An Analysis of Minimum Frontage Zoning to Preserve Lakefront Amenities

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ABSTRACT. *The development of lakefront property in northern Wisconsin has prompted, in several towns, minimum frontage zoning stricter than the state standard. Such zoning generates an economic loss by constraining development (development effect), and an economic gain by preserving environmental amenities (amenity effect). Estimation of a hedonic price function for lakefront property in northern Wisconsin quantifies these competing effects. The estimation indicates that at the current margin the economic loss from the development effect is negligible, and the economic gain from the amenity effect may be considerable, raising frontage prices by an average of 21.5%.* (JEL Q25, R52)

> After World War I and during the early twenties, a great road-building program was announced, one which would open up the lake country and make it accessible to tourists. "A Road to Every Lake" was the slogan, and chambers of commerce from nearby communities trumpeted the hope of making the wilderness the greatest resort region of America. No longer isolated, the Superior National Forest would become a mecca for fishermen, "The Playground of the Nation" . . . Could it be true the wilderness would be destroyed? Would the lakes and rivers have roads to them all, with cottages and summer resorts lining their shores as they did in Wisconsin, central Minnesota, and Michigan?
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> —The conservationist Sigurd Olson, writing of Northern Minnesota in *Open Horizons*, 1969.

I. INTRODUCTION

Olson exaggerated; at the time he wrote the North Woods of Wisconsin still included hundreds of undeveloped lakes, and it remains a prime vacation destination with ample opportunities for a wide variety of outdoor recreation activities including fishing, canoeing, hiking, hunting, and skiing.[1] Yet Olson's alarm for the future of remote places still rings clear today in Wisconsin and elsewhere. According to the Wisconsin Department of Natural Resources (1996), development on North Woods lakes of 500–1,000 acres in size increased by nearly 800% since the mid-1960s.[2] An indication that development pressure continues is the remarkable increase in the price of lakefront property. For instance, prices on the Eagle River Chain rose from an average of $250 per frontage foot in 1990 to $900 per foot in 1994. The report enumerates the problems with lakefront development: reduced water quality due to eutrophication, more noise from motorboat and jet ski traffic, and reduced scenic values. It concludes:

> It could be our very passion for these natural lakes and wild places, the very reasons we seek them out, will be the engine for their elimination. Not because we want to harm them, but because there are just too many of us longing to find that last special lake, free from the pressure of the civilized world.

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[1] Throughout this document, the "North Woods" of Wisconsin refers to the portion of the state north of state highway 64. This is a fairly remote area with thousands of lakes (2,000 in Vilas County alone) and two national forests. The major industries of the region are tourism and forestry.

[2] The report measures development as the number of residences on a lake.

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From an economic perspective, a call to action is premature; it is not clear that the benefits of controlling lakefront development exceed the costs. Though the initial visitors to a remote place may treasure wilderness above all else, subsequent visitors are more tolerant of a wilderness somewhat despoiled.

This study investigates the economics of one recent attempt to control development in the North Woods, the imposition of minimum frontage zoning on lakefront property. The literature on the economics of zoning is often contradictory (a good review is Pogodzinski and Sass 1991; Knapp 1998 reviews studies of the factors influencing residential property values, including zoning ordinances). Three features of this literature are especially noteworthy in the current context. First, there is a concern about whether zoning matters, in the sense that it yields costs and benefits capitalized into land values. The challenge to the efficacy of zoning is primarily from empirical studies in urban areas showing that land prices are invariant across zones. This result is frequently misinterpreted; see, for instance, Brownstone and DeVany (1991), and the comment on their paper by Colwell and Sirmans (1993). As Fischel (1980, 1990) observes, that land prices are invariant to zoning is not prima facie evidence that zoning does not matter. In general an interzonal price gradient in an urban area reveals potential gains from trade that a community can exploit in the long run by altering the form and geography of its zones. The value of zoning is maximized when property prices in the interior of all zones is the same. In the case of lakefront zoning in remote areas like the North Woods it would be possible to add lakes to, or subtract lakes from, the set of zoned lakes to drive the interzonal price gradient to zero, indicating that the social value of the zoning regulation is maximized. The empirical analysis presented below uses hedonic price analysis to determine the appropriate direction of this adjustment.

Second, there is a concern that by failing to accommodate voluntary exchange between landowners and the community, zoning impairs the efficient use of land (Crone 1983). In a Coasean world, developers negotiate among themselves at no cost to achieve the efficient level of development, and zoning is superfluous at best. In the real world with high transactions costs it is no longer obvious that zoning is necessarily welfare-reducing, though it remains possible there is a better (more efficient) regime for developing a space.[3] The discussion in this paper focuses only on the question of whether minimum frontage zoning is welfare-improving relative to the status quo alternative, when the decision faced by lakefront owners is solely the private one of how much frontage to own.[4]

Third, a substantial proportion of the theoretical literature does not incorporate any kind of externality. Not surprisingly, this omission often leads to the conclusion that zoning decreases welfare. Of those studies which explicitly model an externality, the following several are especially relevant to our investigation. Peterson (1974) measures the price effects of zoning on suburban homes in Boston. He hypothesizes three price effects from zoning: a fiscal effect on property taxes and services; a negative development effect on how land is used; and a positive amenity effect arising from the preservation of environmental amenities. In his empirical analysis he found evidence of the latter two price effects. Studies of agricultural zoning generally conclude that zoning reduces the price of agricultural land, due to the development effect (see, for instance, Knaap 1985 and Vaillancourt and Monty 1985). Henneberry and Barrows (1990) counter that agricultural zoning may increase the price of agricultural land by mitigating the negative externalities imposed on farms by nearby non-agricultural uses. In their empirical analysis they find that for large parcels distant from the urban fringe, agricultural zoning raises land prices. To date, only three empirical studies have attempted to

[3] Here we use the term "transactions costs" broadly to include what Fischel (1994) calls "second-order" transactions costs associated with nonconvexities in development.

