SILUS
WORKING
PAPER

What is a tree worth?
Green-city Strategies and Housing Prices

Susan M. Wachter and Grace Wong
The Wharton School

September 2010

~ *SILUS* ~
Spatial Integration Laboratory for Urban Systems

A Collaboration between the Wharton GIS Lab
and the Center for Science and Resource Management at USGS

1. Introduction

Greening projects are generally viewed as a positive development in the neighborhood. Of all 32 elected mayors in the largest 100 metropolitan cities in 2005, 15 of them mentioned a greening program in their electoral platform. It has been argued that environmental interventions such as tree planting programs that make environmentally sound behaviors easier to engage in and their economic returns more apparent are more effective than public education efforts that focus on changing attitudes. (Summit and Sommer 1997) While there has been some quantitative analysis on the value of trees in the urban planning literature (Anderson and Cordell 1985, 1988), complemented by survey evidence that inner city residents factor in tree in their residence location decisions (Getz et al. 1982), little has been said about the direct causal impact of greening programs which will be the basis of a cost-and-benefit analysis of such programs.

The aim of this paper is to shed light on the impact of tree plantings on the quality of life. Specifically, we test the correlation of tree plantings with housing sale prices, interpreting the price differentials directly attributable to the plantings as compensating differentials in the housing market. We use the Geographic Information System to map out positions of all new tree plantings and housing sales in Philadelphia between 1998 and 2003, for a comparative study by both distances to tree plantings and by when the transaction took place relative to the tree planting. Also, a comparison is made between two nonprofit tree planting programs, organized by the Fairmount Park Commission and the Philadelphia Horticultural Society (Fairmount and PHS programs henceforth).

There are four main reasons why one might expect a price change correlated to tree planting events in proximity to the parcel. First, the value of the trees should be reflected in the post-tree-planting sales price. Second, any increase in social capital or environmentally protective behavior resulted from the tree plantings will be also capitalized in prices. Third, it is conceivable that home sellers use tree plantings to signal otherwise unobservable characteristics of the neighborhood, such as social capital, to potential homebuyers. Fourth, the tree planting might proxy for qualities of the house or neighborhood that are unobserved by the econometrician but capitalized in home prices. These omitted variables might or might not have a direct relationship with tree plantings. Unlike the first three mechanisms, the omitted variable bias can be in either direction.[1]

We attempt to disentangle these explanations by carefully constructing the treatment and control groups. Primarily we focus on the tree plantings by the Fairmount Park Commission, which responds to requests of tree by individual Philadelphian city residents. A comparison between parcels sold within 1000ft of a between-sales Fairmount planting with other sales reveals a statistically significant planting-related premium between 7 to 11 percent. Two percentage points of this premium can be attributed to the value of the trees. We argue that the omitted variable bias is around 2 percent, by comparing parcels along the propensity of ever getting a tree. There is evidence that the identified price differential is significant and stable within 4000ft of the planting.

In order to shed some light on the important of social capital creation versus that of signaling, we also explore data of another tree program in Philadelphia. The green city program under the Philadelphia Horticultural Society (PHS) requires coordinated effort

[1] For example, a tree planting might be a result of the residents' willingness to take care of the environment (positive, reverse causality), a need for cosmetic improvements to a run-down neighborhood (negative, reverse causality), or heterogeneous tastes (either direction, statistical correlation).

by residents on the same block. If creation of social capital were the main driver behind the positive price change related to the Fairmount Park Commission tree plantings and if unobserved characteristics play a relatively small role, then we would expect a significant and positive price change related to a PHS planting, of a magnitude larger than what is found using Fairmount trees. On the other hand, the aim of the PHS program is to create a better living environment for struggling neighborhoods, so the baseline price difference unrelated to the tree plantings – the selection bias – is expected to strongly negative. The signaling effect can point either way relative to that of Fairmount trees. When compared to all other housing sales in the city, houses within 1000ft of a PHS planting were sold at a discount. No strong evidence is found for positive changes related to PHS plantings, pointing to small effects, if any, brought by the plantings. One possibility is a lagged response to signaling in less affluent neighborhoods, which is a subject of future research.

