An Ecological and Physical Investigation of Pittsburgh Hillsides
ECONOMICS REPORT to the City of Pittsburgh Hillsides Committee

Economics of Hillside Slope Development

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I. Introduction

Hillside slopes are both natural and man-made, the latter resulting from cuts for highways, railroads, developments, and mining. The variety of slopes and associated landscape features, such as vegetative cover and streams, define the topographic relief of an area. Each element of relief - slopes, cover and streams - can have different roles in defining a landscape, although they are often tightly associated. The character of the slopes - steepness, elevation, geophysical composition - and local ecological conditions – rainfall, climate - will define the vegetation and hydrology of the landscape. Consequently, one must consider the complete ecological complex associated with hillsides, not just the steepness of its slopes. It is this complex that performs various ecological functions and produces valuable services.

II. The Value of Landscape Defining Topographic Features

Topographic relief is a large-scale landscape defining element that can be so unique and interesting that it provides identity to a place. Urban areas noted for their variegated relief include San Francisco, Seattle, San Diego, and Pittsburgh. Other urban areas are geophysically defined by the juxtaposition of flat and variegated landscape relief, such as Denver, Phoenix and Albuquerque. The topographic features of an urban landscape, and their associated ecological elements, thus play an important role at a large scale by defining a place as unique and memorable. These place defining landscape features generate values that flow from that definition, such as living and tourist interest. The Point in Pittsburgh would not be so unique and identifying if it were not for the contiguous topographic relief and even the elevated vantage points from which to view the joining of major rivers.

These unique, place defining topographic values are at such a large scale that it is difficult to place economic values on them. They would permeate all economic transactions of the region, from housing markets to commercial viability. Variegated topographic relief is attractive to people and defines the place as unique and interesting. Housing values are higher and wages lower as people desire to live in a variegated, unique and interesting landscape. While many studies have shown the property value and wage effects of environmental amenities, such as climate, clean air and water, greenspace, and forested landscapes, no one has done a similar study for the economic values of topographic relief, per se.

This variegated topographic relief is a very large scale defining landscape element crucial to the definition of a place. As this relief is diminished, either geophysically through landscape transformations, or visually through land use changes, so is the uniqueness and place defining character of this element. This relief can be lost piece-by-piece, as each transformation is thought to contribute only marginally to changing the landscape character of a region. But with each piece goes a little bit of the place defining element.

The elements of value that contribute to the uniqueness and memorability of a topographically variegated landscape are complex and often purely psychological. Viewsheds are often large and permit the observer to see large distances, view the variety of natural landscape features, such as valleys, hills and rivers, as well as view the variety of human activities in that landscape and in their economic world. These views are intriguing to the senses. As hillsides become developed, the natural landscape features disappear and something of value is lost from the viewshed. What this loss is worth, economically, is a challenge to estimate, although studies have shown what it may be worth to people to have broader vistas, or to have natural vistas altered by human activities and structures.

In addition to the visual values at the tops of variegated topographies, there may be some psychological values associated with safety and serenity on the tops of hillsides. While people are not likely to fear marauding invaders climbing the slopes behind their homes, there may still be some sense of safety when a large area of nearby landscape is inaccessible. Also, just the lack of development on hillsides would provide a region of tranquility in addition to possibly extensive views. These values may be reflected in the prices of properties near undeveloped hillsides. Empirical tests of these effects on property values can be made, although no one has done it. Studies of the property value impacts of forested landscapes are related, but have not been done in the context of hillside landscapes.

Valleys associated with variegated topographic relief would have diminished value as elements of that relief disappear. Living in valleys has always appealed to people. This is not only because it costs less to construct in valleys than on hillsides, but because there are psychological benefits associated with safety, serenity, and upward visualizations of natural hillsides that appeal to people. The belief that people will not build on hillsides provides some comfort that at least the perimeter of the valley will remain serene and natural. A psychological element of coziness and safety of a valley is lost when hillsides become developed. These values to valley properties in a topographically variegated area should be reflected in increased property values, although no one has attempted to make such estimates. A confounding issue is that it is necessary to compare valley properties with others not in a variegated landscape, but that have other similar property determining characteristics, such as proximity to jobs and ease of access. Such comparisons may be difficult, as valley communities are often isolated economically (e.g., West Virginia coal communities).

Variegated topographic features, such as hills, valleys and rivers, often play important roles in defining economic regions and social communities. Hills come to define communities, as geographic mobility is an important determinant of a community or neighborhood. And hills or rivers provide natural boundaries that define spaces, and provide convenient natural features that satisfy human needs for place definition. To the extent these boundaries are less identifiable, as they might be with development of hillsides, the sense of community and neighborhood is diminished. While historic definitions of neighborhoods may be maintained on maps and urban directories, the psychological value of these definitions are diminished as the places become blurred and communities integrated across their historic natural boundaries. One has only to look at San Francisco to see how development of almost every landscape feature has visually blurred any sense of neighborhood place. For this reason, the Association of Bay Area Governments, the regional planning organization, has as one of its six major environmental and land use objectives, to "Create and enhance community identity through protection of community separators, hillsides, ridge lines and viewsheds, riparian corridors and key landscape features." (http://www.abag.ca.gov/planning/rgp/menu/ menub.html)

The economic value of the identification and integrity of neighborhoods and communities through variegated landscape features is difficult to quantify even though this identification is a fundamental element in people's social, religious, and economic lives. But its loss can possibly be felt in varied ways, such as loss in social capital (networks of social relationships and sense of trust and caring), increases in crime rates, loss of interest in local political processes, and out-migration of young people. While a portion of the economic costs of crime can be measured, other elements of social capital and community cohesion are difficult, if not impossible, to value economically.

III. Ecological Values of Hillside Slopes

Hillside slopes, and their associated vegetation and streams, have functional ecological values. Slopes, per se, define a topography and related habitat that determine biological diversity at a small scale. Various plants may thrive in the steeply sloped, well-drained, and climate protected micro-regions of topographic relief. This resulting vegetation is critical to establishing the hydrologic and climate regimes of the sloped and surrounding areas, and may be difficult to replace if disturbed. Steeply sloped hillsides also provide unique or highly favored habitats for some animal species. So these sloped hillsides may play an important role in protecting biodiversity. The value of this biodiversity is difficult to estimate, but does have both local and regional value.

Hillsides are critical landscape features in determining hydrologic conditions. Vegetative cover of hillsides is essential to a variety of hydrologic processes, including management of sheet flow, uptake, and sediment loss through water flow and raindrop impacts on soils. The more steeply sloped the hillside the more severe the hydrologic effects of vegetative loss will be. The value of vegetative cover then increases with degree of slope. This value can be measured by the increased costs associated with more rapid and higher volume run-offs from sloped areas. These costs include stormwater management costs, flood protection or damage costs, as well as costs associated with increased stream sedimentation, such as water treatment costs and recreational fisheries losses. These costs are measurable, but depend upon the hydrologic and sediment fate modeling of watersheds.

