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MUNICIPAL SOLID WASTE INCINERATOR IMPACTS ON RESIDENTIAL PROPERTY VALUES AND SALES IN HOST COMMUNITIES* **

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ABSTRACT

Property value effects of new municipal waste incinerators often concern residents in prospective host communities. Despite numerous studies of property values using standard approaches, the results show insignificant or inconsistent results. This article describes in detail the mechanism that determines property value differences in response to waste facility impacts and tests the key issues in the process. Key items and assumptions that underlie the linear "hedonic property value" model include: 1) the facility's impacts, 2) residents' and potential buyers' perception and understanding of the impacts, and 3) assumptions that property value data is well behaved and that other factors in the real estate market are constant. The analysis of property values at waste facilities shows that many studies reveal insignificant or marginal effects. Few show significantly negative impacts and some show positive property value impacts. A detailed case study of property values and sales at a new incinerator site shows no significant effects of facility impacts on sales prices or on the number of sales in the host community. Tests of key assumptions show that some are poorly met by the data. Property value guarantees are offered as a method of encouraging residents to accept the facility, but the guarantees do not sway the most concerned respondents. In conclusion, the implications for facility siting are discouraging because the

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results do not corroborate the standard approach to predicting property value impacts. Therefore, analysts are left without a method to predict impacts or to determine effective methods of addressing residents' concerns. The results mean that future research must carefully trace residents' perceptions of impacts at the time of purchase, test the model's assumptions, and adapt the model accordingly.

Because property value losses are often a major concern for residents near waste facilities in general and near incinerators in particular, property value impacts are considered to be a simple, market-based dollar measure for intangible impacts. Moreover, residents' concerns can be addressed by property value guarantees pegged to the fair market value of the property without the impacts. This article analyzes the value judgment mechanism that leads to price differentials, tests for price differences and sales effects, evaluates price guarantees as a compensation mechanism, and identifies the implications for siting and research. Five key issues are examined:

1. Do conventional property value studies provide consistent estimates of impacts?
2. Do facility impacts significantly affect property prices if analyzed with a properly specified model?
3. Do waste-to-energy plants affect property sales in the absence of significant price impacts?
4. Are the key assumptions of the linear multiple regression property value model valid?
5. Do property value guarantees sway opposing residents to accept modern incinerators?

Specifically, some of the key assumptions and relationships are tested to determine whether and how property values and sales can be predicted from facility impacts. Under issues (1) and (2), previous studies are reviewed and a case study of a property value model is tested with a properly defined impact zone. The effects on property sales are evaluated at the same study site to check whether lack of knowledge or lower sensitivity are reflected in real estate sales to address question (3). Several key assumptions of the linear regression model are tested. Finally, the effectiveness of property value guarantees is assessed. In the next section, current theory is reviewed and results of a literature review and of empirical tests at an incinerator site are presented.

THEORY OF NOXIOUS FACILITY IMPACTS AND PROPERTY VALUE DIFFERENCES

Although the connection between undesirable facility impacts and residential property values is intuitive, the causal mechanism that translates impacts into

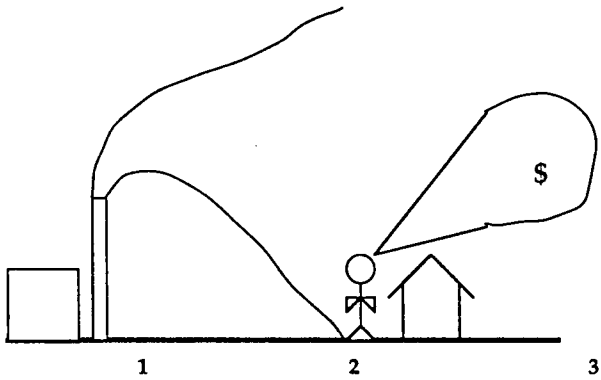
value differences and the analytical model's underlying assumptions and procedures are worth reviewing to detect sources of error or inaccuracy.

Residential property values reflect the expected capability of the parcel to provide the owner with desirable qualities for the enjoyment of residential activities [1]. Thus, the value of residential property is generated by the scarcity of parcels with specific characteristics: location in a certain city, community, or area; distance to work, shopping, schools; amenities such as view, quiet, safety; and any other desirable attributes. Conversely, any changes that affect the enjoyment of the property as perceived by the owner, such as the impact of a waste facility, will diminish the capability of the property to produce the expected yields of residential enjoyment. However, the loss will only carry over to a buyer if he or she knows of the changes and is equally or more sensitive to the effects. The market price declines only if a large proportion of potential buyers at the time of purchase perceive the effects to be undesirable, so that there are more affected homes than insensitive buyers.

Many of the impacts of a waste facility on a host community have been noted as undesirable, including physical impacts of health risks, nuisances, and environmental change, social impact of stigma to the community image, political impacts of loss of control, unfairness of one area bearing the impacts while others enjoy benefits, loss of confidence in government, and, finally, economic impacts as property-value depreciation (or slower appreciation), longer times to sell homes, and retardation of development [2]. The physical changes may affect the non-physical issues of community image, control, fairness and confidence in the community's perception. These intermediary impacts may combine in residents' perceptions to increase property value differences. Thus, both physical and nonphysical impacts alike can affect property values as long as they are perceived to detract from residential enjoyment. Finally, easily perceived impacts (noise, odor, view) will be more readily reflected in property values than insidious, long-term effects [3].

Because the market price reflects the value of the expected future stream of residential enjoyment from the property, the price includes any expected changes to the property's characteristics. Thus, if quiet homes are expected to become more noisy, then their value relative to other homes will decline [4] if all other factors remain the same. While this process seems simple enough, the facility impacts combine to a set of beliefs about the resulting changes to environmental quality dimensions that influence the quality of residential enjoyment provided by properties in the host community. Homeowners or potential homebuyers in effect additively or multiplicatively combine impact levels (weighted according to the type of impact) to a value judgment. The value judgment is then reflected as a difference between the fair market value of the residential property and the price of the property with the impact [5]. The cause-effect mechanism consists of three steps (see Figure 1):

1. Facility impacts are generated by the operation and cause changes in the host community;



Facility Impacts

- Impact levels, duration, frequency, etc. are constant
- Impact indicators are accurate and correlate linearly with all impacts

Residents' and Buyers' Perception

- Perceive impacts accurately
- Have perfect knowledge of impacts
- Equally sensitive
- Consider only impact levels at home location

Value Judgment

- Linear value curve
- Normally distributed data
- Constant variance
- Low collinearity
- Real estate market at equilibrium, and unaffected by other factors, buyers' and sellers' have perfect knowledge

Figure 1. Property value impact decision process.

2. The impacts are sensed or perceived by affected residents and potential buyers; and
3. The changes are translated through residents' value judgment and are expressed as appropriately discounted price offers.

The crucial point is that, theoretically, all perceived changes caused by the facility are reflected in changes in property values. Property-value differences should, therefore, summarily reflect all impacts that are caused by the facility and that are perceived to harm residential enjoyment. The value differences between affected and unaffected parcels can replace the measurement of numerous intangible impacts with a simply summary dollar measure. If this hypothesis is true, then property-value guarantees could be very effective in addressing waste facility impacts to gain host community acceptance.

