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REVIEW PAPER

The effect of rivers, streams, and canals on property values

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Abstract

Rivers, streams, and canals support a variety of critical agricultural, industrial, transportation, ecological, and household uses. They also provide important aesthetic, recreational, and sociocultural benefits. This review paper synthesizes the evidence to date regarding the value of these linear water features as aesthetic and recreational resources to adjacent and nearby residents. Specifically, it summarizes 25 studies that have used the hedonic pricing method to calculate the effects of views of and proximity to rivers, streams, and canals on surrounding residential property values. The majority of studies indicated that significant positive property price effects are associated with river, stream, and canal view and proximity, though these effects appear less definitive in rural than urban settings. Implications of the body of evidence for planning, management, and development are discussed, and potential effects of climate change and diversion policies are highlighted. Improvements in measurement facilitated by advanced geographic information systems and rigorous spatially explicit regression techniques are noted.

KEYWORDS

aesthetic, canal, hedonic, property value, recreation, river, stream, view

1 | INTRODUCTION

Linear water features including rivers, streams, and canals are critical elements of the earth's ecosystem, supporting essential agricultural, industrial, and household uses, serving as transportation routes, and providing habitat for a variety of flora, fauna, and aquatic species. Though not always considered as critical as the services aforementioned, such features also fulfil important aesthetic, recreational, and sociocultural functions. Cooper (1953) described how "Rivers, like clarions, sing to the ocean of the beauty of the earth, the fertility of plains, and the splendor of cities" (p. 11), whereas Coates (2013) writes of rivers of life, riches, recreation, and inspiration. Because rivers, streams, and canals are typically considered pleasant to look at and be on or near, at least in most western contexts, access to and views of them are typically capitalized into property prices in the form of sales price premiums. Though the existence and magnitudes of these effects have been summarized for features such as wetlands (Brander, Florax, & Vermaat, 2006) and parks (Crompton, 2005), no such review of linear water features exists.

Among economists, the distinction is made between market and non-market values. Market values represent the price at which an asset or commodity such as timber or grain changes hands on the open market. Some benefits, however, are not tradable and do not have prices that can be established in the marketplace. The protection of endangered and threatened species, unobstructed scenic views, and the maintenance of cultural heritage are all examples of factors on which non-market values can be placed by individuals and society (National Research Council, 1999). Identification of non-market values by resource planners and managers, and their balanced consideration alongside traditional use values, is critical to the comprehensive understanding and assessment of water-based ecosystems: "Despite growing recognition of the importance of ecosystem functions and services, they are often taken for granted and overlooked in environmental decision-making. Thus, choices between the conservation and restoration of some ecosystems and the continuation and expansion of human activities in others have to be made with an enhanced recognition of this potential for conflict and of the value of ecosystem services. In making these choices, the economic values of the ecosystem goods and services must be known so that they can be compared with the economic values of activities that may compromise them and so that improvements to one ecosystem can be compared to those in another" (Committee on Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems, 2005, p. 2). With specific reference to rivers, Lansing, Lansing, and Erazo (1998, p. 1) succinctly note that "If we allow our notion of value to be defined exclusively by market value, we must always prefer to put rivers in pipes," a conclusion they characterize as an "absurdity." However, as noted by Jorda-Capdevila and Rodríguez-Labajos (2016, p. 1), although the "benefits of marketed goods and services provided by water withdrawals such as irrigation, water supply and hydropower production are well-known", others including rivers' recreational, aesthetic, cultural, and existence values "are less studied."