The benefits of maintaining a forested landscape to control stormwater runoff are illustrated in a study done in Los Angeles, CA (Pincetl, et al, 2003). The study used a Geographic Information Systems (GIS) program, called CITYgreen (developed by American Forests), to analyze the impacts of tree cover on stormwater runoff, air pollution and urban temperatures. The study site was 146 acres, and included nearly 1900 trees. The GIS model was then used to predict runoff, pollution removal and temperatures under various “greening” scenarios, including the base case of current existing conditions. The study then created scenarios of increases in streetside trees, trees in parking lots, and introduction of permeable surfaces to parking lots. Using a value of $275 per cubic foot for managing stormwater runoff, the model estimated that current vegetative cover in the 146 acre study area saved $930,000 in stormwater infrastructure costs. However, the aggressive cover scenario with its additional planting, etc., would result in cost savings of over $7 million; or nearly $6 million more cost savings than under current conditions. This represents approximately $41,000 per acre of cost savings attributable to more intensive tree cover. While results are likely to differ substantially with topography, existing land cover and rainfall conditions, they are suggestive of the magnitudes of values of natural services provided by tree cover.

Another study in the Los Angeles, CA, area analyzed the effects of trees on rainfall interception and runoff reduction (Xiao and McPerson, 2002). A mass and energy balance rainfall interception model was used to simulate rainfall interception processes (e.g., gross precipitation, free throughfall, canopy drip, stemflow, and evaporation). Annual rainfall interception by the 29,299 street and park trees was 193,168 m^3 (6.6 m^3/tree), or 1.6% of total precipitation. The annual value of avoided stormwater treatment and flood control costs associated with reduced runoff was $110,890, or $3.60 per tree.

The stratified geomorphology of many steeply sloped hillsides provide for the gradual seep of groundwater down hillsides. Maintaining a low flow of groundwater is especially important in regions with coal and other mineral deposits that may cause acidification. Slow flow and hillside vegetation may provide for water treatment before reaching streams. Disturbing this geophysical and vegetative regime may have severe adverse consequences for stream quality as flows are increased and treatment is diminished. The economic value of hillside disturbances can be large, as the costs of acid mine drainage attest.

Hillsides and their vegetative cover will play some roles in local climate conditions depending on the topographic context. Changing the cover, as would occur with development, may increase wind flows and create greater extremes in temperature conditions at the micro-climate level. These climate effects would alter conditions in associated valleys and hilltops; increased heating and cooling costs may result. It is not clear whether these climate effects of loss of vegetative cover would be more or less severe in more steeply sloped hillsides.

A major study of the pollution removal and heating/cooling values of trees was done for the Chicago, IL, metropolitan area (McPherson, et al., 1997). The study found that increasing tree cover by 10% (corresponding to about three trees per building in the Chicago landscape context) could reduce total heating and cooling energy use by 5 to 10% ($50–$90 per year). On a per-tree basis, annual heating energy can be reduced by about 1.3% ($10 per tree per year), cooling energy by about 7% ($15 per tree per year), and peak cooling demand by about 6% (90.3 kW). This $25 annual savings per tree suggest a present value of cost savings of $500 per tree, using a 5% discount rate. For typical suburban wood-frame residences, shade from three trees can reduce annual heating and coolings costs 10 years after planting by $15 to $31 per year, and 20 years after planting by $29 to $50 per year.

The ecological function of trees in recycling gases and nutrients allows them to play a critical role in managing human created hazardous and toxic pollutants. Recent studies of fine particulate pollutants suggest the importance of managing fine particles. These fine particles adhere to tree leaves, so leaving hillsides with significant tree cover is important to fine particle pollution control (New York Times, May 18, 2004). Assuming the benefits of control exceed their costs, the value of this control can be measured by the costs of alternative methods for controlling the same volume of pollutants; e.g., industrial and auto emissions. An acre of trees would then have a pollution control economic value that depends on its leaf surface area.

Several studies have focused on the pollution control benefits of tree cover. The Los Angeles study (Pincetl, et al., 2003) estimated that the value of a typical acre of urban land, under current tree densities, for removal of ozone precursors (but trees produce ozone also), sulfur dioxides, nitrogen oxides, and small particulates ranged from $18 to $80 per acre with current tree planting densities. These benefits are based on avoiding more costly methods of point and non-point source pollution controls. Under a more aggressive urban planting program, the per acre value for pollution control rose to $142 to $185 per acre, illustrating the potential benefits of more dense urban tree cover; or the loss in benefits from deforestation and hillside development.

Using estimates from various studies of the pollution control values of urban trees, McPherson et al. (1997) concluded that the roughly 50.8 million trees in the Chicago urban region removed 5575 tons of air pollutants per year (0.22 pounds per tree per year) and sequestered 315,800 tons of carbon per year (12.4 pounds per tree per year). We can use their cost of alternative pollutant control of $1650 per ton and the cost of carbon removal by other means of $20 per ton, respectively to calculate the economic value of a tree for pollutant removal. This value is $0.30 per tree per year. The present value of a tree, using a 5% discount rate, is then $6 per tree. This may seem like a small value, but if tree densities are 50 trees per acre in an urban forested landscape, an acre of trees is worth $300 per acre. This would be the pollutant removal services component of the value of social loss from deforesting a one acre plot of urban trees.

The deforestation of urban tree cover, as is most likely to occur with hillside development, results in significant loss of “natural infrastructure.” The loss of tree covered landscapes results in substantial losses of natural systems services, such as aesthetics, water management, climate control, and pollution control. These are real social losses, and are not likely to be considered in the largely private decisions surrounding development. While urban communities may charge developers for physical infrastructure costs, such as streets, lighting, sewage, water supply, etc., there are few instances where developers are charged for damage to “natural infrastructure.” For example, Cincinnati charges for the value of trees in instances where someone wishes to remove a tree for a road widening, new driveway, utility upgrade or billboard visibility

(Architecture Division, Cincinnati, OH). The value of the tree is determined using an appraisal method created by the Council of Tree and Landscape Appraisers (http://www.sufa.com/appraisals.html). However, this value is a private property enhancement-based value, and not the type of socially-based, natural infrastructure value being considered here. The studies note above suggest the types of social development fee that could be charged for this loss in natural infrastructure through tree removal.

IV. Public and Private Values of Hillsides

Public values of hillsides and the associated vegetation are benefits that accrue to the public-at-large; they are available to all to enjoy. Such values include visual aesthetics and interest, biodiversity protection, climate control, nutrient and toxic pollutant management, flood and erosion control, community and neighborhood identification, unique place definition, tranquility, and natural awe. These are the broad, public values of a landscape. While they may accrue to everyone, and you have to only pass through to experience them, they can easily be destroyed by those whose private interests dominate their own share of the public values.