Methodology to Estimate Property Value Differences

The conventional approach to testing and determining property value impacts consists of estimating with multiple regression of housing, neighborhood and facility impact data the coefficients of the independent variables in the hedonic

(enjoyment seeking) equation for residential housing prices. In the standard linear form, the equation appears as follows:

$$P_i = b_0 + b_1 \cdot X_{1i} + b_2 \cdot X_{2i} + \ldots + b_n \cdot X_n + b_{n+1} \cdot Y_{1i} + \ldots + b_{n+m} \cdot Y_{mi} + e_0 \qquad (1)$$

The equation predicts P_i, the price of residential property i, with b_i to b_{n+m} as the model parameters to be estimated, i.e., the implicit unit prices for increments in property characteristics (X_1 to X_m) or in exposure to facility impacts (Y_1 to Y_n). The terms b_0 and e_0 are, respectively, the constant and the error terms. The parameters are estimated with multiple regression analysis of property sales prices regressed on property and neighborhood characteristics and on impact exposure variables. The null hypothesis states that the exposure to facility impacts does not explain variation in sales prices. For the null hypothesis to be rejected at least one indicator impact must be shown to significantly explain variation in property prices.

Model Assumptions

Although simple, this approach implicitly makes several key assumptions that deserve to be identified (see Figure 1).

Facility Impact Levels —

1. Impact levels, duration, frequency, etc. are assumed constant and are to remain constant in the expectation of the buyers.
2. Most studies use distance from the facility or angle off downwind direction as indicator variables to represent the level of all facility impacts. The regression method assumes that the impact variables accurately represent indicator levels that correlate linearly with the entire set of actual impacts. For some impacts (e.g., for views in the view impact field), these assumptions hold true, while for others, they probably do not (e.g., air quality impacts, groundwater plumes, etc.).

Residential Homeowners' and Buyers' Perception of Facility Impacts —

1. The property value model assumes that all indicator variables are well and accurately perceived by sellers and buyers in the sense that they have equally good opportunity to sense impact changes and distinguish different levels. Some impacts, however, are clearly more apparent than others; one can contrast, for example, obvious odors, noise, views with insidious slight deterioration of air quality that can only be determined with sophisticated monitoring equipment. Readily perceived impacts are expected to more significantly detract from property values than subtle ones.
2. Buyers and sellers are assumed to have perfect knowledge of the impacts, that is, to be aware of the levels and the significance of indicator levels. This is clearly impossible for insidious impacts as well as impacts that do not

occur regularly or frequently, given the (usually) short period of time buyers spend at a new home location before making an offer.

3. The model implies that transactions take place between equally sensitive buyers and sellers. If buyers are less sensitive than sellers, or if some buyers are less sensitive than others, then the representative price difference for impacts will not be reflected in the sales price.
4. The level of impacts are usually determined or predicted only at the location of the residence. The impacts may be readily perceived at other locations in the community that the residents may frequent. Thus, the impact level at the location of the home may not be the only impact indicators that owners and potential buyers take into account.

Residents' Value Judgments —

1. The hedonic linear multiple regression model assumes a linear relationship of all independent variables, including house and neighborhood characteristics as well as impact (indicator) variables on property values. This assumed functional form ignores impact-value curves that may contain thresholds and significance levels. Further, other functional forms of the value curve (quadratic, exponential, etc.) are conceivable. The best fit is not necessarily achieved with the linear form. Most likely, the results of testing only the linear form show no significant effect, when there may indeed be one of a different shape.
2. Multiple regression methods assume normally distributed data with equal variation, i.e., homogeneous. Although this assumption is not unreasonable for large data sets, it is worth checking for the usually small numbers of sales in rural host communities.
3. Independent variables are furthermore assumed not to exhibit collinearity. This assumption is necessary to avoid indeterminate estimates for the contributions of each independent variable to the explanatory power of the regression equation because it covaries with other variables.
4. The model also makes several other assumptions about the real estate market. First, it assumes that, apart from the facility impacts, no other extraneous factors affect property prices. The market is assumed to be in equilibrium and all other factors that could affect prices are assumed to be constant. Sellers and buyers are again assumed to have perfect knowledge of the real estate market, so they can be assumed to accurately compare affected with similar, but unaffected properties to make appropriately discounted price offers for impacted properties.

INCINERATOR IMPACTS AND PROPERTY SALES

Should property sales prices not fully or consistently reflect the incinerator's impacts on the residential enjoyment of the property, or, should the owner not be

willing to sell the property at a price that reflects the impact depreciation, then the incinerator's effects could be manifested as influences on the number of sales or on the time between listing and sale of an impacted property.

Residential real estate transactions are commonly initiated by existing residents who decide to list their property for sale. Then, potential buyers consider the listed properties and decide to make an offer to buy at a certain price, depending on the perceived value of the property, presumably relative to other properties on the market in a certain market area. Thus, real estate transactions entail two separate decisions that may differ in their judgment of waste facility impacts. Potential sellers' and buyers' decisions must therefore be analyzed separately.

Existing Residents' Decision to Sell

The selling process hinges on a decision that weighs the expected costs (including intangible costs) and revenues of staying against those of moving. The siting of a waste facility influences this decision by creating the perceived negative impacts, or losses, I, as perceived by an existing household in the host community. The impact loss I is commonly assumed to be reflected in property price decrease D from the fair market value of the property without the facility. Further, the moving household will incur search and moving costs R, as well as a loss of the consumer surplus (i.e., the value above the price) including the special value to the existing owner, S, (i.e., personal attachment to the property) that is not reflected in the sales prices. Thus, for existing residents in the host community, the moving criterion can be stated (after [6]) as

$$\text{if } I > D + R + S, \text{ then the household will move} \tag{2}$$

where

I = value of facility impacts as perceived by household;
D = depreciation of property value as reflected in sales price;
R = search and moving costs; and
S = consumer surplus and special value.

The fair market value of the property does not enter the equation explicitly, since both sides of Equation (2) represent losses from the fair market value. Hence, the decision to move because of facility impacts is not affected by the fair market value but, rather, by the comparison of the losses for moving and staying options. If the facility impacts, I, are considered by the household to be larger than the price difference plus moving costs plus surplus value then these households will tend to move. In contrast, if the sum of cost terms on the right side of Equation (2) appears larger than the impact loss, then the impact value will be borne as the smaller loss. The absence of any property price depreciation D, however, decreases the loss value on the right side of the equation, and all else being equal, leads to more households moving out. Remember that the seller basically

determines the price at which he or she is willing to list, and, ultimately, to sell the property. Thus, listing an impacted property at going market rate (i.e., without decrease in price) is an opportunity for existing residents to limit their losses if they are prepared to wait longer in the hope of an offer at full market price from an unwitting or insensitive buyer.

Potential Buyers

The decision rule for potential buyers of impacted properties can be stated as follows:

$$\text{if } I < D + S, \text{ then buyer will move in} \tag{3}$$

If the value of the facility impacts is less than the decrease in sales price plus the surplus value, then the marginal buyer will move in. However, the evidence that waste facility impacts are not consistently reflected in sales price (i.e., D = 0) may reflect buyers' lower sensitivity to the impacts, or their lack of information about the impacts or about the real estate market [7, 8]. These two cases are discussed separately to distinguish their effects on real estate sales.