2. Data

The housing price dataset at hand has been filtered in order to include only arms-length transactions. All transactions with the price of $500 or below were dropped, as were transactions where the seller and buyer was the same person. Moreover, residential properties outside Philadelphia (property zip code starting with “191”) or those sold by the government, HUD or the sheriff were discarded. 1,151 Fairmount tree plantings and 1,668 PHS tree plantings are merged by location to the housing sales data set.

Table 1 shows the summary statistics for the full sample, and those housing sales with a Fairmount or PHS tree planting within 100/ 500 feet *between sales*. The percentage of parcel sales that took place in proximity of a tree planting is shown in Table 2 by the relative timing of the sales and the plantings. Relative to all houses being

sold, parcels situated within 100/ 500 feet within either type of tree plantings between sales are smaller in size. While houses near PHS plantings are more likely to be adjacent to vacant lots, the opposite is true for those near Fairmount plantings. The same difference is also reflected by the sales price from the previous sale transaction. A comparison of the differences between current and previous sales prices, it is evident that Fairmount plantings took place in fast-growing neighborhoods while PHS plantings typically occurred in areas with below-average price growth. This suggests systematic pre-tree planting differences that need to be controlled for in the price analysis.

3. Empirical Evidence – Fairmount Plantings

To investigate price movements correlated with tree plantings, the following regression is performed:

(1) $$P_{it} = \alpha + \mu P_{it-1} + \beta Tree_{it} + \gamma H_i + C_i + \xi Gap_{it} + \sigma(P_{it-1} * Gap_{it}) + Time_t + \varepsilon_{it},$$

where P_{it} and P_{it-1} are the real sales price and the previous real sales price in logs, α a constant term, H_i a group of housing characteristics, C_i the census-tract fixed effects, Gap_{it} a measure of time lag between the sales and the previous sales and ε_{it} an error term clustered at the census-tract level.[2] $Time_{it}$ stands for a group of time controls: year fixed effects, quarter fixed effects and a set of census tract-specific linear time trends. By controlling for census-tract fixed effects, all comparisons are within tracts. Any time-invariant factors are absorbed by lagged price P_{it-1}. By regressing on sales prices while controlling for lagged price and the gap between sales, instead of regression on a rate of price change, more flexibility in functional form is allowed for.

[2] Housing characteristics included in regressions presented in this paper are those that demonstrate a stable and robust relationship with the dependent variable. Adding other controls decreases precision of estimates but does not the main conclusions.

Table 3 makes a simple comparison between sales of parcels with a Fairmount tree planting within 1000ft either before or after sales, with other parcels. Columns 1 and 2 suggest that relative to all other sales in Philadelphia, controlling for housing characteristics and seasonal effects as described above, sales price for parcels that were sold within 1000ft of previous or future Fairmount tree plantings are 2.30 percent higher. Remarkably, this differential does not diminish significantly when those sales are compared to sales within 4000ft of previous or future Fairmount tree plantings and is reduced slightly when compared to sales within 2000ft of previous or future Fairmount tree plantings (columns 3 to 6). This suggests a baseline, within-tract price differential around 2 percent on average due to unobserved factors correlated to the propensity of ever getting tree plantings within 1000ft.

When the treatment group is defined as all parcel sales that occurred *after* a Fairmount tree planting within 1000ft, any price differential can be interpreted as either a real change in the quality of the parcel (including the intrinsic value of the trees and promotion of social capital and environmentally conscious behavior), a revelation of its quality (the signaling effect), a third factor effect that coincided with the tree planting (e.g., an exogenous increase in awareness that led to tree plantings and possibly other positive neighborhood changes) or a combination of these. Table 4 presents the results. Relative to all other sales in the same census tract, parcel sales after a Fairmount tree planting within 1000ft were priced between 9 and 11 percent higher (columns 1 and 2). When compared to other parcel sales that also occurred after a Fairmount tree planting but were further away (2000ft and 4000ft, columns 3 to 6), this effect becomes close to zero and insignificant. This implies that the main factors that drive the 9 to 11 percent

price differential work at a level above the immediate neighborhoods. Compared to the differential found in Table 3, this differential is less likely to be driven by other factors unrelated to tree plantings because those factors would have to coincide with the tree plantings not only in space but also in time. Notably, it is also significantly larger in size. This lends support to the notion that either the tree plantings themselves or the drivers behind the tree plantings (e.g., a signaling motivation) led to price increases.

