# An Analysis of Minimum Frontage Zoning to Preserve Lakefront Amenities

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February 2000

**Abstract**
The development of lakefront property in northern Wisconsin has prompted minimum frontage zoning in several towns. 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 is modest, raising frontage prices by an average of 7 to 12 percent.

## An Analysis of Minimum Frontage Zoning to Preserve Lakefront Amenities

*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?*

–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, development on North Woods lakes of 500-1000 acres in size increased by nearly 800 percent 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.*

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; to our knowledge there is no more recent review). 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, and the comment on their paper by Colwell and Sirmans. 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

[1] Throughout this document, the "North Woods" of Wisconsin refers to the heavily forested, sparsely populated northern tier counties of the state, roughly north of state highway 64.

[2] Wisconsin Department of Natural Resources, "Northern Wisconsin's Lakes and Shorelands: A Report on a Resource Under Pressure". January 1996, 18 pgs..

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 goal of a hedonic price analysis is 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). 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 of no zoning.

Third, a substantial proportion of the theoretical literature –in their review of the economic theory of zoning, Pogodzinski and Sass (1990) put this proportion at one-half –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 separately identify the development effect and the amenity effect (Maser et al. 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 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.

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

## II. The Economic Rationale for Minimum Frontage Zoning

We begin with a model in which all lakefront is undeveloped and the same, and all lakefront owners have identical preferences. The total length of shoreline is $T$. Development along a lake impacts the amenity flow to each property on the lake. We assume that the amenity flow is determined by the density of lakefront development. This is captured by the amenity function $A(K,\phi)$, where $K$ is the total capital along the lakefront, and $\phi$ denotes exogenous factors affecting the amenity flow, such as lake water quality and distance to the nearest primary road. The amenity function is decreasing in $K$.

Let $f$ denote the frontage of a lakefront property, let $k$ denote the capital on the property, and let $x$ denote the consumption of a composite good with price normalized to unity. The utility of a property owner is denoted by $U(f,k,A(K,\phi),x)$.[4] It is not possible to enjoy the amenities of a lake without *both* strictly positive frontage and strictly positive capital. Status quo utility –that is, utility in the absence of lakefront property –is $U^y \equiv U(0,0,0,y)$, where $y$ is income.

We define $W(f,k,A(K,\phi),y,U^y)$ as the willingness-to-pay (WTP) function for frontage. It is the amount paid by an individual for frontage $f$ and capital $k$ on a lake with amenity flow $A(K,\phi)$ that leaves her no worse off than she would be without lakefront property. Formally, it is the solution to

$$U^y = U(f,k,A(K,\phi),y-W) .$$

Assuming that $U$ is nondecreasing in $f$, $k$, $A$, and $y$, $W$ is also nondecreasing in $f$, $k$, $A$, and $y$.

Consider now the problem of a planner choosing $f$ to maximize the net benefit of lakefront development. Given the planner's choice of $f$, lakefront owners choose the level of capital satisfying,

$$\frac{\partial W}{\partial k} = c, \tag{1}$$

where $c$ is the exogenous price of capital. Denoting by $k(f)$ the lakefront owner's choice of capital, the planner's problem can be stated as,

$$\max_f \frac{T}{f}\cdot\left[W\left(f,k(f),A\left(\frac{k(f)T}{f},\phi\right),y,U^y\right)-c\cdot k(f)\right], \tag{2}$$

where $T/f$ is the number of lakefront property owners, and the bracketed expression is the net value of frontage. Letting $M = T/f$ denote the number of lakefront owners, the first-order necessary condition is

$$\frac{\partial W}{\partial f} = \left[\frac{(W-c\cdot k)}{f}\right]-\left[M\cdot\frac{\partial W}{\partial A}\frac{\partial A}{\partial K}\cdot\left(\frac{\partial k}{\partial f}-\frac{k}{f}\right)\right] . \tag{3}$$

[4] Presumably utility depends on *how* capital $k$ is allocated along the property's lakefront. In this case our utility function is the conditional indirect utility function with capital best distributed along the lakefront.

The left-side derivative is the direct marginal benefit of frontage. The right-hand side is the social price of a unit of frontage. It is the opportunity cost –the shadow price –of a marginal increase in frontage.[5] This opportunity cost reflects competing effects, represented by the bracketed terms in (3). Expanding frontage implies the removal of some lakefront property owners. The economic cost of this removal is the compensation required to induce owners to leave voluntarily. At the margin this cost is the *private* price of frontage, $(W-c\cdot k)/f$. Yet removing some lakefront owners indirectly benefits those remaining, by increasing the flow of amenities to their properties. At the margin this amenity benefit is the second bracketed expression in (3).

Critical to the analysis –and to the justification for minimum frontage zoning –is the assumption that the lakefront owner's choice of capital is decreasing or inelastic in frontage. To show this, we multiply the amenity benefit of a marginal increase in frontage by the positive constant $\frac{f}{k}$ to obtain

$$M\cdot\frac{\partial W}{\partial A}\cdot\frac{\partial A}{\partial K}\cdot\left[\frac{T}{f}\left(\varepsilon_{kf}-1\right)\right],$$

where $\varepsilon_{kf}$ is the elasticity of capital with respect to frontage. If $\varepsilon_{kf}<1$, then this amenity benefit is positive, as assumed in the analysis below; increasing the frontage of each ownership reduces the density of capital on the lake, thereby increasing the flow of amenities. If $\varepsilon_{kf}>1$, then increasing frontage serves to *increase* the density of capital on the lake, and thus planners should pursue *maximum* frontage zoning.

Figure 1 illustrates the planner's solution. All curves in Figure 1 denote equilibrium values, in the sense that *all* properties have frontage *f*. The private price of frontage is denoted by $p(f)$. The social price of frontage is denoted by $p^s(f)$. The marginal benefit of frontage is denoted by *MB*, and the average benefit is denoted by *AB*. The shapes of the price functions in Figure 1 reflect the interplay between the direct and amenity values of frontage. When a lake is divided into many small parcels the price of frontage is low because the amenity flow to each parcel is low –people are not willing to pay as much per frontage unit on a crowded lake. When a lake is divided into a few large parcels the amenity flow is high, but the price of frontage is low nonetheless because the private marginal benefit of frontage is low –the owner of already extensive property gains relatively little utility from additional frontage. At some intermediate level of subdivision the price of frontage is maximized.

At the solution the total value of developed property is $T\cdot B$, and the value of the undeveloped lake is then $T\cdot D$.[6] That the private price function $p(f)$ reaches its maximum at the solution $f^*$ is not coincidence; by construction the planner's objective function is equal to the product of this price and the constant *T* (see (2) above).

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[5] Note that an increase in frontage refers to an increase in *f, frontage per property*; total shoreline does not change. Note too that unless otherwise specified, frontage price refers to the price *per unit of frontage*, not price per property.

[6] The amount $T\cdot(B-D)$ is the value of capital on the lakefront.