[4] We leave for future investigation the possibility of a "private cooperative" solution, in which landowners cooperate to obtain the efficient density of development without intervention by the state. There do exist private lake associations in the North Woods, but these have no power to regulate lakefront development.

separately identify the development effect and the amenity effect (Maser, Riker, and Rosett 1977; Mark and Goldberg 1986; Grieson and White 1989). All concerned urban markets, and none found a significant price effect from zoning.

Our analysis is similar in spirit to these studies. We assume that lakefront owners prefer low density development, in which case minimum frontage zoning has a positive effect on the value of existing developed properties, and an ambiguous effect on the value of undeveloped properties, due to a negative development effect and a competing amenity effect. The next section of the paper provides a simple theoretical model of minimum frontage zoning to motivate the hedonic price analysis of minimum frontage zoning in Vilas County, Wisconsin, presented in Section 3. The hedonic analysis is noteworthy for its attempt to do more than simply ascertain the net price effect of zoning; it attempts to distinguish the relative magnitudes of the development and amenity effects. We conclude the paper in Section 4 with several brief remarks.

II. THE ECONOMIC RATIONALE FOR MINIMUM FRONTAGE ZONING

The economic rationale for regulating lakefront development is straightforward. Lakefront owners gain utility from the amenities generated by a clean lake, such as scenic views, solitude in nature, and clean water for recreational activities like swimming and fishing. New lakefront development diminishes the flow of such amenities to existing development, but insofar as these amenities are quasi-public goods, the full social cost of their diminishment does not enter the developer's decision calculus. Left unregulated, development of the lake exceeds the welfare-maximizing level.

Minimum frontage zoning presumes that development is inelastic with respect to frontage. For instance, doubling a property's frontage will result in less than a doubling of its level of development, however defined. If this is the case, then minimum frontage zoning generates an *amenity effect*: by impeding development, such zoning preserves the flow of amenities to lakefront properties. It follows that possibly social welfare can be improved by enforcing a minimum frontage constraint.[5]

A welfare increase due to minimum frontage zoning is not a sure thing. Because such zoning restricts the subdivision of property, it necessarily restricts the flow of private goods and services from the land. This reduction in the flow of private goods and services is the *development effect* of zoning. At the margin, the matter of whether minimum frontage zoning generates a positive net economic effect turns on a comparison of the amenity and development effects. This is an empirical question.

The case examined here involves minimum frontage zoning in some towns in Vilas County, Wisconsin. By state law, the minimum frontage for residential properties not served by a public sewer is 100 feet. Certain towns in Vilas County have increased this standard to 200 feet. The impact of this change can be illustrated graphically. To this end, let $p(f_i, F_n)$ denote the market price per unit frontage of undeveloped property i, where f_i is the frontage of property i, and F_n is the minimum frontage zoning restriction on lake n, taking the value of 0 when lake n is unzoned.[6] The market value of property i is then $p(f_i, F_n) \cdot f_i$.

Now consider the price per unit frontage that would arise if the boundaries of the property were permanent; if, in other words, the property holds no option for assembly or subdivision, perhaps due to a deed covenant. We call this the "fixed boundary" price (the *FB* price), and denote it by $FB(f_i, F_n)$. The minimum frontage restriction affects *FB* only via its effect on the flow of amenities to the property.

Reasonable examples of these functions with no frontage restriction ($F_n = 0$) are shown in Figure 1. Two factors explain the shape of the *FB* price. First, the production of lakefront amenities is initially convex in frontage; some amenities are simply

[5] If the development of property were elastic with respect to frontage, a *maximum* frontage constraint would be a relevant regulatory instrument.

[6] The price function includes other arguments, such as the size of the lake. Such variables are described in the empirical analysis to follow in section three. Here they are suppressed.

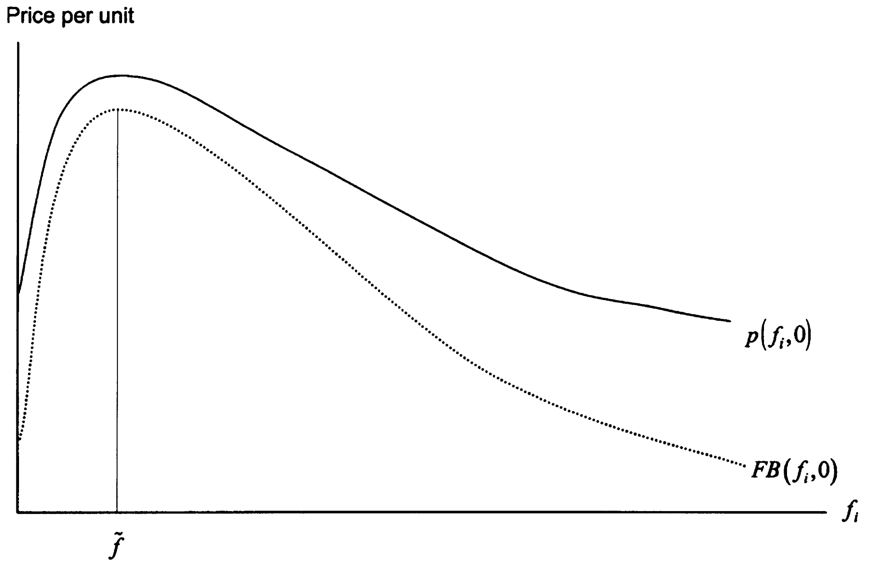

FIGURE 1
THE PRICE OF LAKEFRONT IN THE ABSENCE OF ZONING

''choked off'' from very small frontages. Second, the marginal willingness to pay for lakefront amenities is decreasing. The typical result of these effects is an *FB* price that initially rises and then falls.