Table 5 tells a similar story. Here the treatment group consists of the first parcel sales that occurred after a Fairmount tree planting, but not the second or third. In a comparison between the between-sales-planting treatment group and all other sales (again controlling for census tract fixed effect), the price differential is between 9 to 10 percent. This becomes insignificant when the comparison group is limited to sales that also occurred immediately after Fairmount tree plantings but were further away. Because this price differential is tied to the one-time shock of a tree planting, this is even stronger support for price increases that are driven by factors that either resulted from or resulted in tree plantings.

The intrinsic value of a tree can be expected to affect house prices around a relatively small area. Tables 6 to 8 use a 100ft distance cutoff to explore this. Notably, there is no significant price differential related to the likelihood of ever having a tree planting in close proximity (Table 6).[3] Compared to results in Table 3, this reinforces the idea that the process that generates tree plantings works at a more macro-level. Table 7, where the treatment group consists of parcel sales after a Fairmount tree planting within 100ft, presents results that are remarkably similar to those using a 1000ft cutoff in Table

[3] On average, a city block is one-tenth of a mile, which is 528ft. A tree planting within 100ft means a tree directly in front of the parcel or its immediate neighbors. In comparison, 4000ft is about 8 city blocks.

4. The only difference is that the price differential as compared to the whole sample (columns 1 and 2) is about 2 percentage points higher. This suggests that the intrinsic value of a tree planting, which is the most likely to vary in strength spatially among the 4 main factors behind the tree-price correlation, is around 2 percent. Again, columns 3 to 6 indicate that the tree-price correlation is largely motivated at a more macro level. The lack of statistical power prevents precise comparisons between the parcels with plantings within 100ft and those with plantings within 500ft to 4000ft directly, but the point estimates in columns 3 to 6 are not far from 2 percent.

Table 8 uses parcel sales with between-sales tree plantings as the treatment group. As argued before, the price differential between this treatment group and other sales is more closely tied to tree plantings than that found in Table 7. Evidence consistent with earlier results is found comparing Tables 7 and 8. Slightly larger price differentials are identified when we focus on parcel sales with between-sales tree plantings, which diminish both in size and significance when we hold the timing of the planting constant and vary the distance to the plantings.

To sum up, we find that parcels located within 1000ft of between-sales Fairmount tree plantings sold at a 9 to 10 percent premium on average. The average premium for parcels within 100ft of a between-sales planting is 11 to 13 percent. A comparison of these results points to an intrinsic value of a tree planting at around 2 percent. Using all parcel sales after a planting as the treatment group produces very similar results, with slightly smaller point estimates. Remarkably, these price differentials large diminish when comparing the parcels at different distances but within 4000ft from the between-sales plantings. A baseline comparison along the propensity to have a tree planting in

proximity, using all parcels that have ever had plantings within 100ft (or 1000ft) as the treatment group, indicates that omitted variable bias is around 2 percent.[4] We argue that, after controlling for census tract fixed effects, parcel characteristics and time effects, it is unlikely that the substantial price differentials presented are due to some omitted factors unrelated to tree plantings but somehow coincide with them both in space and time. Therefore we conclude there is a significant price differential related to the tree plantings, between 7 to 11 percent, which is remarkably constant within 4000ft of the plantings. We posit that this is largely due to social capital (or other positive attitude) creation or a signaling effect, on the top of an intrinsic value of the plantings at around 2 percent.

4. Empirical Evidence – PHS Plantings

The main purpose of investigating the PHS tree plantings is to exploit the differences in the application process as compared to the Fairmount plantings. As described in the introduction, PHS plantings involve a much more significant level of coordination and cooperation among neighbors in order to obtain a tree planting on the block they live on. If social capital creation were a main driver behind the price differential identified in the previous section, we expect to find an even larger differential looking at PHS plantings. On the other hand, the intrinsic value of trees can be expected to be the same across the programs and both the signaling effect and the omitted variable bias can point in either direction. Equation (1) is estimated as before using PHS plantings. One difficulty of exploring the relationship between PHS plantings and housing prices is the limited number of parcel sales close to the plantings and thus lower statistical power. Table 9 summarizes the results, each row showing the price differential comparing a

[4] We acknowledge that this is not a perfect measurement of the omitted variable bias, partly because parcels that have tree plantings in proximity in an out-of-sample year will be wrongly put in the control, instead of the treatment, group.

given treatment group (row) with various control groups (column). In the last six columns the timing of the tree planting is held constant and the only factor that varies between the treatment and control groups is the distance to the planting: the control groups are further away from the plantings. These comparisons give us an idea how localized any tree-related price changes are.