2 | PURPOSE AND APPROACH

The purpose of this paper is to provide the first known synthesis of the evidence to date regarding the value of linear water features as aesthetic and recreational resources to adjacent and nearby residents as measured using the hedonic pricing method (HPM). More specifically, empirical findings relating to the effects of views of, and access to, rivers, streams, and canals on surrounding residential property values are discussed. Hedonic pricing allows individuals' (in this case, home buyers') preferences to be revealed to the researcher via their willingness to pay (WTP) for certain non-market qualities (e.g., a view of or proximity to a linear water feature). The HPM is based on the notion that a good's value is a function of the utility derived from its intrinsic properties or characteristics (see Lancaster, 1966, Griliches, 1971, and Rosen, 1974 for early applications). When applied to housing, the HPM recognizes that the price of a house reflects the value of the bundle of structural, neighbourhood, community, locational, environmental, and time of sale attributes that it possesses. These attributes vary between properties and buyers, because different people value different characteristics in varying ways. The regression model used to empirically estimate attribute prices may most simply be expressed as

$$P = P_i + P_s X_s + P_n X_n + P_c X_c + P_l X_l + P_e X_e + P_t X_t + \varepsilon,$$

where P represents observed property prices; X_s is the vector of structural attributes; X_n neighbourhood attributes; X_c community attributes; X_l locational attributes; X_e environmental attributes; X_t time attributes; and ε the stochastic disturbance term. The HPM is widely recognized as the most appropriate approach via which to estimate the value of the amenity, safety, and health benefits embedded in the market prices of housing and land (Hearne, 1996). The review presented here therefore builds upon Jorda-Capdevila and Rodríguez-Labajos (2016), in which the authors summarize 34 publications in the period 1987–2015 that calculated the socio-economic values of restoring environmental flows using one of six broad categories of valuation method: production based, for example, market price and net factor income; cost based, for example, avoided cost and replacement cost; revealed preference, for example, travel cost and hedonic pricing; stated preference, for example, contingent valuation and choice experiment; benefit transfer; and non-monetary.

Searches were conducted for English-language contributions from all countries using combination of keywords "river," "stream," or "canal" with "hedonic," "property price," or "property value." Journal articles as well as grey literature (e.g., technical reports, working papers, theses, and dissertations) were sought, as were studies that considered the values of rivers, streams, and/or canals as secondary to some other primary focus. To maintain a clear focus on linear water features, studies that made only generic reference to "water bodies," without clear definition of the type of water features under analysis, were excluded. Similarly, studies that combined linear (e.g., rivers and streams) and areal (e.g., oceans and lakes) features under a single measurement were not considered, because these are fundamentally different types of feature offering distinct benefits and experiences. For example, neither Cho, Bowker, and Park (2006), which considered proximity to the "nearest lake, river or stream" in Knox County, Tennessee, nor Cohen, Cromley, and Banach (2014), which focus on "wetlands and water bodies" (including lakes, ponds, and rivers), were included. The review does, however, embrace contributions from both economics and resource/amenities domains, an important contribution because crossover between these two spheres remains relatively minimal. All results referenced were statistically significant (at the level listed in the corresponding summary table), and all values are in U.S. dollars unless stated otherwise.

3 | FINDINGS—RIVERS

The effects of rivers on nearby property values are considered in three contexts: urban, rural, and larger regions of mixed land use.

3.1 | Urban

In urban settings, proximity to a river has been shown to have a positive effect on property values in Boston, Massachusetts (Li & Brown, 1980) and Minneapolis–St. Paul (Anderson & West, 2006). In the latter case, the sales price increase of 0.027% for each 1% decrease in distance to the nearest river was larger than that found for parks or golf courses. In Portland, however, distance to the nearest river had no impact on sales price, though lake proximity did (Mahan, Polasky, & Adams, 2000). In Perth, Australia, river view commanded a price premium of 28%, whereas proximity resulted in a premium of AU $387 per block for locations up to nine blocks away (McLeod, 1984). Houses with a view of the South Saskatchewan River in the City of Saskatoon sold for an average of CAN$11.48/sq ft more than houses with no such view, though this premium varied by neighbourhood (from CAN$0.84/sq ft to CAN$26.76/sq ft); the average premium for a multi-dwelling unit with a river view was CAN$34 per month, and the total annual value of river view to the city was estimated at CAN $1.2 million in $1,989 (Kulshreshtha & Gillies, 1993). In Guangzhou, China, location within 500 m of the Pearl River increased the sales price of a high-rise apartment by just over 13%, making this factor the third largest contributor to value after apartment size and height/storey (Jim & Chen, 2006); a later study estimated the average sales price premium for a view of the Pearl River or one of its tributaries to be 8.2%, though that contribution varied from 7.3% in older parts of town to 13.7% in newer areas (Jim & Chen, 2007).