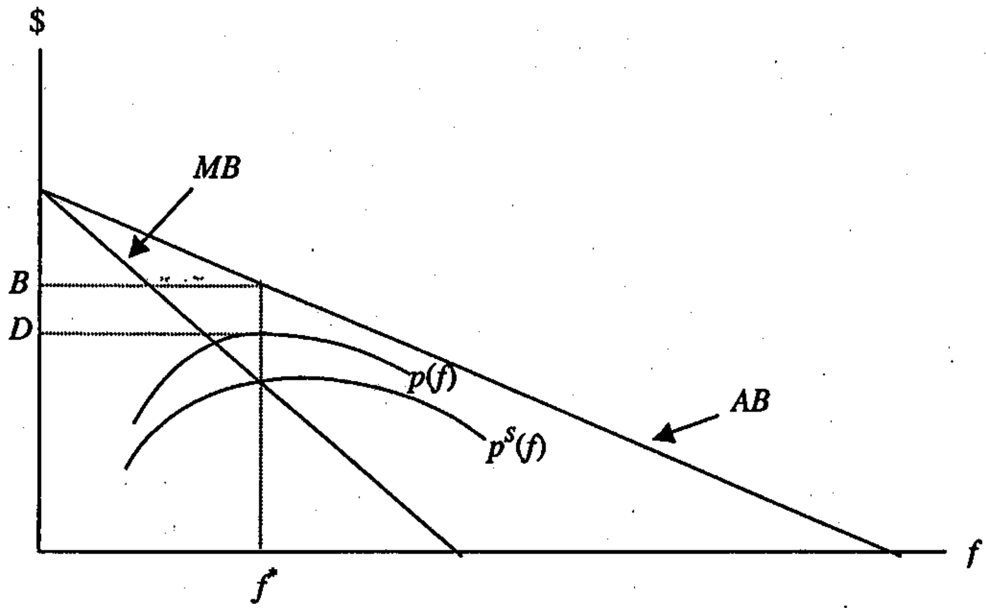


**Figure 1.**

Now compare this to the market outcome under zoning. The market generates a solution to a problem similar to that of the planner, but the amenity level is treated parametrically –the amenity is not a private good chosen by lakefront property owners –and frontage is constrained by minimum frontage level $F$. Formally this problem is,

$$\max_f \frac{T}{f} \cdot \left[W\left(f, k(f), A, y, U^y\right) - c \cdot k(f)\right] \qquad (4)$$
$$s.t. \qquad f \geq F$$

Letting $\lambda$ denote the Lagrange Multiplier for the inequality constraint, the first-order condition for an interior solution is,

$$\frac{\partial W}{\partial f} = \frac{W - c \cdot k}{f} - \lambda \qquad (5)$$

A comparison of (3) and (5) motivates the economic rationale for minimum frontage zoning. The unrestricted market regime ($F$=0, so $\lambda$=0) is inefficient because the amenity benefit of frontage is external to the market. This is apparent by examining the market response of lakefront owners to an initial allocation of undeveloped frontage equal to $f^*$, the welfare-maximizing level derived from the planner's problem (2). Figure 2 extracts portions of Figure 1 relevant to this situation. Given the amenity level $A^* = A\left(\frac{k(f^*)T}{f^*}, \phi\right)$, a lakefront owner's marginal willingness to pay for frontage is

$$MWTP^* = \partial W / \partial f \Big|_{A^*},$$

where the asterisk indicates the amenity level is fixed at $A^*$. That the amenity is treated as fixed distinguishes the lakefront owner's *MWTP* function from the marginal benefit function, which considers a *universal* marginal change in frontage, and the attendant change in amenities. At $f^*$,

$$MWTP^* = MB(f^*) = p^S(f^*) < p(f^*).$$

The first equality holds by definition; the remaining relationships are established in the previous discussion of (3).

Because lakefront owners' marginal willingness to pay for frontage at $f^*$ is less than the equilibrium price of frontage $p(f^*)$, they attempt to sell frontage. Holding price constant at $p(f^*)$, frontage per property falls to $f'$. But with all properties using less frontage, the amenity value falls to $A' \equiv A\left(\frac{\tilde{k}(f')T}{f'}, \phi\right)$, and the *MWTP* function shifts to $MWTP'$. At $f'$ the marginal willingness to pay is less than the new equilibrium price $p(f')$, and so once again property owners sell frontage as the process repeats. This iterative process is strictly conceptual –we do not argue that the market actually functions this way –and it terminates at the intersection of the marginal benefit function and the price function $p(f)$ at frontage level $f^{**}$. Here the marginal willingness to pay for frontage given amenity level $A^{**}$ just equals the price of frontage $p(f^{**})$. The total value of undeveloped lakefront is $T \cdot G$, and the aggregate welfare loss compared to the welfare-maximizing solution is $T \cdot (D - G)$.

Using the foregoing graphical development, it is easy to see that for an undeveloped lake there exists a range of welfare-improving values of the zoning restriction *F*. With reference to Figure 2, this range is $f^{**} \le F \le f^U$. If *F* lies below $f^{**}$, the zoning restriction is non-binding, and provides no net economic gain. If *F* lies above $f^U$, the zoning restriction is too severe, and the cost of zoning exceeds the benefit.

The conflict intrinsic to zoning is apparent in Figure 2. Setting $F = f^*$ preserves amenities, maximizing the welfare of lakefront owners. On the other hand, at $f^*$ the price of frontage is greater than a lakefront owner's marginal willingness to pay for it, and the owner would gain if *solely* relieved of the burden of the zoning restriction. This is the manifestation of the development effect of zoning.