Private values of hillsides and the associated vegetation are much narrower than the public values. These would include the space on which to build a structure, and some of the public-type values that may be more accessible through land ownership. For example, the serenity and visual values of variegated, natural landscapes may be purchased along with the land that is on or proximate to these variegated landscapes. This "capture" of some of the public value may, ironically, diminish that public value for others. One developer opens up a hillside for development, claiming the natural, visual and serenity values of the development. Another does the same. Eventually, all hillsides are developed, and these amenities are lost to both private and public users. Any premiums paid for the original features of the landscape are eroded away.

Various studies have shown that property values are higher when nearby landscape amenities are present (see cites above). These elevated property values reflect only those amenities that can be experienced more extensively by proximate land ownership. These would include views, serenity, natural landscapes, recreational opportunities, biodiversity, etc. But these are also values that accrue to some degree to the public-at-large; I can see the tree covered hillside just by driving by, but I cannot see it all the time unless I purchase property.

However, there are some public values that may be incorporated partially in property values at a large scale. Air pollution and climate management afforded by vegetated hillsides are examples; an entire valley benefits, so one has to "buy into the valley" to enjoy those amenities. Flood and erosion protection of a vegetated hillside is another example; one would pay more for land downstream of a protected hillside.

To the extent that we observe property values increasing in proximity to natural and protected hillsides, we are likely observing the more immediate effects of views, aesthetics, uniqueness, and serenity on property values. The much larger region may also benefit from the other values mentioned above, but the identification of this enhanced value may be more difficult, as it affects the entire region. The local effect is just the marginal difference that proximity makes to property values.

V. Taxes and Hillside Slope Values

The fundamental, immediate values of hillsides and associated ecological conditions are a result of the aesthetic and functional services provided by these hillsides. These types of values have been discussed above. They accrue to the public-at-large, the regional as a whole, as well as to private landowners. When we consider the value to the society of these hillsides, we must think in terms of their ecological and social services.

Taxes are the collection of funds necessary to pay for public services provided by taxing authorities. Higher tax bases provide taxing authorities with greater opportunity to finance public services. When regional and local tax bases are improved as a result of amenities such as hillsides, or better flood and erosion management, public services can be enhanced and contribute to higher quality of life. So maintaining tax bases commensurate with the level of public services demanded is important to a community.

The tax benefits, and the ability to provide public services, associated with hillside landscapes depend upon the extent to which properties values are enhanced by these landscapes. Diminishing landscape features, through developments or other landscape alterations, can adversely impact values of properties locally and regionally. Recall that the premium people would be willing to pay for access to attractive hillside landscapes may not be just a local effect, but may positively impact property values of the region as a whole. There are public values that enhance life in a region with variegated landscapes, and these increase property values regionally. Considering increased property values, say within ¼ mile of the top of a hillside, is not adequate accounting for hillside values. Consequently, the property tax increases associated with a limited geographic area immediately proximate to the hillside does not fully measure the tax benefits of that hillside. It would show the minimum tax value of the hillside.

VI. Economic Valuations of Urban Environmental Amenities

Economists have employed several different methods to establish the economic values of urban amenities and disamenities. These methods include hedonic pricing and contingent valuation. Hedonic pricing takes market prices of residential housing and relates those prices to characteristics of the structures (age, number of bedrooms, etc.), neighborhoods (income, age distribution, etc.) and proximate landscape features or economic activities that are expected to add or detract from the desirabilities of locations (Farber, 1998; Boyle and Kiel, 2001; Jackson, 2001). Landscape amenities would include lakes, streams, open spaces, forests, parks, etc. Economic disamenities would include congestion, noise, industrial activities, power lines, etc. Well-accepted empirical techniques are used to establish the effects of these amenities and disamenties separate from the structural and neighborhood characteristics of sampled properties; i.e., we obtain these amenity and disamenity effects alone.

The standard measure used to reflect amenities and disamenities is "distance to the site" (Kohlhase, 1991; Kiel and McCain, 1995; Hite et al., 2001; Kiel and Zabel, 2001). Deaton and Hoehn (2004) summarize the disamenity literature and find that estimated hedonic models show that property values increase with distances from landscape or economic disamenities such as superfund and hazardous waste sites (Ketkar, 1992; Kiel, 1995; Kolhase, 1991; Thayer, et al., 1992), solid waste landfills (McClelland, et al., 1990; Reicher, et al., 1992; Smolen, et al., 1992), overhead power lines (Colwell, 1990), pipelines (Maani and Kask, 1991; Simons, 1999), incinerators (Kiel and McCain, 1995), storage tanks (Simons, et al., 1997), and railroad tracks (Strand, 2000).

VI.1 Urban Open and Green Spaces

There has been some research on the property value implications of urban amenities. Crompton (2000) reviewed 25 studies investigating the relationships between open and green spaces and neighboring property values. He concluded that 20 of these studies showed clearly that there were positive impacts. Several are these studies are relevant to the issue of preserving and restoring urban landscape amenities. One of the earliest hedonic studies of urban open spaces was by Correl, et al. (1978) of a Greenbelt in Boulder, CO. This study used walking distance from the nearest greenway access point to test whether houses similar in all other relevant characteristics (structure, distance to city center, age, etc.) would have higher sales prices if located closer to greenways. This relationship was clearly supported, as the following estimates suggest:

Walking Distance From Greenbelt	Typical House Sales Price ($1975)	Incremental Distance Effect on Price ($1975)
Less than 30 ft	$54,379	+$4,031
30 – 1000 ft	$50,348	+$1,176
1001 – 1283 ft	$49,172	+$2,980
1284 – 2000 ft	$46,192	+$4,986
2001 – 3200 ft	$41,206	blank
Source: Correl, et al. (1978)		

For example, column 3 shows that a house located less than 30 feet from the Greenbelt sold for $4,031 ($1975) more than a house located 30 to 1000 feet from the Greenbelt. A house within 30 feet would have sold for $13,173 ($4,986+$2,980+etc) more than a similar house 2001-3200 feet from the Greenbelt. This latter incremental value of proximity to the Greenbelt is roughly 27% of the value of a typical house in their sample.

Correl, et al. (1978) also estimate the increased property tax revenues to city and county governments, and school and special districts of the incremental property values created by the Greenbelt. They estimated that the aggregate property tax base increased by $5.4 ($1975) as a result of the Greenbelt, yielding additional tax revenues of $0.5 million annually. These additional tax revenues, when discounted at 5% over a 30 year period would increase the present value of tax revenues by $8.4 million.

A hedonic study of five urban parks in Columbus, OH, showed that direct proximity to a park increased the sales prices of houses (Weicher and Zerbst, 1973). If a house was adjacent to, and faced the park, it sold for $3,431 ($1967) more than a similar house not adjacent to a park. This represented roughly 23% of the typical house value in their sample. However, they also found that houses backing onto a park sold for prices similar to all houses in the sample, suggesting the park effect was very localized.

