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A Meta-Analysis of Hedonic Studies to Assess the Property Value Effects of Low Impact Development

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Abstract: Stormwater runoff from urban areas is a significant source of water pollution in the United States. Many states are promoting low impact development (LID) practices, which provide a variety of direct and ancillary ecosystem services. We describe a meta-analysis designed to evaluate the property value benefits of LID practices that reduce impervious surfaces and increase vegetated areas in developments, and present an example application to a hypothetical land use scenario. From the many hedonic property valuation studies of the benefits of general open space, we identified 35 studies that valued open spaces that were similar in nature to the small, dispersed open spaces characteristic of LID. The meta-regression estimates the percent change in a home's value for an observed percent change in open space within a specific radius of a parcel, based on changes expected to result from LID approaches that increase green spaces. Our results indicate that the design and characteristics of a project affect the magnitude of benefits, and that values decline with distance. More broadly, the meta-analysis shows percent change and proximity are robust determinants of household willingness to pay for aesthetic and other services associated with local availability of small, dispersed open spaces resulting from LID, but that values for other features, including type of vegetation and recreational use may be site-specific. Policymakers and developers could draw on our synthesis of site characteristics' effects to maximize benefits from open space associated with LID.

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1. Introduction

Stormwater runoff from urban areas is a significant source of pollution to our nation's waters. According to the National Research Council report *Urban Stormwater Management in the United States,* stormwater discharges from the built environment remain one of the greatest challenges of modern water pollution controls, "as this source of contamination is a principal contributor to water quality impairment of waterbodies nationwide [1] (page vii)" Many states are using regulations, incentives, or educational campaigns to encourage use of low impact development (LID) or green infrastructure (GI) practices that harvest, infiltrate, and promote evapotranspiration to prevent stormwater runoff. Successful LID and GI practices provide ecosystem services by increasing the amount of stormwater retained on site, thereby improving surface water quality and hydrology in water bodies that receive stormwater runoff, enhancing groundwater recharge, reducing flood risk and preventing soil erosion [2].

Along with these primary benefits, many LID and GI practices can provide additional ecosystem services such as carbon sequestration, air quality improvements, microclimate regulation, wildlife habitat, water purification, and aesthetic benefits of augmented landscape features. The improved ecosystem services, in particular augmented landscape features, may be reflected in increased property values for both newly developed properties in locations employing these techniques, and existing properties located near areas with increased green spaces.

Comprehensive analysis of the benefits and costs of LID and GI should include values of direct and ancillary ecosystem services provided by these practices. In this paper, we present a meta-analysis designed to evaluate the property value effects from the increased green spaces in areas developed using LID and GI practices, as compared to those provided by conventional development. The green spaces resulting from LID and GI practices are typically small and dispersed in nature, and often do not provide recreational values [3–6]. Thus, our investigation focuses on values for small, dispersed green spaces, and also evaluates the differences in value between open spaces with and without recreational uses. Such values have not been investigated in a meta-analysis to date, although there is growing policy emphasis on promoting LID and GI practices. We present an example application of the meta-regression to a hypothetical land development scenario.

LID encompasses a wide variety of development approaches that often attempt to integrate "site design, natural hydrology, and smaller controls to capture and treat runoff" [2]. Applications range from subtle to dramatic site alterations, some of which increase the percent of vegetated and tree-covered land in a subdivision relative to conventional subdivisions. Examples of LID implementation include, "…preserving natural areas, minimizing and disconnecting impervious cover, minimizing land disturbance, conservation (or cluster) design, using vegetated channels and areas to treat stormwater, and incorporating transit, shared parking, and bicycle facilities to allow lower parking ratios" [7].

These approaches can be applied to both commercial and residential development. As an illustration of typical changes to a residential development, Figure 1 compares a conventional subdivision to a subdivision that employs one type of LID technique, referred to as Conservation Design, where clustered development allows for more contiguous open space preservation [8].

Figure 1. Comparison of (**a**) a conventional subdivision design and (**b**) a site plan developed using conservation design practices. (Figure courtesy of Minnesota Pollution Control Agency, adapted by the authors).

(**a**)
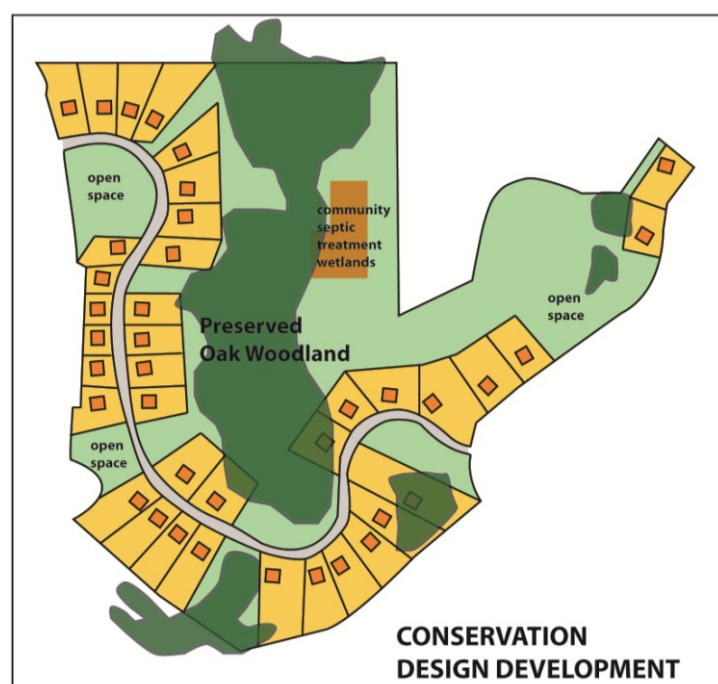
(**b**)

Although residential LID sometimes results in smaller lot sizes and less space between homes, it can also provide more open space, and better views of that open space, than conventional subdivision design. In some cases recreational opportunities may also be enhanced (e.g., by including soccer fields or walking trails). To the extent buyers and sellers in the housing market are aware of and perceive amenity benefits from LID, we expect that such benefits will be capitalized into the value of a home. While homes both within (on-site) and near (off-site) an LID development experience additional green space, on-site parcel values may reflect the net effect of increased green space and changes in other project attributes, such as reduced parking area, the qualitative feel of living in a clustered neighborhood, *etc.* As such, there may be qualitative differences in observed property value effects for on-site *vs.* off-site but nearby properties.

Existing studies show mixed and location-specific relationships between property value effects of on-site lot size and shared open space. Some studies have demonstrated that, while in general buyers prefer larger lot size, they are willing to trade a decrease in lot size for larger shared open space or for decreased distance to shared open space [9–12]. Typically, this trade does not occur at a one-to-one rate of substitution; further, the rates of substitution have been shown to vary by location [10,11]. In some cases, larger lots are more valuable than increased shared open space, while in other cases shared open space compensates for smaller lot sizes [10,11].

Open space effects on nearby (off-site) property values are also well studied. A large body of economic literature provides insights into changes in property values due to changes in tree cover, proximity to open space, or presence of parks or forested land in the neighborhood. Numerous studies have shown that increased vegetated open space leads to increases in nearby residential property values e.g., [9,13–18], although negative or inconclusive effects have also been reported [19–21]. However, very few studies directly address values related specifically to LID practices [5,9,12,16–18,22–27], and many of these studies use non-uniform measures of open space to evaluate effects of these practices on property values, rendering a direction comparison of the results infeasible.

However, conducting original hedonic pricing studies such as these to support analysis of land management decisions is rarely feasible due to time or resource constraints. Thus, the majority of such analyses rely on benefit transfer from existing economic literature. Previous benefit transfers that estimate the effects of LID practices on property values have used point transfers of open space values [28,29]. If the study site does not provide a very close match to the policy site, point value transfer is likely to yield biased estimates. While functional transfers based on meta-analysis are not necessarily free of such bias, they allow analysts to incorporate site specific factors (e.g., open space size and characteristics) in the valuation function and thus reduce potential bias [30,31]. Meta-analysis is increasingly being used to conduct and inform function-based benefit transfer [32–34] because it can incorporate and address systematic variations in value [35–39]. While both the choice of a single study for point transfer and the choice of multiple studies to include in a meta-analysis require the analyst to make subjective judgments, meta-analysis allows analysts to synthesize information from a broad range of locations, study site characteristics and open space attributes, thereby potentially offering more robust estimates and minimizing transfer errors relative to point transfer [40].

An important factor in any benefit transfer is the ability of the study site or estimated valuation equation to approximate the resource and context under which benefit estimates are desired. The open space typical of LID developments will often be small and dispersed, rather than large and contiguous.

Furthermore, although LID open space does not generally provide recreational benefits, some developers have begun purposively incorporating parks, sports fields, and other recreational features [5,41]. As is common, data in our meta-analysis provide a close but not perfect match to the LID context. From the many hedonic property valuation studies of the benefits of general open space, we identified 35 studies that value open spaces similar in nature to the small, dispersed open space characteristic of many LID practices. We estimate a meta-regression model (MRM) of the percent change in a home's value for a given percent change in open space area within a specified radius of the parcel. Additionally, because our model is intended to be used for benefit transfer, following Boyle *et al.* [30], we examine various factors that indicate whether the estimates are robust or fragile.

In Section 2, we discuss the selection of relevant studies, and characteristics and preparation of the data; in Section 3 we discuss model specification and results; in Section 4 we present an example application; and Section 5 is a summary of findings and implications for policy and management decisions.

2. Study Selection and Data Preparation

Study selection involves screening studies to ensure that they are appropriate to the goal of the analysis and that they measure a consistent and theoretically appropriate effect [30]. Our study objective is to predict the willingness to pay (WTP) for marginal changes in open space resulting from policies that encourage or require LID practices relative to more conventional development approaches. Through our process of study selection, we thoroughly screened studies and, through a number of iterations and internal reviews of the data, eliminated many studies deemed irrelevant. Following guidance from economic literature [30] we maintained theoretically consistent welfare measures by including only values from hedonic studies to, and converted measures of open space effects to a common metric—the percent open space within a given radius of a home.