The market price lies everywhere above the *FB* price because the market price reflects the potential to one day either subdivide the property, or combine the property with adjacent properties. For small properties this option value is relatively high due to the property's expected value in the assembly of a larger parcel.[7] For large properties this option value is relatively high due to the opportunity to subdivide the property. In Figure 1, the difference between the market price and the *FB* price is smallest where the *FB* price is greatest, reflecting the case that the optimal property size currently is likely to remain so in the future.

Minimum frontage zoning has three effects on price: a development effect capturing the reduction in the marginal willingness to pay for frontage restricted from subdivision; an amenity effect associated with the eventual disposition of other properties on the lake; and a general equilibrium price effect arising to the extent that zoning some lakes affects development on other, unzoned lakes. We leave aside the general equilibrium effect with the understanding that ultimately the analysis is concerned with incremental increases in zoned frontage. The other effects, as applied to Vilas County, Wisconsin, are examined in sequence in Figures 2 and 3. These figures focus on the downward-sloping portion of the price functions, because the issue at hand is the subdivision of lakefront property into smaller, more valuable parcels, and subdivision makes economic sense only when the frontage price is falling at the margin.

Consider first the development effect under the statewide minimum frontage requirement (hereafter called the ''state minimum regime'') of 100 feet. The state minimum effectively forbids the subdivision of properties with less than 200 feet of frontage. Consequently, as frontage approaches 200 feet from below, the market price $p(f_i, 100)$ approaches the fixed boundary price, because

[7] Throughout the discussion, lakefront property is measured in terms of frontage. So, for instance, a small parcel is one with relatively little frontage.

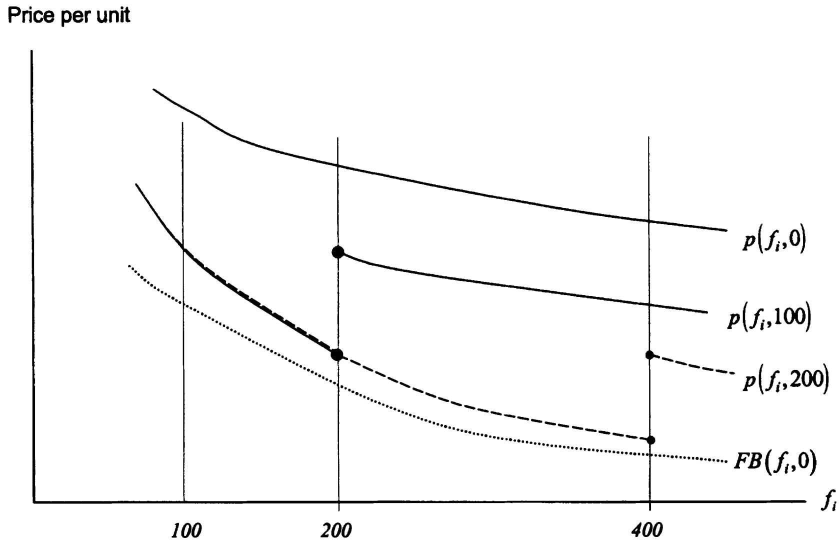

FIGURE 2
THE DEVELOPMENT EFFECT OF MINIMUM FRONTAGE ZONING

the option to subdivide is not available.[8] This is shown in Figure 2. The price jumps at 200 feet because equal subdivision of the property becomes feasible. This jump does not necessarily reach the value $p(200, 0)$, which is the unit price of property i in the absence of zoning, and includes the option to subdivide the property into multiple, unequal parcels.

The development effect of increasing the minimum frontage requirement to 200 feet (hereafter called the "200-Feet Rule") is to shift the price function from $p(f_i, 100)$ to $p(f_i, 200)$, in the manner shown in Figure 2. No longer is there a price jump at 200 feet, as all properties in the neighborhood of 200 feet, in particular those just over 200 feet, are restricted from subdivision. Instead, the market price continues to approach the fixed boundary price before jumping at 400 feet. This jump does not necessarily reach $p(400, 100)$, for the same reason that $p(400, 100)$ does not necessarily reach $p(400, 0)$: greater restrictions reduce the flexibility in property division. For instance, under the state minimum regime a property with 400 feet of frontage can be divided into 3 parcels of 150, 150, and 100 feet of frontage. Under the 200-Feet Rule the same property can be divided into only two parcels of 200 feet each.

In Figure 3, the shift in the price function under the 200-Feet Rule from $p(f_i, 200)$ to $p'(f_i, 200)$ reflects the amenity effect. This effect arises via the anticipated effect of the 200-Feet Rule on the future state of development on the lake. Less future development is expected under the 200-Feet Rule than under the state minimum regime, and this is capitalized in property prices. As drawn in Figure 3, if frontage is less than M, the amenity effect sufficiently compensates for the development effect to assure an increase in property prices. If frontage is greater than M but less than 400 feet, this is no longer true, and the net effect of the 200-Feet Rule compared to the state minimum regimum is to reduce the property price. More generally, the shaded area in Figure 3 denotes the feasible region for the market price after the 200-Feet Rule is imposed. Note in particular that as a theoretical matter, properties with less than 200 feet of frontage are no less valuable under the 200-Feet Rule than under the state minumum regime, and properties with more than 200 feet may be more or less valuable.