A hedonic study of two towns in England (Cheshire and Sheppard, 1995) found that publicly accessible open space within one kilometer of a property significantly increased the sales price. Each percentage point increase in open space increased the typical housing price by 1.5%. What is most interesting about their study is that the magnitude of this impact was greater in the town where such open space was relatively scarce (1.9%) than in the town where such space was abundant (1.1%). As economists would suggest, increased scarcity raises the price of access to open space.

A hedonic study of Portland, OR, open spaces (Bolitzer and Netusil, 2000), which include public parks, natural areas, and golf courses shows that these amenities have large and statistically significant effects of property sales prices. For example, a property (and associated structural improvements) sold for $2105 ($1990) more if located within 1500 feet of any type of open space than properties further from those amenities. This added value represented slightly more than 3% of the average sales prices in the sample. Also, each additional acre of open space increased the sales price of these nearby properties by $30 ($1990). So a property within 1500 feet of a 30 acre park would sell for $3005 more than a similar property located beyond 1500 feet of the park. The study also found that proximity to a golf course increased the sales price by more ($3400) than proximity to a public park ($2262), but that proximity to private parks did not positively impact prices. A further refinement of the distance measure divided distances from open spaces into distance intervals. The positive impacts of open spaces diminished with distance from the open space as follows:

Distance from Open Space	Positive Impact on Sale Price ($1990)
0-100 feet	$3523
101-400 feet	$2755
401-700	$1983
701-1000 feet	$1522
1001 – 1300 feet	$1455
1301 – 1500 feet	$1004
Source: Bolitzer and Netusil, 2000	

Another study of Portland, OR, housing markets tested a larger range of amenities and disamenities (Wu, et al., 2004). This study finds that sales prices are significantly higher for residences that have more parks or public open spaces within their zipcode areas, are closer to a park,, river or wetlands, and are situated at higher elevations with broader views. In addition, sale prices are higher when development densities are lower. The study finds that developers build at lower densities in locations where there is more park or open space and where elevations are higher, so an indirect effect of open space and elevated views is that housing densities are lower and lots command a higher price for that reason also; i.e., there are both direct and indirect effects of these landscape amenities on prices.

Wu et al. (2004) summarize these amenity effects on the price of a typical house in their sample as follows:

Amenity	Increase in House Price Per Square Foot ($1994)	Increase in Typical 1500 Sq Ft House Price ($1994)
Increase percent of zipcode land area in parks or open space by 5%	$0.73/ft^2	$1095
Reduce distance to nearest park by 1000 ft	$0.24/ft^2	$360
Increase elevation by 100 ft	$2.39/ft^2	$3585
Reduce distance to nearest river by 1000 ft	$0.42/ft^2	$630
Reduce distance to nearest lake by 1000 ft	$0.18/ft^2	$270
Reduce distance to nearest wetlands by 1000 ft	$0.71/ft^2	$1065
Source: Wu, et al., 2004		

For example, increasing the percentage of area in a zipcode that is in parks or open space by 5 percent increases the square foot price of a house by $0.73, and the full price of a typical 1500 sq ft house by $1095. The largest amenity effect is the increase in lot elevation, suggesting more extensive views; increasing lot elevation by 100 feet increase the typical house price by $3585.

A study of Baltimore-Washington, DC, residential sale prices by Irwin (2002) has sought to disentangle the various dimensions of open space that may contribute value to properties. This study distinguishes between whether lands surrounding a property are preserved or have development potential, whether they are publicly or privately owned, and between different types of land use. The study finds that forests on private land have a greater value to properties than either pastureland or cropland when using a broad 400 meter region. It finds that both private lands with conservation easements and public lands add to the value of properties. However, when a narrower region of 100 meters is used, the study finds that increases in forested lands actually reduce property values. So the scale at which private forested lands are considered has a substantial impact on whether they are viewed favorably; at a small local scale, private forests have a negative value, while at a larger scale they have positive value. It may be that at local scales the potential developability of private forest lands is viewed as a threat, but not at larger scales. The study finds that conversion of one acre of pastureland to private conservation land within the 100 meter region surrounding a residential property increases the typical property sales price by $3307 ($1997), or 1.9%. Conversion of an acre of pastureland to public land increases property values by $994 ($1997), or 0.6%. Conversion of an acre of pastureland to low density residential or to commercial/industrial reduces the value of a property by $1530 ($1997), or 0.9%, and $4450 ($1997), or 2.6%, respectively. While converting an acre of pastureland to private forest within the 100 meter region surrounding a property decreased sales prices by $1424 ($1997), or 0.8%, the same conversion within a 400 meter region increased sales prices by $280. This small forest value at even a larger regional scale may be due to the fact that these private forested lands are potentially developable, so people would be unlikely to pay much of a premium for likely fleeting forests.

Urban forested areas may include amenities such as aesthetic, ecological, human physical and psychological health (pollution and noise control), and recreational opportunities. Proximity to such a landscape amenity should command a higher property value. This has been shown to be the case in several studies. Tyrvainen (2000) has shown that a one kilometer increase in distance from the nearest forested urban area reduced property prices by 5.9%, other characteristics of the property being the same. In addition, the same study showed that the market commanded a 4.9% premium for properties with a view of the forest. This suggests that maintaining natural viewsheds has substantial economic value. While the tastes and preferences for these amenities among Finish people may differ from those of Pittsburghers, this study suggests the order of magnitude of this amenity effect.

Geoghegan (2002) has tested whether "developable" and "permanent" open spaces near residences in the Baltimore-Washington, DC, area have positive impacts on sales prices. She hypothesizes that permanent open spaces (including parks and lands with conservation easements) will have a more substantial effect of prices that developable open spaces (cropland, pasture, and forests). She finds that the percentage of lands within 1600 m that are open spaces has a positive and significant effect on residential sales prices. Furthermore, land in permanent open space has a considerably greater effect on prices than developable open space, as she expected. For example, a 10% increase in the percentage of land in permanent open space would increase sales prices of the average home in the sample from $241,000 to $247,285, or roughly $6300 ($1996). A similar increase in developable open space increases sales prices by only $1700 ($1996).

In a study that used both hedonic and contingent valuation methods, Earnhart (2001) found that the value of homeowners in Fairfield, CT, of having a forested area near their homes was $10,967 ($1996), or 4.5% of the value of a typical home in his sample. He also found that having an open field was valued at $2,208 ($1996), or 0.9% of a typical home value, by local residents.

Thorsnes (2002) has studied the effects of forest preserves on residential housing prices in Grand Rapids, MI. He found that lots backing onto a permanent forest preserve sold for $5800 to $8400 ($2000) more than other lots in the subdivisions considered. These premia represented 19 to 35 percent of the lot prices, respectively. Interestingly, lots immediately across the street from lots backing on the preserves did not command a market premium, suggesting that the forest proximity effect was very localized.