To identify potentially relevant studies for the open space meta-analysis, we conducted an in-depth search of the economic literature using a variety of sources and search methods. We reviewed over 180 studies, including nine stated preference studies, and over 100 hedonic studies of property value changes from improved amenities associated with, or similar to those achieved from LID practices. The remaining studies are either reviews of other studies; benefit transfers; general information on LID practices, costs, and benefits; studies based on avoided costs; studies of public perceptions that do not include values; or case studies of actual LID developments, most of which focus on costs to developers. After further screening, we included data from 35 hedonic studies in the meta-analysis, based on the following criteria:

- *Valuation method and values estimated*: Selected studies were limited to those that used hedonic valuation techniques to measure a percent change in home value. We excluded stated preference studies to avoid issues related to different formulations of the dependent variable and different welfare measures provided by hedonic and stated preferences studies.
- *Specific amenity valued*: We eliminated studies that valued open spaces labeled as golf courses, large parks or forests, water features, or agricultural land. We also excluded studies related to any open space larger than 100 acres. Open spaces with these features are not generally relevant to open spaces provided by LID practices.
- *Study location*: Selected studies were limited to those conducted in the United States.

- *Ability to convert values to similar terms*: Original studies estimated the value of open space amenities in terms of a change in one of several different metrics: either a home's distance to open space, a home's adjacency to open space, or the proportion of a home's neighborhood kept in open space. To complete a meta-analysis based on studies using different methods, we first converted all measures into a single common metric—the proportion of a home's neighborhood in open space (measured by a specific radius around the home). Studies that could not be converted because of a lack of information were not included in the final data set.

The 35 studies provided 119 observations, with multiple estimates of changes in property values available from 26 studies. For each observation, we computed a measure of WTP for open space, standardizing all reported results into an estimated percent change in property value given an observed percentage change in open space, e.g., [42].

2.1. Converting Open Space Measures to Comparable Metrics

All of the original studies in our data set estimated property value premiums associated with open space; however, individual studies used one of several measures of open space availability, including percent of open space in a buffer surrounding a home, adjacency to open space and distance to open space. To examine these studies in aggregate (*i.e.*, in meta-analysis), we first converted all open space measures into a common metric across studies: the percentage of land surrounding a home that is in open space cover. Seventy of the 119 observations included in the model were originally in terms of percent or area of open space feature(s) within a buffer area around homes; these observations were used in their original form. In these studies, the size of the buffer areas ranged from 715 m^2 to 8.14 km^2 (mean 1.02 km^2), and the baseline percent open space within the buffers ranged from 0.24% to 99% (mean 3.77%). Two observations were originally in terms of adjacency to open space, and 47 were originally in terms of distance to open space. To convert measures of open space into a single metric (the percentage of open space in a buffer surrounding a home) for these 49 observations, we applied conversion methods developed by Kroeger [43] (see also [44]). We refer readers to Appendix 1 for additional details on conversion methods.

2.2. Description of the Meta-Analysis Data

Studies used in the meta-analysis were conducted between 1996 and 2012, and applied standard, generally accepted hedonic valuation methods. The 35 studies include 32 journal articles and three academic or staff papers. All selected studies focus on the relationship between existing open space and property values in the United States. None of the included studies examined exogenous changes in open space (*i.e.*, property values before and after a change in the actual amount of open space on the ground); rather, studies examined variation in sales price based on variation in proximity to, adjacency to, or the surrounding amount of open space. Beyond this, the studies vary in several additional respects. Differences include the specific type, size and features of open space valued, size of the surrounding area considered or distance to open space, population density of the study area, and geographic region. Twenty-two of the observations value amenities on individual parcels, as opposed to properties adjacent to or in proximity to open space.

We included studies evaluating a variety of open space types, and categorized these into four groups:

- *a general/combined category of vegetated open space*, which includes all studies that either estimate values for more than one type of open space as a group, simply specify "open space" as the variable of interest, or that examine vegetated open space that is not primarily tree-covered;
- *a category for open space that is primarily tree-covered*;
- *a category for riparian buffers and habitat*; and
- *a category for wetlands.*

Table 1 lists the number of studies and observations addressing each type of open space in the final data set used in the analysis. Many of the included studies also examined open spaces not directly relevant to LID, including forests (as opposed to tree-covered residential or urban areas), golf courses, and farmland. We excluded those observations from the analysis.

Table 1. Amenities valued in studies included in the meta-analysis.

Category	Number of Studies	Number of Observations in Model
All Studies	*35*	*119*
By Amenities Valued		
General vegetated but non-tree open space or combination of open space types	17	54
Open space (primarily trees)	12	38
Riparian buffers	2	13
Wetlands	4	14

The most appropriate studies for the policy context, in terms of increased open space resulting from LID, examine small and dispersed open spaces characterized by pockets of green space distributed throughout a development project. Because LID-associated open space is typically neither large nor generally supportive of recreation, we distinguished open spaces based on their dispersion and recreational amenity provision. We categorized studies based on information reported in original studies, supplemented with best professional judgment where necessary. Table 2 presents categorization results:

- Recreational amenity provision (*Recreational*) was assigned to the site if the open space was described as a park, greenway, trail or path; or authors mentioned public access;
- Assignment to the *"Large/Contiguous"* category relied more often on professional judgment, and was based on assessment that the open space context was not best described as "small spaces dispersed throughout a study area." Greenways, blocks of open space, and other single-feature spaces were all assumed to be large and not dispersed. If a study examined distance to a single feature but the open space was in the spirit of LID green space—*i.e.*, green space as a subdivision-level feature—this was categorized as small and dispersed.

Because open spaces that provide recreational amenities also tend to be contiguous (not dispersed or fragmented), and tend to be permanent landscape features protected from development (Table 2), modeling these features as independent attributes would introduce collinearity in the meta-regression. We thus bundled these jointly-provided open space amenities, using combined indicators for (1) open

spaces that are protected, but dispersed and do not provide recreational amenities (n = 15); and (2) open spaces that are contiguous, and are also recreational and/or protected (n = 34). The base case in regressions is a third category, open space that is dispersed (not contiguous), not protected, and not recreational (n = 70). There were 12 intermediate cases (just recreational; just contiguous; dispersed but recreational and protected), which are not included in the data points included in the model (n = 119).

Table 2. Frequency table of open space by characteristics.

Open Space Features	Open Space Type N observations (%)			
	General Vegetated Open Space	**Open Space (primarily trees)**	**Riparian Buffers**	**Wetlands**
Large/Contiguous Recreational and	3 (5%)	1 (2%)	0	2 (13%)
Large/Contiguous	22 (41%)	6 (16%)	0	0
Small Dispersed and Not Recreational	29 (54%)	31 (82%)	13 (100%)	12 (86%)
Total	*54*	*38*	*13*	*14*

Note: There were no observations in the category "Small, Dispersed and Recreational."

Among all observations included in this study, 42% of those examining wetlands, 35% of observations in the general open space category, and 16% of observations examining trees showed a negative relationship between increased area and sale price. Authors of the original studies posited a variety of reasons for negative results in their studies, including potential omitted variable bias (e.g., studies where the majority of observations were from neighborhoods with other disamenities [12,45]), and potential disamenities from particular open spaces (e.g., insects or increased flooding risks for properties near wetlands [46,47], or increased noise or traffic related to urban parks [12,48,49], or uncertainty regarding future uses of the open space [50,51]). The studies cover all regions of the country, with 20 observations in the Northeast, 21 in the Midwest, 28 in the South, and 50 in the West (Table 3). However, in each region many of the observations come from a small number of studies, often by the same authors. We did not include regions as an explanatory variable in the final model, because we did not feel confident that regional differences can be generalized from this sample. See further discussion in the modeling section, below.

The studies cover a range of population densities, from relatively low density (54 people per square mile) to high density (28,160 people per square mile). This covers the 55th to 99th percentiles of the U.S. by county [52]. Of the 35 studies, one study was conducted in a rural area (less than 67 people per square mile), eight were conducted in exurban areas (67 to 805 people per square mile), 24 were conducted in suburban areas (from 805 to 6574 people per square mile), and two were conducted in an urban area (more than 6574 people per square mile), based on density definitions found in the U.S. EPA's Integrated Climate and Land-Use Scenario (ICLUS) model [53]. In initial model formulations, we used a continuous population density variable. However, this variable was not statistically significant, so we instead included a dummy variable for exurban and rural densities, with the base case being urban and suburban densities.

Table 3. Selected summary information for studies.

Author(s) and Year	State	N observations	Radius, or range of radii (m)	Open Space Types
Abbott and Klaiber [54]	AZ	3	305–610	General Vegetation
Acharya and Bennett [55]	CT	2	402–1609	General Vegetation
Anderson and West [56]	MN	1	469	General Vegetation
Bark *et al.* [48]	AZ	12	210–1179	Riparian; General Vegetation
Bin [57]	OR	2	1524–1676	Wetland
Bin and Polasky [47]	NC	3	234–402	Wetland
Bolitzer and Netusil [58], Lutzenhiser and Netusil [59]*	OR	8	276–457	Trees; General Vegetation
Bowman *et al.* [17]	IA	2	287–287	General Vegetation
Cho *et al.* [60]	TN	2	2762–2925	General Vegetation
Cho *et al.* [61]	TN	3	326–481	Trees
Cho *et al.* [10]	TN	1	2422	General Vegetation
Cho *et al.* [62]	TN	1	1609	Trees
Donovan and Butry [63]	OR	1	30	Trees
Doss and Taff [46]	MN	4	251–502	Wetland
Geoghegan *et al.* [64]	MD	2	100–1000	General Vegetation
Hardie *et al.* [65]	MD	1	235	Trees
Heintzelman [19]	MA	6	161–1609	General Vegetation
Irwin [66]	MD	2	400–400	General Vegetation
Kaufman and Cloutier [67]	WI	1	368	General Vegetation
Kopits *et al.* [9]	MD	1	415	General Vegetation
Mahan *et al.* [68]	OR	3	1091–1091	Wetland
Munroe [45]	NC	2	1070–1070	General Vegetation
Netusil [20]; Netusil *et al.* [69]*	OR	14	17–805	Riparian; Wetland; Trees
Ready and Abdalla [50]	PA	12	400–400	Trees; General Vegetation
Sander and Polasky [70]	MN	3	226–612	Trees; General Vegetation
Sander *et al.* [71]	MN	6	21–443	Trees; General Vegetation
Saphores and Li [72]	CA	3	15–200	Trees
Shultz and King [73]	AZ	1	5391	Riparian
Smith *et al.* [51]	NC	4	61–114	General Vegetation
Stetler *et al.* [74]	MT	3	250–250	Trees
Thorsnes [75]	MI	2	229–486	Trees
Towe [76]	MD	1	409	General Vegetation
Troy and Grove [77]	MD	3	482–482	General Vegetation
White and Leefers [78]	MI	2	805–805	General Vegetation
Williams and Wise [12]	FL	2	157–1459	General Vegetation

Note: *: Studies were considered to be a single study in the model due to similarities in data, the same study location, and common author.