3.2 | Rural

Evidence with respect to river value in rural areas is more mixed. Moore and Siderelis (2001) investigated the value of frontage on, and distance to, that portion of the Farmington River in west central Connecticut that is imbued with National Wild and Scenic River designation. Bordering the river accounted for 42% of adjacent land value; however, the premium effect declined rapidly with distance, dropping from $168/ft at 118 ft from the river to $3.76 at 1 mile, $1.25 at

3 miles, and $0.63 at 6 miles. In contrast, in Michigan, White and Leefers (2007) reported that proximity to a National Scenic River had no influence on prices of surrounding land parcels. Similarly, Kruse and Ahmann (2009) found no significant influence on property prices fronting the Klamath River in northern California, an unexpected finding they attributed to a small sample size and varying environmental and economic conditions across the study area.

Tapsuwan, MacDonald, King, and Poudyal (2012) showed a significant, non-linear sales price decrease with distance from the River Murray in South Australia. For the average house 1 km from the river, decreasing that distance to 0.50 km increased the value by AU $245,000 (average sales price not stated); most of the proximity effect was lost by a distance of 2 km. A river recreation index was also incorporated, to account for the variety of activities available. The average house enjoyed an additional increase in value of $27,000 if in an area of high river recreation attractiveness, but a decrease of $14,000 if attractiveness was deemed to be low. Tapsuwan, Polyakov, Bark, and Nolan (2015) also demonstrated a significant river proximity effect in the same study area.

3.3 | Larger mixed-use regions

In a study including all parts of England, the implicit price of river proximity was greater than those for a variety of protected land types, though was only significant in one of five models tested (Gibbons Mourato, & Resende, 2014). Morgan, Hamilton, and Chung (2010) compared the price effect of proximity to two rivers (one polluted and one not) in Augusta County, Virginia. Increasing distance to the river resulted in a significant decline in prices along both rivers, though the magnitude of the coefficients indicated marginal WTP to locate 1 ft closer to the clean river was larger than that for the polluted waterway. Noting the natural experiment afforded by the geographic setting, the authors attributed differences in WTP to variation in water quality, though the effect of this variation was not explicitly accounted for.

Two relatively recent studies have assessed the effects of dam removal on proximate property prices, with both sets of authors identifying local property owners' concerns about loss of value upon removal as a major impetus for their study. These concerns were not supported in either case, suggesting that lake/reservoir frontage/proximity is no more valuable than river proximity. In the first case, in Wisconsin, no significant difference in price was found between properties with frontage on a small impoundment versus on a free-flowing river, whereas non-frontage property within 0.25 mile of a free-flowing river was found to be worth significantly more than property near a recently removed or current impoundment (Provencher, Sarakinos, & Meyer, 2008). In the second case, increasing distance to the Kennebec River in Maine had a positive and significant effect in both cases analysed, though this negative proximity effect declined substantially (i.e., proximity to the river became less unattractive) after dam removal (Lewis, Bohlen, & Wilson, 2008). The river proximity coefficients were confounded at both sites, however, by the correlation between proximity to the river and proximity to the two cities considered. Table 1 summarizes the key characteristics and results of the studies reviewed above.