[8] Note, though, that the option to combine the property with neighboring parcels keeps the market price above the fixed boundary price.

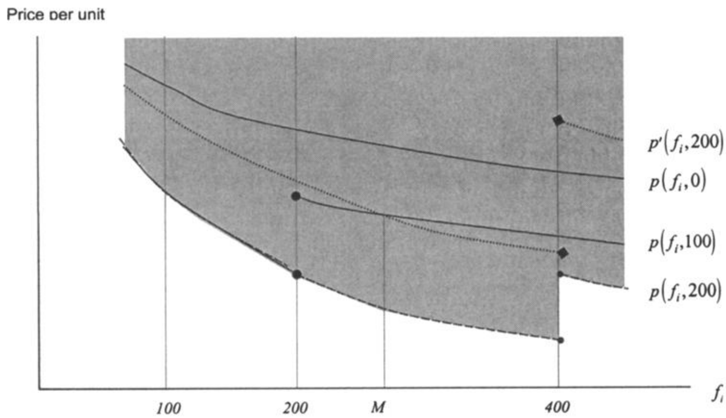

FIGURE 3
THE AMENITY EFFECT OF MINIMUM FRONTAGE ZONING

III. AN APPLICATION TO MINIMUM FRONTAGE ZONING IN NORTHERN WISCONSIN

The foregoing discussion serves as a guide to an empirical hedonic price function for undeveloped private lakefront property in Vilas County, Wisconsin, and several adjacent towns in Oneida County, all in the North Woods.[9] In the face of rapid second home development in the North Woods in the late 1960s, the state of Wisconsin adopted a statewide zoning ordinance restricting single-family properties on lakes and streams to a minimum of 20 thousand square feet and 100 feet of frontage. The size of structures remains unregulated by the state, though all dwellings must be a minimum 75 feet from the shore. Several towns in Vilas County have adopted more stringent lakefront zoning regulations, as reported in Table 1. Conversations with planners and developers in Vilas County indicate that invariably the binding constraint under the new restrictions is the frontage constraint. With this in mind, in the empirical analysis we simplify the zoning structure, considering only the 200-foot minimum frontage restriction.

The Data and the Hedonic Price Function

For the analysis we used data for 893 undeveloped properties sold in the study area between January 1986 and December 1995. The data were obtained from several different sources. For equalization purposes, the Wisconsin State Bureau of Revenue obtains each year data on a random sample of "arm's length" property sales, recording the county and town of the property, whether the land is developed or vacant, the presence/absence of water frontage, the sale price and date, and the parcel code (used to locate the parcel on a county parcel map). The sample used in the analysis reflects all sales in this database for which the property was undeveloped lakefront in the study area, and for which we were able to locate the property on a county parcel map. Conceivably we could have included developed properties in the analysis, netting out the value of structural improvements. Unfortunately, in most towns information on structural improvements is difficult to obtain. Access to the public records of structural characteristics used in tax assessments can be difficult, because private assessors with whom the towns contract for assessment services hold these records. Moreover, the match of records held by assessors with the parcel codes used by the State Bureau of Revenues is not transparent.

By tracing the data recorded by the State Bureau of Revenues to the appropriate county parcel maps, we obtained for each sale the location of the property, the lake on

[9] The Oneida towns are Minocqua, Hazelhurst, and Sugar Camp.

TABLE 1
VILAS COUNTY TOWNS WITH LAKEFRONT RESTRICTIONS MORE STRINGENT THAN THE STATE RESTRICTION

Town	Year	Min. Width (ft.)	Min. Area (sq. ft.)
Boulder Junction	1972	200	40,000
Conover	1977	200	40,000
Lac du Flambeau	1994	200	30,000
Land O'Lakes	1972	200	40,000
Manitowish Waters	1986	200	50,000
Presque Isle	1959	200	65,340
Winchester	1995	200	60,000

which the property is located, and the area and frontage of the property. Data on lake characteristics were obtained from the Wisconsin Department of Natural Resources.

The unit price of frontage depends on the amount of frontage and the property area. With this in mind, the estimated hedonic price function takes the log-linear form,

$$\ln p_{it} = \beta_{0t} + \beta_{1t}f_i + \beta_{2t}\ln f_i + \beta_{3t}area_i + \ldots, \quad [1]$$

where p_{it} is property i's market price per frontage foot in year t in 1998 US dollars; f_i is the frontage in feet; and $area_i$ is the property area in acres. Parameters are indexed by time to account for the possibility that the price function changes over time. We include $\ln f_i$ on the right-hand side in part to gain flexibility in the specification, but primarily to avoid an unnecessary restriction in the implied specification of the hedonic function for lakefront property values. With P_{it} denoting the sale price of property i, $P_{it} = p_{it} \cdot f_i$, [1] can be restated,

$$\ln P_{it} + \ln f_i = \beta_{0t} + \beta_{1t}f_i + \beta_{2t}\ln f_i + \beta_{3t}area_i + \ldots, \quad [2]$$

and so [1] is consistent with the model of property values,

$$\ln P_{it} = \beta_{0t} + \beta_{1t}f_i + (\beta_{2t} - 1)\ln f_i + \beta_{3t}area_i + \ldots. \quad [3]$$

This shows that to omit the term $\beta_{2t}\ln f_i$ from [1] is to assert that in [3] the coefficient on $\ln f_i$ is equal to -1, an assertion we choose to avoid. The model presented here can be estimated using [1] or [3]. The discussion in the preceding theoretical discussion concerned price *per unit frontage*, which is in fact the metric used in discussions of North Woods development, and so we keep this metric in the estimation.

