observers that a location on or near a body of water confers a price premium. Yet the literature is actually mixed on the effect of distance to water on household welfare. Consistent with intuition is the analysis of Stumborg et al. (2001), who find that distance to a large lake (Lake Mendota in Madison, Wisconsin) has a negative effect on household willingness to pay for reductions of phosphorus loading of the lake, presumably because households closest to the lake value improvements to the lake most highly. Moore et al. (2006) find a similar result for Green Bay, Wisconsin. In a hedonic examination of property values in the vicinity of Lake Austin, a 1600 acre reservoir on the Colorado River in Austin, Texas, Lansford and Jones (1995) also find that distance to the reservoir has a negative effect on property values. By contrast, Chattapodhyay et al. (2005) find that property values rise with distance from Waukegon Harbor, a Superfund site on Lake Michigan.

Perhaps the most interesting results related to the current study are those obtained by Mahan et al. (2000). The authors find that the effect of the distance of a residence to a wetland depends on the wetland type (open vs. forest vs. scrub-shrub vs. emergent) and shape (linear, such as along a stream, vs. a polygonic "areal" shape). The authors find, for instance, that property values fall with distance to an areal open wetland, but rise with distance to a linear open wetland. Bin (2005) finds that proximity to an open wetland has a positive effect on property value, while proximity to three other types of wetlands –the same types used in Mahan et al –has a negative effect on property values.

In light of the available literature, there are two plausible explanations for the results concerning H20DIST, FRONTDUM, and LNFRONT. The first is that these results simply reflect the dominance of negative effects associated with proximity to the types of water bodies in our study. Such effects include the risk of flood damage, perennial damage issues such as water seepage into basements, mosquito infestations on impoundments, foul odors associated with algae blooms and decaying vegetation, and so on, as well as effects arising from legal restrictions on the use of land near waterways, some of which are imposed to mitigate the above-mentioned negative effects, such as rules concerning housing construction on flood plains, or rules to reduce eutrophication of an impoundment . It is worth emphasizing that many of the reservoirs formed by impoundments at the study sites are quite small and shallow (Table 2).

An alternative explanation is that the model is misspecified. In particular, because the commercial district is adjacent to the waterway at a number of the study sites –many of the impoundments were originally created in the service of a mill, and historically these mills anchored a village's commerce –the effects on property value of H2ODIST, FRONTDUM, and LNFRONT are confounded by their collinearity with the distance between the residence and the commercial district, a relationship that we do not include in the model. One might expect that the greater the distance between a residential property and the village's commercial district, the higher the property price, at least in the range of the distances covered by our data (all properties are within a quarter-mile of the waterway). If this is the case, the positive sign on H2ODIST, and the nonsignificance of FRONTDUM and LNFRONT, may reflect the confounding influence of proximity to the commercial district.

To explore this possibility, we developed a dummy variable for those sites where the commercial district was clearly not along the waterway, and then re-estimated the models (linear and exponential) with interactions between the dummy variable and the variables H2ODIST, FRONTDUM, and LNFRONT.[4] In neither of these amended models were the interactions statistically significant, either alone or as a group, lending some measure of support to the conclusion that the results reported in Table 3 are "real". At the very least, the results raise doubts that the value of shoreline property along small impoundments and streams in the study area is much higher than neighboring property.

The result for the variable INTACT indicates that a property within a quarter mile of an impoundment is no more valuable than a similar property at a site where a dam was recently removed. By comparison, the statistically significant coefficient on FREEFLOW, along with the nonsignificance of INTACT, indicates that a property within a quarter mile of a free-flowing river is worth roughly $13,700 more than a similar property at a site of a recently removed *or current* impoundment.

[4] The sites identified as having no (or very little) commercial property along the waterway were Black Earth, Deforest, Island Woolen, Marshall, and Token Creek.

Finally, the coefficients on INTACT-FRONT and INTACTUP are not statistically significant, indicating that holding frontage at an impoundment confers no price premium relative to holding frontage along a free-flowing river.