Less-Sensitive Buyers

Less-sensitive buyers place lower values on the impacts than do the existing residents or other buyers. Some buyers may be less sensitive due to lower physical sensitivity (e.g., to noise, odor, etc.), prior exposure and adaptation to similar impacts at a previous residence, or a lifestyle that avoids exposure, e.g., does not include outdoor activities and therefore may not be sensitive to noise, odor, and view impacts. If no sales price discount is offered to offset the impacts, then impact-sensitive buyers will be less likely to purchase such properties if enough unaffected properties are available elsewhere. Therefore, less sensitive buyers will tend to be the only ones prepared to buy affected properties at full market value. Therefore, if a significant portion of potential buyers are sensitive and are not even shown impacted properties or, if shown, do not make an offer on such properties, then the number of potential buyers is restricted to the less-sensitive households. As a result, impacted properties without sales price decreases may take longer to sell because of the smaller number of less-sensitive potential buyers. The outcome would be reflected as a longer average time period between listing and sale of impacted properties.

Uniformed or Misinformed Buyers

The characteristic of misinformed buyers is that they do not have full information about the facility impacts or about availability and sales prices for similar unaffected properties on the market. As a result, their decisions to buy at an undiscounted price do not fully reflect the waste facility impacts on the value of

the property. In contrast to the previously discussed less-sensitive buyers, misinformed buyers do not knowingly discount the impacts, but rather, they are not able to base their decisions on the full set of facts. Thus, initially, the effect of misinformation is similar to that of lower sensitivity, because both decrease the impact value I in the buyers' decision rule (see Equation (3)). In consequence, misinformed buyers are more likely to purchase undiscounted impacted properties, because the smaller the I, the more likely the surplus value S of the property to the buyer will exceed the negative value of the impacts (see Equation (3)). Undiscounted properties will therefore tend to be sold to misinformed and insensitive buyers, possibly with the same results of longer time on the market because of the restricted number of available less-sensitive or misinformed potential buyers.

Misinformed buyers, however, undergo a further step in their decision process in that after moving in, they may acquire full information through exposure to the facility's impacts or through awareness of the availability of similar unaffected properties elsewhere at comparable sales prices. At this time, misinformed buyers may shift their valuation of impacts to reflect the newly gained facts. This shift results in an increase of impact value I, so they are faced with the decision whether to move out. For this decision, they follow the same decision rule as the original residents (see Equation (2)). In absence of any sales price decreases, misinformed buyers may leave again without monetary losses (possibly except for additional search and moving costs), similarly to the original residents. The overall effect is a higher turnover rate in impacted areas, as documented in the noise contours at the Sydney airport [6].

INCINERATOR IMPACTS AND RESIDENTS' RESPONSE TO PROPERTY VALUE GUARANTEES

Regardless if property value losses or sales disruptions occur, property value guarantees may address residents concerns about residential property impacts. In order to test their significance as a tool for facility siting, the residents' concerns about property value impacts are identified. Then, residents' were asked to consider property value guarantees as a simple, market-based way of addressing incinerator impacts.

Property-value guarantees (PVGs) are a form of compensation for losses in market sales price of residential property near waste disposal and other undesirable facilities [9, 10]. Usually PVGs ensure that property owners receive the hypothetical fair market value for their properties without the influence of the facility. This hypothetical fair market value is established by up to three independent appraisals. The facility proponent guarantees property values by either paying the owner the difference between sales price and hypothetical fair market value if the sales price is lower, or by buying the property outright if no reasonable offer is received within a defined time period (usually three to nine months).

PVGs are usually extended to all existing property owners in a defined area around the facility site at the time of site selection. Subsequent owners and additional parcels resulting from subdivision after site announcement are thus excluded. Provisions are made to ensure arm's-length sales prices.

PVGs, in theory, prevent any market-value losses to existing owners at the time of site selection. They do not, however, cover any special or sentimental value to the present owners [1], nor are search and moving costs included. Finally, PVGs address losses only to those residents who actually sell and move. Residents who decide to stay and put up with the facility are not compensated for their losses. For long-term residents who are attached to their communities, the facility impacts may constitute a substantial loss without, however, causing them to move. Thus, PVGs do not cover all losses to all residents. Nonetheless, PVGs should address concerns about property-value losses regardless if these losses consistently occur or can be reliably measured [8]. Since PVGs guarantee fair market value to present owners, this approach should increase host community acceptance if residents are concerned about property values.

METHODS AND RESULTS

A general review was conducted of studies on property value impacts of noxious facilities. The research approach at the study site consists of selecting a typical incinerator and host community, assessing the facility's physical impact footprint on the community, collecting real estate sales data and statistically testing for effects of impacts on prices and sales. During the same time period, residents were surveyed to identify their concerns and their opinion of property value guarantees. The results of each phase of the study are presented following the description of the methodology.

Review of Property Value Impact Studies

Ten research studies of property value impacts near waste facilities were reviewed [7]. Two studies cover several municipal solid waste (MSW) incinerator sties [11, 12], while the others focus on landfills [13-18]. The reviewed studies comprise six cases that confirm significant negative effects on property values, eight cases that show no significant effects, and one study that reports positive effects. Both significant and insignificant findings resulted from studies that used multiple regression analysis on sales prices, and from those that relied on comparison of comparable sales.

The price decreases due to facility impacts may be offset by inflation, or may occur only as slower future appreciation rates or slower development rates. Most reviewed studies take inflation into account by adjusting sales prices, or by including a variable for the date of sale in the hedonic price equation [12, 13]. Some studies specifically test for differences in appreciation rates [12-14] and

find no significant effects. Three studies also address development rates around waste facility sites and show no significant effects. As a result, future appreciation and development rates do not appear to reflect facility impacts.

The reported results do not show a consistent or reliable pattern of significant differences in residential property values. This is puzzling, because host community opposition is often very strong at waste facilities. Many studies relied on indicators (distance, view, etc.) that may not accurately reflect facility impacts. A detailed impact assessment is required to determine specific exposure of sold properties at a well-defined study site.

Case Study of Property Values Sales and Guarantees

Incinerator study site: host community, facility, and siting process — The Marion County incinerator is located about 7 mi (11 km) north of Salem, OR, close to Interstate I-5, in the village of Brooks (see Figure 2). The mass burning grate incinerator is owned and operated by a private firm with financing through