Row 1 confirms that the PHS program target the neighborhoods in need: parcels that have ever had a PHS planting within 1000ft sold at a discount of around 8 percent that remains stable when parcels that have ever had a PHS planting within 2000ft or 4000ft are used as the control group, implying that the price discount is relatively localized at a 1000ft-radius. Surprisingly, the parcels that have ever had a PHS planting within 100ft, i.e., those with a higher propensity to request a PHS planting, do not systematically sell at a significant discount (row 2). These together imply that most of the homeowners who took advantage of the PHS program in fact own houses of average quality in a below-average neighborhood of a 1000ft radius (about 2 city blocks).

Row 3 shows a price discount between 6 to 11 percent for parcels that were sold after a PHS planting within 1000ft, which is not statistically different from that measured in row 1. Using parcel sales with between-sales tree plantings within 1000ft produces similar results (row 5). Therefore there is no strong evidence that PHS plantings decreased the negative price differential in a systematic way for parcels within 1000ft and there is unlikely to be significant social capital creation during the process, because this impact is expected to work at a multi-block level. This suggests that the significant price premium identified in the previous section is likely to be due to a signaling effect, where

residents request trees from Fairmount Park Commission to signal neighborhood qualities otherwise unobservable to homebuyers.

Any positive impact of the PHS plantings within 100ft is not precisely measured using this sample (rows 4 and 6). While the point estimates of the price differentials are less negative, there is not enough statistical power for inferences.

5. Conclusion

This study makes use of a rich data set with precise location information for all housing sales and tree plantings in Philadelphia between 1998 and 2003. We explore how housing prices evolve around tree plantings. Four main hypotheses are proposed: a positive impact due to the intrinsic value of trees, a positive impact due to generation of social capital, a positive signaling effect and a correlation to unobserved factors of ambiguous sign. We attempt to discriminate among these factors by exploiting variations in both timing and geographical locations of tree plantings relative to housing sales.

In addition, we investigate tree plantings through two separate agencies, the Fairmount Park Commission and the Philadelphia Horticultural Society. Because the latter requires a much higher level of coordination among residents, this sheds light on the importance of social capital creation.

For the Fairmount tree program, a 7 to 11 percent price differential is identified. It is a relatively stable effect within 4000ft of the tree plantings, largely driven by either social capital creation (and attitude changes) or a signaling mechanism. Findings using the PHS tree program suggest that social capital might be a less important channel. Targeting at struggling areas, there is evidence that the PHS tree program was utilized by relatively better-off pockets (with a 1000ft radius) in low-price neighborhoods. Any

positive changes brought by the PHS tree plantings were not detected with sufficient statistical power. Therefore we conclude that tree plantings serve as an effective signaling mechanism for home sellers with a small intrinsic value (around 2 percent). Any positive returns from increase in social capital or environmentally-conscious behavior are not apparent in our data.

Reference

Anderson, L. M., & H. K. Cordell, 1985. Residential Property Values Improve by Landscaping With Trees. *Southern Journal of Applied Forestry* 9: pp. 162-166.

_____, 1988. Influence of Trees on Property Values in Athens, Georgia (USA):A survey on Actual Sales Prices. *Landscape and Urban Planning* 15: pp 153-164.

Getz, D., Karow, A. and Kielbaso, J. J. (1982) Inner city preferences for trees and urban forestry programs. *Journal of Arboriculture* 8: pp. 258-263.

Summit, J. & R. Sommer, 1997. Urban Tree-Planting Programs – A Model for Encouraging Environmentally Protective Behavior. *Atmospheric Environment* 32: pp 1-5.