The price of frontage depends on the lake's current state of development, which affects the current and future amenity flow to a property. In the empirical analysis, the proportion of lakefront in each of the following four categories represents a lake's state of development: tribal, public, large private tract, and small private tract. Tribal land is generally undeveloped frontage held by one of Wisconsin's several Indian tribes. Public land is undeveloped property held by the county, state, or federal government, usually national forest land. Large private tracts are private frontages held in parcels of five acres or more. Small private tracts are private subdivisions, or parcels of five acres or less. These categories reflect those used in Rockford™ plat maps, the best source of historical data on property boundaries in the North Woods.[10]

Formally,

$$\ln p_{it} = \cdots + \beta_{4t}pub_{nt} + \beta_{5t}large_{nt} + \beta_{5t}small_{nt} + \ldots, \quad [4]$$

[10] Rockford Map Publishers, Inc. Internet address: www.rockfordmap.com. For Vilas and Oneida counties, Rockford plat maps are published every two years. In the analysis, a lake's state of development is defined by that plat map with publication date nearest the recorded date of the associated property's sale.

where pub_{nt} is the proportion of public land on lake n (the lake on which property i is found) in year t, $large_{nt}$ is the proportion of private large tracts, and $small_{nt}$ is the proportion of private small tracts. The coefficients on these variables reflect the increase or decrease in the natural log of frontage price due to a marginal reallocation of lake frontage from tribal land to the relevant land category. Tribal lands are not included to avoid collinearity with the intercept.

A number of other locational variables influence the price of lakefront property. Accounting for these variables expands the price function to:

$$\ln p_{it} = \cdots + \beta_{7t} village_i + \beta_{8t} forest_i + \beta_{9t} county_i + \beta_{10,t} surface_n + \beta_{11,t} shore_n + \beta_{12,t} stratif_n + \ldots, \quad [5]$$

where $village_i$ is the driving distance to the nearest village with major services (either Minoqua-Woodruff, or Eagle River) in miles; $forest_i$ is the shortest driving distance to the Nicolet National Forest in miles; $county_i$ is a dummy variable taking a value of one for properties in Vilas County; $surface_n$ is the surface area of the lake in square miles; $shore_n$ is the miles of shoreline; and $stratif_n$ is a stratification index for the lake, as specified in Lathrop and Lillie (1980),

$$stratif_n = \frac{\text{max depth(feet)} + 4.5}{\log_{10} \text{area(acres)}}.$$

This last variable can be interpreted as a rough "pollutability" index. Lakes that are strongly stratified are less able to assimilate phosphorus, because mixing of upper and lower layers is relatively limited.

The function includes two property-specific variables obtained from USDA soil maps:

$$\ln p_{it} = \cdots + \beta_{13,t} build_i + \beta_{14,t} marsh_i + \ldots, \quad [6]$$

where $build_i$ is a "buildability" index taking a value of one to three, with a high value indicating that the soil is most amenable for building, and $marsh_i$ indicates whether a wetlands is on the property.

Following the analysis in Section 2, the price effects of the minimum frontage requirements are embodied in the set of terms

$$\ln p_{it} = \cdots + \beta_{15,t} d1_i + [\beta_{16,t} d1_i \cdot d2_{nt} + \beta_{17,t} d1_i \cdot d2_{nt} \cdot f_i + \beta_{18,t} d3_i \cdot d2_{nt}] + [\beta_{19,t} d2_{nt} \cdot large_{nt} \cdot f_i + \beta_{20,t} d2_{nt} \cdot small_{nt} \cdot f_i] + \ldots, \quad [7]$$

where $d1_i$ is a dummy variable taking a value of one if the property's frontage is greater than 200 feet; $d2_{nt}$ is a dummy variable taking a value of one if, at the time of sale, the lake on which the property lies is governed by the 200-Feet Rule; and $d3_i$ is a dummy variable taking a value of one if the property's frontage is greater than 400 feet.

The first term in [7] captures the jump in price under the state minimum frontage requirement of 100 feet (see Figure 2), with $\beta_{15,t} \geq 0$. Finding that $\beta_{15,t}$ is not significantly different from zero indicates the state minimum does not present a binding constraint; there is no gain in property value, in other words, from being "released" from the state minimum. The first set of bracketed terms captures the development effect of the 200-Feet Rule. Note that this effect applies only to properties with frontage greater than 200 feet. Under the 200-Feet Rule there is no longer a price jump at 200 feet, and so we hypothesize the equality, $\beta_{15,t} = -\beta_{16,t}$. The term $\beta_{17,t} d1_t \cdot d2_{nt} \cdot f_i$ captures the difference in the slope of the price function under the state minimum regime and the 200-Feet Rule, for frontages greater than 200 feet. Under the state minimum regime the prospect of subdividing the property keeps the price relatively high, perhaps even climbing, between 200 and 400 feet, whereas under the 200-Feet Rule the price approaches the fixed boundary price. With this in mind, we expect $\beta_{17,t} < 0$, as indicated in Figure 2. Finally, the term $\beta_{18,t} d3_i \cdot d2_{nt}$ captures the price jump at 400 feet under the 200-Feet Rule, with $\beta_{18,t} > 0$.

TABLE 2
DESCRIPTIVE STATISTICS

Variable	Mean	St. Dev.	Minimum	Maximum
p	268.47	280.01	1.48	3,540.80
f	210.850	215.64	10.00	2,500.00
area	2.860	5.05	0.01	59.70
pub	0.066	0.15	0	0.95
large	0.302	0.23	0	1
small	0.601	0.24	0	1
village	14.960	9.19	0.90	36.90
forest	0.869	1.23	0	5.50
county	0.813	0.39	0	1
surface	0.746	1.02	0.01	5.96
shore	5.356	4.69	0.10	28.70
stratif	17.291	7.33	4.20	51.97
build	1.5711	.73	0	1
marsh	0.040	.20	0	1

The second set of bracketed terms captures the amenity effect of the 200-Feet Rule. The amenity effect applies to *all* private property on a lake restricted by the 200-Feet Rule, and due to its nature as an externality its magnitude depends on the lake's potential for additional development, as represented by $small_n$ and $large_n$.

