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Public open-space conservation under a budget constraint*

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Abstract: This paper analyzes the fiscal and land value impacts of public open-space conservation in a budget-constrained city. It derives the necessary and sufficient conditions for open-space conservation to increase the level of municipal services and the total land value within the city. The theoretical results, together with the empirical evidence found in the literature, suggest that open-space conservation can increase the level of municipal services and total land value in a significant share of American cities even if it generates no amenities. Open space conservation will likely increase total land values and municipal services in metropolitan areas that have stringent land use regulations, high development densities, and relatively little open space, but will likely reduce municipal services and total land values in small, lightly regulated cities surrounded by rural land and fiscally constrained in providing essential public goods. (H4, R3, Q2).

Keywords: Open space, amenity, land value, municipal services, property tax rates

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1. Introduction

Open space provides vital ecosystem services and public benefits, yet an estimated 6,000 acres of U.S. open space are lost each day as more people choose to live at the urban fringe and in scenic rural areas (U.S. Forest Service, 2007). In response to rapid land conversion, many communities are developing programs to preserve open space. From 1998 to 2009, U.S. voters approved 1,684 conservation initiatives in local and state referenda, providing a total of $54 billion for open-space conservation (The Trust for Public Land, 2010). The implementation of locally based, long-term open-space conservation plans has been touted as a critical element of "smart growth" in the United States (U.S. Environmental Protection Agency, 2009).

The popularity of open-space conservation should be no surprise; many of its benefits, such as improved amenities and property values, are highly visible, while some costs are often concealed as opportunity costs imposed by government budget constraints—money spent to conserve open space cannot be used for other public goods valued by local residents.

This article models the fiscal and land-value effects of open-space conservation in a place where local government faces a budget constraint. The main contribution is the integration of a real property–value model with the key features of local jurisdictional models (Epple et al., 1984; Epple and Romer, 1991; Ellickson, 1971). Because the model endogenously determines community characteristics such as property tax rate and municipal services, it provides a useful tool for studying the fiscal and land-value effects of open-space conservation.

Many hedonic studies evaluate capitalization of open space into nearby property values. Some distinguish between protected open space (e.g., public parks) and developable open space (e.g., privately owned agricultural land) and find that protected open space increases nearby home values, while developable open space has a lesser, insignificant, or even negative effect on home values (Irwin, 2002; Irwin and Bockstael, 2001; Geoghegan, 2002; Geoghegan et al., 2003). Other studies distinguish between publicly accessible open space and privately owned land and find that public access increases the impact of open space on home values (Cheshire and Sheppard, 1995, 1998). Anderson and West (2006) find that the value of proximity to open space is affected by neighborhood demographic and locational characteristics, such as income, crime, and distance to the city center. Taken together, these studies suggest that the price and welfare effects of open-space conservation depend on both the features of the open space in question and the characteristics of surrounding neighborhoods (Klaiber and Phaneuf, 2010).

Open-space conservation affects not only nearby property values, but also the whole community (Wu, 2006). Walsh (2007) develops an equilibrium framework to analyze the impact of open-space conservation on the entire metropolitan landscape. He finds that different strategies for spending a fixed amount on open space can have markedly different landscape and welfare implications. Wu and Plantinga (2003) examine the effect of open-space policy on urban development patterns and find that open-space conservation can lead to more development as well as non-contiguous development. An important contribution of the current study is that it examines the interaction of fiscal and conservation policies in a budget-constrained city. Coordinating conservation and fiscal policies is becoming increasingly important for local jurisdictions as they spend more tax dollars on land conservation. This paper presents a model to identify the key parameters that determine the fiscal effects of open-space conservation. It then applies the model to examine the effect of open-space conservation on the total land value within the city. The paper concludes with a discussion of the major insights gained from this analysis.

2. The model

Consider a city that provides municipal services and public open space to local residents and finances these services through a local property tax. The total land area within the city is *A,* and the total area of public open space is *S*. Open space provides amenities, the level and spatial distribution of which depend on the nature and configuration of the land preserved. We assume that, for each given area, open space is best designed so that there is a one-to-one relationship between the amount of land preserved, *S*, and the level of open-space amenities in the city, $a(S)$.