A study of the effects of green spaces on residential property values in Los Angeles shows that a roughly 10% increase in the amount of green spaces within 500 feet of a house results in a 1.5% increase in expected sales prices (Pincetl, et al., 2003). This is an additional $3,400 per property. The study also notes that creation or purchases of green spaces by urban governments are self-financing, as the increase in property values and resulting annual tax revenues would be sufficient to pay off purchases over fifteen years.

In a study of green spaces in Baltimore City and County, MD, Yu and Farber are assembling data reflecting the relationship between proximity to green spaces (parks, forested areas, golf courses, etc.) and residential property sales prices. This study is in its preliminary stages, but initial results, illustrated below, suggest the same types of relationships found in prior studies summarized above:

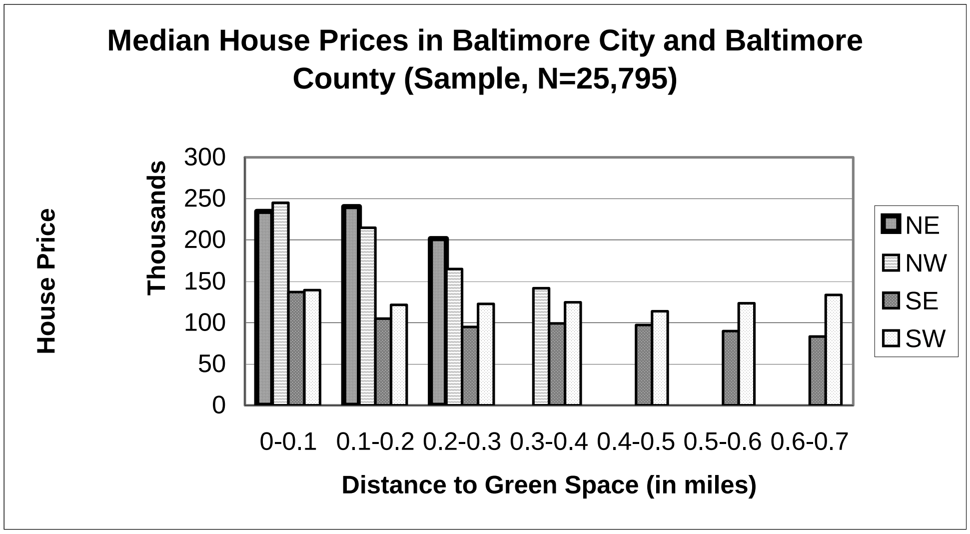

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Figure 1
Housing Prices and Proximity to Green Spaces, Baltimore, MD

This graph illustrates that sale prices generally decline with distances to the nearest green spaces (NE, NW, etc. represent regions of the city/county geographic area). For example, a property adjacent to a green space in the NW section of the region would sell for roughly $250,000 ($1998); but a property located in the same region but 0.2-0.3 miles from a green space would sell for $160,000 ($1998). At this preliminary stage of the research, this is not a hedonic study as housing structures and neighborhoods are not identical.

VI.2 Contingent Valuation Studies

A difficulty with hedonic studies is that they capture only what buyers are willing to pay for amenities that they would enjoy. The values to non-buyers of potential spillover effects of open space, such as views, flood and biodiversity protection, and other "public" types of amenities are not reflected in studies based on property values. One useful method to estimate these broader, more public values, is contingent valuation. In essence, it involves direct questioning of the public about what they might be willing to pay, or what they might require in compensation for saving or remediating open spaces.

A useful study by Breffle, et al. (1998) of the willingness to pay to preserve a 5.5 acre parcel of undeveloped land in Boulder, CO, used this contingent valuation technique. They surveyed households within one mile of the property, which was being considered for development. They estimated that the typical household would be willing to pay $294 ($1991) to preserve the property as open space. This estimate ranged from $1197 for households within 0.1 miles of the property to $47 for households living between 0.9 and 1.0 miles of the property. They propose that the $47 willingness to pay reflects the broad public values that are in addition to what people might pay to live close to the open space land. They also estimated that preserving this 5.5 acre parcel was worth $774,000 ($1991) to households within this one mile neighborhood of the site; i.e., roughly $141,000 per acre.

A survey conducted for the National Association of Realtors (2001) revealed that 50% of the respondents would be willing to pay 10% more for a house located near a park or protected open space. Nearly 60% stated that if they were in the market for a new home, they would be likely to select one neighborhood over another if it was close to parks and open space.

VI.3 Urban Wetlands

Wetlands in urban areas can play important economic and ecosystem roles. Their ecological functionality to moderate and treat water runoff, from rainfall or groundwater, is important to maintaining downstream water quality and regulate runoff volumes. Their functionality as habitat enhances biodiversity and resulting recreational and aesthetic activities. The health and integrity of wetlands depends upon the ecological condition of the watershed, including the extent, location and character of hillside vegetation.

Given the important ecological and economic roles of wetlands, it is not surprising that proximity to urban wetlands commands a property price premium. Mahan, et al. (2000) have investigated the magnitude of this wetlands premium in a study of Portland, OR. Their hedonic study concludes that increasing the size of the nearest wetland increases the residence sales price by $24 ($1995), or 0.02% of the average house sales price. Reducing the distance to the nearest wetland by 1000 feet increases the sales price by $436 ($1995), or 0.4% of the house price. The type of wetland (open water, emergent vegetation, scrub-shrub or forested) did not matter. The study also found that living 1000 feet closer to a stream increased sales prices by $259 ($1994) which suggests that wetlands are more desirable to live near than streams.

VI.4 Landscape Water Quality

The quality of water in one's landscape can be valued not only for health and safety associated with contact, but also for aesthetics, and for the psychological comfort that nature is working well and our lands and their waters are not polluted. The quality of local streams, rivers, and lakes depend upon the biogeophysical conditions of associated watersheds. Development of vegetated and forested hillsides contributes to degradation of water quality through sediment, nutrient and toxic runoff. For example, a recent study of land cover in the Pittsburgh region illustrates that increased tree cover in a township's landscape increases the percentage of streams in that township that meet PA Clean Streams standards (Farber and Argueta, 2000). This relationship is illustrated below:

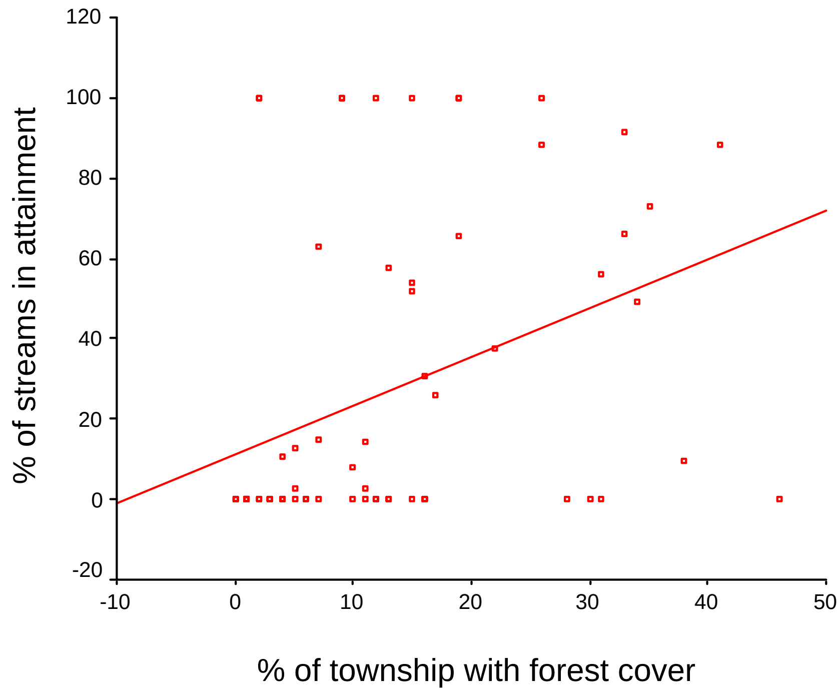


Figure 2
Relationship Between Forest Cover and Stream Water
Quality Attainment Across Allegheny County Townships

A further refinement of this study focused on land use in 600 ft buffers of streams. Streams were four times more likely to be out of attainment when buffers were dominated by residential uses than when they were dominated for forests. The study also found that when population densities were high, stream quality was low.

A study of nitrate concentrations and the percentage of a watershed that is forested showed a clear positive impact of forest land cover on nitrates in streams (USGS, . This relationship is shown below:

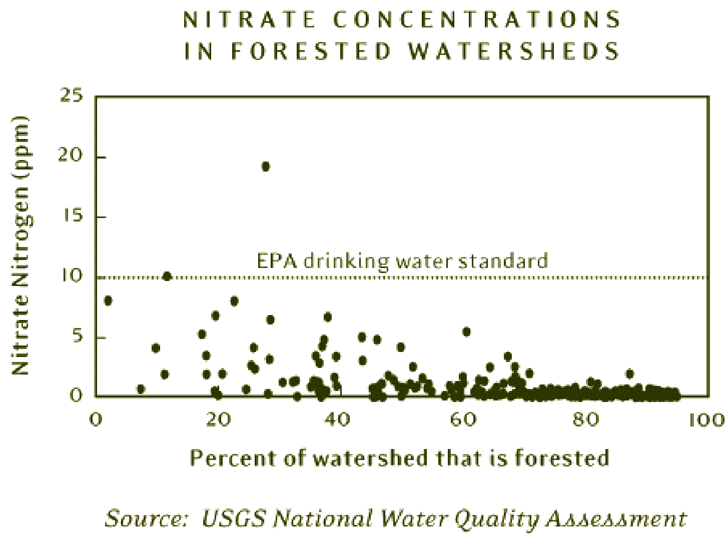


Figure 3
Stream Nitrate Concentrations and Forestation of Watersheds

These studies clearly indicate the positive ecological impact that forest land cover has on water quality in watersheds.

Several studies have focused on the economic valuation of water quality as reflected in property values. Valuing water quality implicitly places value on maintaining an ecologically healthy watershed. A study by Poor, et al. (2001) has used hedonic pricing to determine the value of improvements in lake water quality in several towns in Maine. For Augusta and Lewiston, the study shows that housing prices are between $2,756 ($1993) and $8,985, or 3-9% of the typical house price, higher when the nearest lakes' water clarity is improved by one meter; i.e., one can see objects one meter deeper in the lake.

Leggett and Bockstael (2000) use the hedonic method to investigate the water quality impacts of Chesapeake Bay on surrounding property values. They find that a doubling of fecal coliform counts (from 103 per 100mL to 203 per 100mL) reduced property sales prices by $5,114 to $9,824 (1995), or 1.4%-2.6% of the typical property sales price. They also estimated that improving counts to the state standard for roughly 500 waterfront properties in Anne Arundel County would be worth roughly $12 million to these property owners. Of course, this does not include the benefits to non-waterfront property owners, such as recreationists and commercial fishermen. This study illustrates the substantial benefits from maintaining water quality.

VI.5 Ecological Economics: Landscape Preservation and Economic Development

A typical model of economic development in which landscape amenities are part of the development portfolio is that improving landscape amenities will increase the desirability of a region, resulting in increased housing prices, reduced wages as people are more willing to live there, increases in employment, and increases in both residential and commercial development as people move in and enhance the labor force and demands for commercial activities (Riddel, 2001). Riddle (2001) focuses on the effects of an open space purchase program in the Boulder, CO, area. She looks at the development dynamics over time of such a municipal bond funded program initiated in Boulder in the mid-1980's. Her empirical estimates suggest that over a six year period the 15,000 acre open space purchase program would increase employment by 1650 persons, average wages would fall slightly, 150 new residential units would be built, and average housing prices would increase by $10,125, or 3.75% of the average price. These are effects of the open space program that are intermingled with the broader effects of extensive economic development in the Boulder area.

Other ecological-economic relationships are suggested by the studies cited above. For example, attempts to limit population densities in some critical ecosystems can have positive ecological effects, such as reduced stormwater runoff from impervious, developed surfaces, and improved water quality from reductions in nutrient runoff. The positive ecological effects, in turn, have positive economic implications. In addition to reducing flooding costs and creating more valuable, higher quality waters, such improvements can positively effect economic development as the desirability of living in such an area is enhanced. In this sense, ecological development is also economic development.

VI.6 Summary of Economic Value of Urban Environmental Amenities

Research on the economic value of urban environmental amenities, such as open spaces, has primarily focused on the impacts of these landscape features on residential property values. Property value effects are one important consideration when valuing these amenities. However, property values capture only a portion of the broad ecological and economic values of landscape-based amenities. Property markets reflect only what people are willing to pay for private land and the associated amenities they can obtain privately or enjoy more extensively only through the purchase of that land; i.e., what we may consider as "private" benefits. There is a wide range of benefits associated with open space landscapes that may be enjoyed without having to purchase the property; i.e., what we would term "public" benefits. While the forested landscape view from a purchased property may be superior to viewing an extensively developed landscape, one does not need to purchase the property to obtain, at least, some portion of the visual benefits. While a property located near a park or accessible undeveloped landscape feature may command a higher price because of proximity, others may also enjoy that feature although their access may not be as easy.