The expected sign of the amenity effect is positive, with $\beta_{19} > \beta_{20} > 0$; the greater the proportion of lakefront in private property, the greater the amenity flow induced by the 200-Feet Rule. Moreover, because small tracts are already more developed than large tracts, the future amenity flow induced by restricting the subdivision of small tracts is relatively low. To the extent small tracts are already fully developed, $\beta_{20} = 0$.

The hedonic price function terminates with a normal disturbance,

$$\ln p_{it} = \cdots + \varepsilon_{it}, \ \varepsilon_{it} \sim N(0,\sigma_t), \qquad [8]$$

capturing the unobserved features of the property, such the view of the lake, distance to neighbors, and so on.[11]

Table 2 provides the mean, standard deviation, and range of the variables used in the analysis. The average price of frontage is \$220.90 per foot (1998 dollars), and the average frontage length is 211 feet. Approximately 81% of all properties are in Vilas County. 32.4% of the properties are located on lakes with 200-feet minimum frontage requirements. Among these, the majority (61.4%) are restricted by the 200-Feet Rule. Table 3 gives an additional breakdown of the distribution of frontage. Special attention is given this variable because it is the focus of the zoning restriction (19.9% of the total number of properties).

Results and Discussion

Previous authors have found that hedonic regressions are not temporally stable (Palmquist 1980; Edmonds 1985). The case at hand is no different; a model in which all parameters are fixed over the ten-year sampling horizon is rejected at the 95% confidence

[11] At a 90% confidence level (the low level is to increase power), the Breusch-Pagan test indicates acceptance of the null hypothesis of homoskedasticity within each year except one (1993). Other tests that are more powerful than the Breusch-Pagan test *given a priori knowledge of the form of potential heteroskedasticity*, in particular, the Harvey test and the Glesjer test, give mixed results. For five of the ten years of the sample, the Harvey test accepts the null, while for four years the Glesjer test accepts the null. In light of these mixed results, we chose to impose homoskedasticity within each year. The hypothesis of *temporal* homoskedasticity, where the variance of the disturbance is not only constant within each year, but the same from year to year, is rejected by a likelihood ratio test at the 95% confidence level, and so we report results for the case where the disturbance is temporally heteroskedastic.

TABLE 3
DISTRIBUTION OF OBSERVATIONS WITH RESPECT TO FRONTAGE

	Governing Restriction at Time of Sale	
	State Minimum	200-Feet Rule
Frontage	Number of Observations	
$0 < f < 100$	38	12
$100 \leq f < 200$	412	99
$200 \leq f < 300$	77	111
$300 \leq f < 400$	40	18
$400 \leq f < 500$	17	16
$500 \leq f < 700$	7	13
$700 \leq f < 1000$	10	9
$f \geq 1000$	3	11
Total	604	289

level.[12] Consequently, we estimated the hedonic price function separately for each year.

Table 4 presents average values of coefficient estimates across the ten, year-specific hedonic price functions, along with other statistics concerning the functions.[13] So, for instance, the average value of the coefficient on frontage (f) is $-1.530\text{E-}4$, and ranges from a low of $-1.832\text{E-}3$ in 1986 to a high of 1.360E-3 in 1993; for five of the ten years the sign of the estimated coefficient is the same as the sign of the average value (negative); for three of the ten years the coefficient has the same sign as the average value *and* is statistically significant at the 90% confidence level, and for one year the coefficient has the opposite sign of the average value and is significant at the 90% confidence level.

The results are generally consistent with theory and intuition. As expected, lakeshore in public land is generally preferred to lakeshore in private land ($\beta_4 > \beta_5, \beta_6$). That the signs on *pub*, *small*, and *large* are all usually positive indicates that lakefront in any of these categories is generally preferred to lakefront in tribal land. This may reflect uncertainty about future development of tribal lands. In the absence of the 200-Feet Rule, lakeshore in small tracts is generally preferred to lakeshore in large tracts ($\beta_6 > \beta_5$), which contradicts intuition, and perhaps is due to uncertainty about the nature of future development on large tracts in the absence of zoning restrictions. Alternatively, this result may be due to omitted variable bias. The reasoning of this latter explanation is that heavily developed lakes are this way in part because they are more attractive in a manner not captured by the analysis. The effect of omitting such unobserved "lake attractors" is an upward bias on the estimates of β_6 and β_{20} (those coefficients involving the variable *small*), and a downward bias on the estimates of β_5 and β_{19} (those coefficients involving the variable *large*).

The coefficient estimates for the development and amenity effects are generally consistent with the theory of the previous section. On the matter of whether properties on lakes governed by the state minimum experience a price jump at 200 feet, the relevant results are the sign of β_{15} and the significance of the restriction $\beta_{15} = -\beta_{16}$. In only half the years is the sign of β_{15} positive as expected, and in only one of these years is the coefficient significantly different from zero at a 90% confidence level. In all of the years in which β_{15} is positive, the restriction $\beta_{15} =$

[12] The log likelihood value of the unrestricted model with parameters free to vary from year to year is −671.76. The log likelihood value of the restricted model is −885.80. The likelihood ratio test statistic is 428.08. Under the null hypothesis that the restricted model is the true model, this statistic is distributed Chi-squared with 189 degrees of freedom. The null hypothesis is rejected at the 95 percent confidence level.