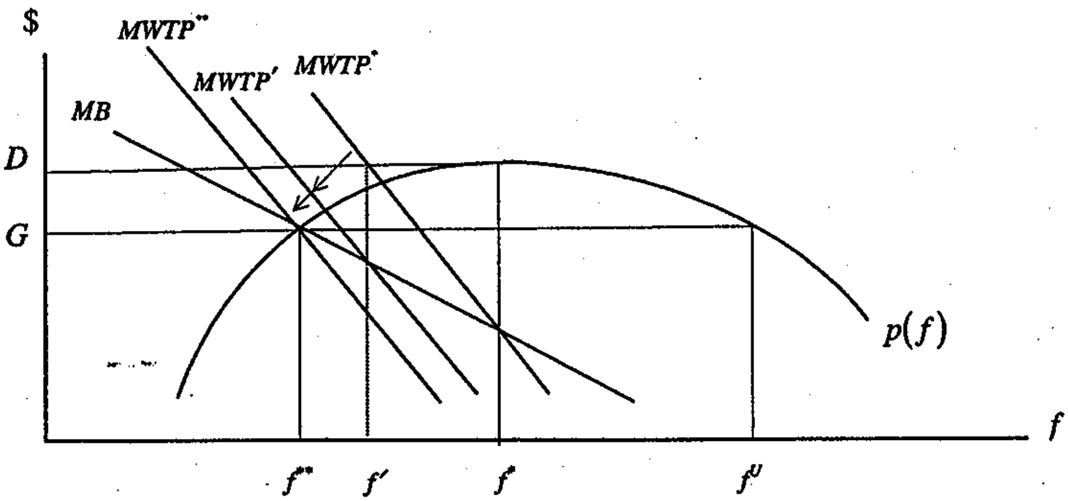


**Figure 2.**

*Complications*

Assembling and subdividing property involves significant transactions costs, especially when properties are already developed. This is one reason lakes remain undeveloped thirty years after Sigurd Olson's alarm. Cognizant of the quasi-irreversiblity of development, lakefront owners hold undeveloped frontage with the expectation that it is most profitably developed at a later time. They hold large parcels because it is cheaper to subdivide frontage than it is to negotiate the assembly of smaller contiguous parcels. The upshot is that positive transactions costs make the development decision a dynamic one in which the price of a lakefront property reflects not simply the willingness to pay for the property in its current state, but also the willingness to pay for it in its anticipated future state, broadly defined to include the property's eventual subdivision or assembly, and the eventual state of the lake on which it lies.

Suppose, for instance, that unanticipated minimum frontage $F$ lying in the interval $\left[f^{**}, f^{U}\right]$ is imposed on a lake with frontage already allocated among undeveloped properties. If the exchange of property is costless, then the equilibrium price function $p(f)$ still applies, and under zoning frontage owners will redraw frontage into lengths of $F$ to obtain a price of $p(F)$. But typically such a lake-wide adjustment is costly, so the matter of reallocating frontage is reduced to subdividing existing properties and combining adjacent properties. No longer is there a single equilibrium price; rather, the unit price of frontage under zoning depends on both the value of $F$ for each lake in the region, and the initial (pre-zoning) division of frontage.

Denote the price of property $i$ on lake $n$ by $p(f_i, F_n, \omega_i, \phi_n)$, where $f_i$ is the frontage of property $i$; $F_n$ is the minimum frontage zoning restriction on lake $n$, taking the value of 0 when lake $n$ is unzoned; $\omega_i$ is a vector of characteristics of property $i$, such as property area; and $\phi_n$ is a vector of characteristics of lake $n$, such as lake surface area and the current state of development on the lake. A reasonable example of the price function for property $i$ in the absence of zoning, $p(f_i, 0, \omega_i, \phi_n)$, is shown in Figure 3. Also illustrated are WTP curves with amenities fixed at their levels *before zoning*, as indexed by the

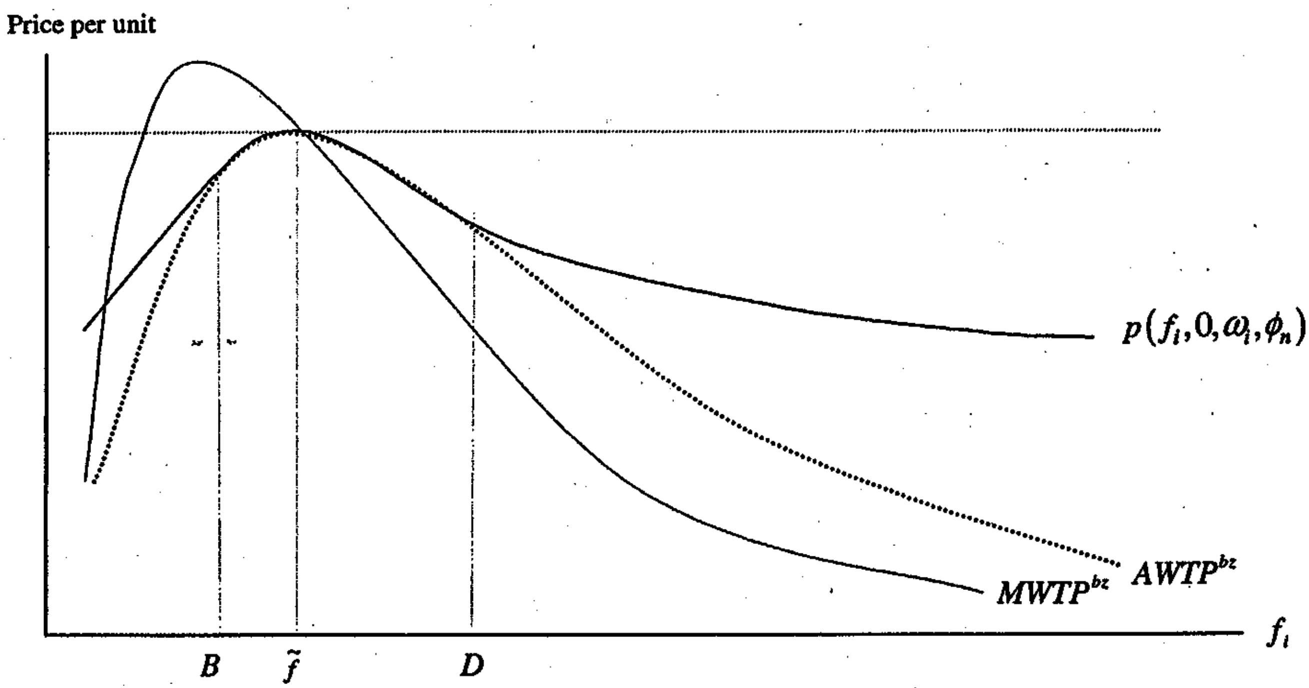


**Figure 3.**

superscript $bz$.[7] The *AWTP* function is conceptually different from the average benefit function *AB* considered in Figure 1 because for *AWTP* the amenity flow is fixed (this is the same distinction made between the *MB* and *MWTP* functions in Figure 2). Importantly, both the *MWTP* and *AWTP* functions pertain to the utility derived from the frontage *in its current state*, without the prospect of combining or subdividing. If the frontage of property $i$ is less than $B$ in Figure 3, the price per unit is greater than $AWTP^{bz}$ due to the potential gain from combining the frontage with an adjacent parcel. At point $B$ the gain from combining the parcel with a neighboring parcel is just equal to the transactions cost of such a move, so the frontage owner is indifferent between combining the property and leaving it in its current state. If the frontage of property $i$ lies between $B$ and $D$, frontage is in its best use; nothing is gained by either combining with adjacent properties or subdividing, because the cost of altering frontage boundaries is prohibitive. At frontage level $D$, the gain from subdividing the parcel is just equal to the transactions cost of subdividing. Above this level the price per unit is once again greater than $AWTP^{bz}$, because there is a positive net gain from subdividing. The exact nature of the difference between $p(f_i, 0, \omega_i, \phi_n)$ and $AWTP^{bz}$ depends on the nature of transactions costs. As these costs decline for property $i$ (leaving the transactions costs for all other properties the same), the price function "flattens" along the light horizontal line in Figure 3 as it converges identically to the maximum price, $p(\tilde{f}, 0, \omega_i, \phi_n)$.[8]

Minimum frontage zoning has three effects on price: a development effect associated with reducing the marginal willingness to pay for frontage by restricting subdivision; an amenity effect associated with the eventual disposition of other properties on the lake, as conveyed via $\omega_n$; and a general equilibrium price

[7] For simplicity we continue to assume homogeneity of preferences. Relaxing this assumption, the WTP curves denote the upper envelope of individual WTP curves.