There is an entire set of benefits from landscape features that may largely accrue to the public, and any premium paid for a property by an individual would reflect, at best, only a small portion of that public value; for example, protection of biodiversity, protection of downstream areas from flooding, protection of streams from nutrient runoff, local climate moderation are public benefits of forested landscapes. But when a person considers purchasing and developing a property in that landscape setting, they are unlikely to be willing to pay for those broad public values as they do not have to be proximate to the feature to enjoy them. The point is that property value studies of premiums people are willing to pay for the existence of, or proximity to, certain landscape features will capture only a portion of the broad public benefits of these features.

With the caveat of the prior paragraph in mind, there have been a considerable number of studies demonstrating that open space (parks, forests, greenways, golf courses, etc.) commands a residential property price premium. Residential properties that are closer to these features command higher sales prices. Properties for which there are more open space areas in their vicinity command higher sales prices. There is evidence that open spaces that are less likely to be developed in the future (publicly owned, private conservation easements) generate a higher price premium for nearby residential properties than open spaces whose future development is more probable (private forested lands, crop and pasture land).

While a variety of techniques could be used to assess the broad public values of land uses, contingent valuation, or simply asking the public what they might be willing to pay to preserve or restore some ecological feature, can be useful in determining landscape values beyond those for which a person would pay by purchasing property. One such study estimated that these public values can be very large. The study suggested that the policy implication of this public willingness to pay might be to publicly fund programs that preserve or restore desirable landscape features, such as potentially developable open spaces. Of course, this is what we do when we purchase conservation easements or properties for parks through public or non-profit organizations.

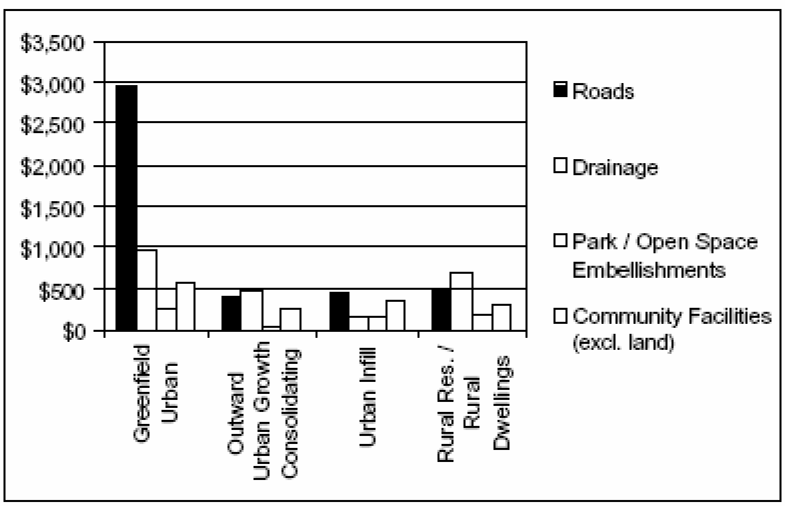
The ecology of a watershed is an interconnection between land cover and streams. Landscape features in one part of the watershed ecosystem can impact other parts. For example, studies noted above have shown relations between forest cover, streamside vegetation and stream quality. Consequently, some of the value of open spaces would be their functional contribution to downstream watershed quality, including wetlands and stream/lake quality. Studies summarized above have shown that both wetlands and water quality have values, some of which are translated into property price premiums for proximity to wetlands or higher water quality. This suggests that managing ecosystems to preserve and enhance their ecological functionalities can also have positive economic implications.

Economic measures of private and public values associated with open spaces have been tested and empirically determined. They have been shown to exist in a variety of geographic and cultural contexts. Insofar as these values are capitalized in to property values, open spaces can contribute substantially to tax bases for communities. An advantage of using open spaces to contribute tax value is that there may be a cost savings over other forms of tax base enhancement as open spaces may not require the extensive infrastructure typical of other forms of development. In fact, open space induced enhancements in local tax bases may be substantial enough to fully fund programs to preserve or restore these open spaces.

At least one study has focused on the relationships between ecological landscape conditions and economic activity. It suggested and tested whether enhanced open space conditions make an area more desirable, increasing property prices as people seek to live there, reducing wages as people want to live there, and increasing local commercial economic activity as people live and buy locally. The study found that these relationships did exist for the studied community. This is another example of how maintaining or enhancing ecological conditions can have positive economic impacts to a community; i.e., an ecological-economic win-win.

VII. Physical Infrastructure Costs

The costs of developing physical infrastructure (roads, drainage, sewers, lighting, water supply, etc.) in hillside environmental have to be substantially higher than in areas with low topographic relief. We were unable to find published studies that illustrated this. However, there have been studies showing that new development is more costly than infill development, as much of the infrastructure is already in place for the latter. An example of such a study is the Urbecon (2003) study of Victoria, AU. Figure 1 shows that road costs in urban greenfields (undeveloped urban sites) are at least six times as high as road costs in urban infill areas. Drainage costs are roughly five times higher for urban greenfields that infill areas. It is reasonable to expect that these physical infrastructure development cost differences would be even greater for urban "hillside greenfields" than urban infill areas.



Source: Urbecon (Dec 2003), published by SGS Economics and Planning, Sidney AU.

Figure 4
Average Physical Infrastructure Development Costs, per Dwelling, by Developing Area in Victoria, AU

VIII. Costs and Revenues of Residential Development

A frequently stated objective of local government officials for developing vacant and open spaces lands is to increase tax bases in order to fund public services. However, there is an extensive literature that compares the public service costs and revenues to local governments from various types of land use. This literature has originated largely from the debates about conversions of open space and agricultural lands to residential development. These cost of community services (COCS) studies have taken annual local public service costs (law enforcement, fire protection, ambulance services, inspections, street maintenance, street lighting, garbage collection, solid waste disposal, health and human services, culture and recreation, education, conservation and debt service) and allocated them to land uses. A similar allocation of local tax and fee revenues is made to land uses. The result is a ratio of expenses to revenues, or revenues to expenses, by land use. An example of this type of study is shown below for Amherst, MA.