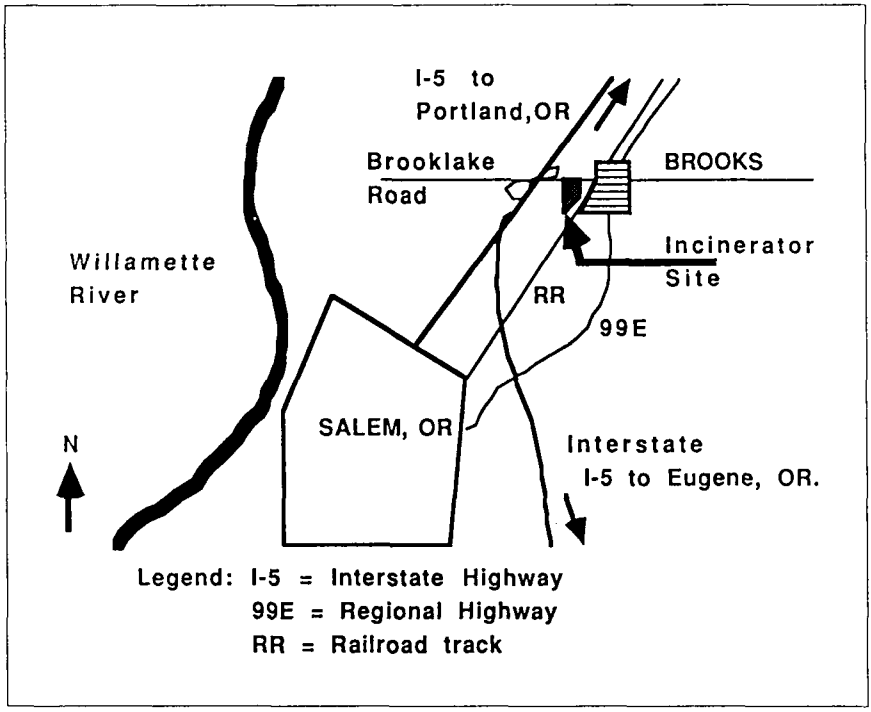


Figure 2. Location of incinerator site.

the county. The facility began operation in 1986 and accepted about 135,000 metric tons per annum of municipal waste from Marion County, 70 percent of which was generated by the City of Salem. Recently, Marion County and the operators were granted a permit to burn 171,000 metric tons per annum. The incinerator is equipped with a quasi-dry chemical scrubber and baghouse filters.

Brooks, the host community, is an unincorporated farm village of about 300 residents. It serves as a service center for the farms and rural residences in the area. The village itself comprises a church, retirement village, mobile home parks, some older shacks, post office, fire department, hardware and farm stores, and some onion warehouses among the railroad tracks. Outside the village, the area comprises approximately 250 rural residential homes and small clusters of houses and farms. Eighty percent of households live in single-family homes and own their own homes; 50 percent have lived in the community for over five years [19]. The incinerator generates slight air quality deterioration within 300-1,500 m (985-4,920 ft) from the site in prevailing wind directions with a slight chance of significant quality impacts at 700-800 m (2,300-2,625 ft). View of stack and steam plume extends up to 5 km (3 miles) from the site, while noise recognition extends to 600-800 m (1,970-2,625 ft) from the site (see [7, 8]). The siting process was initiated by the site announcement in the media in March 1983 [20]. The opposition to the incinerator launched numerous appeals and managed to have the issue voted on in the county election of March 1984. Finally, there were delays in the financing before construction started in September 1984. The facility was completed and began operation in May 1986. Thus, the following four events mark crucial times in the siting process. The real estate analysis will test the data relative to these events:

1. The announcement of the site at the end of March 1983;
2. The referendum election in March 1984;
3. The beginning of construction in late September 1984; and
4. The plant start-up in May 1986 and continuous operation through the end of the study period, December 1988.

Property Sales Prices

Method and data collection — Sales data (see Table 1) for 145 residential and rural residential property listing between 1982 and 1987 were compiled [21]. The 145 listings in the data set constitute 1.2 percent of the total 10,344 sales in the metropolitan area of Salem-Keizer. Multiple listing service (MLS) data of actual sales prices has been shown to be preferred over appraised and assessed values [3, 13]. Each property in the data set was coded for exposure to specific facility impacts (see Figure 3). Sales dates are included to account for time-varying factors (inflation, interest rates). Multiple regression analyses were run on the UBC-SPSSX program with forced entry of all independent variables. No data transformations were done.

Table 1. Residential Property and Facility Impact Variables

Dependent Variables (1)	Independent Variables (2)
Sales Price Days on Market	Property characteristics Number of bedrooms Age Floor Space Condition Amenities – Fireplace – Basement – Garage Lot Size Market characteristics Listing date Sales date Facility impacts Distance to facility View of facility Noise Air emission risks Air quality

Results — The multiple regression of price on property characteristics and incinerator impacts was calculated for three periods of the siting process:

- 1983-1987, including both siting and operational phases together;
- 1983-1984, covering the siting process before any construction or physical impacts had occurred; and
- 1985-1987, covering the construction and operation phase separately.

The results are listed for the three time periods in Table 2. Explanatory power of sales prices is good with R^2 values at 0.44 to 0.76. However, none of the facility impact variables are significant in explaining variation in prices during any of the three siting phases. The incinerator impacts do not affect sales prices.

Property Sales and Time on Market for Sale

Method and data collection — All residential properties in the area that were listed between January 1982 and December 1988 were selected from the Salem Multiple Listing Services (MLS) Quarterly Sold Books [21]. Although more sales

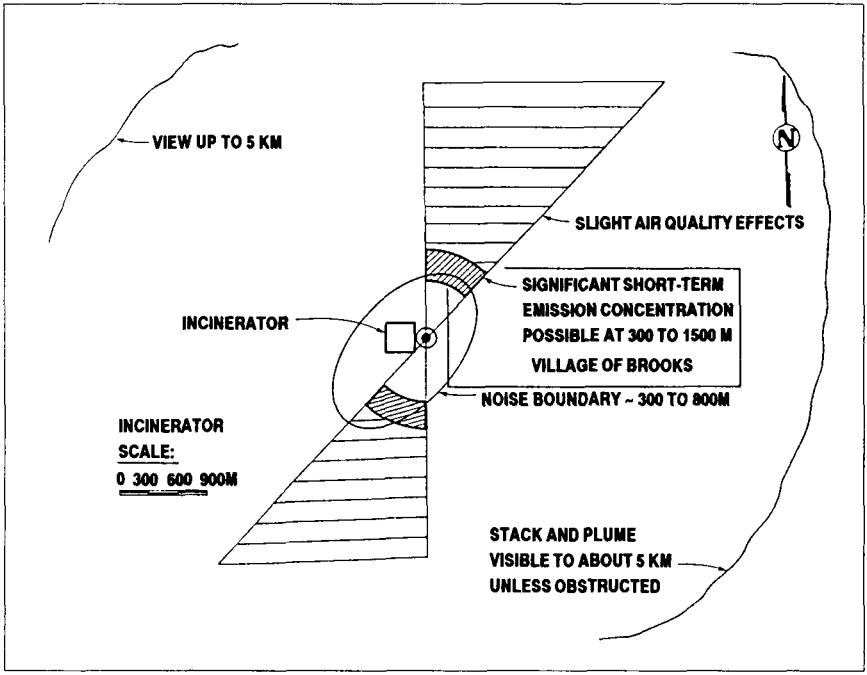


Figure 3. Incinerator impact footprint.

data prior to 1982 would have been useful, the older sales records did not allow these sales to be identified. The data set contains all MLS listings during the period of the major siting events (see Figure 4). An estimate indicated that approximately 20 percent of all property sales are sold by owners and are therefore not included in the MLS data set (personal communication, S. Talbert 1988). The variable list includes all the variables in Table 1, as used in the price regression. The data analyses focus on two variables: 1) the number of listings for sale to reflect the number of households that wish to move out of the host community; and 2) the time on the market to reflect the limited number of insensitive or misinformed households willing to buy impacted properties at undiscounted prices. A frequency analysis was conducted on the listings by quarter to test for significant increases in the number of listings in response to the four major siting events. Significantly higher numbers of listings after these events support the hypothesis that households respond to the incinerator by taking action to move. Further, the ratios of sold to unsold listings were cross-tabulated by year and were tested by a chi-square analysis for association with the siting events. Significant differences indicate that the number of sold to unsold property listings may vary in response to siting events, in particular if more properties are listed (at full price) but fewer actually sold.