[8] As transactions costs fall for all properties, a general equilibrium response may change the maximum price of property $i$.

effect arising to the extent that zoning affects development on other 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 are examined in sequence in Figures 4 and 5.

Consider first, in isolation, the development effect of zoning, illustrated in Figure 4. The minimum frontage restriction is denoted by $F_n>0$. In the figure, the price of frontage after zoning coincides with the price of frontage before zoning up to frontage level *D*, after which it coincides with average willingness to pay up to frontage level *E*, after which it takes an intermediate position.

Figure 4 illustrates several points. First, in the absence of an amenity effect the willingness to pay to consume a given amount of frontage remains unchanged after zoning; the before-zoning WTP functions still apply. Second, the negative effect of zoning falls on properties differentially. Properties with frontage less than *D* (the frontage level above which subdivision is optimal in the absence of zoning) are not affected, because below *D* it is not economically rational to subdivide property. Third, between *D* and *2F* the price of frontage remains equal to $AWTP^{bz}$ after zoning, because subdivision is not permissible. This remains true for the case where *F*>*D*, not shown in the figure. Fourth, at some frontage level no less than *2F*, the price of frontage departs from $AWTP^{bz}$, because subdividing the property is both permissible and economically optimal. Properties with frontage *2F can* be split evenly, but such a split may not be economically optimal. If it is –if, in other words, the gain from splitting the property in half covers the cost of subdivision –then at *2F* the price jumps to some level between $p(2F,0,\omega_i,\phi_n)$ and $AWTP^{bz}$.[9]

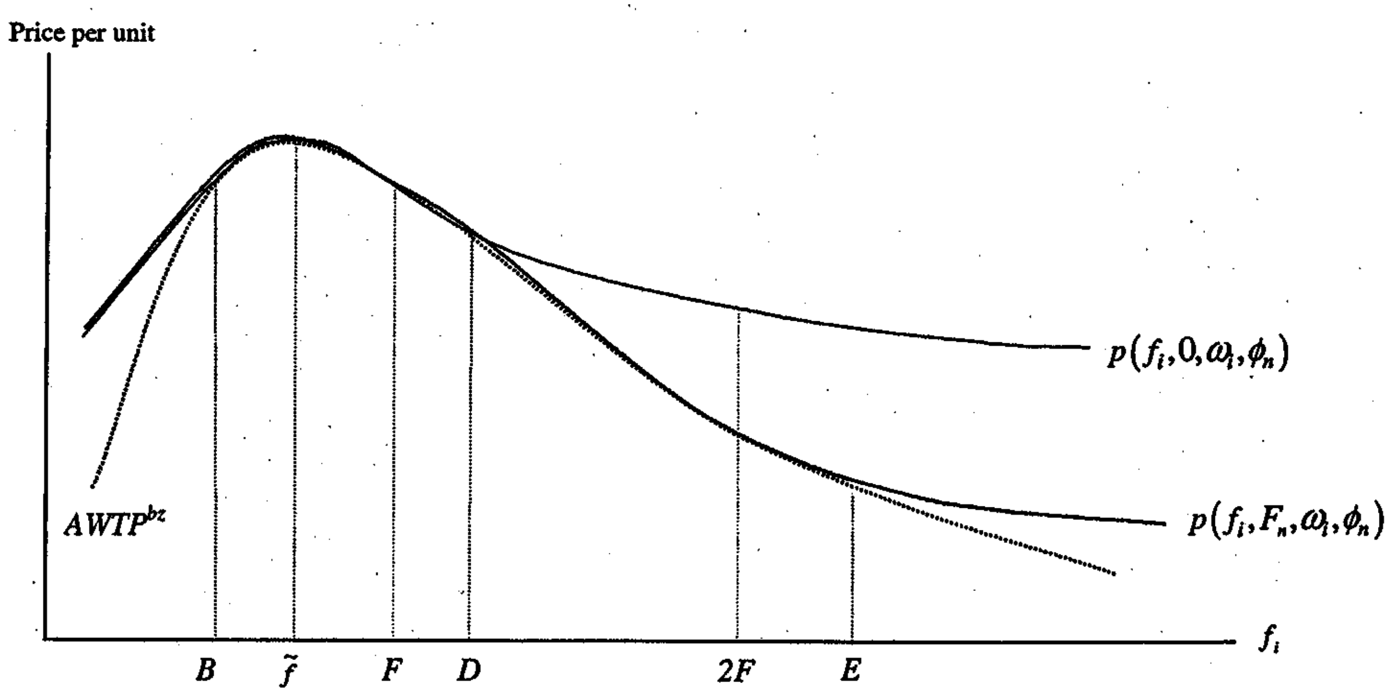


**Figure 4.**

[9] Note that $p(2F,0,\omega_i,\phi_n)$ is the *maximum* unit price of property *i* in the absence of zoning; this maximum may involve subdivision different from an equal division of the property.

Alternatively, at some frontage greater than *2F* it becomes economical and feasible to subdivide property, at which point the price of frontage under zoning departs from average willingness to pay. In Figure 4, this point is *E*.

Figure 5 adds to Figure 4 the case of an amenity improvement from zoning (Case 2; the case of a development effect only is Case 1). This improvement arises via the effect of the zoning regulation on the future state of development on the lake, which is conditional on the current state of development implicit in $\phi_n$. Shading indicates the feasible region for the after-zoning price. A change in the flow of amenities due to zoning impacts the willingness to pay for frontage, and so associated with Case 2 is an alternative, after-zoning representation of average willingness to pay, $AWTP^{az}$.

The price of property with frontage less than *D* must increase after zoning, because zoning enforces an increase in the flow of amenities. The price of property with frontage greater than *D* may increase or decrease, depending on whether the increase in the amenity flow is sufficient to offset the direct loss (development effect) imposed by the zoning restriction. In Case 2, the price of property *i* increases after zoning if $f_i$ is less than *G*, and decreases after zoning if $f_i$ is greater than *G*.

Properties with before-zoning frontage less than *F* that are *grandfathered* –allowed improvements without further subdivision, despite failing to meet the zoning requirement –do not necessarily benefit from zoning. If the zoning restriction is set such that *F*>*D*, and if property *i* lies between *D* and *F*, then under zoning the property may be harmed, because whereas the before-zoning price of the property reflects an economic gain from subdivision, under zoning the property is no longer subdividable.