Municipal services and open-space amenities are capitalized into property values (see, e.g., Yinger, 1982; Irwin, 2002). Many previous studies of urban land prices consider amenities and the quality of public services explicitly (see, e.g., Potepan, 1996; Rose, 1989; Manning, 1988). These studies implicitly acknowledge that land value reflects the capitalized values of rents for housing services (Potepan, 1996). While rent is an explicit price for tenants, it is an implicit price for homeowners. Here we use the Porteba framework (Poterba, 1984, 1991) to model the capitalization of municipal services and open-space amenities into urban land value. This framework stipulates that equilibrium requires owners of real properties, such as land, to earn the same return as on other assets. By making the local property tax rate, τ, and the level of municipal services, *g,* explicit, the value of land for residential development, *P*, can be written as

$$P = \frac{r(S, a(S)) g^{\mu}}{\tau + c}, \tag{1}$$

where $r(S, a(S))$ is the rental value of housing services obtained by using the land for residential development, and *c* is the non-tax cost of home ownership, such as depreciation and mortgage interest rates. Municipal services, such as city water and sewer, enhance the value of residential land, as reflected by the parameter $\mu \in (0,1)$. Equation (1) states that the value of land for residential development equals the present value of the stream of housing services provided by the land, discounted at the rate of user cost of home ownership.

The rental value of housing services r is determined by supply and demand. Demand for housing services, $H^d(r,a(S))$, decreases with rent r and increases with amenities a. Variables such as household income also affect demand for housing services (Potepan 1996). Here we suppress these variables to emphasize the role of open-space amenities. The supply of housing services, $H^s(r,S)$, can be written as $H^s(r,S)=h^s(r)(A-S)$, where $h^s(r)$ is the level of housing services provided per unit of land and increases with rent. Formally, $r(S,a(S))$ is defined by $H^d(r,a(S))=H^s(r,S)$. Differentiating this equation with respect to S gives:

$$\frac{dr}{dS}=\frac{r}{S(A-S)(\varepsilon_r^{H^d}+\varepsilon_r^{H^s})}\left[S+(A-S)\varepsilon_a^{H^d}\varepsilon_S^a\ \right]>0, \tag{2}$$

where $\varepsilon_r^{H^d}=-\frac{\partial H^d}{\partial r}\frac{r}{H^d}$, $\varepsilon_r^{H^s}=\frac{\partial H^s}{\partial r}\frac{r}{H^s}$, $\varepsilon_a^{H^d}=\frac{\partial H^d}{\partial a}\frac{a}{H^d}$, and $\varepsilon_S^a=\frac{da}{dS}\frac{S}{a}$, which are all positive. Equation (2) indicates that open-space conservation increases residential land rent even if it generates no amenities, because it reduces the land supply. The more inelastic the supply and demand of housing services, the larger the impact of open-space conservation on residential land rent. Thus, a local government seeking to maximize land values might be tempted to conserve as much land as possible, given the impact of induced land scarcity on prices and the contribution of open space to amenity values. However, as shown below, open-space conservation may come at the expense of a higher property tax rate and a lower level of municipal services, both of which depress land prices, leading to a tradeoff situation. In addition, with the total amount of land fixed within the city, maximizing total land value is the same as maximizing land price, whereas maximizing total private land value entails an additional tradeoff between reducing the total amount of private land and increasing per-unit land price. In the following analysis, we distinguish policies that maximize total land value from policies that maximize total private land value (excluding public open space).

Assume all land within the city except the public open space is private and is assessed for taxes. The total property tax revenue, T, for the city is

$$T = \tau(A-S)P = \frac{\tau(A-S)r(S,a(S))g^{\mu}}{\tau+c}. \tag{3}$$

The city's annualized cost of open-space conservation is

$$C^{s} = cSP = \frac{cSr(S,a(S))g^{\mu}}{\tau+c}. \tag{4}$$

Equation (4) indicates that the cost of open-space conservation, the level of municipal services, and the property tax rate are all simultaneously determined. As more land is preserved for open space, the opportunity cost of conservation changes due to conservation's impacts on amenities, land supply, tax base, and the level of municipal services.

Following Borcherding and Deacon (1972), the cost of municipal services is assumed to be $C^{g} = g(A-S)^{\lambda}$, where $\lambda \in [0,1]$ is a parameter indicating the economy of scale in the provision of municipal services, with $\lambda = 1$ indicating no economy of scale and $\lambda = 0$ indicating the largest economy of scale, with all municipal services being pure non-rival public goods.

The local government that seeks to maximize total land value chooses the property tax rate and the level of municipal services that solves the following:[1]

$$\underset{(\tau,g)}{Max} \ \frac{Ar(S,a(S))g^{\mu}}{\tau+c} \quad \text{s.t.} \quad C^{s}+C^{g} \le T. \tag{5}$$

[1]Alternatively, the local government could choose the property tax rate and the level of municipal services to maximize total *private* land value within the city. But this would not change the property tax rate and the level of municipal services the government would choose.