Table 2. Multiple Regression Results-Sales Price on Incinerator Impacts

Variables (1)	N (2)	Multiple Regression Coefficient R^2 Overall Equation (3)	Partial Correlation Coefficient (4)	T (5)	Probability (6)	Significance (7)
(a) Entire Siting and Operating Period – April 1983 to December 1988						
Sales price on facility impacts	76	0.76	–	–	0.0000	Significant
(Constant)	–	–	–	4.9	0.000	Significant
Distance to facility	–	–	-0.013	0.099	0.92	Nonsignificant
View of facility	–	–	0.027	0.206	0.84	Nonsignificant
Noise	–	–	-0.016	-0.121	0.9	Nonsignificant
Air emission risks	–	–	-0.03	0.025	0.98	Nonsignificant
Air Quality	–	–	0.049	-0.32	0.71	Nonsignificant
(b) Siting Periods – April 1983 to September 1986						
Sales price on facility impacts	30	0.44	–	–	0.44	Significant
(Constant)	–	–	–	0.21	0.35	Nonsignificant
Distance to facility	–	–	-0.24	-0.93	0.37	Nonsignificant
View of facility	–	–	0.09	0.33	0.75	Nonsignificant
Noise	–	–	-0.05	0.21	0.84	Nonsignificant
Air emission risks	–	–	-0.03	-0.11	0.91	Nonsignificant
Air quality	–	–	-0.09	-0.33	0.75	Nonsignificant
(c) Construction and Operation Period – July 1986 to December 1988						
Sales price on facility impacts	45	0.57	–	–	0.0004	Significant
(Constant)	–	–	–	0.36	0.72	Nonsignificant
Distance to facility	–	–	-0.8	-0.39	0.7	Nonsignificant
View of facility	–	–	0.06	0.03	0.98	Nonsignificant
Noise	–	–	0.023	0.12	0.90	Nonsignificant
Air emission risks	–	–	-0.04	-0.19	0.85	Nonsignificant
Air quality	–	–	0.09	-0.46	0.65	Nonsignificant

Finally, to determine whether recent in-moving households tended to move out more frequently, as predicted for the misinformed buyers, the number of resales is used as an indicator. Specifically, the properties that sold in the siting and construction period between April 1983 and June 1986 and that resold between July 1986 and December 1988 are determined as a percentage of the total sales in the same period. These resales indicate households that moved in and out of the host community within five years during the incinerator siting. The percentages are compared to the 1980 census figures for the proportion of households that remained less than five years in the community.

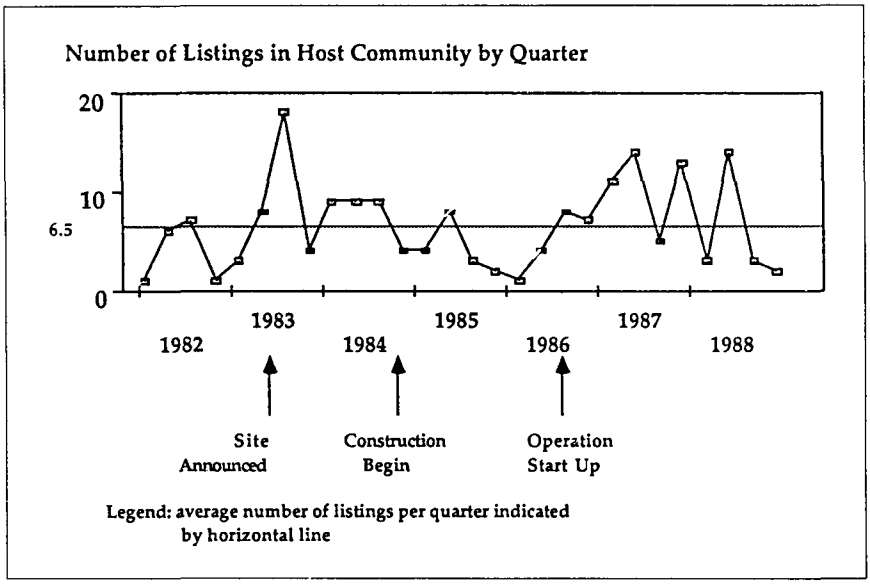


Figure 4. Property listings and siting events.

Results — The numbers of residential property listings by quarter are expected to increase in response to significant siting events if the current owners fear the facility's impacts and can sell at full market price. The listing frequencies are shown in Figure 4 with the major siting events. Although an increase to eighteen listings constitutes a doubling or tripling in the quarter following the first site announcement in late March 1983, the eighteen listings in the third quarter of 1983 are statistically not significantly higher than the average of nine listings per third quarter nor higher than the average 6.5 listings per quarter for the entire study period. This test is, however, hampered by the small frequencies in this typical rural host community. Moreover, no similar response occurs after the other siting events (e.g., after the election in March 1984).

The yearly listings in the host community (see Figure 5) substantially increase in 1983 and 1984. These increases are not reflected in the number of listings in sales area 3 or in the total number of listings in the Salem MLS area. As a corollary test, the proportions of sold to unsold (i.e., expired, withdrawn, or terminated) listings by the year of listing are compared (see Figure 5). The chi-square results indicate a significant association of the ratio to the year of listing. From inspection of Figure 5 it is apparent that of the properties listed in 1983, the year of the site announcement, 79 percent went unsold, whereas in the next five years the proportion of sales recovers to 50 percent in 1984 and up to a maximum of 75 percent sold in 1985 and 1986. Thereafter, the sold proportion returns to 50 percent.

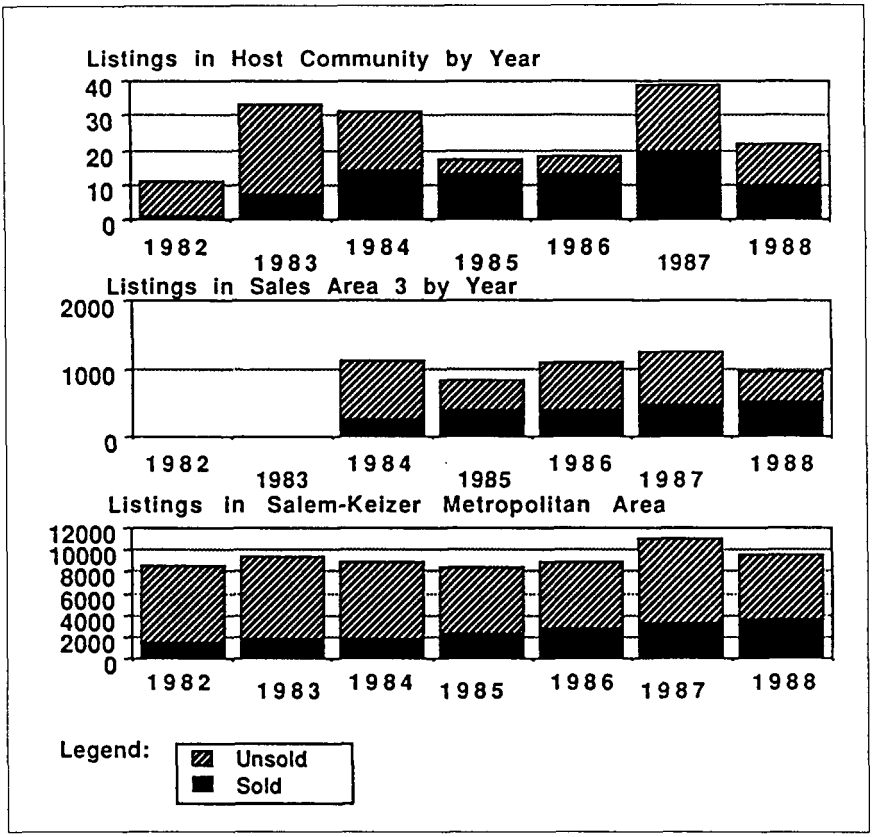


Figure 5. Property listings by year and outcome.