3. Meta-Analysis Regression Model and Results

3.1. Variable Selection and Specification

Based on findings of the studies in the data set and the large hedonic literature, our initial hypothesized model included a set of explanatory variables. We tested variables accounting for systematic variation in open space types and amenities, original study site housing markets, and interactions between sale price and proximity to open space. Incorporating these variables allows one to use the meta-analysis to tailor function-based benefits transfer between study and policy sites. Not all variables were ultimately included in the MRM due to data limitations (see below). We initially tested models including the following variables:

- type of open space;
- percent change in open space;
- size of the radius indicating maximum distance from open space amenity, both as continuous and categorical variables;
- size of open space amenity;
- population density of the study region;
- income (proxied by mean or median home value in the original studies);
- lot size;
- geographic region;
- whether the open space occurs on a property; or off-site, but near a property;
- whether the open space is protected;
- whether the open space provides recreational amenities;
- whether the open spaces considered are dispersed/fragmented.

One would expect variations in value of open space across regions, particularly in arid *versus* wet regions, and in more urbanized *versus* less urbanized regions (although this difference may be captured by the population density variable). However, regional variable coefficients were not statistically significant. Addition of the regional dummies did not improve the fit of the model or the magnitude or significance of other variables. Moreover, studies for particular open space types were often conducted by the same authors in the same geographic areas, which may result in "authors' effects" rather than geographic effects. Thus, we excluded geographic region in the final MRM. We also tested for significant differences in value for studies converted from distance or adjacency measures (as described above), by including dummy variables for those studies in preliminary models, and found no significant differences. Although the lot size variable is not significant, we elected to include it in the final MRM because of the potential tradeoffs between lot size and open space. Results for this variable are discussed further below. Table 4 presents variable names, descriptions, and summary statistics for the variables included in the final model.

Table 4. Summary statistics for meta-regression variables.

Variable Name	Definition	N (%)	Mean
Percent Change in Price	*Dependent Variable*. Percent change in sale price of a house reported in the study, given the percent change in open space	-	0.14%
pctincr_lt250	Percent increase in open space for homes within 250 m of the open space (as specified in original study, or calculated from the original study using a 1% increase)	-	1.99%
pctincr_250to500	Percent increase in open space for homes between 250 and 500 m of the open space (as specified in original study, or calculated from the original study using a 1% increase)	-	2.17%
pctincr_REdens	Interaction variable: percent increase in open space, where study area had rural/exurban population density, =0 otherwise (*i.e.*, where study area had suburban/urban population density)	-	1.15%
OS_riparian	Dummy variable; =1 if open space is riparian area, =0 otherwise	13 (10.9%)	-
OS_wetland	Dummy variable; =1 if open space is a wetland, =0 otherwise	14 (11.8%)	-
OS_trees	Dummy variable; =1 if open space is trees or tree cover, =0 otherwise	38 (31.9%)	-
OS_general	Omitted case for the OS_ series. Dummy variable; =1 if open space is specified as general; a mix of uses; or not specified, =0 otherwise	52 (45.4%)	-
Protected, dispersed, and not recreational	Dummy variable, =1 if conditions in "Variable Name" column are met	15 (12.6%)	-
Contiguous, recreational and/or protected	Dummy variable, =1 if conditions in "Variable Name" column are met, =0 otherwise	34 (28.6%)	-
Dispersed, not recreational, not protected	Omitted case for the open space amenity series. Dummy variable, =1 if conditions in "Variable Name" column are met, =0 otherwise	70 (58.8%)	-
Lot size in acres	Average lot size	-	0.82
Home price	Mean or median home price for the study area. Data are from original study, or US Census data if not reported in original study (thousands of 2013$)	-	$246.32

The dummy variables for open space types (*OS_riparian*, *OS_wetland*, and *OS_trees*) may be included in the model as intercept shifters, as slope shifters, or both [79]. Based on model testing, we found that the open space dummy variables did not substantially improve explanatory power of the model through interaction with the percent change variable (*i.e.*, as slope shifters). In preliminary models, we included a continuous variable for radius size of the open space buffer (as reported in the original study or calculated from data in the original study), and tested several alternative specifications of this variable, such as using a squared term to capture diminishing marginal effects with increasing distance. While the continuous variable did not show a significant effect on percent change in sale price, categorical variables indicated that the effect of percent change in open space on the percent change in property value varied based on the radius of the area in which the open space increase occurred (a rough proxy for a home's distance from open space). Thus, the final model employs dummy variables that categorize observations in terms of radius size in which open space changes occur, using zones of less than or equal to 250 m and from 250 to 500 m. We categorized

study data by zone using information from the original studies (see Table 3). The smallest zone, where open space increases are evaluated within a 250 m radius, captures properties with on-site or adjacent open spaces and properties with off-site open space within 250 m. The subsequent buffer area, from 250 to 500 m in distance, roughly corresponds to both the mean radius in the final sample of studies (583 m, range 15–5391 m), and to a generally accepted quarter-mile distance threshold for "walkability" between residences and open space destinations [80]. Preliminary models including larger radius buffers suggested open space increases of the type and size evaluated in our model and in radius zones larger than 500 meters were not reflected in property values.

3.2. Model Specification and Results

We followed the suggestions of Nelson and Kennedy [81] (as far as the data allowed) in specifying the model and testing model specifications. Sample heterogeneity leading to differences in effect size estimated by the original studies is an important issue in meta-analysis. This could be caused by real differences in effects due to differences in home buyers' preferences or residential property markets across geographic regions, changes in preferences over time, and variations in the types of open space and other landscape characteristic of the study location. These differences may also occur because of different study designs and methods. One way to address this is by including regressors that explain the variation, and another is to allow for random effects across studies [81]. With multiple observations per study (observations range from 1 to 12 per study), one can expect some correlation across observations from a single study. In addition, meta-data often exhibit heteroskedasticity [81]. When we tested for the presence of random effects (using the Breusch-Pagan Lagrangian multiplier test), we found significant evidence of cross-sectional heterogeneity; however, a Hausman specification test indicated the random effects were biased (e.g., correlated with included explanatory variables). With cross-sectional variation, one alternative to random effects is a fixed-effects model. However, since 27% (10 of 35 study clusters) lacked variation in key explanatory variables (e.g, no within-study variation in radius), we did not select the fixed effects approach. Because not all original studies reported variance of study estimates, we were unable to estimate a weighted model using inverse variance weights, as recommended by Nelson and Kennedy [81]. In substitution, we gave equal weight to each study by weighting the study's observations by the inverse of the number of observations per study. We tested our models for heteroskedasticity, and found that heteroskedasticity was not an issue for these data.

Table 5 shows the model results for the selected model. This model explains 89 percent of the variation in property price, and most coefficients are statistically significant and of the expected sign, where there is an expected sign. Compared to open spaces that are dispersed/fragmented, do not provide recreational amenities, and are not permanently protected (the omitted case, which is characteristic of open spaces expected to result from LID), property value effects are higher for permanently protected, dispersed, and non-recreational spaces; and for permanently protected, contiguous, and/or spaces that provide recreational amenities (although this effect is not significant). The model results also show higher willingness-to-pay for open space in trees or riparian areas compared to general open space (omitted case).

We captured the effect of distance from open space improvements on property price by using two interaction variables between buffer size categories (0–250 m. and 250–500 m) and the percent increase in open space. Coefficients on these variables illustrate a diminishing marginal effect of a percent increase in open space as distance of the buffer increases. A percentage increase in open space is valued less in rural and exurban population density areas compared to suburban and urban density areas. Prior studies have found that wetlands, trees, and riparian areas elicit inconsistent effects on property values, including negative, positive, and zero effects (e.g., reviewed in [14]). The coefficient on wetlands is not significant, indicating that the value of open space that is wetlands is not significantly different from that of the general open space category. Several factors may contribute to the identified overall positive effect of trees and riparian areas in this model including: (1) observations from studies evaluating the effect of open space providing high-quality wildlife and bird habitat; and (2) the study-weighting approach, which gave higher weight to observations which came from studies with fewer meta-data observations.

The negative coefficient for the log of lot size indicates that, all else equal, homes with larger lots will have a smaller percent change in price when open space increases. This provides weak support for the hypothesis of a tradeoff between lot size and open space size. However, the coefficient is not significant. The coefficient on home price is negative and significant, though extremely small. This implies that homes with higher values will have a slightly smaller price response to an increase in nearby open space, as compared to lower-valued homes.

Table 5. Linear weighted regression: % change in willingness to pay (WTP).

Variable	Parameter Estimate	Standard Error
Intercept	0.039	0.079
pctincr_lt250	0.169***	0.006
pctincr_250to500	0.102***	0.005
pctincr_REdens	−0.063**	0.020
OS_trees[1]	0.245***	0.065
OS_riparian[1]	0.252*	0.117
OS_wetland[1]	−0.013	0.084
Protected, dispersed, and not recreational[2]	0.392***	0.074
Contiguous, recreational and/or protected[2]	0.081	0.067
Ln(lot size in acres)	−0.018	0.025
Home price ($thousands)	−0.0009***	2.48×10^{-7}

Notes: $F_{10,108} = 165$, $p < 0.0001$; Number of observations = 119; Adjusted R^2 = 0.93; Number of studies = 35; *: Significant at the 0.05 level; **: Significant at the 0.01 level; ***: Significant at the 0.001 level; [1]: Base case for vegetation type is "general" (*i.e.*, various types, undefined, or vegetated but not primarily tree-covered) open space; [2]: Base case for open space category is dispersed, not protected, not recreational.