The solution of this maximization problem gives the following results:

Proposition 1. *The property tax rate and the level of municipal services that maximize total land value within the city equal*

$$g^* = \left[\frac{\mu r(S, a(S))}{(A-S)^{\lambda-1}}\right]^{\frac{1}{1-\mu}}, \tag{6}$$

$$\tau^* = \frac{c}{1-\mu}\left(\mu + \frac{S}{A-S}\right). \tag{7}$$

Proof. Using (3) and (4), the city's budget constraint can be rewritten as

$$\frac{cAr(S, a(S))g^{\mu}}{\tau + c} + g(A-S)^{\lambda} \leq (A-S)r(S, a(S))g^{\mu}.$$

At the optimum, the budget constraint holds with equality; otherwise, a smaller τ exists that satisfies the budget constraint and increases land values. Substituting the constraint into the objective function, the maximization problem becomes

$$\underset{g}{Max}\ \frac{1}{c}[g^{\mu}r(S, a(S)) - g(A-S)^{\lambda-1}] \tag{8}$$

with τ being set to balance the budget. This shows that the land-value-maximizing level of municipal services maximizes the rental value of housing services minus the cost of municipal services per unit of service area. Solving the first-order condition of the maximization problem (8) for *g*, we obtain (6). Substituting g^* into the budget constraint and solving for τ, we obtain (7). ■

Equations (6) and (7) reveal the key parameters that determine the property tax rate and the level of municipal services that maximize total land value. These include economy of scale in the provision of municipal services (λ), land price elasticity with respect to municipal services (μ), and the non-tax cost of home ownership (*c*). Specifically, the land-value-maximizing level of municipal services g^* is higher when (a) there is a larger economy of scale in the provision of those services (i.e., λ is small), and (b) the land price is more elastic with respect to municipal services (i.e., μ is larger). The land-value-maximizing property tax rate τ^* is higher when the land price is more elastic with respect to municipal services (i.e., μ is larger) and when the non-tax cost of home ownership *c* is larger. With a reduction in the user cost of home ownership, such as a decrease in the mortgage interest rate, home values increase, and the city can raise the same tax revenue with a lower property tax rate.

To derive the key parameters that determine the fiscal impact of open-space conservation, we differentiate equations (6) and (7) with respect to *S*.

Corollary 1

$$(a)\ \frac{\partial \tau^*}{\partial S} = \frac{cA}{(1-\mu)(A-S)^2} > 0, \quad (9)$$

$$(b)\ \frac{\partial g^*}{\partial S} > 0 \ \ iff\ \varepsilon_a^{H^d} \varepsilon_S^a (A-S) > [(1-\lambda)(\varepsilon_r^{H^d} + \varepsilon_r^{H^s}) - 1]S. \quad (10)$$

Proof. Equation (9) follows directly by differentiating (7) with respect to *S.* To derive equation (10), we first differentiate (6) with respect to *S* to obtain

$$\frac{dg^*}{dS} = \frac{g^*}{1-\mu}\left[\frac{1}{r}\frac{dr}{dS} + (\lambda - 1)\frac{1}{A-S}\right]. \quad (11)$$

Thus, $\frac{\partial g^*}{\partial S} > 0$ if and only if

$$\frac{S}{r}\frac{dr}{dS} > (1-\lambda)\frac{S}{(A-S)}. \quad (12)$$

This suggests that open-space conservation increases municipal services if and only if the elasticity of residential land rent with respect to open space exceeds the ratio of the area of public open space to the area of private land, adjusted by the economy of scale in municipal services. Substituting (2) into (12) gives (10). ■

Corollary 1 provides several insights about the fiscal impacts of open-space conservation. First, although open-space conservation always increases the land-value-maximizing property tax rate, it can increase or decrease the land-value-maximizing level of municipal services. In particular, if the demand and supply of housing services are sufficiently price inelastic such that $(\varepsilon_r^{H^d} + \varepsilon_r^{H^s}) < 1/(1-\lambda)$, open-space conservation increases the level of municipal services even if it generates no amenities. By reducing the supply of developable land, open-space conservation increases the rental value of housing services and hence the marginal benefit of municipal services. In addition, when there is an economy of scale in providing municipal services, open-space conservation also increases the marginal cost of municipal services by reducing the service area. It increases the marginal benefit more if the demand and supply of housing services are sufficiently price inelastic, such that $(\varepsilon_r^{H^d} + \varepsilon_r^{H^s}) < 1/(1-\lambda)$.