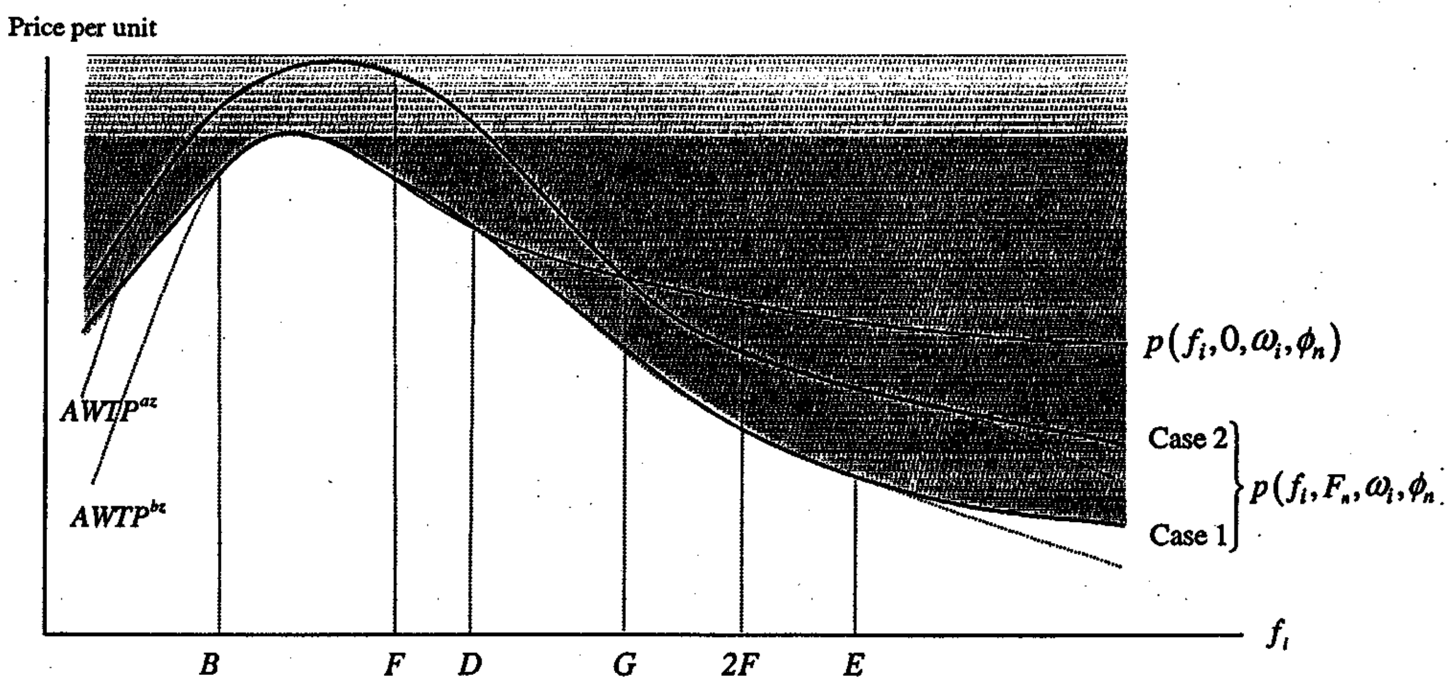


**Figure 5.**

## III. An Application to Minimum Frontage Zoning in Northern Wisconsin

The foregoing theoretical discussion serves as a guide to the development of a hedonic price function for undeveloped private lakefront property in Vilas County, Wisconsin, and several adjacent towns in Oneida County.[10] These counties are part of Wisconsin's North Woods, a heavily forested and fairly remote area with thousands of lakes (including 2000 in Vilas County) and two national forests. The major industries of the counties are tourism and forestry.

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 zoning regulations, as reported in Table 1.

**Table 1. Vilas Towns with Lakefront Restrictions More Stringent than the State Restriction**

| *Town in Vilas* | *Year* | *Min Width (ft.)* | *Min Area (sq. ft.)* |
|---|---|---|---|
| Boulder Junction | 1972 | 200 | 40000 |
| Conover | 1977 | 200 | 40000 |
| Lac du Flambeau | 1994 | 200 | 30000 |
| Land O'Lakes | 1972 | 200 | 40000 |
| Manitowish Waters | 1986 | 200 | 50000 |
| Presque Isle | 1959 | 200 | 65340 |
| Winchester | 1995 | 200 | 60000 |

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. In the discussion below this restriction is called the 200-Foot Rule, and the original statewide restriction is called the status quo regime.

### *Data Sources and the Hedonic Price Equation*

For the analysis we used data for a random sample of 892 undeveloped properties sold in the study area between January 1986 and December 1995. The data were obtained from several different sources. The State of Wisconsin SAS Data Base, compiled by the Wisconsin State Bureau of Revenues, records for every property sale in the state the county and town of the property, whether the land is developed or vacant, presence/absence of water frontage, sale price, sale date, and parcel code (the parcel's plat book identification number). From this database we obtained sales of undeveloped lakefront properties in the study area. Conceivably we could have included developed properties, netting out the value of structural improvements in the econometric analysis. 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 these records are held by private assessors with whom the towns contract for assessment services. 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 plat books, we obtained for each sale the location of the property, the lake on which the property is located, and the area

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

and frontage of the property. Data on lake characteristics were obtained from the Wisconsin Department of Natural Resources.

To account for broad economic factors influencing the market for frontage over time, and to capture the effect on lakefront prices of parcel size, as measured by both land area and frontage length, the hedonic price function takes the log-linear form,

$$\ln p = \sum_{t=1}^{10}(\beta_t D_t + \beta_{t+10} D_t \cdot f) + \beta_{21} f^2 + \beta_{22} area + \ldots, \tag{6}$$

where $p$ is property price per frontage foot in 1986 US dollars; $D_t$ is a binary dummy variable taking a value of one if the sale was made in year $t$ of the study period ($t=1$ for sales in 1986, $t=2$ for sales in 1987, and so on); $f$ is the frontage in feet; and *area* is the area of the property in acres.

In the theoretical model the price of frontage depends on the lake's overall state of development, which affects the 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™ maps, the only accessible source of historic data on property boundaries in the North Woods.[11] Formally, under the status quo regime

$$\ln p = \ldots + \beta_{23} pub + \beta_{24} large + \beta_{25} small + \ldots, \tag{7}$$

where *pub* is the proportion of public land on the lake, *large* is the proportion of private large tracts, and *small* 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:

$$\begin{aligned} \ln p = \ldots &+ \beta_{26} village + \beta_{27} forest + \beta_{28} county \\ &+ \beta_{29} surface + \beta_{30} shore + \beta_{31} stratif + \ldots \end{aligned}, \tag{8}$$

where *village* is the distance to the nearest village with major services (either Minoqua-Woodruff, or Eagle River) in miles; *forest* is the shortest driving distance to the Nicolet National Forest in miles; *county* is a dummy variable taking a value of one for sales in Vilas county; *surface* is the surface area of the lake in square miles; *shore* is the miles of shoreline; and *stratif* is a stratification factor for the lake,[12]

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[11] Rockford Map Publishers, Inc. On the World Wide Web at www.rockfordmap.com .