4 | FINDINGS—STREAMS

4.1 | Effects of stream proximity

Mahan et al. (2000) demonstrated an increase in sales price of $259 with each 1,000 ft decrease in distance to the nearest stream in Portland, Oregon (relative to the average $122,570 house, 1 mile from a stream), whereas Sander and Polasky (2009) found that reducing the distance to the nearest stream in Ramsey County, Minnesota, by 100 m generated a $127 increase in price (for the average priced home of $255,955, 1 km from a stream; for comparison, these translate into premiums of $0.259/ft [from a starting point of 5,280 ft] in Oregon and $0.387/ft [at 3,281 ft] in Minnesota). More recently, location within 0.25 mile of a creek in Portland, Oregon, or Vancouver, Washington, was found to have a highly significant effect on property prices in six of seven sets of results presented, though this effect was in most cases insignificant when the buffer was extended to 1 mile (Netusil, Kincaid, & Chang, 2014). These urban U.S. examples contrast with findings from rural Michigan (White & Leefers, 2007), where proximity to a stream was found to have no significant impact on property prices. The only known non-U.S. study found a negative stream proximity effect (Bonetti, Corsi, Orsi, & De Noni, 2016, for Milan, Italy), though this effect was mitigated by stream quality.

4.2 | Effects of restoration projects

Stream frontage in the Mohawk watershed of western Oregon commanded a premium of 7% (Mooney & Eisgruber, 2001). However, the existence and increasing width of a treed riparian buffer, a measure actively encouraged by the State of Oregon Plan for Salmon and Watersheds in an attempt to restore coastal salmon populations, reduced value by 3–11% for an average house with a 50 ft buffer. This finding contrasts with an earlier analysis of California properties near which streams had been restored as a result of the Department of Water Resources' Urban Stream Restoration Program, which saw price increases of $4,500–19,000, or 3–13% of mean property price, depending on the specific restoration project under consideration (though none of these involved a treed buffer; Streiner & Loomis, 1996). When the latter premiums were applied to all impacted properties and those premiums translated into property tax equivalents, the additional taxes generated contributed “far more revenue” (p. 277) than the programme's cost. Table 2 summarizes these studies' results.

5 | FINDINGS—CANALS

A handful of studies have investigated the influence of canals on property prices (Table 3). Garrod and Willis (1994) found that properties located directly on a London canal commanded a premium of 2.9%, whereas being adjacent (without frontage but within 200 m) increased prices of 1.5%. Canal-side location in the Midlands, a region of central England home to a dense network of canals constructed during the Industrial Revolution, commanded a premium of just over 5%. In the Netherlands, being adjacent to a canal was found to have an insignificant impact on prices in one area, whereas canal view commanded

TABLE 1 Summary of hedonic studies of rivers (in chronological order)