3.3. Tests for Robustness of Parameter Estimates

We followed a set of procedures for testing robustness of the model's parameter estimates suggested by Boyle, *et al.* [30]. In addition to the study selection procedure discussed in Section 2, above, we tested for sample selection bias, horizontal robustness (inclusion/exclusion of observations

or studies), and vertical robustness (inclusion/exclusion of variables). The details of these tests are presented in Appendix 2.

The objective of examining sample selection is to determine whether included studies randomly represent the possible universe of studies, or whether they follow some systematic pattern of selection, which may bias the resulting estimates of property value changes. Following previous researchers [30,82], we examined the representativeness in terms of states where studies were conducted. Our results do not indicate strongly significant sample selection error based on geography.

Tests of horizontal robustness attempt to identify influential observations or groups of observations by removing single observations or all observations from a single study (with replacement) and investigating the effects on parameter estimates. We found that, although there were three influential observations and six influential studies, none of these studies or observations had influential effects on our key policy variables, or on the majority of other estimated coefficients. The influential observations and studies are shown in Appendix 2, Table A3.

Vertical robustness is tested by sequentially dropping each explanatory variable from the equation and evaluating the impacts of this removal on remaining variables. Results suggest that none of the variables are robust according to both of Leamer's [83] robustness criteria, but that several meet at least one robustness criterion (Appendix 2). Two main variables (*pctincr_lt250* and *pctincr_250to500*) and two additional variables (the dummies for *OS_trees* and protected, dispersed, and not recreational) meet the extreme bounds criterion and the less-stringent interdecile range criterion; while the *OS_rip* variable meets only the interdecile criterion (Table A5). Two other variables (*pctincr_REdens* and *home_price*) meet the significance criterion.

In summary, these tests of robustness indicate that the MRM is generally robust to individual observations, and key variables (*pctincr_lt250* and *pctincr_250to500*) used in benefit transfer are both horizontally and vertically robust. Other variables were less robust to either horizontal or vertical tests. While robustness of parameter estimates suggests similarity among studies and regressors, fragility does not necessarily lead to the conclusion that the model is inappropriate for benefit transfer [30].

4. Example Application of the MRM to LID

To demonstrate the effects of varying open space characteristics on WTP for marginal increases in small, dispersed open spaces, we present a benefit transfer to a hypothetical policy scenario in which future construction projects begin to provide increased open space relative to "conventional" development. Although the policy application is hypothetical, we used land development forecasts for a 21-year period (2013–2033) in Illinois watersheds and LID case studies, showing the degree to which LID approaches can provide additional open space relative to conventional development [6]. We used the estimated meta-regression to estimate the potential economic value of increased open space by type of open space and distance from a property, relative to conventional development, using projected LID and conventional development activity.

First, we forecast the overall area of commercial and residential development projected to occur in Hydrologic Unit Code 12 (HUC-12) watersheds over the 21-year period (2013 to 2033), using forecasted population growth and construction values extrapolated from historical distributions of observed project characteristics (derived primarily from EPA's Integrated Climate and Land-Use

Scenarios [53], IHS Global Insight construction forecasts [84], Reed Construction [85], and the U.S. Census [86]). The development forecasts are not designed to project precise development locations within watersheds, so we assumed all development within a watershed and year occurs as a single circular project.

Then, we modified projections to represent a hypothetical policy scenario in which developers adopt LID approaches that maintain more open space than conventional development. True developer choices about adopting these approaches depend on a suite of factors, including existing local ordinances, construction type and construction density, and the financial impact of choosing LID *versus* conventional development [87,88]. For our application, however, we simply modeled an impervious cover reduction scenario that produced a 30% increase in vegetated open space (compared to conventional approaches) in most new developments. The open space change is based on clustered residential development case studies in Zielinski [6], and we limited the hypothetical policy to projects in all but the most highly urbanized areas, assuming using space to manage stormwater would be infeasible in these areas due to a lack of infiltration capacity, the high opportunity cost of land, and other factors. Our forecasted conventional projects had from 4% to 90% open space in the baseline. Adding 30% more open space to projects with large proportions of open space in baseline results in implausibly-low levels of impervious cover (e.g., a 30% increase on a 80% baseline results in over 100% open space). Assuming some land area in developments would always remain impervious (e.g., building footprints and roads), we limited open space increases that exceeded the open space cover on each project to no more than 91% of an individual project (to maintain realism). Thus, some of the scenarios result in open space additions that are less than 30% increases of open space compared to conventional project design. With the exception of open space percentage, all other attributes (e.g., project size) remain identical for the conventional development and LID scenarios. In the scenarios, development occurs over time so that, in any particular year, changes in open space can be considered to be marginal relative to the total HUC-12 area.

Application of the property value meta-analysis to evaluate the benefits from open space provided by LID requires information on the following variables:

- Number of new properties in LID developments using practices that increase green spaces;
- Number of affected existing properties less than 250 m and between 250 and 500 m from these LID developments;
- Population density for the policy area;
- Baseline property value, *i.e.*, the value of homes in the base year;
- Anticipated percent change in open space. This is the expected reduction in open space lost to development achieved by LID, relative to the baseline (no LID) conditions.
- Anticipated characteristics of additional open space resulting from LID (*i.e.*, percent of tree cover, potential recreational use of this space, whether the space is dispersed or not, and protection status).

4.1. Estimating Benefits

The next major step in the analysis of open space values was to use the MRM to estimate the change in rental-equivalent housing values in each buffer zone and year, aggregated by HUC-12 watershed, in our Illinois case study. We then calculated total present value of benefits of open space

by summing the present discounted values of these benefit flows. The following sub-sections describe these calculations in more detail.

4.1.1. Benefit Transfer Based on Meta-Analysis Regression

We used the MRM to estimate the percentage change in annualized rental-equivalent property values given changes in LID open space (relative to conventional development) in each HUC-12, project, buffer zone, and year. The general approach follows standard methods illustrated by Shrestha *et al.* [34] and Bergstrom & Taylor [32], among many others [89]. The estimated MRM allows us to forecast the increase in the annual rental value of a property based on model variables that represent percentage changes in open space under the LID scenario, radius size, characteristics of the open space valued, and population density.

The meta-analysis uses a simple benefit function of the following general form:

$$\%\Delta(\text{HomePrice}) = \text{Intercept} + \sum \text{Coefficient}_i \times \text{Independent Variable}_i \tag{1}$$

Here, the dependent variable $\%\Delta($*HomePrice*$)$ represents the percent change in price of a home. The MRM can be also used predict percentage changes in the annual rental-equivalent value of a home since the price of a home is simply the sum of the discounted future annual rental-equivalent values of living in that home [90–93]. We estimated the annual rental-equivalent home value by first calculating the average current value per home for each HUC-12, and then converting the aggregate housing values to annual rental-equivalent housing values by multiplying housing values (for each distance buffer, year, and HUC-12) by a 3% discount rate [94]. The average current home value for a given watershed is estimated as a weighted average of the present-day median home values in all Census tracts intersecting the HUC-12 (using American Community Survey 5-year estimates [95]). The current home value in the HUC-12 watersheds with predicted new and re-development was $151,875, translating to an average annual rental value (at a 3% discount rate) of $4556. Although real housing prices do vary considerably over time, long term price trends are difficult to predict [96], and predicting trends in home values is beyond the scope of this study.

We assigned a value to each model variable based on the policy context and the social and environmental characteristics (e.g., percent tree cover, population density) of each HUC-12, project, distance buffer, and year. Table 6 presents the variables, estimated coefficients, assigned variable values, and explanations for assigned values that vary across locations. We assumed that (1) additional open spaces associated with LID would be dispersed and unprotected areas comprised of either trees or general vegetation; and (2) relative tree cover at developments would vary regionally and consistently with nearby developed areas. The area-weighted average percent tree cover for each watershed was estimated based on the National Land Cover Database (NLCD) 2001 [97] tree canopy data for areas with developed land use types, using county-level summary tables generated by the U.S. Forest Service [98]. To evaluate the incremental value of recreational amenities provided by LID, we considered land development scenarios with and without recreational amenities.

4.1.2. Total Benefits of LID Use

We calculated the total change in annualized property values by estimating the percentage change in rental-equivalent housing values in each buffer zone around each development project in each HUC-12 and year, and then multiplying the predicted percent change in housing rental values by aggregate housing rental values. As discussed above, these rental values were based on 2011 median home values from the American Community Survey [95]. The MRM is structured so that the marginal effect on property values of an increase in open space depends on the size of the change in open space and the distance from the open space. Based on the aggregate predictions of changes in housing values for each HUC-12 watershed and year, we then calculated the sum of the total present discounted value of the change in rental values in each HUC-12. This sum represents the projected benefits of using LID in that HUC-12, over the period of analysis (21 years). In this calculation, all future benefits were discounted back to 2013 dollars using a 3 percent discount rate and then annualized over 21 years. Table 7 shows example calculations for one watershed for one year, comparing results with and without recreation.

Table 6. Model coefficients and independent variable assignments.

Variable	Coefficient	Assigned Value	Explanation
Intercept	0.039	1	Set to *one* as a default value.
pctincr_lt250	0.169***	Varies by HUC-12, buffer zone, and year	Set to the percentage increase in open space if evaluating properties within 250 m of a project, Set to zero otherwise.
pctincr_250to500	0.102***	Varies by HUC-12, buffer zone, and year	Set to the percentage increase in open space if evaluating properties between 250 and 500 m of a project, Set to zero otherwise.
pctincr_REdens	−0.063**	Varies by HUC-12	Values vary by population density of study area. Set to the percentage increase in open space if watershed had ≥800 people per square mile in 2011; set to zero if watershed has <800 people per square mile in 2011.
OS_riparian	0.252*	0	Set to zero because riparian buffer area is not expected to increase with LID options.
OS_wetland	−0.013	0	Set to zero because wetland area is not expected to increase with LID options.
OS_trees	0.245***	Varies by HUC-12	Set to a percentage of the increase in open space that is tree cover; assumed to equal the watershed's average tree cover (derived as an area-weighted average of county-level data).
Protected, dispersed, and not recreational	0.392***	0	Set to zero because open space associated with LID is not typically permanently protected.
Contiguous, recreational and/or protected	0.081	0 or 1	Set to zero for to evaluate the LID scenario without recreational amenities; set to one to evaluate the scenario with recreational amenities.
Ln(lot size)	−0.018	−1.139	Set to natural log of median lot size in state of Illinois (0.320 ac).
Home price ($thousands)	−0.0009***	Varies by HUC-12	Set to median home value (2013$) of intersecting Census Tracts [95].