[13] Complete results are available at *www.aae.wisc.edu/provencher.*

TABLE 4
STATISTICS FOR ESTIMATED HEDONIC PRICE EQUATIONS

Variable	Coefficient	Average Value Across Years	Minimum Value (Year)	Maximum Value (Year)	No. of years coefficient has the same sign as the average value	No. of years coefficient has the same sign as (different sign than) the average value, and is significant at 90% C.L.[a]
constant	β_0	11.95	4.196 (1987)	19.17 (1993)	10	10 (0)
f	β_1	−1.530E-4	−1.832E-3 (1986)	1.360E-3 (1993)	5	3 (1)
ln(*f*)	β_2	−7.364E-1	−2.042 (1993)	−1.556E-1 (1986)	10	7 (0)
area	β_3	−7.791E-3	−1.032E-1 (1992)	2.553E-2 (1988)	3	1 (0)
pub	β_4	2.170	3.571E-1 (1990)	7.252 (1987)	10	8 (0)
large	β_5	1.074	−6.425E-1 (1993)	6.088 (1987)	7	4 (0)
small	β_6	1.481	−2.343E-1 (1992)	7.787 (1987)	7	5 (0)
village	β_7	−8.029E-3	−7.498E-2 (1986)	1.712E-2 (1987)	5	2 (1)
forest	β_8	4.102E-2	−6.369E-2 (1990)	1.732E-1 (1986)	6	4 (0)
county	β_9	1.869E-2	−3.852E-1 (1992)	5.294E-1 (1995)	6	3 (2)
surface	β_{10}	1.789E-1	1.139E-2 (1993)	3.407E-1 (1986)	10	5 (0)
shore	β_{11}	2.724E-2	1.232E-3 (1986)	6.291E-2 (1993)	10	4 (0)
stratif	β_{12}	8.793E-4	−2.439E-2 (1987)	1.915E-2 (1986)	5	3 (2)
build	β_{13}	8.596E-3	−1.396E-1 (1995)	1.760E-1 (1987)	5	4 (3)
marsh	β_{14}	4.314E-2	−5.386E-1 (1993)	8.434E-1 (1995)	5	2 (2)
d1	β_{15}	−4.306E-2	−6.669E-1 (1986)	3.039E-1 (1988)	5	0 (1)
d1 · d2	β_{16}	3.063E-1	−9.513E-1 (1989)	1.158 (1986)	7	3 (1)
d1 · d2 · f	β_{17}	−2.122E-3	−6.714E-3 (1988)	3.984-3 (1995)	8	4 (0)
d3 · d2	β_{18}	3.564E-1	−1.306 (1986)	2.596 (1988)	6	4 (1)
d2 · large · f	β_{19}	2.839E-3	5.077E-3 (1989)	1.318E-3 (1986)	10	6 (0)
d2 · small · f	β_{20}	9.524E-4	−2.686E-3 (1995)	4.004E-3 (1990)	7	3 (0)

[a] Confidence levels apply to one-tailed tests.

$-\beta_{16}$ is accepted at the 90% confidence level, though it is important to note that for all of these years, and in fact for every year of the sample save one (1992), it is also true that the joint restriction $\beta_{15} = -\beta_{16} = 0$ is not rejected at the 90% confidence level. In other words, the data indicate there is no price jump at 200 feet under the state minimum regime, and consequently there is no price fall at 200 feet when the 200-Feet Rule is imposed.

The 200-Feet Rule appears to have a negative development effect on properties with frontage between 200 and 400 feet ($\beta_{17} < 0$), and there is good evidence that under the 200-Feet Rule the price of frontage jumps at 400 feet ($\beta_{18} > 0$). The coefficients on the amenity effects are generally positive and significant at the 90% confidence level. For all years but one, the estimate of β_{19} is greater than that of β_{20}, indicating that as expected, the amenity effect of the 200-Feet Rule is generally greater on a lake with relatively more land in large tracts than small tracts.

Overall, the amenity effect appears to dominate the development effect. This is apparent by calculating from the model the expected sale price under the 200-Feet Rule of each sample property sold under the state minimum regime, for the year in which the property was sold. Formally, letting $p_{it}^{0}(f_i, 100)$ denote the *observed* sale price of property i under the state minimum regime, the expected price under the 200-Feet Rule is

$$E\{p_{it}(f_i, 200)\} = p_{it}^{0}(f_i, 100) \cdot E\left\{\exp\left(\begin{array}{l}[\beta_{16,t}d1_i + \beta_{17,t}d1_i \cdot f_i + \beta_{18,t}d3_i] \\ +[\beta_{19,t}large_{nt} \cdot f_i + \beta_{20,t}small_{nt} \cdot f_i]\end{array}\right)\right\}. \quad [9]$$

The augmentation of the observed price by the expectation on the right-hand side of [9] reflects the amenity and development effects in [7]. This expectation is consistently estimated by simulation, using the joint distribution of the estimators of $\beta_{16,t}$ through $\beta_{20,t}$.

For sample properties sold under the state minimum regime, the average expected price under the 200-Feet Rule is $335.92 per foot, 21.5% greater than the average observed sale price under the state minimum regime ($275.97). The model predicts that 87.4% of properties with frontage less than 200 feet would increase in price (the theoretical model predicts this figure is 100%), and 66.7% of properties with frontage greater than 200 feet would increase in price. If we accept the evidence from the data that under the state minimum regime there is no price jump at 200 feet, and consequently under the 200-Feet Rule there is no corresponding price drop ($\beta_{15,t} = \beta_{16,t} = 0$), the expected price under the 200-Feet Rule is on average $325.57 per foot, 18% greater than the average observed sale price under the state minimum regime. In this case, the model predicts that only 42.3% of properties with frontage greater than 200 feet would increase in price.