Exponential Model

The exponential model generates results qualitatively similar to those found for the linear model. The coefficient on IMPROVE is nearly identical to that in the linear model. The coefficient on LNLOTSIZE has the expected sign, and indicates that increasing a lot from ¼ acre to ½ acre increases the land value of property (that is, the value of the property net the value of the structure) by about 16%. At the estimated median land value in the sample ($35,900), this is an increase of $5744. The coefficient on TSALE indicates that residential land values rise at 3.9% per year after inflation ($1400 at the median price). As in the linear model, H2ODIST has a positive effect on property prices. In this model, increasing the distance to shoreline from >0 (just off the shore) to 1/8 mile increases the value of land by 10.8%, or $3880 at the sample median land price.

The biggest difference between this model and the linear model is the statistically significant effect of frontage on land price, as indicated by the statistical significance of the coefficients on FRONTDUM and LNLOTSIZE, though the practical effect of frontage would appear to be generally small, and counterintuitive at the margin. A property with a median amount of frontage (118 feet) is 3.9% more valuable than a similar property without any frontage ($1390 at the median land price). Yet in the range of the data the predicted marginal effect of frontage is actually negative; the model predicts that properties with 81 feet of frontage (the 25^{th} percentile of frontage properties) are 12.3% more valuable than properties without frontage, while properties with 136 feet of frontage (the 75^{th} percentile of frontage properties) are only 0.9% more valuable.

As with the linear model, this model provides evidence that a free-flowing river adds value to a nearby property (a property within ¼ mile) compared to the baseline (that is, a property sold after removal of a nearby dam). The median property is worth $13,900 more at a FREEFLOW site. On the other hand –and again, as with the linear model –the model provides no statistical evidence that residential property in the vicinity of an existing impoundment adds value to a property compared to the baseline scenario (INTACT is not statistically significant). Nor is there statistical evidence that frontage property in the vicinity of a small dam is more valuable than frontage property on a free-flowing river (INTACT-FRONT and INTACTUP are not statistically significant, either together or individually).

Table 6. Estimation Results

Variable	**Linear Model**		**Exponential Model**	
	Coefficient Estimate	**Standard Error**	**Coefficient Estimate**	**Standard Error**
C	104,750.**	10,140.	11.774**	0.2103
H2ODIST	8.5776**	3.176	$1.5567 \cdot 10^{-4}$ *	$0.7730 \cdot 10^{-4}$
FRONTDUM	39,024.	36,890.	1.0303**	0.36164
LNFRONT	-7188.1	7435.	-.20798**	.07474
DISTMSN	-822.77**	113.6	$-2.0106 \cdot 10^{-2}$ **	$0.3449 \cdot 10^{-2}$

DISTMKE	-232.89**	75.37	$-4.3767 \cdot 10^{-3}$ **	1.82610^{-3}
LNLOTSIZE	18,151**	2979.	.31718 **	0.04782
INTACT	-1043.0	3419.	$4.5807 \cdot 10^{-2}$	$9.379 \cdot 10^{-2}$
INTACT-FRONT	-5620.4	12,840.	$4.4254 \cdot 10^{-2}$	$30.12 \cdot 10^{-2}$
INTACTUP	-400.92	10,980.	$-5.4786 \cdot 10^{-2}$	$30.27 \cdot 10^{-2}$
FREEFLOW	13,733.**	4194.	0.32696 **	0.09635
TSALE	1947.0**	606.0	$3.9378 \cdot 10^{-2}$ **	$0.8469 \cdot 10^{-2}$
IMPROVE	0.78650**	0.05283	0.78724 **	0.03056

* Signifcant at .05 level; ** Significant at .01 level

IV. Discussion

The general conclusion that emerges from the data is that shoreline frontage along small impoundments confers no noticeable increase in residential property price compared to frontage along free-flowing rivers, and that residential property located in the vicinity of a free-flowing river is more valuable than identical property located in the vicinity of an impoundment. Moreover, although the analysis is cross-sectional, the results are consistent with the conclusion that removing a dam does little harm to property values in the short run (2 years in the study), and serves to increase property values in the long run, as the stream and associated riparian zone matures to a “natural” free-flowing state, or is managed as a desirable open space.