Notes: *: Significant at the 0.05 level; **: Significant at the 0.01 level; ***: Significant at the 0.001 level.

Table 7. Sample benefits calculations for study area watershed for one year.

Variable	Illustrative Watershed	
Basic Characteristics	**Without Recreational Benefits**	**With Recreational Benefits**
HUC-12 Number	070900050304	070900050304
Year of Development	2017	2017
Policy Scenario		
Baseline (Conventional) Project Open Space (ac)	43	43
On-Site Change in Project Open Space (%)	30%	30%
Median Home Value ($2013)	$148,958	$148,958
Population Density	Rural/Exurban	Rural/Exurban
% Tree Cover	5.43%	5.43%
Open Space Assumed to Provide Recreational Benefits	**No**	**Yes**
Within 250 m radius		
On-site and Off-site Housing Units in Buffer (count)	112	112
Per-Home Perceived Change in Open Space in Buffer (%)	7.8%	7.8%
Per-Home Change in Value (%)	0.88%	0.96%
Per-Home Change in Total Value ($)	$1,311	$1,430
Per-Home Change in Annual Rental Equivalent Value ($)	$39	$43
Un-Discounted Benefit in Year of Development, All Homes in Buffer	$4,398	$4,803
Within 250 to 500 m radius		
Off-site Housing Units in Buffer (count)	102	102
Per-Home Perceived Change in Open Space in Buffer (%)	4.95%	4.95%
Per-Home Change in Value (%)	0.25%	0.33%
Per-Home Change in Value ($)	$372	$492
Per-Home Change in Annual Rental Equivalent Value ($)	$11	$15
Un-Discounted Benefit in Year of Development, All Homes in Buffer	$1,119	$1,488
Watershed-Wide		
Total Benefit, In Year of Development	$5,516	$6,291
Number of years homes accrue the benefit (development year through 2033)	17	17
Total Net Present Value in 2013 (2013$)	$66,462	$75,795
Annualized Net Present Value Over 21-year period	$4,312	$4,917

Note: Change in rental equivalent value is calculated as the total change in home value times the discount rate (3%).

Table 8 shows summary statistics for all HUC-12 watersheds in the case study state of Illinois. There are 813 HUC-12 watersheds in Illinois, ranging from 5865 to 60,450 acres. Individual HUC-12 watersheds affected during the analysis period (*i.e.*, 2013 to 2033) contained a total of 8693 to 10,017 homes, allowing for housing growth over time. Among the subset of watersheds projected to experience new residential construction in at least one year of the analysis (n = 547, 67%), new construction added roughly 50 homes per year (range 41–71). On a per-watershed basis, these new homes marginally change the available housing stock (<1% increase), suggesting that the mix of homes in the market does not materially change as a result of the hypothetical policy. When examining

only the homes near projected developments (*i.e.*, within 500 m), the average total number of affected houses per watershed per year ranged from 170 to 233 per year, with 66 to 95 in the 250 m buffer and from 103 to 137 in the 250–500 m buffer. The 250 m buffer includes new homes in the development project.

Perceived mean increases in open space range from 1.3% to 3.7% per home across the 250 m and 250–500 m buffers. The use of LID without recreational amenities is expected to result in an annual increase of $30 and $10 in per-property mean rental value for houses in the 250 m and 250–500 m buffers, respectively. As expected, including recreational amenities in LID further enhances property values in the vicinity of the development project. For example, in the 250 m buffer, the expected increase in property values is 13% higher compared to the "no recreational amenity case" (*i.e.*, $34 *vs.* $30). Although the mean per-watershed increase in property values is relatively modest, ranging from $3.9 to $10.5 thousand per year with and without recreation in the 250 m buffer (from $2.0 to $5.9 thousand per year in the 250–500 m buffer) the aggregate annualized benefits for the state of Illinois can be substantial and range from $31.0 to $36.0 million, without and with recreational benefits. We note that the estimated increase in property values represents a subset of environmental benefits associated with LID.

Table 8. Mean (range) values over all watersheds, by buffer zone.

Mean (range) Values		250 m Buffer	250–500 m Buffer
Number of Affected Homes		75 (66–95)	115 (103–137)
Perceived Percent Change in Open Space per Home	30% Increase Scenario (%)	3.1 (2.7–3.7)	1.5 (1.3–1.9)
Predicted Percent Change in Annual Rental Value per Home	Without Recreational Benefits (%)	0.44 (0.4–0.53)	0.15 (0.13–0.17)
	With Recreational Benefits (%)	0.52 (0.48–0.61)	0.11 (0.09–0.16)
Predicted Change in Annual Rental Value per Home	Without Recreational Benefits	$30 ($26–$37)	$10 ($9–$12)
	With Recreational Benefits	$34 ($31–$42)	$15 ($14–$17)
Predicted Change in Annual Rental Value per Watershed	Without Recreational Benefits	$5,057 ($3,851–$9,869)	$2,593 ($1,995–$4,940)
	With Recreational Benefits	$5,543 ($4,272–$10,548)	$3,336 ($2,644–$5,908)

5. Discussion

We have presented a MRM designed to evaluate the property value benefits of LID or GI practices that reduce impervious surfaces and increase vegetated areas in residential or commercial developments. Typically, LID practices produce small, dispersed areas of open space that often have no recreational value. The widespread implementation of these practices could provide numerous ecosystem services in the form of both direct benefits (e.g., on-site stormwater retention and associated improvements to watershed hydrology and water quality) and ancillary benefits (e.g., air pollutant removal, microclimate regulation, and wildlife habitat provision). The objective of this study was to estimate values for just one of the many ancillary ecosystem services that may be provided by LID: the aesthetic benefits provided by increased vegetated open spaces, as they are reflected in increased property values.

While LID is implemented to protect and improve water quality, it often provides additional ecosystem services such as carbon sequestration, water temperature regulation, air quality improvements, microclimate regulation, wildlife habitat, and aesthetic benefits of augmented landscape features. The

improved ecosystem services, in particular augmented landscape features, may be reflected in increased property values.

We developed and estimated a MRM with 119 observations from 35 studies, including only studies that are most relevant to the small, dispersed types of open space likely to result from LID. Because our model is intended for use in benefit transfer, our analysis included robustness tests [30]. Based on robustness tests, we conclude that neither national research priorities nor our choices in selecting a subset of studies for an analysis of small, dispersed spaces appear to bias conclusions drawn from our meta-analysis. The estimated MRM is generally robust to individual observations, and key variables used in benefit transfer—those describing the percent change in open space at different distances—are both horizontally and vertically robust. Overall, we are confident that value transfer based on this equation is as accurate as possible, given underlying data, but do recommend caution in interpreting results based on the less-robust variables.

Our benefit transfer example, which illustrated the application of the meta-analysis function to a hypothetical policy scenario, wherein new developments in Illinois watersheds are constructed with up to 30% more open space as compared to conventional development, illustrated the utility of using a meta-analysis function that can tailor value estimates to site-specific changes. Nevertheless, the benefit transfer exercise also demonstrates that relatively small benefits arise from increases in small, dispersed open spaces, such as those typical of some LID options. This is to be expected, as some of the more conservative LID approaches, such as reducing street width, produce marginal changes in open space. However, when evaluated over many developments, and when combined with the numerous other benefits that may be provided by low impact development (e.g., improved watershed hydrology and air pollution removal by vegetation), our results suggest landscape-wide amenity values of LID can be significant. Some developers use LID that provides additional open space areas for recreation [5,41]. We compared the results of our model when evaluating sites with recreational uses to sites without recreational uses, and found that on-site and nearby off-site homeowners may value LID plans that use contiguous blocks of open space that provide recreational amenities more than those which do not provide these features.

Like prior meta-analyses based on hedonic price equations [42,99], we examined insights from multiple real estate markets across the United States. This enabled us to comment broadly on the average relationship between open space and property values. Nonetheless, our final meta-regression did not include region-specific effects due to small sample sizes. While regional dummy variables would have allowed practitioners to coarsely tailor our national results to specific geographic contexts, we recommend using other variables in the regression, such as local tree cover and open space types pertinent to local contexts.

Our results indicate that the design and characteristics of a project affect the magnitude of benefits, and that values decline with distance. More broadly, the meta-analysis shows that the percent increase in open space and proximity are robust determinants of household WTP for aesthetic and other services associated with local availability of small, dispersed open spaces, but that values for other site features (e.g., tree cover or recreational use) may be site-specific. Policymakers and developers could draw on our synthesis of the property value effects of various site characteristics to maximize benefits from open space associated with LID. We, however, note that while changes in property values capture

a portion of the net benefits of LID, they may not address the full suite of LID benefits (e.g., energy savings from improved house shading).

Acknowledgments

Conflicts of Interest

The authors declare no conflict of interest.

Appendix 1: Methodology to Convert Distance from Open Space and Adjacency to Open Space to Percent Changes in Open Space

1.1. Converting Distance to Percent

The conversion of a home's distance to nearby open space features into the percentage of open space in a buffer surrounding a home proceeds in several conceptual steps [43]. First, we drew a circular buffer area around homes, with a radius equal to the baseline average distance between homes in the study and the nearest open space feature. In the baseline, open space features abut but do not overlap the perimeter of the home buffer (Figure A1a). We simulate a reduction in the distance between homes and open space by "moving" the open space from its original position to one which overlaps the home buffer (Figure A1b). Open space is "moved" closer to the home by the mean change in distance examined in the original study. Then, we calculated the resulting percent increase in open space within the home buffer as the ratio of the area of overlap to the total area of the home buffer.