Author (year)	Study site/location	Dependent variable, mean[b]	Year(s) analysed	Method, sample size, functional form, and (adjusted) R^2 (as applicable)	Key findings regarding water feature impacts on property values
Li and Brown (1980) [a]	Southeast Boston, MA, United States	Sales prices of SFH, mean $30,069	1971	HPM, 781 properties, linear form with log of distance, 0.79–0.81	Effect of proximity to ocean and river of similar magnitude of significance, though substantially lower than proximity to expressway interchange. $/% values not provided.
McLeod (1984) [a]	Perth, Western Australia	Sales prices of residential dwellings, mean AU$46,173	1978	HPM, 168 properties, four non-linear forms, 0.78	Premium for "unimpeded view of substantial body of river" AU $13,100 (28%); proximity premium $387 per block, up to nine blocks away (compared to premium of AU$1,502/ block but over only four blocks for park). Both sig. at 5%.
Kulshreshtha and Gillies (1993) [a]	South Saskatche-wan River, City of Saskatoon, Canada	Sales prices (SFH), monthly rents (multi-dwelling units)	1986 and 1987	HPM, 393 houses and unknown number of multi-dwelling units, linear form, 0.92	Houses with river view sold for average CAN$11.48/sq ft more than those without view, premium varied by neighbourhood (CAN$0.84–26.76/ sq ft); average premium for multi-dwelling unit with river view CAN$34/month.
Mahan et al. (2000) [a]	Portland, OR, United States	Sales prices of SFH, mean $123,109	1992 to 1994	HPM, 14,485 properties, log–log form, 0.76	Distance to nearest river insignificant.
Moore and Siderelis (2001)	Farmington River, west central CN, United States	Land values of SFH, mean $50,837 per acre	1986 to 2001	HPM, 253 properties within 6 miles of river, linear-log form, 0.08	Bordering river accounted for 42% of adjacent land value; effect on land value $168/ft for properties bordering the river, $3.76 at 1 mile, $1.88 (2 miles), $1.25 (3 miles), $0.94 (4 miles), $0.75 (5 miles), and $0.63 (6 miles). Proximity to river explained 8% of all land values within 6-mile zone.
Anderson and West (2006) [a]	Minneapolis–St. Paul, MN, United States	Sales prices of SFH, mean $142,322	1997	HPM, 24,862 properties, log–log form, 0.88	Sales price increased 0.027% for each 1% decrease in distance to nearest river. Lake and river proximity premiums larger than those for parks (0.004), special parks (0.025), or golf courses (0.006; all sig. "at or near 1%").
Jim and Chen (2006) [a]	Guangzhou, China	Sales prices of apartments, mean RMB5,907.50/m^2	2003 to 2004	Four HPMs, 652 units, linear and semi-log forms, 0.92–0.95	Location within 500 m of Pearl River increased sales price by RMB1,299.93/m^2 in full linear model, accounted for 13.2% of price in modified semi-log model (sig. at 0.01).
Jim and Chen (2007) [a]	Guangzhou, China	Sales prices of apartments	2004	HPM, 521 units, semi-log form, 0.69–0.73	Premium for view of Pearl River or a tributary: Old town 7.3%, new town 13.7%, combined sample 8.2%.
White and Leefers (2007) [a]	Wexford County, MI, United States	Sales prices of SFH	2000 and 2001	HPM, 256 properties (split into two categories, subdivision and non), linear form, 0.47–0.65	Proximity to a National Scenic River insignificant in both models.
Kruse and Ahmann (2009)	Klamath River, northern California, United States	Sales price/acre of properties (<10 acres), mean $20,090	1998 to 2006	HPM, 590 properties (developed and undeveloped), semi-log form, 0.70	River frontage coefficient insignificant.
Lewis et al. (2008) [a]	Augusta and Waterville, Kennebec River, ME, United States	Sales prices of SFH (lots of 1 acre or less), mean $89,671 (Augusta) and $91,116 (Waterville)	1997 to 2005	Two HPMs, 1,027 (Augusta) and 1,134 (Waterville) properties, semi-log form, 0.59 (Augusta) and 0.64 (Waterville)	Augusta: Coefficient on distance to river/dam positive and sig. at 1%; negative influence of river proximity declined since dam removal (marginal WTP to be farther from the dam $2.43/m prior to removal but $0.16 after removal). Waterville: Coefficient on distance to river/dam positive, sig. at 1% (marginal WTP $7.30/m pre-dam removal, declining to $1.80/m post removal).
Provencher et al. (2008) [a]	South-central Wisconsin, United States	Sales prices of SFH (lots of 1 acre	1993 to 2002	Two HPMs, 773 properties within 0.25 mile of water body, linear and	No sig. price difference between properties fronting small impoundment versus free-flowing

(Continues)

TABLE 1 (Continued)