[12] Lathrop, R. C., R. A. Lillie, 1980, "Thermal Stratification of Wisconsin Lakes", in *Trans. Wis. Acad. Sci., Arts, and Letters*, 68:90-96. Lakes that are strongly stratified are less able to assimilate phosphorus nutrients, because mixing of upper and lower layers doesn't occur.

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

This last variable can be interpreted as a rough "pollutability" index. Several property-specific variables were also examined in the analysis, including a "buildability" index of the quality of the soil for residential construction. None of these variables was statistically or practically significant, and so they are omitted from the model presented here.

According to the theoretical analysis, the 200-Foot Rule generates an amenity effect and a development effect. In the hedonic price equation, these effects are embodied in the set of terms

$$\begin{aligned}\ln p = \ldots &+ \left[\beta_{32} d \cdot large \cdot f + \beta_{33} d \cdot large \cdot f^2 + \beta_{34} d \cdot small \cdot f + \beta_{35} d \cdot small \cdot f^2\right] \\ &+ \left[\beta_{36} dd \cdot f + \beta_{37} dd \cdot f^2\right] + \ldots\end{aligned} \tag{9}$$

where $d$ 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 a 200-Foot Rule, and $dd$ is a dummy variable taking a value of one if at the time of sale the property is effectively constrained by the 200-Foot Rule. The meaning of "effectively constrained" requires some elaboration. In the study area properties with less than 200 feet of frontage at the time the zoning restriction is imposed are grandfathered –allowed the improvements permitted under preexisting zoning, but *not* allowed subdivision. Suppose prior to the enactment of the 200-Foot Rule a lake were free of minimum frontage restrictions. Then for the lake's undeveloped, grandfathered properties the 200-Foot Rule would represent an effective constraint, because part of the value of these properties derives from the option to subdivide them in the future. In the case at hand, though, grandfathered properties are *not* effectively constrained by the 200-Foot Rule, because the status quo regime (the statewide minimum frontage restriction of 100 feet) already prevents their subdivision. Thus only for grandfathered properties is $dd$=0.

The first bracketed expression on the right-hand side of (9) accounts for the amenity effect, and the second bracketed term accounts for the development effect. Distinguishing these effects in this manner is not arbitrary. The development effect befalls only those properties effectively constrained by the 200-Foot Rule. The amenity effect applies to *all* private property on a lake restricted by the 200-Foot Rule, and due to its nature as an externality its magnitude depends on the lake's potential for additional development, as represented by *small* and *large*.

The expected sign of the amenity effect is positive, with

$$\operatorname{sgn}\left(\frac{\partial\left[\beta_{32} d \cdot large \cdot f + \beta_{33} d \cdot large \cdot f^2\right]}{\partial large}\right) = \operatorname{sgn}(\beta_{32} + \beta_{33} \cdot f) > 0$$

$$\operatorname{sgn}\left(\frac{\partial\left[\beta_{34} d \cdot small \cdot f + \beta_{35} d \cdot small \cdot f^2\right]}{\partial small}\right) = \operatorname{sgn}(\beta_{34} + \beta_{35} \cdot f) \geq 0$$

in the range of the data; the greater the proportion of lakefront in private property, the greater the amenity flow induced by the 200-Foot Rule. Moreover, because small tracts are already more developed than

[13] To argue that the development effect *does* depend on the composition of property along the lakefront is to argue that a property owner is more (or less) likely to subdivide a property as the proportion of private land along the lake increases.

large tracts, the future amenity flow induced by restricting the subdivision of small tracts is relatively low, and so we expect $\beta_{32} + \beta_{33} \cdot f > \beta_{34} + \beta_{35} \cdot f$ in the range of the data. To the extent small tracts are already fully developed, $\beta_{34} = \beta_{35} = 0$.

The hedonic price equation terminates with an independent, normally distributed disturbance,

$$\ln p = ... + \varepsilon, \qquad (10)$$

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

Table 2 provides the mean, standard deviation, and range of the variables used in the analysis. The average price of frontage is $124 per foot (1986 dollars), and the average frontage length is 211 feet. Approximately 81% of all properties are in Vilas county. 32.1% of the properties are located on lakes with 200 foot minimum frontage requirement; among these, the majority (61%) are restricted by the 200 Foot Rule (19.6% of the total number of properties). The maximum distance to the Nicolet National Forest is 5.5 miles, with a mean of less than a mile, indicating little dispersion of the observations with respect to *forest*. The average lake surface area is less than a square mile. 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.

**Table 2. Descriptive Statistics**

| Variable | Mean | St. Dev. | Minimum | Maximum |
|---|---|---|---|---|
| *p* | 123.650 | 122.67 | 0.83 | 1573.00 |
| *area* | 2.860 | 5.05 | 0.01 | 59.70 |
| *f* | 210.850 | 215.64 | 10.00 | 2500.00 |
| *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 |
| *d* | 0.321 | 0.47 | 0 | 1 |
| *dd* | 0.196 | 0.40 | 0 | 1 |

**Table 3. Distribution of Observations with Respect to Frontage**

| Frontage | Number of observations |
|---|---|
| $0 < f < 100$ | 50 |
| $100 \leq f < 200$ | 511 |
| $200 \leq f < 300$ | 188 |
| $300 \leq f < 400$ | 58 |
| $400 \leq f < 500$ | 33 |
| $500 \leq f < 700$ | 20 |
| $700 \leq f < 1000$ | 19 |
| $f \geq 1000$ | 13 |
| total | 892 |

### *Results and Discussion*

Table 4 presents the estimated parameters of the hedonic price equation (6)-(10), and of a preferred restricted version of the equation. To save space, results for the twenty time-related dummies and dummy interaction terms in (6) are omitted from Table 4; these are available in a full copy of the estimation results available at the web address footnoted below.[14] All coefficients for omitted variables are statistically significant at the .001 level for both the full and preferred versions of the model.

The preferred model omits three terms. The first of these, $dd \cdot f$, pertains to the development effect. In the full model this term is nonsignificant. The other omitted terms, $d \cdot small \cdot f$ and $d \cdot small \cdot f^2$, pertain to the amenity effect. The coefficients on these terms are nonsignificant in the full model, indicating that small tracts are fully developed, or nearly so, and thus do not significantly influence the amenity flow of the 200-Foot Rule.

Before examining the results more closely, we note two analyses of the model specification. A reasonable hypothesis is that the variance of the disturbance is conditional on some of the explanatory variables. Results of testing for heteroskedasticity were mixed. For instance, Breusch-Pagan-Godfrey tests involving all explanatory variables failed to reject the null hypothesis of homoskedasticity. Chi-square statistics for the tests were 35.53 (36 df) and 34.85 (33 df) for the full and preferred models, respectively. The results presented in Table 4 assume homoskedasticity.