Second, when there is no economy of scale in the provision of municipal services, open-space conservation increases the land-value-maximizing level of municipal services. This can be shown by noting that the necessary and sufficient condition for $\frac{\partial g^*}{\partial S} > 0$ holds when λ =1. When there is little economy of scale in the provision of municipal services, open-space conservation does not affect the marginal cost of municipal services per unit of land, but it increases their marginal benefits. Therefore, the land-value-maximizing level of municipal services increases with open-space conservation.

Third, the fiscal effect of open-space conservation depends on the amount of land preserved. When little open space exists in the city, some land conservation will increase the level of municipal services if $\varepsilon_a^{H^d}\varepsilon_S^a > 0$ at S=0. However, as more land is preserved for open space, it will eventually reduce the level of municipal services if $(\varepsilon_r^{H^d} + \varepsilon_r^{H^s}) > 1/(1-\lambda)$ at S=A. The necessary and sufficient condition for $\frac{\partial g^*}{\partial S} > 0$ holds when S is close to zero, but breaks down when S is large enough.

Fourth, the effect of open-space conservation on municipal services depends on the characteristics of the city. In small cities surrounded by rural land, additional open-space may not generate additional amenities or land scarcity because there are close substitutes for new open space and developable land. In those cities, open-space conservation has little effect on the rental rate of housing services, and the condition (12) for $\frac{\partial g^*}{\partial S} > 0$ cannot hold. In contrast, in large cities with high development densities and relatively little open space (e.g., Los Angeles), large parcels of new open space tend to provide a high level of amenities and increases land scarcity. In addition, both the demand and supply of municipal services tend to be inelastic (Carruthers and Úlfarsson, 2008). Condition (10) indicates that open-space conservation will likely lead to a higher level of municipal services in those cities.

Finally, open-space conservation increases the land-value-maximizing level of municipal services if it generates amenities but does not reduce either the amount of developable land or the tax base. The analysis above assumes that open-space conservation reduces the tax base and the total cost of municipal services. If the preserved land were undevelopable or located outside the city, it would not change the marginal cost of municipal services, but rather would increase the marginal benefits because of the amenities it would provide. This suggests that preserving undevelopable land that yields little in property tax revenues (such as wetlands or brownfields) or preserving land outside the city will increase the level of municipal services.

3. The impact of open-space conservation on land values

Ignoring the fiscal impacts, open-space conservation would appear to increase land values by creating land scarcity and amenities. However, open-space conservation competes for funding with other municipal services. As more tax revenue is allocated to open-space conservation, the local government must either raise property taxes or spend less on other municipal services. Both of these measures tend to depress land values.

Substituting (6) and (7) into (5), we obtain the total land value as a function of open space area:

$$TLV = \frac{1-\mu}{c}\left[\frac{\mu^{\mu} r(S, a(S))}{(A-S)^{\lambda\mu-1}}\right]^{\frac{1}{1-\mu}}. \tag{13}$$

Differentiating (13) with respect to S gives:

Proposition 2. Open-space conservation increases the total land value within the city if and only if

$$\varepsilon_a^{H^d} \varepsilon_S^a (A-S) > [(1-\lambda\mu)(\varepsilon_r^{H^d} + \varepsilon_r^{H^s}) - 1]S. \tag{14}$$

Several results follow directly from (14). First, if the demand and supply of housing services are sufficiently price inelastic, such that $(\varepsilon_r^{H^d} + \varepsilon_r^{H^s}) < 1/(1-\lambda\mu)$, open-space conservation increases the total land value even if it generates no amenities. By reducing the supply of developable land, open-space conservation increases the rental value of housing services and the marginal benefit of municipal services, leading to an increased supply of municipal services. Although open-space conservation also increases the property tax rate, which tends to reduce land values, the positive effect on land value from the reduced supply of land and the increased municipal services outweighs the negative effect of the increased tax rate when the demand and supply of housing services are sufficiently price inelastic.

Second, open-space conservation cannot increase the total property value if it comes at the expense of lower municipal services, even after the property tax rate is optimally adjusted (i.e., increased by a fraction of $S/[\mu(A-S)]$ of the original tax rate).[2] The necessary and sufficient condition (14) for an increased total property value cannot hold when the necessary and sufficient condition for a higher level of public service (10) fails. Intuitively, open-space conservation increases the property tax rate, which has a negative effect on land values. The negative effect can be totally offset only if the value of housing services increases by a sufficient amount, such that the land-value-maximizing level of municipal services also increases.