It seems possible that the facility site announcement may have caused an increase in listings in 1983 and 1984. This may reflect the initial fear of expected impacts in the host community in 1983 and 1984. After the election in 1984 though, the market appears to catch up in 1985 and 1986 and settles back to normal. The fact that in 1983 67 percent of listings were withdrawn by the sellers contrasts with other years wherein 5 percent to 35 percent of listing were withdrawn and indicates a strong change in 1983 of some households' initial decisions to sell. The change in decisions may result from acceptance of the facility through adaptation, or may reflect the realization that listed properties will not sell at the price desired. There were, however, no significant differences in list and sale prices during this period. Either change shifts the outcome of the moving decision (according to Equation (2)) towards staying in the host community. Finally, the number of homes bought in the siting period (April 1983 to June 1985) and resold in less than five years averages approximately 25 percent of properties

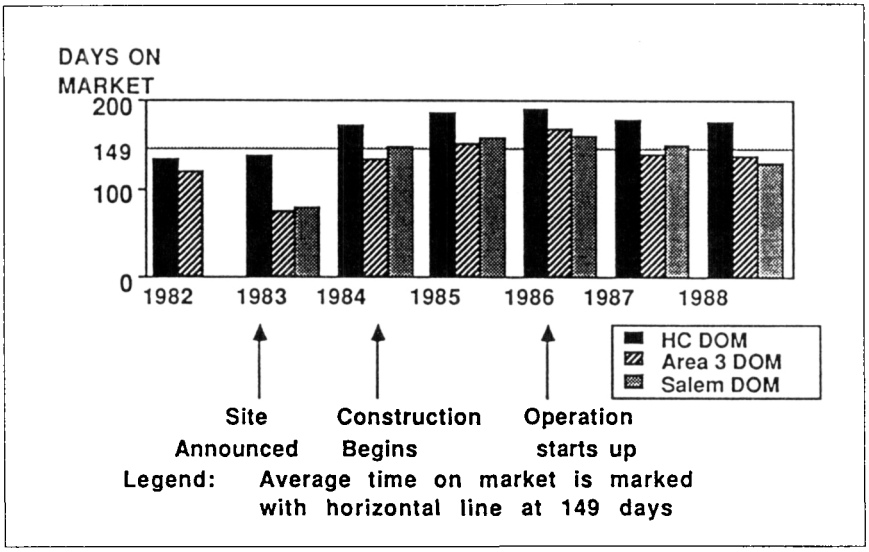


Figure 6. Time to sell for residential properties.

sold between July 1985 and December 1988, the construction and operation period. Thus, the percentage of households in the host community that move in and then move out is lower than the 52 percent of households in the census tract that move in less than five years (1980 census, 1983). Households moving in that are potentially unaware of the facility do not significantly increase the number of households that move in and then move out.

The average time on the market for sold residential properties in the host community is compared to average values for the larger sales area that encompasses the site (sales area 3) and those in the entire Salem-Keizer multiple-listing sales area (see Figure 6). From inspection, the days on the market (DOM) for properties in the host community are consistently slightly higher but, except for 1983, not significantly different (see Figure 6). Individual *T*-tests of differences of means by year for host community, area 3 and Salem-wide DOM statistically confirm these observations [22].

The next test of variation in time on the market is conducted by calculating the analysis of variance of DOM by time (quarter) of listing for a total of 171 sold and unsold properties. The results show significant variation of DOM by time of listing. However, the average times on the market to sell properties listed immediately after crucial events (see quarters 3 and 4, 1983, quarters 2, 3, and 4, 1984, and quarter 3, 1986) are not significantly higher than the average of 149 days. Hence, there is no significant evidence to link the facility siting with longer time on the market to sell residential properties in the affected host community.

Table 3. Multiple Regression Results-Days on Market on Incinerator Impacts

Variables	N	Multiple Regression Coefficient R^2 Overall Equation	Partial Correlation Coefficient	T	Probability	Significance
(a) Entire Siting and Operating Period – April 1983 to December 1988						
Days on Market on facility impacts	76	0.05			0.05	Significant
-(Constant)				6.17	0.000	Significant
-Distance to facility			-0.224	-1.99	0.051	Significant
-View of facility			0.004	0.03	0.98	Nonsignificant
-Noise			0.006	0.06	0.95	Nonsignificant
-Air emission risks			-0.028	-0.23	0.82	Nonsignificant
-Air Quality			0.097	0.86	0.39	Nonsignificant
(b) Siting Period – April 1983 to September 1986						
Days on Market on facility impacts	30	0.22			0.25	Nonsignificant
-(Constant)				3.40	0.002	Significant
-Distance to facility			-0.33	-1.72	0.10	Nonsignificant
-View of facility			-0.01	0.73	0.94	Nonsignificant
-Noise			-0.01	1.76	0.09	Nonsignificant
-Air emission risks			-0.24	-1.26	0.22	Nonsignificant
-Air quality			-0.19	0.98	0.36	Nonsignificant
(c) Construction and Operation Period – July 1986 to December 1988						
Days on Market on facility impacts	45	0.11			0.41	Nonsignificant
-(Constant)				1.75	0.09	Nonsignificant
-Distance to facility			-0.11	-0.69	0.49	Nonsignificant
-View to facility			0.05	0.33	0.74	Nonsignificant
-Noise			0.21	-1.35	0.18	Nonsignificant
-Air emission risks			-0.07	-0.46	0.65	Nonsignificant
-Air quality			0.23	1.5	0.14	Nonsignificant

The third test consists of a multiple regression of DOM on property characteristics and coded facility impacts for each sold property. The analyses are conducted for the following three time periods as used in the price regressions. The results are shown in Table 3 under these headings. For the entire siting and operation period, the distance from the facility significantly correlates with the number of days on the market. The negative sign for the partial coefficient is expected and indicates that the days on the market decrease with increasing distance. Although the correlation is barely significant, and explains only 5 percent of the variation in DOM, the results indicate that the average time on the market decrease by about two days for every kilometer increase in distance. During neither of the two shorter periods do any facility impacts correlate significantly with the time on the market (see Table 3).

In summary, the results show no effect on the number of sales, and only a weak effect of the facility on the length of times required to sell residential properties in the host community during the siting period.