Critical to the estimation of a hedonic price function using several years of data is the assumption that the price function is stable over the horizon of the sample. If this is not true the estimation yields an object that is not the price function for the study period, but instead is an unidentified "blend" of price functions arising as the market for lakefront property evolves over time. For both the full and restricted versions of the model presented below, Chow tests fail to reject the hypothesis that the estimated price function is the same for the first five years of the study period as it is for the last five years, with F-statistics at the 63rd and 42nd percentiles for the full and preferred models, respectively, and so we have some confidence that the dummies and dummy interaction terms in (6) are adequate to correctly identify the function.[15]

The results are generally consistent with theory and intuition. As expected, lakeshore in public land is

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[14] www.aae.wisc.edu/provencher. Alternatively, a full copy of the regression output can be obtained by contacting the authors.

[15] $F$=1.067 ($df_1$=37, $df_2$=818) for the full model; $F$=.937 ($df_1$=34, $df_2$=824) for the preferred model.

preferred to lakeshore in private land ($\beta_{23} > \beta_{24}, \beta_{25}$). That the signs on *pub*, *small*, and *large* are all positive indicates that lakefront in any of these categories is preferred to lakefront in tribal land. This may reflect uncertainty about future development of tribal lands. In the absence of the 200-Foot Rule, lakeshore in small tracts is apparently preferred to lakeshore in large tracts ($\beta_{25} > \beta_{24}$), perhaps because of uncertainty about the nature of future development on large tracts.

**Table 4. Hedonic Price Function ln(*p*)[a]**

| | | Full Model | | | Preferred (restricted) Model | | |
|---|---|---|---|---|---|---|---|
| Variable | Coefficient | Coefficient Estimate | Standard Error | ρ-Value[b] | Coefficient Estimate | Standard Error | ρ-Value[b] |
| $f^2$ | $\beta_{21}$ | 3.374E-06 | 6.228E-07 | 1.000 | 2.967E-06 | 5.153E-07 | 1.000 |
| *area* | $\beta_{22}$ | 6.152E-03 | 6.370E-03 | 0.833 | 6.742E-03 | 6.353E-03 | 0.856 |
| *pub* | $\beta_{23}$ | 1.297 | 0.2558 | 1.000 | 1.305 | 0.2543 | 1.000 |
| *large* | $\beta_{24}$ | 0.5055 | 0.2342 | 0.984 | 0.4762 | 0.2336 | 0.979 |
| *small* | $\beta_{25}$ | 0.8140 | 0.2182 | 1.000 | 0.8551 | 0.2154 | 1.000 |
| *village* | $\beta_{26}$ | -7.588E-03 | 3.221E-03 | 0.009 | -5.667E-03 | 2.979E-03 | 0.029 |
| *forest* | $\beta_{27}$ | 1.404E-02 | 2.144E-02 | 0.744 | 1.499E-02 | 2.139E-02 | 0.758 |
| *county* | $\beta_{28}$ | 7.063E-02 | 6.896E-02 | 0.847 | 8.790E-02 | 6.799E-02 | 0.902 |
| *surface* | $\beta_{29}$ | 0.1393 | 3.685E-02 | 1.000 | 0.1360 | 3.674E-02 | 1.000 |
| *shore* | $\beta_{30}$ | 4.142E-02 | 8.138E-03 | 1.000 | 4.161E-02 | 8.117E-03 | 1.000 |
| *stratif* | $\beta_{31}$ | -1.976E-03 | 3.206E-03 | 0.269 | -1.633E-03 | 3.173E-03 | 0.303 |
| $d{\cdot}large{\cdot}f$ | $\beta_{32}$ | 3.208E-03 | 9.101E-04 | 1.000 | 3.162E-03 | 6.916E-04 | 1.000 |
| $d{\cdot}large{\cdot}f^2$ | $\beta_{33}$ | -2.289E-06 | 8.987E-07 | 0.006 | -2.020E-06 | 6.336E-07 | 0.001 |
| $d{\cdot}small{\cdot}f$ | $\beta_{34}$ | 1.072E-03 | 7.973E-04 | 0.910 | - | - | - |
| $d{\cdot}small{\cdot}f^2$ | $\beta_{35}$ | -1.171E-06 | 8.404E-07 | 0.082 | - | - | - |
| $dd{\cdot}f$ | $\beta_{36}$ | -1.329E-04 | 6.830E-04 | 0.423 | - | - | - |
| $dd{\cdot}f^2$ | $\beta_{37}$ | -7.070E-07 | 8.168E-07 | 0.193 | -8.838E-07 | 3.532E-07 | 0.006 |

[a] Adjusted $R^2$ is .4451 and .4449 for the full and restricted models, respectively.
[b] The ρ-value equals $F(t_k)$, where $F$ is the CDF for the $t$-distribution, and $t_k$ is the $t$-statistic of the estimate.

Distance to a major town has a negative effect on property price, suggesting that though vacationers go to the North Woods to "get away from it all", they don't want to go too far. The nonsignificance of *forest* is surprising, but may reflect the lack of variability in the data (see Table 2). That *stratif* is not significant is consistent with a common perception that water quality in North Woods lakes is uniformly excellent.

The coefficients estimates for the last six terms in Table 4 are generally consistent with the theory of the previous section. Except for frontages in the upper tail of the sample frequency distribution –that is, except where the support of the data is weak –the amenity effect of the 200-Foot Rule is positive, and increasing as the proportion of lakefront in private property increases. In particular, in the preferred model the amenity effect is positive for properties with less than 1565 feet of frontage (for only five sample properties is frontage greater), and in the full model the amenity effect is positive for properties with less than 2289 feet (for only one sample property is frontage greater). In both models the development effect is negative as expected.

As a practical matter, though, the amenity effect is significant and the development effect is not. This is apparent by calculating the price effect of extending the 200-Foot Rule to sample properties currently under the status quo regime. The 200-Foot Rule increases the price (in 1998 dollars) of such properties by an average of $15.82 per foot (12.3%) under the full model, and by an average of $9.07 (7.1%) under the preferred model. Figures 6a-b present this price effect, as calculated using the preferred model, on a property-by-property basis. In the figures properties are ordered by frontage. Figure 6a concerns only those properties for which frontage is less than 200 feet, and so only the amenity effect applies. Figure 6b concerns those properties for which frontage is at least 200 feet, in which case the development effect applies. In both figures the horizontal axis is labeled every 40 observations, and so, for instance, the high incidence of sample properties with 100 feet in Figure 6a generates multiple "100-foot" labels. The maximum price in the figures is 400 feet. There are a handful of properties in the sample with prices greater than this, but we omit these to increase the scale of the figures, thereby improving their clarity. Each sample property in the figures is associated with a gray line anchored by a black dash. The black dash denotes the *observed* frontage price. The other end of the gray line marks the property's expected frontage price were the 200-Foot Rule imposed. The length of the gray line thus measures the expected price change due to the 200-Foot Rule. With a few exceptions, the Rule generates a price increase. The increase is generally greater for properties with a higher initial price per foot, though in percentage terms the Rule does not favor the more valuable properties. Of course, these price effects are at the current margin –they apply given the current extent of minimum frontage zoning.