Third, open space is more likely to increase land value when there is little economy of scale in providing municipal services. Condition (14) is more likely to hold when λ is larger. Open-space conservation competes for funding with other municipal services. When there is less economy of scale in municipal services, the opportunity cost of open-space conservation will be smaller.

Fourth, the effect of open-space conservation on land value depends on the amount of land preserved. When little open space exists in the city, some land conservation will increase the total land value within the city if $\varepsilon_a^{H^d}\varepsilon_s^a > 0$ at S=0. However, as more land is preserved, it will eventually reduce the level of municipal services if $(\varepsilon_r^{H^d} + \varepsilon_r^{H^s}) > 1/(1-\lambda\mu)$ at S=A. The necessary and sufficient condition (12) holds when S is near zero, but breaks down when S is large enough.

Finally, the effect of open-space conservation on total land value depends on local characteristics. In small cities surrounded by rural land, extra open space may not generate

[2] Note that $\frac{\tau^*(S)-\tau^*(0)}{\tau^*(0)} = \frac{S}{\mu(A-S)}$.

additional amenities or land scarcity because there are close substitutes for new open space and developable land (i.e., ε_S^a is near zero and $(\varepsilon_r^{H^d} + \varepsilon_r^{H^s})$ is large). In this case, (12) does not hold, indicating that open-space conservation in such cities reduces total land value. In contrast, in large cities with high development densities, stringent regulatory environments, and relatively little open space, large parcels of new open space tend to provide a high level of amenities and create additional land scarcity (i.e., ε_S^a is large and $(\varepsilon_r^{H^d} + \varepsilon_r^{H^s})$ is small). In those cities, open-space conservation tends to increase total land value.

The city government may be more interested in protecting private land values. In this case, we can show the following:

Proposition 3. Open-space conservation increases the total value of ***private*** *land within the city if and only if*

$$\varepsilon_a^{H^d} \varepsilon_S^a (A - S) > [(2 - (1+\lambda)\mu)(\varepsilon_r^{H^d} + \varepsilon_r^{H^s}) - 1]S. \tag{15}$$

Because the right-hand side of (15) is larger than the right-hand side of (14), (14) is more likely to hold than (15), suggesting that open-space conservation is more likely to increase the total value of all land within the city than to increase the total value of *private* land. This reflects that maximizing private land values entails an additional tradeoff between reducing the total amount of private land and increasing the per-unit land price, whereas maximizing total land value is the same as maximizing the per-unit land price. However, the key parameters and the fundamental forces that affect the two total values are the same.

Proposition 3 suggests that the two sides of (15) must be equal when the total private land value is maximized. From this equation, we can derive the following:

Corollary 2. The share of land for public open space that maximizes the total private land value within the city is defined by

$$s^* = \frac{\varepsilon_a^{H^d} \varepsilon_S^a}{\varepsilon_a^{H^d} \varepsilon_S^a + [(2-(1+\lambda)\mu](\varepsilon_r^{H^d} + \varepsilon_r^{H^s}) - 1} . \tag{16}$$

As more land is preserved for open space, the demand and supply elasticities of housing services and the elasticity of amenities may change. Thus, equation (16) only implicitly defines the land-value-maximizing share of open space. Equation (16) shows that, other things equal, more land should be preserved for public open space when (a) the demand and supply of housing services are less price elastic, (b) the level of amenities is more elastic with respect to the amount of land preserved, and (c) the demand for housing services is more elastic with respect to the level of amenities.

4. Empirical evidence

Key parameters that determine the fiscal and land price effects of open space conservation are $\varepsilon_r^{H^d}, \varepsilon_r^{H^s}, \varepsilon_a^{H^d}, \lambda, \mu,$ and ε_S^a. Empirical information about these parameters is uneven. Many studies provide estimates of the price elasticity of housing demand. A consistent finding is that demand for housing services is price inelastic. Sirmans and Redman (1979) estimate price elasticity of demand for urban residential land ($\varepsilon_r^{H^d}$) in 52 urban areas and report values between 0.32 and 0.68. Hanushek and Quigley (1980) estimate price elasticity of housing demand and report two estimates for Pittsburgh households and two for Phoenix households. The 95% confidence intervals of the two Pittsburgh estimates are (0.33, 0.95) for the basic model and (0.22, 0.54) for the expanded model. The corresponding estimates for Phoenix households are (0.20, 0.71) and (0.19, 0.63), respectively. These estimates are smaller than those reported by Muth (1971) and by Polinsky and Ellwood (1977), who estimate price elasticity from the production of new single-family detached housing with 95% confidence intervals of (0.51, 0.99) and (0.56, 0.86), respectively. The mean value of the six estimates of the price elasticity of housing demand from the three studies is 0.56.