Figure A1. Conceptual illustration of converting distance-based measures to percent-based measures. (**a**) Open space abutting the buffer; (**b**) Open space "moved" to overlap the buffer.

(**a**)	(**b**)
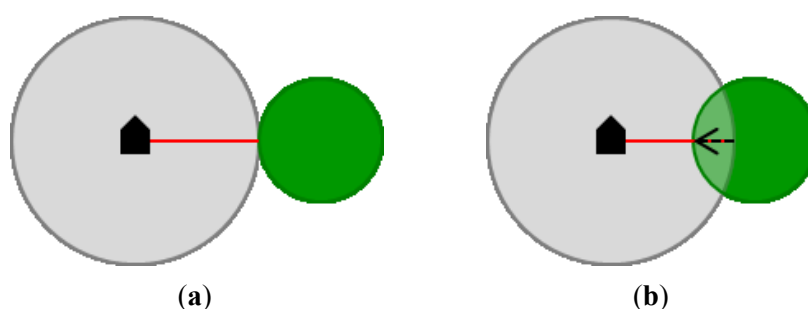
1.2. Converting Adjacency to Percent

We converted adjacency-based measures to percent-based measures using a similar approach, illustrated in Figure A2 (adapted from Kroeger [43]). In the figure, the arrow indicates the mean distance between a non-adjacent home in the study area (black) and an open space feature (green rectangle). By definition, the associated gray home buffer contains no portion of the open space. Shifting this circle such that its center is at the location of the average home which is adjacent to the open space (in red) increases the percent of open space in the home buffer. We calculate the percent increase in open space for adjacent homes (relative to non-adjacent homes) as the ratio of the overlapping area of the two buffers and the area of the adjacent home buffer (following Kroeger [43], p. 19).

Figure A2. Example of percent change in open space calculation.
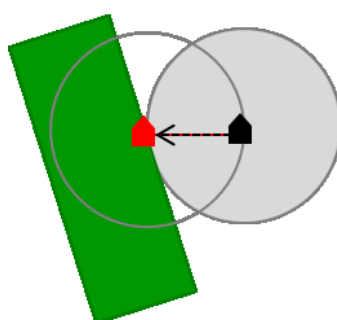
Appendix 2: Detailed Results of Model Robustness Tests

2.1. Sample Selection

Table A1 presents results of the sample selection equation, where the dependent variable is 0 for states with no study and 1 for states with at least one study. Explanatory variables are: the percent of each state's land area in developed land use from the US Forest Service [98] (a proxy for the importance of open space scarcity as research issues); the median home value in the state from the 2011 ACS summary [95] (indicating the relative value of residential homes); and the state's population density from 2012 Census data extrapolations (intended to represent relative development pressure). All three of the variables are significant, indicating that research priorities for open space valuation may be influenced by these factors.

Table A1. Selection equation.

Variable	Parameter Estimate	Standard Error
Intercept	−2.964**	1.046
Percent developed land	25.81*	11.22
Median home value	0.00001*	0.0000046
Population density/mile^2	−0.0071*	0.0033

Notes: *: Significant at the 0.05 level; **: Significant at the 0.01 level.

From these results, we computed the inverse Mill's ratio (IMR) and re-estimated the meta-regression including the estimated IMR as a regressor. Results are shown in Table A2. The coefficient on IMR is

only marginally statistically significant (*p*-value of 0.08) in our meta-regression, and therefore indicates a lack of sample selection error based on geography.

Table A2. Linear weighted regression with IMR: % change in WTP.

Variable	Parameter Estimate	Standard Error
Intercept	−0.148	0.146
pctincr_lt250	0.170***	0.003
pctincr_250to500	0.102***	0.002
pctincr_REdens	−0.065***	0.015
OS_trees[1]	0.258*	0.119
OS_riparian[1]	0.132	0.097
OS_wetland[1]	0.029	0.071
Protected, dispersed, and not recreational[2]	0.308*	0.148
Contiguous, recreational and/or protected[2]	0.074	0.057
Ln(lot size)	−0.032	0.024
Home price ($thousands)	−0.0008.	4.43×10^{-7}
IMR	0.146.	0.082

Notes: Number of observations = 119; Number of studies = 35; .: Significant at the 0.1 level; *: Significant at the 0.05 level; **: Significant at the 0.01 level; ***: Significant at the 0.001 level; [1]: Base case for vegetation type is "general" (*i.e.*, various types, undefined, or vegetated but not primarily tree-covered) open space; [2]: Base case for open space category is dispersed, not protected, not recreational.

2.2. Horizontal Robustness

To test for influential observations, we used the Cook's D statistic, which tests for both influence and leverage, applied to the model after removing each observation in turn, and found that three of the 119 observations in the data (from two studies) were influential (D > 1). We further tested horizontal robustness by removing each study in turn and using F-tests to test for changes to all parameters as a group. We found that six of the 35 studies had significant effects on some parameter estimates, though none affected our key policy variables. Table A3 lists the studies and observations found to be influential, based on the Cook's D statistic (for observations) and F-tests (for studies), following Boyle *et al.* [30].

Table A3. Influential observations and studies.

Study Name	Influential observations/Total observations	Influential Study
Bolitzer and Netusil [58]	1/8	No
Thorsnes [76]	2/2	No
Hardie *et al.* [65]	0/1	Yes
Heintzelman [19]	0/6	Yes
Kopits *et al.* [9]	0/1	Yes
Kaufman and Cloutier [67]	0/1	Yes
Shultz and King [74]	0/1	Yes
Saphores and Li [73]	0/3	Yes

Because our intention is to use the meta-analysis for benefit transfer, we further examined the changes in parameters for each model with one of the influential studies eliminated. Table A4 shows parameter estimates for the full model and for models estimated without each of the influential studies. Highlighted coefficient estimates indicate parameters that lost statistical significance in models based on a reduced dataset. We found that most of the estimated coefficients remained similar among, and did not lose significance across all models. The exceptions are the dummy variable for open space that is primarily tree-covered, which is significantly different at conventional levels ($p < 0.05$) in the full model, but only marginally significantly different than zero ($p < 0.10$) with the omission of Hardie, *et al.* [65]; and the dummy for riparian open space, which is no longer statistically significant when Shultz and King [74] is omitted.

2.3. Vertical Robustness

We tested vertical robustness following Boyle *et al.*'s [30] methods, based on Leamer's extreme bounds analysis [83]. By dropping explanatory variables from the equation, one can evaluate the stability of remaining variables' coefficient estimates, in terms of magnitudes and levels of statistical significance. We estimated the regression with each possible linear combination of variables and examined the results. Leamer deemed a variable robust if, across all linear combinations, its estimate remains statistically significant and if its extreme bounds (the estimate plus or minus two standard deviations) do not cross zero. None of the MRM variables are robust according to both of Leamer's criteria. Two main variables—*pctincr_lt250* and *pctincr_250to500*—and two additional variables—the dummies for *OS_trees* and protected, dispersed, and not recreational—meet the extreme bounds criterion but not the significance criterion (Table A5). Two other variables—*pctincr_REdens* and *home_price*—meet the significance criterion but not the extreme bounds criterion. Leamer's extreme bounds conditions are sometimes considered overly strict; Boyle *et al.* [30] suggest two alternative criteria: (1) checking for a particular variable's robustness only among the iterations where that variable was significant at a pre-specified level; (2) using the interdecile range (10th and 90th percentile values) rather than the extreme bounds. Based on the interdecile range condition, six of the 10 variables were found to be robust, including the important policy variables (Table A5).

Table A4. Effects of removing influential studies on parameters.

Variable	All Studies	Omits Shultz and King [74]	Omits Hardie *et al.* [65]	Omits Kopits *et al.* [9]	Omits Heintzelman *et al.* [19]	Omits Kaufman and Cloutier [67]	Omits Saphores and Li [72]
Intercept	0.039	0.024	0.030	0.050	0.008	0.054	0.164**.**
PctIncr_lt250	0.169***	0.169***	0.172***	0.170***	0.171***	0.169***	0.171***
PctIncr_250t500	0.102***	0.102***	0.104***	0.102***	0.102***	0.102***	0.104***
PctIncr_REdens	−0.063**	−0.062**	−0.053**	−0.059**	−0.060***	−0.064**	−0.065**
OS_trees	0.245***	0.244***	0.124**.**	0.227***	0.182***	0.241***	0.200**
OS_riparian	0.252*	0.093	0.214*	0.245*	0.216*	0.242*	0.235*
OS_wetland	−0.013	−0.002	0.002	−0.030	−0.024	−0.030	−0.032
Protected, dispersed, not recreational	0.392***	0.388***	0.212**	0.441***	0.338***	0.394***	0.429***
Contiguous, recreational and/or protected	0.081	0.092	0.047	0.077	0.057	0.090	0.060
Ln(lot size)	−0.018	−0.010	−0.032	−0.013	−0.015	−0.026	−0.003
Home price ($thousands)	−0.00088***	−0.00080**	−0.00069**	−0.00087***	−0.00051*	−0.00093***	−0.00138***

Notes: **.**: Significant at the 0.1 level; *: Significant at the 0.05 level; **: Significant at the 0.01 level; ***: Significant at the 0.001 level.

Table A5. Vertical robustness tests.

Variable	Mean estimate	EB Minimum	EB Maximum	10th Decile	90th Decile	EBA Result	P-value Result	Interdecile Result
intercept	0.047	−0.433	0.412	−0.176	0.259	fail	fail	fail
pctincr_lt250	0.097	0.079	0.106	0.084	0.105	pass	fail	pass
pctincr_250to500	0.168	0.152	0.176	0.154	0.175	pass	fail	pass
pctincr_REdens	−0.018	−0.083	0.048	−0.067	0.039	fail	pass	fail
OS_trees	0.577	0.127	1.092	0.171	0.976	pass	fail	pass
OS_riparian	0.185	−0.132	0.650	0.014	0.432	fail	fail	pass
OS_wetland	−0.042	−0.307	0.242	−0.191	0.101	fail	fail	fail
Protected, dispersed, and not recreational	0.275	0.043	0.475	0.130	0.399	pass	fail	pass
Contiguous, recreational and/or protected	0.324	−0.086	0.851	−0.002	0.644	fail	fail	fail
ln(lot size)	0.024	−0.036	0.105	−0.023	0.086	fail	fail	fail
Home price ($thousands)	−0.00054	−0.00127	0.00052	−0.00106	−0.00004	fail	pass	pass

Note: All values for means, extreme bound minima and maxima, deciles, and concluding remarks are taken over all combinations of variable exclusions, including estimates that are both significant and insignificant at $p < 0.10$.