Tests for validity of assumptions — Four key assumptions underlying the multiple regression approach to estimating the hedonic equations are tested to determine the possibility of effects on results. These assumptions were tested for all six regression equations reported in this article, i.e., three for sales price and three for the numbers of days on the market.

- The validity of the linear regression equation is tested by plotting standardized residuals with predicted values. Any observable pattern would indicate that the linear equation does not well fit the data.
- The normal distribution of the residuals is tested to indicate nonnormal distribution, misspecification of the model, small number of residuals and nonconstant variance. Histograms of standardized residuals are plotted and compared with an expected normal distribution. Also, the cumulative probability distributions of observed and expected standardized residuals are plotted to identify discrepancies. Any serious discrepancy would indicate a violation of the normality assumption or of a related misspecification.
- Homogeneity of variance in the data is verified by plotting standardized residuals with predicted values and all independent variables (with interval scales). If the residuals show unequal variance over the range of values of the other variables, then the homogeneity assumption is not valid.
- Multicollinearity among independent variables is tested by forcing all variables into the regression equation and testing for tolerance. Tolerance is defined as the proportion of variability in one independent variable that is not explained by other independent variables. If the tolerance is less than 0.01 for any variable, then multicollinearity may be the cause.

The results of these four tests show that the first three assumptions of linearity, normality and homogeneity are moderately or poorly met, while multicollinearity is low in this sample (see Table 4). Therefore, the lack of significant correlation of facility impacts on property prices and days on market could stem from inappropriate assumptions about the data.

Property Value Guarantees

Method and data collection — Residents' opinions and attitudes were obtained by a survey in host and control communities at landfill and incinerator study sites. Approximately fifty respondents in the host community were selected by systematic random sampling from a list of all street addresses within 3 km (1.9 mi) of the incinerator site boundaries. Approximately fifty control respondents were selected by systematic random sample of addresses from telephone books after

Table 4. Test of Multiple Linear Regression Assumptions

	Linearity	Normality	Homogeneity	Multicollinearity
Sales Price 1983-88	Good	Moderate	Moderate for - Distance - View Poor for - Lot size	Weak
Sales Price 1984-84	Fair	Poor	Moderate for - Floor space - List date - View Poor for - Bedrooms - Quarter of listing	Weak
Sales Price 1984-88	Poor	Moderate	Moderate for - Floor space - View Poor for - Bedrooms - Lot size	Weak
Days on Market 1983-88	Fair	Moderate	Moderate for - Lot size Poor for - Bedrooms	Weak
Days on Market 1983-84	Moderate	Poor	Poor for - Price - Lot size - Distance - Quarter of sale	Weak
Days on Market 1984-88	Fair	Moderate	Moderate for - View - Year of sale Poor for - Bedrooms - Floor space - Lot size	Weak

eliminating inner city addresses. In this way, the control group comprises residents of communities comparable to typical host communities, i.e., communities on or outside the urban growth boundary [8]. The sample size of fifty was selected in order to obtain twenty-five to thirty-five valid responses in each sample group with the obtained response rates of 50 to 60 percent, with slightly higher rates among the host group than among controls. Overall, this response rate is

reasonably good. A 95 percent confidence limit was considered significant with 90 percent judged marginally significant.

Results — Host-community respondents were asked to state their agreement or disagreement with statements about possible incinerator impacts on the host community. A significant proportion of respondents believe that the facility causes a variety of physical and nonphysical impacts in the host community. Property-value impacts are perceived to occur. Furthermore, physical (nuisances, health risks, and environmental change), social (community image), and political impacts (loss of control, unfairness) are significantly mentioned [23]. Beliefs about property-value impacts are significantly correlated with overall attitude about the incinerator in the host community [5].

In a scenario put to all respondents in host and control communities, the waste facility is identified as the cause of an intolerable situation in the community. The owner/operator offers to compensate for property-value losses if the residents decide to move. Respondents are asked to state whether they consider the offer very unfair, somewhat unfair, acceptable, or completely fair. 51.5 percent of respondents in the host and 41 percent in the control group consider property-value guarantees fair compensation. Conversely, however, 48.5 percent and 59 percent of respondents in host and control groups, respectively, do not accept property-value guarantees as fair compensation for an intolerable facility. The results indicate that property-value guarantees will achieve approximately 50 percent voluntary acceptance of a facility. Since 50 percent acceptance leaves an equal fraction of opposing residents, the corollary issue is to determine whether PVGs actually sway to acceptance those residents who are annoyed or believe the facility causes negative impacts. Therefore, additional analyses were conducted to test the effect of property-value guarantees on people who are annoyed or hold negative beliefs abut the impacts of the facility. The responses on beliefs about significant facility impacts were cross-tabulated with the opinions on fairness of property-value guarantees (see Table 5). If property value guarantees are effective in gaining acceptance, they should be considered a fair offer by those respondents who initially hold negative beliefs about the impacts of the facility.

The cross-tabulation of residents' concerns about negative impact with opinion of property-value guarantees shows a clear and statistically significant pattern (see Table 5). Respondents in the host community who are more annoyed with the incinerator and who believe the facility causes health risks, depresses property values, harms the community image, or who believe that the local government and the owner/operator are not doing their best to protect the community consider compensation through property-value guarantees significantly less acceptable than other residents. This means that property-value guarantees as a single compensation method do not make this new incinerator more acceptable to those who are most opposed. Even people who believe the facility affects property values (among other things) tend not to consider PVGs fair compensation.

Table 5. Effects on Property Value Guarantees on Acceptance of Facility Impacts at a New Incinerator

Residents' Beliefs		Proportion of Respondents Who Consider Property Value Guarantees (Percent) Sample Size $N = 34$		Chi-Square Statistics DF = 1
Questions (1)	Responses (2)	Fair (3)	Unfair (4)	(5)
Are you annoyed with the facility?	Yes No	36.3 68.7	63.7 31.3	Chi-square = 3.7 Sifnificant
Do you believe the facility decreases property values?	Yes No	38.5 85.7	61.5 14.3	Chi-square = 4.1 Significant
Harms community image?	Yes No	31.3 64.3	68.7 35.7	Chi-square = 3.27 Marginally significant
Creates health risks?	Yes No	12.5 60.0	87.5 40.0	Chi-square = 4.22 Significant
Lowers your confidence in local government?	Yes No	11.1 66.7	88.9 33.3	Chi-square = 5.84 Significant
Lowers your confidence in the owner/operator?	Yes No	17 65	83 35	Chi-square = 4.1 Significant

In consequence, although property-value losses are among the impacts considered significant by residents, PVGs do not appear to address residents' concerns. The findings contradict the expected positive effect of PVGs on host community acceptance by showing that this simple, monetary approach alone is not effective in addressing the various facility impacts.

SUMMARY OF FINDINGS

The review of empirical property-value differential studies at waste disposal facilities and other noxious facilities is inconclusive. Most results show insignificant or marginally significant results, while some show higher property values near the noxious facility sites. Detailed physical impact assessments and property-value analyses are carried out at a typical municipal waste incinerator. The results

show no significant correlation between facility physical impacts and property values.