Compared to demand, supply of housing services is generally much more price elastic. Green et al. (2005) estimate price elasticity of housing supply ($\varepsilon_r^{H^s}$) in 45 Metropolitan Statistical Areas (MSAs) in the United States and find that 24 MSAs have a price elasticity above 5. They also find that all stringently regulated cities have low supply elasticities, while cities with more relaxed regulatory environments and moderate to fast population growth tend to have high elasticities. Population density is also an important predictor of supply elasticity. Regardless of how it is specified, higher population densities produce lower supply elasticities.

Empirical evidence also exists about parameter λ, representing the economy of scale in the provision of municipal services. Carruthers and Úlfarsson (2008) analyze local government expenditures in 3,075 counties in the continental United States and report an estimate of 0.02 for the elasticity of per-capita direct government expenditure with respect to the percent of land area developed. Hortas-Rico and Solé-Ollé (2010) analyze the effect of urban expansion on local government spending in 2,500 municipalities in Spain and find that the elasticity of per-capita spending with respect to urbanized area is 0.05-0.06. With our cost functional form assumption, the per-capita government expenditure equals $g(A-S)^{\lambda-1}d$, where d is population density. Both studies control for population density. Therefore, their results suggest that the value of parameter λ is close to 1, which is consistent with wide-spread findings in the literature that most local government services do not exhibit a significant degree of publicness (Reiter and Weichenrieder, 1997).

There is an enduring debate about the capitalization of local fiscal variables into property values (Yinger, 1982). The debate has stimulated many empirical studies, dating back to the seminal article by Oates (1969), but relatively few directly estimate elasticity of land value with respect to the quality of public goods (μ). One exception is Potenpan (1996), who uses the 1974-1983 Annual Housing Survey data to analyze variation in housing prices, rents, and land prices among 58 U.S. MSAs. He finds that the quality of public services (measured by the percent of households reporting excellent or good quality of public services) is significant in explaining the variation, and reports an estimate of 0.68 for the elasticity of land price with respect to the quality of public services.

Compared to price elasticities of housing demand, sparse empirical evidence exists on the elasticity of housing demand with respect to amenities or open space area ($\varepsilon_a^{H^d}\varepsilon_s^a$). However, empirical findings of price-inelastic housing demand suggest that aggregate housing demand is likely inelastic with respect to the total area of open space in a city, although amenities influence residential location choices within a given city.

While we do not have complete information about all the parameters, several results follow from existing evidence. First, existing empirical findings indicate that open-space conservation can increase total land values for many cities even if it generates no amenities. This occurs when $(1-\lambda\mu)(\varepsilon_r^{H^d}+\varepsilon_r^{H^s})<1$, according to proposition 2. If λ, μ , and $\varepsilon_r^{H^d}$ take values of 1, 0.68, and 0.50, this condition reduces to $\varepsilon_r^{H^s}<2.63$, which is satisfied in 27 percent (12 out of 45) of the cities studied by Green et al. (2005). The corresponding condition for open-space conservation to increase the total *private* land value can be derived using condition (15), which is $\varepsilon_r^{H^s}<1.06$. Thirteen percent of the cities studied by Green et al. (2005) have inelastic housing supply, suggesting that additional open-space conservation increases total private-land value in those cities, even if it generates no amenities.

To ascertain the importance of open space amenities, Figure 1 shows the share of land for open space that maximizes the total private land value, defined by (16), as a function of $\varepsilon_a^{H^d}\varepsilon_s^a$ for three cities with low, medium, and high price elasticities: Philadelphia, San Diego, and Altanta, respectively. The estimated price elasticities of housing supply from Green et al. (2005) for these cities are 3.09, 5.25, and 21.6, respectively. These figures are typical of cities with low, medium, and high price elasticities in Green et al. (2005)'s list. As before, λ, μ, and $\varepsilon_r^{H^d}$ are assumed to take values of 1, 0.68, and 0.50, respectively. Thus, the price elasticity of housing supply is the only parameter that causes the differences between the curves.