References

1. National Research Council. *Urban Stormwater Management in the United States*; National Academy of Sciences Press: Washington, DC, USA, 2008; p.vii.
2. Schueler, T.R.; Claytor, R.A. *Maryland Stormwater Design Manual*; Maryland Department of the Environment: Baltimore, MD, USA, 2000.
3. New York State Department of Environmental Conservation (NYDEC). Stormwater Management Design Manual. August 2010. Prepared by the Center for Watershed Protection. Available online: http://www.dec.ny.gov/docs/water_pdf/swdm2010entire.pdf (accessed on 8 January 2014).
4. Pennsylvania Department of Environmental Protection (PADEP). Pennsylvania Stormwater Best Management Practices Manual. December 2006. Available online: http://www.elibrary.dep.state. pa.us/dsweb/View/Collection-8305 (accessed on 8 January 2014).
5. Lee, J.S.; Li, M.H. The impact of detention basin design on residential property value: Case studies using GIS in the hedonic price modeling. *Landsc. Urban Plan.* **2009**, *89*, 7–16.
6. Zielinski, J. The benefits of better site design in residential subdivisions. *Watershed Prot. Tech.* **2000**, *3*, 633–646.
7. Center for Watershed Protection. Stormwater Management. Available online: http://www.cwp.org/2013-04-05-16-15-03/stormwater-management (accessed on 2 July 2013).
8. Minnesota Pollution Control Agency. Minnesota Stormwater Manual. Available online: http://stormwater.pca.state.mn.us/index.php/Better_site_design (accessed on 6 August 2013).
9. Kopits, E.; McConnell, V.; Walls, M. The trade-off between private lots and public open space in subdivisions at the urban-rural fringe. *Am. J. Agric. Econ.* **2007**, *89*, 1191–1197.
10. Cho, S.H.; Clark, C.D.; Park, W.M.; Kim, S.G. Spatial and temporal variation in the housing market values of lot size and open space. *Land Econ.* **2009**, *85*, 51–73.
11. Cho, S.H.; Lambert, D.M.; Roberts, R.K.; Kim, S.G. Moderating urban sprawl: Is there a balance between shared open space and housing parcel size? *J. Econ. Geogr.* **2010**, *10*, 763–783.
12. Williams, E.S.; Wise, W.R. Economic impacts of alternative approaches to storm-water management and land development. *J. Water Res. Plan. Manag. ASCE* **2009**, *135*, 537–546.
13. Wise, S.; Braden, J.; Ghalayini, D.; Grant, J.; Kloss, C.; MacMullan, E.; Morse, S.; Montalto, F.; Nees, D.; Nowak, D.; *et al*. Integrating valuation methods to recognize green infrastructure's multiple benefits. In Low Impact Development 2010: Redefining Water in the City, Proceedings of the 2010 International Low Impact Development Conference, San Francisco, CA, USA, 11–14 April 2010.
14. McConnell, V.; Walls, M. *The Value of Open Space: Evidence from Studies of Nonmarket Benefits*; Resources for the Future: Washington, DC, USA, 2005.
15. Kearney, A.R. Residential development patterns and neighborhood satisfaction—Impacts of density and nearby nature. *Environ. Behav.* **2006**, *38*, 112–139.
16. Mohamed, R. The economics of conservation subdivisions—Price premiums, improvement costs, and absorption. *Urban Aff. Rev.* **2006**, *41*, 376–399.
17. Bowman, T.; Thompson, J.; Colletti, J. Valuation of open space and conservation features in residential subdivisions. *J. Environ. Manag.* **2009**, *90*, 321–330.

18. Schultz, S.; Schmitz, N. *How Water Resources Limit and/or Promote Residential Housing Developments in Douglas County*; Final Research Report; University of Nebraska at Omaha, Economics Department: Omaha, NE, USA, 2008.

19. Heintzelman, M.A. Measuring the property-value effects of local land use and preservation referenda. *Land Econ.* **2010**, *86*, 22–47.

20. Netusil, N.R. Economic valuation of riparian corridors and upland wildlife habitat in an urban watershed. *J. Contemp. Water Res Educ.* **2006**, *134*, 39–45.

21. Reynolds, J.E.; Regalado, A. The effects of wetlands and other factors on rural land values. *Apprais. J.* **2002**, *70*, 182–182.

22. Netusil, N.R. The effect of environmental zoning and amenities on property values: Portland, Oregon. *Land Econ.* **2005**, *81*, 227–246.

23. Thompson, R. Cost Benefit Analysis of Conservation Developments in Western North Carolina. Master's Thesis, Duke University, Durham, NC, USA, April 2008.

24. Williams, E.S. Hydrologic and Economic Impacts of Alternative Residential Land Development Methods. Ph.D. Thesis, University of Florida, Gainesville, FL, USA, 2003.

25. Nassauer, J.I.; Allan, J.D.; Johengen, T.; Kosek, S.E.; Infante, D. Exurban residential subdivision development: Effects on water quality and public perception. *Urban Ecosyst.* **2004**, *7*, 267–281.

26. Nassauer, J.I.; Wang, Z.; Dayrell, E. What will the neighbors think? Cultural norms and ecological design. *Landsc. Urban Plan.* **2009**, *92*, 282–292.

27. Wachter, S.G.; Gillen, K.C. *Public Investment Strategies: How They Matter for Neighborhoods in Philadelphia—Identification and Analysis*; The Wharton School, University of Pennsylvania: Philadelphia, PA, USA, 2006.

28. Raucher, R.S. *A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds*, *Final Report*; Stratus Consulting Incorporated: Boulder, CO, USA, 2009.

29. Brown and Caldwell; HNTB; Tetra Tech. Determining the Potential of Green Infrastructure to Reduce Overflows in Milwaukee; Milwaukee Metropolitan Sewerage District: Milwaukee, WI, USA, 2011.

30. Boyle, K.J.; Parmeter, C.F.; Boehlert, B.B.; Paterson, R.W. Due diligence in meta-analyses to support benefit transfers. *Environ. Resour. Econ.* **2013**, *55*, 357–386.

31. Van den Bergh, J.C.; Button, K.J.; Nijkamp, P.; Pepping, G.C. *Meta-Analysis in Environmental Economics*; Kluwer Academic Publishers: Dordrecht, Netherlands, 1997.

32. Bergstrom, J.C.; Taylor, L.O. Using meta-analysis for benefits transfer: Theory and practice. *Ecol. Econ.* **2006**, *60*, 351–360.

33. Rosenberger, R.S.; Stanley, T.D. Measurement, generalization, and publication: Sources of error in benefit transfers and their management. *Ecol. Econ.* **2006**, *60*, 372–378.

34. Shrestha, R.K.; Rosenberger, R.S.; Loomis, J.B. Benefit transfer using meta-analysis in recreation economic valuation. In *Environmental Values Transfer*: *Issues and Methods*; Navrud, S., Ready, R., Eds.; Kluwer Academic Publishers: Dordrecht, Netherlands, 2007; pp. 22–43.

35. Rosenberger, R.S.; Loomis, J.B. *Benefit Transfer of Outdoor Recreation Use Values: A Technical Document Supporting the Forest Service Strategic Plan* (*2000 revision*); U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: Fort Collins, CO, USA, 2001.

36. Champ, P.; Boyle, K.J.; Brown, T.C. *A Primer on Nonmarket Valuation*; Kluwer Academic Publishers: Boston, MA, USA, 2003.

37. Woodward, R.T.; Wui, Y.S. The economic value of wetland services: A meta-analysis. *Ecol. Econ.* **2001**, *37*, 257–270.

38. Bateman, I.J.; Jones, A.P. Contrasting conventional with multi-level modeling approaches to meta-analysis: Expectation consistency in U.K. woodland recreation values. *Land Econ.* **2003**, *79*, 235–258.

39. Johnston, R.J.; Besedin, E.Y.; Iovanna, R.; Miller, C.; Wardell, R.; Ranson, M. Systematic variation in willingness to pay for aquatic resource improvements and implications for benefit transfer: A meta-analysis. *Can. J. Agric. Econ.* **2005**, *53*, 221–248.

40. Johnston, R.J.; Rosenberger, R.S. Methods, trends and controversies in contemporary benefit transfer. *J. Econ. Surv.* **2010**, *24*, 479–510.

41. Vladich, H.V. Participatory Spatial Analysis, Ecosystem Services Valuation and The Development of An Integrated Modular Landscape Based on Stormwater Management Framework: A Case Study of A Neighborhood in South Burlington, Vermont. In Proceedings of 7th Bi-annual Meeting of the U.S. Society for Ecological Economics, Burlington, VT, USA, 9–12 June 2013.

42. Smith, V.K.; Huang, J.C. Can markets value air quality? A meta-analysis of hedonic property value models. *J. Polit. Econ.* **1995**, *103*, 209–227.

43. Kroeger, T. *Open Space Property Value Premium Analysis; Project Topic 1H: Development of an Operational Benefits Estimation Tool for the U.S.*; National Council for Science and the Environment; 2006 Wildlife Habitat Policy Research Program: Washington, DC, USA, 2008.

44. Kroeger, T.; Loomis, J.; Casey, F. *Introduction to the Wildlife Habitat Benefits Estimation Toolkit*; *Project Topic 1H: Development of an Operational Benefits Estimation Tool for the U.S.*; National Council for Science and the Environment; 2006 Wildlife Habitat Policy Research Program: Washington, DC, USA, 2008.

45. Munroe, D.K. Exploring the determinants of spatial pattern in residential land markets: Amenities and disamenities in Charlotte, NC, USA. *Environ. Plan. B Plan. Design* **2007**, *34*, 336–354.

46. Doss, C.R.; Taff, S.J. The influence of wetland type and wetland proximity on residential property values. *J. Agric. Resour. Econ.* **1996**, *21*, 120–129.