IV. CONCLUSION

The empirical analysis of this study finds that in the North Woods of Wisconsin, extending the relatively strict minimum frontage requirement found in some towns of Vilas County would, in general, increase the value of lakefront property. As with all hedonic price analyses, the results of the study are valid at the margin. The analysis provides a compass for the *direction* that minimum zoning should take given the current state of lake development. It appears that extending minimum frontage zoning to additional, relatively undeveloped lakes in the study area would yield an economic gain, because the development effect is usually negligible and the amenity effect is often at least modest. But strictly speaking the analysis is silent on the geographic extent of additional minimum frontage zoning. Moreover, the analysis does not address the distributional impacts of such zoning. By reducing structural improvements per foot of frontage, minimum frontage zoning may be harmful to local labor and business even as it increases the value of lakefront property and thus the wealth of property owners, many of whom are urban vacationers.

A matter for future research is the "same conditional distribution" assumption for the prices of developed and undeveloped properties. This assumption maintains that the parameters and form of the hedonic price function are the same for developed and undeveloped parcels, though of course the *values* for variables concerning structural improvements differ across the two types. To the extent this assumption holds, one can generalize to developed properties the welfare results from hedonic analyses of undeveloped properties. Why is this a matter for concern? Our sense is that the North Woods of Wisconsin is typical of remote areas in that obtaining from tax records the structural improvements on a property at the time of sale is difficult and time consuming. Perhaps the best source of such information is multiple listing service (MLS) databases kept by Realtor® associations, but these are privately held, and are complicated by selection bias.

Constraining every lakefront property in a town to a minimum 200 feet of frontage has the virtue of simplicity and perhaps political expediency, but it is also capricious. It does not address the clear implication of the study that the net gains from minimum frontage zoning vary from lake to lake. An alternative is to limit development on some lakes, and to allow the market free reign on other lakes, based on lake characteristics and the current state of lakefront development. Defining zoning categories and allocating lakes across categories are matters for which careful economic analysis can provide insights.

References

Brownstone, D., and A. DeVany. 1991. "Zoning, Returns to Scale, and the Value of Undeveloped Land." *The Review of Economics and Statistics* 73 (Nov.): 699–704.

Colwell, P. F., and C. F. Sirmans. 1993. "A Comment on Zoning, Returns to Scale, and the Value of Undeveloped Land." *The Review of Economics and Statistics* 75 (Nov.): 783–86.

Crone, T. M. 1983. "Elements of an Economic Justification for Municipal Zoning." *Journal of Urban Economics* 14 (Sept.): 184–205.

Edmonds, R. G. 1985. "Some Evidence on the Intertemporal Stability of Hedonic Price Functions". *Land Economics* 61 (Nov.): 445–51.

Fischel, W. A. 1980. "Externalities and Zoning." *Public Choice* 35 (1): 37–43.

———. 1990. "Four Maxims for Research on Land-Use Controls: Introduction." *Land Economics* 66 (Aug.): 229–36.

———. 1994. "Zoning, Nonconvexities, and T. Jack Foster's City." *Journal of Urban Economics* 35 (Mar.): 175–81.

Grieson, R. E., and J. R. White. 1989. "The Existence and Capitalization of Neighborhood Externalities: A Reassessment." *Journal of Urban Economics* 25 (Jan.): 68–76.

Henneberry, D. M., and R. L. Barrows. 1990. "Capitalization of Exclusive Agricultural Zoning into Farmland Prices." *Land Economics* 66 (Aug.): 249–58.

Knapp, G. J. 1985. "The Price Effects of Urban Growth Boundaries in Metropolitan Portland, Oregon." *Land Economics* 61 (Feb.): 26–35.

———. 1998. "The Determinants of Residential Property Values: Implications for Metropolitan Planning." *Journal of Planning Literature* 12 (Feb.): 267–82.

Lathrop, R. C., and R. A. Lillie. 1980. "Thermal Stratification of Wisconsin Lakes". In *Transactions of the Wisconsin Academy of Science, Arts, and Letters* 68:90–96.

Mark, J. H., and M. A. Goldberg. 1986. "A Study of the Impacts of Zoning on Housing Values Over Time." *Journal of Urban Economics* 20 (Nov.): 257–73.

Maser, S. M., W. H. Riker, and R. N. Rosett. 1977. "The Effects of Zoning and Externalities on the Price of Land: An Empirical Analysis of Monroe County, New York." *Journal of Law and Economics* 16 (Apr.): 111–32.

Palmquist, R. A. 1980. "Alternative Techniques for Developing Real Estate Index Prices." *Review of Economics and Statistics* 62 (Aug.): 442–48.

Peterson, G. E. 1974. "The Influence of Zoning Regulations on Land and Housing Prices." Land Use Center Working Paper no. 1207-24. Washington D.C.: The Urban Institute.

Pogodzinski, J. M., and T. R. Sass. 1991. "Measuring the Effects of Municipal Zoning Regulations: A Survey." *Urban Studies* 28 (Aug.): 597–621.

Vaillancourt, F., and L. Monty. 1985. "The Effects of Agricultural Zoning on Land Prices, Quebec, 1975–1981." *Land Economics* 61 (Feb.): 36–42.

Wisconsin Department of Natural Resources. 1996. *Northern Wisconsin's Lakes and Shorelands: A Report on a Resource Under Pressure*. Madison, Wis.: Wisconsin Department of Natural Resources.