Figure 1 indicates that price elasticity of housing supply is an important determinant of the value-maximizing share of land for public open space. In cities with relaxed regulatory environments and high housing supply elasticities, such as Atlanta, Dallas, and Phoenix, preserving more than 15 percent of land within the city for public open space will likely reduce the total private land value given that the total demand for housing is likely inelastic with respect to the total area of open space. The threshold will be less than 4 percent if the elasticity of demand for housing with respect to the total area of open space is 0.5 or below.

In contrast, in cities with stringent land-use regulations and low housing supply elasticities, such as Philadelphia, San Francisco, and Chicago, the value-maximizing share of land for public open space is much more responsive to the amenity-induced demand for housing ($\varepsilon_a^{H^d}\varepsilon_s^a$). When elasticity increases from 0.1 to 0.5, the value-maximizing share of land for public open space increases from 7 to 27 percent. These results, together with those of Green et al. (2005), suggest that open-space conservation will be much more likely to increase private-land values in cities with stringent land-use regulations and high development densities than to increase them in lightly regulated areas with fast population growth.

5. Conclusions

Growing recognition of the economic and environmental benefits of open space has sparked waves of conservation initiatives at local and state levels in the United States. As communities invest more in conservation, it is important to understand its economic and fiscal implications. This paper fills a gap in the literature by investigating the interaction between fiscal and conservation policies in cities facing budget constraints.

Several key insights are gained. First, if the demand and supply of housing services are sufficiently inelastic, some open-space conservation will increase the total land value, even if it generates no amenities. In this case, the positive effect of open-space conservation on land value due to the reduced land supply outweighs the negative effect of increased property taxes, leading to more municipal services and higher property values. However, as more land is preserved for open space, the level of municipal services and the total land value will eventually be reduced if the price elasticities of demand and supply of housing services are bounded from above.

Second, open-space conservation can increase total land value in a significant share of American cities even if it generates no amenities. Using the theoretical results from this paper and parameter values found in the empirical literature, we calculated the threshold of the price elasticity of housing supply, below which open-space conservation increases total land values. We found that if open-space conservation generates no amenities, it increases the total land value in cities where the price elasticity of housing supply is below 2.63, and increases the total *private*-land value in cities where the price elasticity of housing supply is below 1.06. In about 27 percent of the cities in the sample studied by Green et al. (2005), price elasticity of housing supply is below 2.63, and in 13 percent it is below 1.06.

Third, different localities have distinctive and ever-changing characteristics, and alternative solutions to a particular land-conservation problem are seemingly endless. However, by combining our results with those from Green et al. (2005), we can identify the characteristics of cities where open-space conservation is likely to increase total property values. These include metropolitan areas that are heavily regulated, have high development densities, and have relatively little open space. In such places, open-space conservation is likely to generate additional amenities and demand for housing. Combined with inelastic demand and supply of housing, open-space conservation in these cities will likely lead to increased housing prices, more tax revenue, and better municipal services. In contrast, in small, lightly regulated cities surrounded by rural land, more open space may not generate additional amenities or land scarcity because there are close substitutes for new open space and developable land. Open-space conservation in such cities will likely reduce the level of municipal services and total land value.

Finally, open-space conservation can increase the total land value only if it increases the level of municipal services. It is more likely to do that when it (1) provides a high level of amenities, (2) preserves inexpensive land, and (3) reduces the cost of municipal services. Parcels satisfying all three conditions may include brownfields in cities that have high development densities and relatively little open space. Preserving such sites for open space instead of developing them for low-income, high-density housing will likely increase the total property value and the level of municipal services in the city.

References

Anderson, S.T., West, S.E., 2006. Open space, residential property values, and spatial context. Reg. Sci. Urban Econ. 36(6), 773-789.

Borcherding, T.E., Deacon, R.T., 1972. The demand for the services of non-federal governments. Amer. Econ. Rev. 62(5), 891-901.

Carruthers, J.I., and G.F. Úlfarsson. 2008. "Does `Smart Growth' Matter to Public Finance?" *Urban Studies* 45: 1791-1823.

Cheshire, P.C., Sheppard, S.C., 1995. On the price of land and the value of amenities. Economica 62(246), 247-267.

Cheshire, P.C., Sheppard, S.C., 1998. Estimating the demand for housing, land, and neighbourhood characteristics. Oxford Bull. Econ. Statist. 60(3), 357-382.

Cheshire, P.C., Sheppard, S.C., 2002. The welfare economics of land use planning. J. Urban Econ. 52(2), 242-269.