47. Bin, O.; Polasky, S. Evidence on the amenity value of wetlands in a rural setting. *J. Agric. Appl. Econ.* **2005**, *37*, 589–602.

48. Bark, R.H.; Osgood, D.E.; Colby, B.G.; Katz, G.; Stromberg, J. Habitat preservation and restoration: Do homebuyers have preferences for quality habitat? *Ecol. Econ.* **2009**, *68*, 1465–1475.

49. Cho, S.H.; Lambert, D.; Kim, S.; Roberts, R.; Park, W. Relationship between value of open space and distance from housing locations within a community. *J. Geogr. Syst.* **2011**, *13*, 393–414.

50. Ready, R.; Abdalla, C. *GIS Analysis of Land Use on the Rural-Urban Fringe: The Impact of Land Use and Potential Local Disamenities on Residential Property Values and on the Location of Residential Development in Berks County, Pennsylvania*; Department of Agricultural Economics and Rural Sociology, Pennsylvania State University: University Park, PA, USA, 2003.

51. Smith, V.K.; Poulos, C.; Kim, H. Treating open space as an urban amenity. *Resour. Energy Econ.* **2002**, *24*, 107–129.

52. U.S. Census Bureau. *2010 Decennial Census, Summary File 2, PCT1*; U.S. Census Bureau: Suitland, MD, USA, 2010.

53. *U.S. EPA Integrated Climate and Land-Use Scenarios (ICLUS) v1.3, Toolkit for ArcGIS and Datasets for Modeling U.S. Housing Density Growth*; Global Change Research Program, National Center for Environmental Assessment, Office of Research and Development: Washington, DC, USA, 2010.

54. Abbott, J.K.; Klaiber, H.A. Is all space created equal? Uncovering the relationship between competing land uses in subdivisions. *Ecol. Econ.* **2010**, *70*, 296–307.

55. Acharya, G.; Bennett, L.L. Valuing open space and land-use patterns in urban watersheds. *J. Real Estate Finance Econ.* **2001**, *22*, 221–237.

56. Anderson, S.T.; West, S.E. Open space, residential property values, and spatial context. *Reg. Sci. Urban Econ.* **2006**, *36*, 773–789.

57. Bin, O. A semiparametric hedonic model for valuing wetlands. *Appl. Econ. Letters* **2005**, *12*, 597–601.

58. Bolitzer, B.; Netusil, N.R. The impact of open spaces on property values in Portland, Oregon. *J. Environ. Manag.* **2000**, *59*, 185–193.

59. Lutzenhiser, M.; Netusil, N.R. The effect of open spaces on a home's sale price. *Contemp. Econ. Policy* **2001**, *19*, 291–298.

60. Cho, S.H.; Bowker, J.M.; Park, W.M. Measuring the contribution of water and green space amenities to housing values: An application and comparison of spatially-weighted hedonic models. In Proceedings of American Agricultural Economics Association Annual Meeting, Long Beach, CA, USA, 23–26 July, 2006.

61. Cho, S.H.; Poudyal, N.C.; Roberts, R.K. Spatial analysis of the amenity value of green open space. *Ecol. Econ.* **2008**, *66*, 403–416.

62. Cho, S.H.; Roberts, R.K.; Kim, S. Negative externalities on property values resulting from water impairment: The case of Pigeon River watershed. In Proceedings of Agricultural & Applied Economics Association's 2011 Agricultural and Applied Economics Association & Northeastern Agricultural and Resource Economics Association Joint Annual Meeting, Pittsburgh, PA, USA, 24–26 July 2011.

63. Donovan, G.H.; Butry, D.T. Trees in the city: Valuing street trees in Portland, Oregon. *Landsc. Urban Plan.* **2010**, *94*, 77–83.

64. Geoghegan, J.; Wainger, L.A.; Bockstael, N.E. Spatial landscape indices in a hedonic framework: An ecological economics analysis using GIS. *Ecol. Econ.* **1997**, *23*, 251–264.

65. Hardie, I.; Lichtenberg, E.; Nickerson, C.J. Regulation, open space, and the value of land undergoing residential subdivision. *Land Econ.* **2007**, *83*, 458–474.

66. Irwin, E.G. The effects of open space on residential property values. *Land Econ.* **2002**, *78*, 465–480.

67. Kaufman, D.; Cloutier, N. The impact of small brownfields and greenspaces on residential property values. *J. Real Estate Finance Econ.* **2006**, *33*, 19–30.

68. Mahan, B.L.; Polasky, S.; Adams, R.M. Valuing urban wetlands: A property price approach. *Land Econ.* **2000**, *76*, 100–113.

69. Netusil, N.R.; Chattopadhyay, S.; Kovacs, K.F. Estimating the demand for tree canopy: A second-stage hedonic price analysis in Portland, Oregon. *Land Econ.* **2010**, *86*, 281–293.

70. Sander, H.A.; Polasky, S. The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA. *Land Use Policy* **2009**, *26*, 837–845.

71. Sander, H.; Polasky, S.; Haight, R.G. The value of urban tree cover: A hedonic property price model in Ramsey and Dakota Counties, Minnesota, USA. *Ecol. Econ*. **2010**, *69*, 1646–1656.

72. Saphores, J.D.; Li, W. Estimating the value of urban green areas: A hedonic pricing analysis of the single family housing market in Los Angeles, CA. *Landsc. Urban Plan.* **2012**, *104*, 373–387.

73. Shultz, S.D.; King, D.A. The use of census data for hedonic price estimates of open-space amenities and land use. *J. Real Estate Finance Econ.* **2001**, *22*, 239–252.

74. Stetler, K.M.; Venn, T.J.; Calkin, D.E. The effects of wildfire and environmental amenities on property values in northwest Montana, USA. *Ecol. Econ.* **2010**, *69*, 2233–2243.

75. Thorsnes, P. The value of a suburban forest preserve: Estimates from sales of vacant residential building lots. *Land Econ.* **2002**, *78*, 426–441.

76. Towe, C. A valuation of subdivision open space by type. *Am. J. Agric. Econ.* **2009**, *91*, 1319–1325.

77. Troy, A.; Grove, J.M. Property values, parks, and crime: A hedonic analysis in Baltimore, MD. *Landsc. Urban Plan.* **2008**, *87*, 233–245.

78. White, E.M.; Leefers, L.A. Influence of natural amenities on residential property values in a rural setting. *Soc. Nat. Resour.* **2007**, *20*, 659–667.

79. Kennedy, P. *A Guide to Econometrics*, 6th ed.; Blackwell: Malden, MA, USA, 2008.

80. Boone, C.G.; Buckley, G.L.; Grove, J.M.; Sister, C. Parks and people: An environmental justice inquiry in Baltimore, Maryland. *Ann. Assoc. Am. Geogr.* **2009**, *99*, 767–787.

81. Nelson, J.P.; Kennedy, P.E. The use (and abuse) of meta-analysis in environmental and natural resource economics: An assessment. *Environ. Resour. Econ*. **2009**, *42*, 345–377.

82. Hoehn, J.P. Methods to address selection effects in the meta-regression transfer of ecosystem values. *Ecol. Econ*. **2006**, *60*, 389–398.

83. Leamer, E.E. Let's take the con out of econometrics. *Am. Econ. Rev.* **1983**, *73*, 31–43.

84. IHS Global Insight. *U.S. State and Metro Construction Quarterly Briefing*; IHS Global Insight (USA) Inc.: Lexington, MA, USA, 2011.

85. Reed Construction Data. *Connect Database Version 3.1.6*. Reed Construction Data: Norcross, GA, USA, 2008.

86. U.S. Census Bureau. *Economic Census of Construction*; U.S. Census Bureau: Suitland, MD, USA, 2007.

87. Clar, M. *Pembroke Woods*: *Lessons learned in the design and construction of an LID subdivision*; Ecosite, Inc: Columbia, MD, USA, 2003.

88. Clean Water America Alliance. *Barriers and Gateways to Green Infrastructure*; Clean Water America Alliance: Washington, DC, USA, 2011; pp. 1–37.

89. Rosenberger, R.S.; Phipps, T.T. Correspondence and convergence in benefit transfer accuracy: A meta-analytic review of the literature. In *Environmental Values Transfer*: *Issues and Methods*; Navrud, S., Ready, R., Eds.; Kluwer Academic Publishers: Dordrecht, Netherlands, 2007; pp. 23–43.

90. Dougherty, A.; van Order, R. Inflation, housing costs, and the consumer price index. *Am. Econ. Rev.* **1982**, *72*, 154–164.

91. Abelson, P.W.; Markandya, A. The interpretation of capitalized hedonic prices in a dynamic environment. *J. Environ. Econ. Manag.* **1985**, *12*, 195–206.

92. Meese, R.; Wallace, N. Testing the present value relation for housing: Should I leave my house in San Francisco? *J. Urban Econ.* **1994**, *35*, 245–266.

93. Diewert, W.E.; Nakamura, A.; Nakamura, L. The housing bubble and a new approach to accounting for housing in a CPI. *J. Hous. Econ.* **2009**, *18*, 156–171.

94. U.S. Office of Management and Budget. Circular A-4. Subject: Regulatory Analysis. September 17, 2003. Available online: http://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/a-4.pdf (accessed on 08 January 2014).

95. U.S. Census Bureau. *American Community Survey*; U.S. Census Bureau: Suitland, MD, USA, 2011.

96. Shiller, R. *Irrational Exuberance*; Princeton University Press: Princeton, NJ, USA, 2000.

97. Homer, C.; Dewitz, J.; Fry, J.; Coan, M.; Hossain, N.; Larson, C.; Herold, N.; McKerrow, A.; VanDriel, J.N.; Wickham, J. Completion of the 2001 national land cover database for the conterminous United States. *Photogramm. Eng. Remote Sens.* **2007**, *73*, 337–341.

98. U.S. Forest Service Publications & Data. Available online: http://www.nrs.fs.fed.us/data/urban/ (accessd on 8 July 2013).

99. Nelson, J.P. Meta-analysis of airport noise and hedonic property values: Problems and prospects. *J. Transp. Econ. Policy* **2004**, *38*, 1–27.