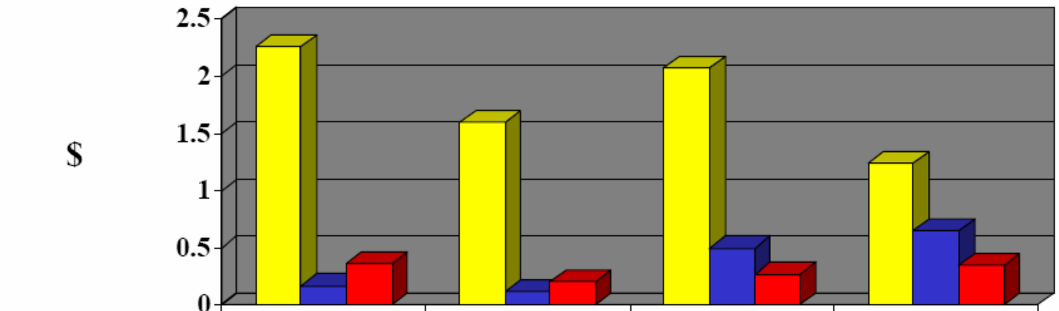
Cost of Community Services Study, Amherst, MA

Land Use Category	Revenues	Expenditures	Revenues Over (Under) Expenditures	Ratio of Revenues to Expenditures
Residential	$ 461,162,106	$ 518,623,795	$ (57,461,689)	**$ 1.00 / $ 1.12**
Commercial	$ 96,512,033	$ 42,624,121	$ 53,887,912	**$ 1.00 / $ 0.44**
Open Land	$ 7,419,403	$ 3,845,626	$ 3,573,777	**$ 1.00 / $ 0.52**
	565,093,542	**$565,093,542**	$ -	

Source: Town of Amherst, Industrial Development Agency, 2000.

The Amherst study shows that for every $1 in revenue collected from residential land use, there was a public service cost of $1.12. Commercial and open land uses raised considerably more revenues than public service costs.

A series of studies of counties in Georgia reveal similar relationships between revenues and costs of community services. These studies are summarized in the figure below:



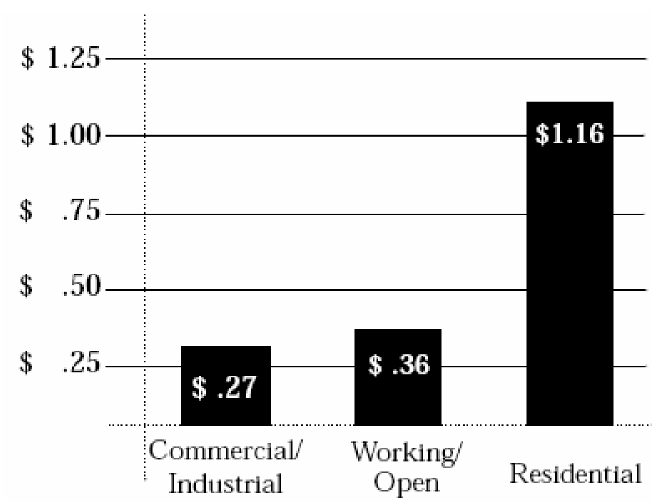
	Appling	Cherokee	Dooly	Jones
Residential	2.26	1.6	2.07	1.24
Comm/Ind	0.17	0.12	0.5	0.65
Farm/Forest	0.36	0.2	0.27	0.35

Source: Dorfman, et al., 2002

Figure 5
Expenditures per $1 in Revenue by Land Use,
Four Counties in Georgia

All counties show expenditures in excess of revenues for residential land use. The largest differential is in rural counties, Appling and Dooly, while the differentials are smaller for Cherokee and Jones, which are rural/suburban counties bordering on Atlanta and Macon.

A summary of 95 studies estimating the costs and revenues of land uses to local governments was compiled by the American Farmland Trust. These studies have been by a variety of researchers, agencies and non-profits in many states. The results of this summary are illustrated below:



Source: American Farmland Trust, 2002.

Figure 6
Summary of 95 Cost of Community Service Studies in the US
Median Ratio of Community Service Costs to Revenues by Land Use Category

The median across all these studies for residential land use shows that for every $1 collected in revenues from this land use, there were community service costs of $1.16 (the median is a statistic in which half the studies exceed $1.16 and half the studies show values less than $1.16). In fact, all 95 studies showed residential land uses having greater costs than revenues. As Dorfman, et al., (2000) note,

> "a growing body of empirical evidence shows that while commercial and industrial development can indeed improve the financial well being of a local government, residential development worsens it."

There were a number of studies done for Pennsylvania, all showing the same general relationships between local public service costs and revenues. These studies are shown below:

SUMMARY OF COST OF COMMUNITY SERVICES STUDIES, REVENUE-TO-EXPENDITURE RATIOS IN DOLLARS

Community	Residential including farm houses	Commercial & Industrial	Working & Open Land	Source
Pennsylvania				
Allegheny Township	1 : 1.06	1 : 0.14	1 : 0.13	Kelsey, 1997
Bedminster Township	1 : 1.12	1 : 0.05	1 : 0.04	Kelsey, 1997
Bethel Township	1 : 1.08	1 : 0.17	1 : 0.06	Kelsey, 1992
Bingham Township	1 : 1.56	1 : 0.16	1 : 0.15	Kelsey, 1994
Buckingham Township	1 : 1.04	1 : 0.15	1 : 0.08	Kelsey, 1996
Carroll Township	1 : 1.03	1 : 0.06	1 : 0.02	Kelsey, 1992
Hopewell Township	1 : 1.27	1 : 0.32	1 : 0.59	The South Central Assembly for Effective Governance, 2002
Maiden Creek Township	1 : 1.28	1 : 0.11	1 : 0.06	Kelsey, 1998
Richmond Township	1 : 1.24	1 : 0.09	1 : 0.04	Kelsey, 1998
Shrewsbury Township	1 : 1.22	1 : 0.15	1 : 0.17	The South Central Assembly for Effective Governance, 2002
Stewardson Township	1 : 2.11	1 : 0.23	1 : 0.31	Kelsey, 1994
Straban Township	1 : 1.10	1 : 0.16	1 : 0.06	Kelsey, 1992
Sweden Township	1 : 1.38	1 : 0.07	1 : 0.08	Kelsey, 1994

Source, American Farmland Trust, 2002.

This table shows that expenditures exceeded revenues by anywhere from 6% (Allegheny Township) to 111% (Stewardson Township).

Some studies have estimated the average house value necessary for a local government to break even on costs and expenditures. For example, the studies of counties in Georgia, shown below, illustrate this break even analysis. For example, In Cherokee County, GA, in order to break even on just the county non-school costs, an average house must be worth $184,200. If we consider only school costs, the average break even value of a house with 2 children must be $644,900 in this county.

Break-even Home Value Estimates for County
and School Budgets: Four Georgia Counties

County	County Break-even	School Break-even With 1 Child	School Break-even With 2 Children	School Break-even With 3 Children
Appling	$192,900	$461,300	$892,600	$1,323,800
Cherokee	$184,200	$331,200	$644,900	$958,600
Dooly	$42,700	$245,400	$480,800	$716,200
Jones	$81,300	$151,000	$281,900	$412,900

Source: Dorfman, et al., 2002.

It should be noted that the typical COCS study considers only average costs and revenues across a jurisdiction. It may be that particular developments, on the margin, could create net revenues or net expenditures to local governments depending upon the values of the properties and additional public service costs. We would expect that hillside developments impose higher public services costs than the average, due to snow removal, and additional difficulties in maintaining streets and sewage facilities. Existing vacant lands where public services infrastructure is in place would likely impose less than average costs of public services.

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