## IV. Conclusion

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 negligible and the amenity effect is 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 distribution" assumption for the prices of developed and undeveloped properties. This is the assumption that after correcting for improvements, developed parcels are no different than undeveloped parcels. 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.

The surprising result for the development effect warrants additional analysis. So too does the matter of selective application of minimum frontage zoning. 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. 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.

**Figure 6a. Price Effect of Extending the 200-Foot Rule to Sample Properties Currently Under the Status Quo Regime (<20 0 feet of frontage)**

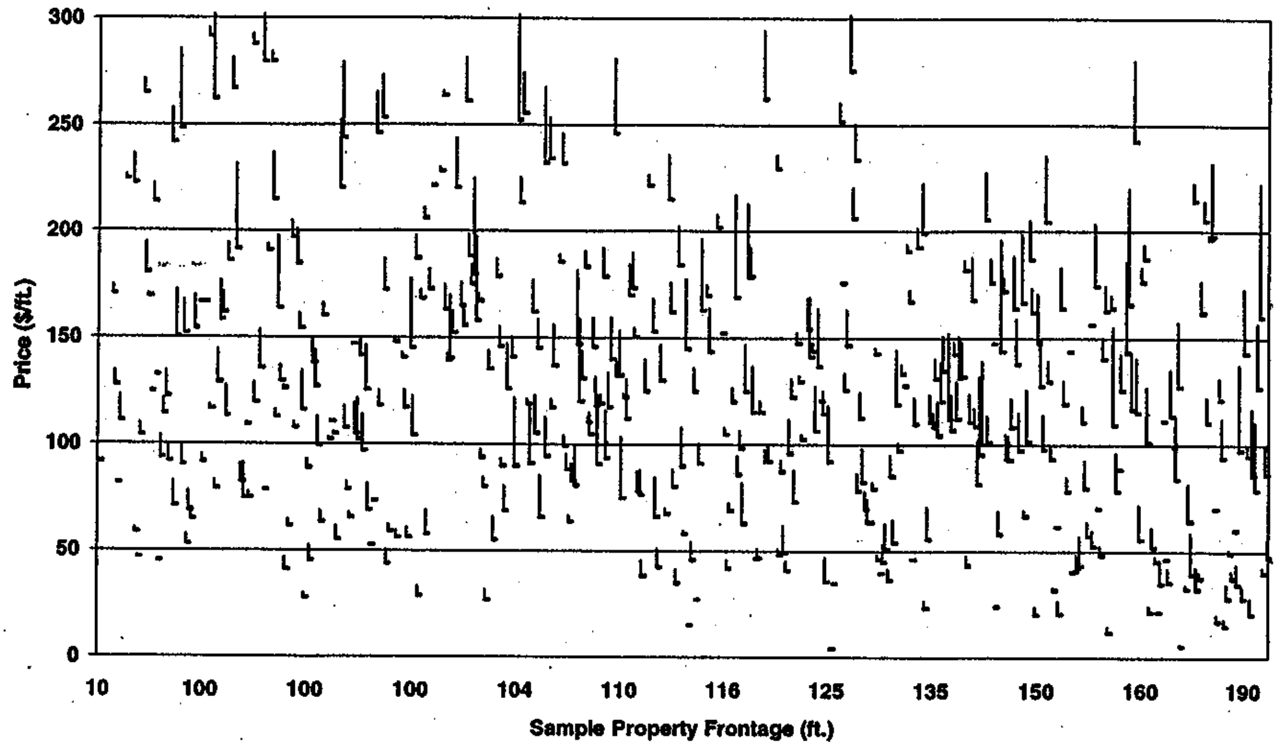
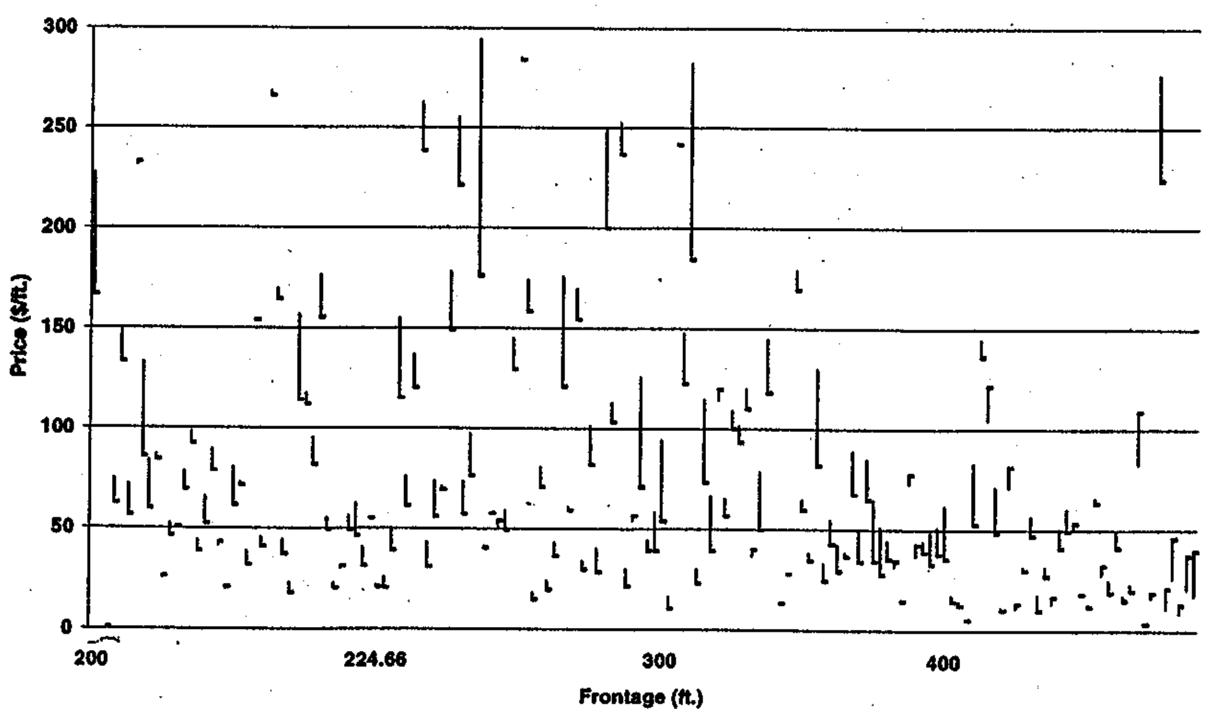



**Figure 6b. Price Effect of Extending the 200-Foot Rule to Sample Properties Currently Under the Status Quo Regime (>200 feet of frontage)**



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