The lack of significant property-value impacts is inconsistent with the strong opposition to these facilities in host communities. Property value differentials as determined by the hedonic price models are, therefore, not consistent indicators of waste facility impacts. In absence of property price impacts in the host community at a modern mass-burn incinerator, theoretical considerations indicate that affected households will tend to move out and may be replaced by less sensitive or misinformed households. As a result, the number of property sales or the time to sell affected residential properties may increase in the host community. Although hampered by small number of sales, as is typical in rural waste facility host communities, this study indicates that existing households do not move out of the host community in significant numbers, despite long and intense opposition with numerous appeals and a county-wide referendum. The evidence indicates that the incinerator does not destabilize the host community. This conclusion, however, does not mean that host community residents do not take losses as a result of facility impacts. Rather, it means that for most households moving would result in a larger loss than living with the incinerator impacts. The absence of significant household moves indicates that residents tend to stay and adapt to the new facility.

Property-value guarantees do not appear to achieve better than 50 percent acceptance among residents. Moreover, property-price guarantees alone are significantly less effective in gaining facility acceptance among people who hold distinct negative opinions about newly sited waste facilities than among less concerned residents. Property-value guarantees therefore do not appear to achieve their main objective of addressing through property values the residents' important concerns about waste facility impacts.

IMPLICATIONS FOR FACILITY SITING AND RESEARCH

The findings are somewhat discouraging, because they do not indicate strong negative impacts on the property market and so do not support the conventional explanation for the mechanisms that are assumed to translate facility impacts into property values and sales. As a result, analysts are left with no clear model to explain nor with a method to predict the impacts of undesirable facilities on property values. However, the research results are important, because they allow the researchers to identify some of the possible causes for the lack of explanation.

The implications for facility siting are unfortunate. The use of property value effects as an indicator for facility impact or as a measure for compensation to achieve host community acceptance is very risky. Extrapolating past results may over- or underestimate actual effects. The lack of a predictive mechanism prevents buyers and lenders from predicting price and sales effects in affected impact zones and precludes effective impact management and mitigation efforts to reduce effects on property values and sensitive land uses. Well intentioned facility

operators are therefore not able to take proper steps to operationally reduce impacts and thereby address host community opposition.

The implications for research therefore focus on poorly understood elements in the causal chain between the facility impacts and the resulting decisions to sell or buy. Tracing facility impacts through residents' belief-attitude systems to their decisions on property sales consists of measuring physical impact indicators that correlate with residents' attitude about their home. Previous studies assume distance to be a good indicator for impacts on residents at the location of their home. This may be an erroneous assumption for four reasons:

- Impact levels may not decline linearly with distance, but rather follow asymptotic, exponential or other curve forms. As a remedy, distance-decay functions for all impacts must be specifically determined and plotted to accurately predict impact levels, frequencies and duration.
- Some impacts may be more apparent and, hence, more readily perceived by buyers. Nuisances of odors, noise and view may therefore affect buyers more than air quality impacts. These nuisances may be more difficult to predict and measure reliably than air or water quality impacts. Surveys of potential buyers, house owners and real estate agents will be required to determine what factors and types of impacts people readily perceive and act on in making purchasing decisions.
- The impact at the specific locations of residents' homes may not indicate residents' perception of impacts in their community. Residents may sense and judge property values based on perceived impact levels at locations throughout the community, e.g., on frequently travelled roads and frequently visited points, etc. Effects of impacts on other locations in the community are ignored by including only residential locations. Impact levels for common, public points in the community should be included in the analysis.
- The conventional model assumes and tests a linear correlation between impact level and value decrease. This functional form of the value curve may, however, consist of thresholds, toes and shoulders that do not conform to the linear forms. Other forms of the value curves must be tested to obtain an optimal fit of value data with impact levels for each type of facility impact.

The analytical method of estimating the hedonic equation with multiple regression has some weaknesses that may cause unreliable results. In particular, the methods of tracking real estate market factors and selecting variables for the hedonic equations must be refined.

- Fluctuation in the house price index for the region or metropolitan area encompassing the host community may shift over the study period of at least three to five years. A price index and possibly an economic indicator should be included in property price analyses.

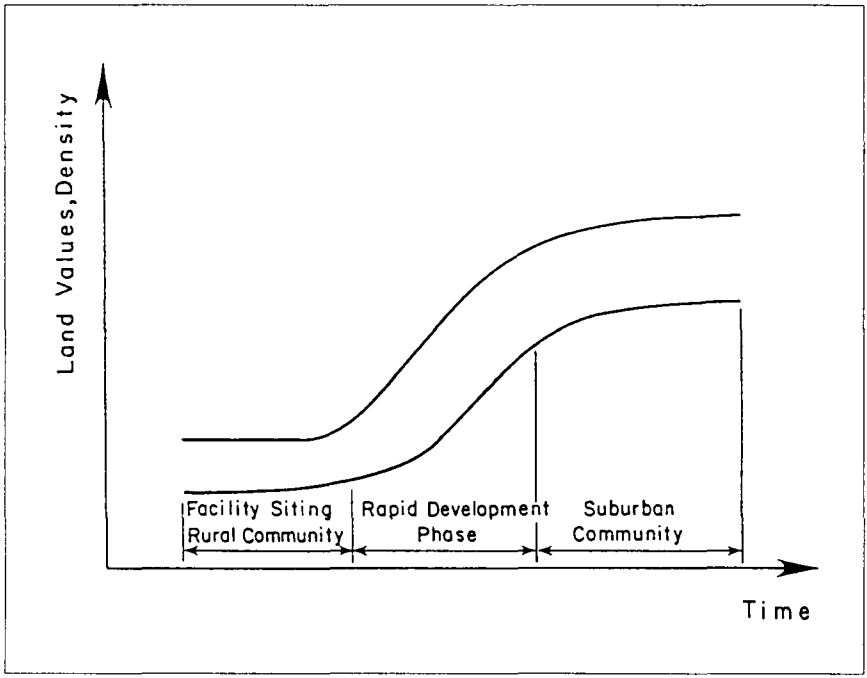


Figure 7. Waste facility siting and host community development.

- Property values in the host community may be affected by development pressure on such areas. Typically, municipal waste facilities are located in low density, rural communities just beyond the urban growth boundary [7]. Later in the facility's life cycle, urban development often overtakes the host community and causes property prices and density to increase (see Figure 7). This effect has been shown to occur and result in denser development right up to the facility boundaries [7]. As a result, negative property value impacts due to proximity to the facility may be offset and result in price increases at such locations. This is possibly the reason why some studies show positive effects of proximity on property prices. The stages of the facility life and of the community's development must be taken into account in the analysis to obtain comparable results.
- Collinearity among independent variables for structural and neighborhood traits and as well as for facility impacts must be minimized in order to avoid variation in the sign and the magnitude of the regression coefficients for different combinations or entry sequences of variables in the regression analysis [24]. Independent variables to be included in the regression analysis must be tested carefully to avoid collinearity to select a lean set of accurate variables for structural, neighborhood and impact characteristics.

- Variable data are usually implicitly assumed to fit normal distributions. However, some tests show that this may not be the case for all variables in all communities. Consequentially, transformations of variables, alternative fitting criteria (rather than least squares), or non parametric maximum likelihood methods should be considered for a robust analysis.

The perspective for future research calls for in-depth and careful analysis of the key issues derived and outlined in this article. This research is being actively pursued as a component of ongoing facility siting and impact management research.

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