Ellickson, B., 1971. Jurisdictional fragmentation and residential choice. Amer. Econ. Rev. 61(2), 334-339.

Epple, D., Filimon, R., Romer, T., 1984. Equilibrium among local jurisdictions: toward an integrated treatment of voting and residential choice. J. Public Econ. 24(3), 281-308.

Epple, D., Romer., T., 1991. Mobility and redistribution. J. Polit. Economy 99(4), 828-858.

Geoghegan, J., 2002. The value of open spaces in residential land use. Land Use Policy 19 (1), 91–98.

Geoghegan, J., Lynch, L., Bucholtz, S., 2003. Capitalization of open spaces into housing values and the residential property tax revenue impacts of agricultural easement programs. Agr. Res. Econ. Rev. 32(1), 33–45.

Green, R.K., Malpezzi, S. and Mayo, S.K., 2005. Metropolitan-specific estimates of the price elasticity of supply of housing, and their sources. Amer. Econ. Asso. Pap. and Proc. 95(2), 334-339.

Hanushek, E.A., Quigley, J.M., 19080. What is the price elasticity of housing demand? The Rev. of Econ. Stat. 62(3), 449-454.

Hortas-Rico, M., Solé-Ollé, A., 2010. Does urban sprawl increase the costs of providing local public services? evidence from Spanish municipalities. Urban Studies 47, 1513-1540.

Irwin, E., 2002. The effects of open space on residential property value. Land Econ. 78(4), 465-480.

Irwin, E.G., Bockstael, N.E., 2001. The problem of identifying land use spillovers: measuring the effects of open space on residential property values. Amer. J. Agr. Econ. 83(3), 698-704.

Klaiber, H.A., Phaneuf, D.J., 2010. Valuing Open Space in a Residential Sorting Model of the Twin Cities. J. Environ. Econ. Manag. 60(2), 57-77.

Manning, C., 1988. The determinants of intercity home building site price differences. Land Econ. 64, 1-14.

Muth, R.F., 1971. The derived demand for urban residential land. Urban Studies 8(October), 243-254.

Oates, W.E., 1969. The effects of property taxes and local public spending on property values: an empirical study of tax capitalization and the Tiebout hypothesis. The J. of Pol. Econ. 77(6), 957-971.

Polinsky, A.M., Ellwood, D.T., 1979. An empirical reconciliation of micro and grouped estimates of the demand for housing. The Rev. of Econ. Stat. 61(2), 199-205.

Potepan, M.J., 1996. Explaining intermetropolitan variation in housing prices, rents and land prices. Real Estate Econ. 24(2), 219-245.

Poterba, J. , 1984. Tax subsidies to owner-occupied housing: an asset-market approach. The Quart. J. of Econ. 99(4), 729.

Poterba, J., 1991. House Price Dynamics: The Role of Tax Policy. Brookings Papers on Economic Activity 22(2), 143–204.

Reiter, M., Weichenrieder, A., 1997. Are public goods public? A critical survey of the demand estimates for local public services. *FinanzArchiv/Public Finance Analysis*. 374-408.

Rose, L., 1989. Urban land supply: Nature and contrived restrictions. J. of Urban Econ. 25, 325-345.

Sirmans, C.F., Redman, A.L., 1979. Capital-land substitution and the price elasticity of demand dfor urban residential land. Land Econ. 55(2), 167-176.

The Trust for Public Land, 2010. LandVote® http://www.tpl.org/tier3_cd.cfm?content_item_id=12010&folder_id=2386 (accessed April 14, 2010).

U.S. Forest Service, 2007. Forest Service Open Space Conservation Strategy. U.S. Dept. of Agriculture, Forest Service, Washington DC.

U.S. Environmental Protection Agency, Smart Growth and Open Space Conservation. http://www.epa.gov/dced/openspace.htm (accessed September 9, 2009).

Walsh, R., 2007. Endogenous open space amenities in a locational equilibrium. J. Urban Econ. 61(2), 319-344.

Wu, J., 2006. Environmental amenities, urban sprawl, and community characteristics, J. Environ. Econ. Manage. 52(2), 527-547.

Wu, J. Plantinga, A.J., 2003. The influence of public open space on urban spatial structure. J. Environ. Econ. Manage. 46(2), 288-309.

Yinger, J., 1982. Capitalization and the theory of local public finance. J. Political Econ. 90(5), 917-943.

Figure 1. The Share of Land for Public Open Space That Maximizes Total Private Land Value in Three Cities with Low, Medium, and High Price Elasticity of Housing Supply