Some caution is necessary in interpreting the results. The conclusion that free-flowing rivers confer a price premium on residential property compared to impounded waters is likely due to the small size of the impoundments at our study sites. The conclusion should not be extended to large impoundments where such activities as fishing, boating, and swimming are especially attractive.

Still, the study results are consistent with other available evidence concerning the restoration of trout streams in Wisconsin. An informal study by Wagner (2001) found that after dam removal riparian property values either remained unchanged, or dropped temporarily and rebounded within two years. Sarakinos and Johnson (2003) report that when the Ward Dam was removed from the Prairie River in Merrill, WI, three homes that were put up for sale before the removal received their pre-removal asking price, with two of the homes purchased by buyers eager to have frontage on a restored trout stream.

We focused attention on a relatively small geographic region because hedonic analysis requires analysis of a single housing market. Nonetheless, we would argue that the general nature of these results apply broadly. To argue otherwise is to argue either or both of two points, one on the demand-side, the other on the supply-side. The demand-side argument is that in other regions the population is more likely to prefer small impoundments over free-flowing rivers, which, given population mobility, implies that individuals choose their regional location based at least partly on this preference ordering. This seems unlikely. The supply-side argument is that the relative abundance of housing in the vicinity of free-flowing rivers compared to housing in the vicinity of impoundments is greater in other regions than in the study area. This would serve to make housing in the vicinity of an impoundment a relatively scarce and thus more valuable commodity.

It is important to keep in mind that economic values generated from hedonic analysis reflect only those benefits and costs that are capitalized in land values. Some of the economic value (both positive and negative) associated with dam removal is not capitalized. For instance, the benefits to nonresidents who visit an impoundment for fishing and swimming will not be reflected in local land values. Similarly, the benefits to nonresidents associated with restoring a stream, such as improved trout fishing, will not be captured in a hedonic analysis. Estimating such values requires an alternative technique, such as contingent valuation.

An important question that the analysis does not completely illuminate is the effect of dam removal on shoreline properties. If these properties retain their frontage, then the results indicate that at least in the long run (after the waterway gains the appearance of a "free-flowing" stream) there is no *frontage-specific* significant change in property price, except for the increase associated with the expansion of the lot size.[5] If these properties lose their frontage as the impoundment waters recede to the original contours of the stream, then the relevant issue is what occupies the land formerly submerged in water. A typical outcome is that a riverside public "greenbelt" replaces the impoundment. Studies generally indicate that open space increases the housing values of adjacent properties, though the effect ultimately depends on the exact nature of the open space; it appears that open space dedicated to nature preservation and "passive experiences" such as hiking and bird-watching is most likely to have a significant positive impact on the value of bordering properties.[6] This being the case, and given the results of the current study, the available evidence is that properties that lose their frontage on impoundments would increase in value as their frontage converts to "frontage" on a riverside greenbelt, so long as the greenbelt is dedicated to preserving the natural features of the riparian zone.

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[5] There is, as discussed previously, a general increase in property price that accrues to *all* properties, nonfrontage and frontage alike.

[6] Correl et al. (1978) found that properties rose with proximity to greenbelts in Boulder, Colorado, though it bears mention that the authors did not include a dummy variable to account for sharing a property boundary with the greenbelt. Do and Grudnitski (1995) find that homes abutting a golf course experience an increase in sale price of 7.6%. Lutenhiser and Netusil (2001) find that properties in Portland, Oregon "adjacent" to open space (within 200 feet) were more valuable than those further away, with this price effect being greatest for golf courses and natural area parks (those parks designed to preserve natural habitat and provide resource-based activities, such as walking and bird-watching), and smallest for urban parks (those parks managed primarily for "nonnatural" recreation, such as ball fields and tennis courts). Previous studies have found similar results indicating that different types of open space have different effects on the value of adjacent properties (see, for instance, Weicher and Zerbst (1973) and More et al. (1982)). Compton (2000) provides a comprehensive review, concluding (pg. 55), "Properties that face or directly abut parks which primarily serve active recreation users are likely at best to show only a small positive value increment attributable to the park…In contrast, the value of properties close to parks offering users a passive experience generally follow a classic distance decay curve with those closest to the park exhibiting the highest increments of value".

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