Author (year)	Study site/location	Dependent variable, mean[b]	Year(s) analysed	Method, sample size, functional form, and (adjusted) R^2 (as applicable)	Key findings regarding water feature impacts on property values
		or less), mean $112,247		exponential forms	river. Non-frontage property within 0.25 mile of free-flowing river worth $13,700–13,900 more than property near recently removed or current impoundment (sig. at 1%).
Morgan et al. (2010)	Two rivers (middle, not polluted, and south, polluted), Augusta County, VA, United States	Assessed total value (house and land, means $294,049 and $273,655) and assessed land value (means $78,969 and $68,007)	Not stated	Four spatial-lag HPMs, 2,069 properties on Middle River and 1,252 properties on South River, log form	Coefficients on distance to river negative and sig. (at <1%) in all four models. Marginal WTP to locate 1 ft closer to Middle River: $5.41 (total value) and $2.67 (land value). Marginal WTP to locate 1 ft closer to South River: $3.77 (total value) and $1.41 (land value). Value of improving South River quality to that of Middle River $7.3–12 million.
Tapsuwan et al. (2012) [a]	Murray-Darling Basin, South Australia	Sales prices of SFH	Not stated	Traditional and spatially explicit HPMs, 752 properties, semi-log form, 0.67–0.68	Sales price decreased with distance to river (sig. at 1%). For average house 1 km from river Murray, decreasing distance to 0.50 km increased value by AU$245,000; additional increase of $27,000 if in an area of high river recreation attractiveness but decrease of $14,000 if attractiveness was deemed to be low.
Gibbons, et al. (2014) [a]	England	Sales prices of houses, mean £194,040	1996 to 2008	Five traditional HPMs, 1,011,831 properties, semi-log form, 0.52–0.87	Coefficient on distance to river sig. (at 1%) and negative in one of five cases (indicating 0.9% drop in price with each additional kilometre), insignificant in other four. Implicit price of river proximity greater than that of coastlines, national parks or reserves, or National Trust properties.
Tapsuwan et al. (2015) [a]	Murray-Darling Basin, South Australia	Sales prices of SFH	2000 to 2011	Traditional and spatially explicit HPMs, 31,706 properties, log form (double log for distance variables), 0.41–0.42	Coefficient on distance to river sig. and negative in both cases. In spatial model, for average property 3 km from river, increase in proximity to river by 1 km associated with AU$2,414 increase in price.

Note. HPM = hedonic pricing model; SFH = single family houses; sig. = significant; WTP = willingness to pay.

[a]refereed.

[b]Mean value of dependent variable listed for those studies in which mean stated by original author(s).

premiums of 4% and 5% in a second site (Luttik, 2000). The most recent study found that canals in Milan, Italy, have a highly significant positive impact on the prices of nearby properties, with a price decline of €220.49/m from a canal's edge (Bonetti et al., 2016). In the United States, Conner, Gibbs, and Reynolds (1973) demonstrated a premium of $809 (31%) for vacant residential lots in the Kissimmee River Basin, whereas Nelson, Hansz, and Cypher (2005) found that canals in a residential development in Arlington, Texas, generated an average premium of $175 per front foot, or 11% on average.

6 | DISCUSSION

6.1 | Summary of studies reviewed

The 25 studies reviewed reveal the value of views of and access to linear water features as demonstrated by the willingness of adjacent and nearby homeowners to pay property price premiums for these qualities; these findings held true across a variety of settings. Only seven studies generated any insignificant findings, and just three generated significant coefficients of the opposite sign expected. In the latter cases, the likely causes of those anomalies could typically be explained in terms of unusual characteristics of the study area, or by the method employed. The positive effect of a water view appears to hold across the variety of water feature types considered, that is, for rivers, streams, and canals. In urban settings, the premium associated with river views was typically in the range of 10–30%, though in rural areas the effect of river view/access was less definitive; this finding seems intuitive given the predominance of a variety of natural features (lakes, rivers, streams, forests, parks, open fields, etc.) in rural areas, that is, their broad supply. Canal-side locations in urban European settings imbued premiums of 2–5%, whereas in newer residential developments in the U.S. premiums were in the order of 10–30%. These variations might reflect cultural variations in values and/or historical factors, for example, in Europe, canals were originally built during the Industrial Revolution to facilitate transportation, or as flood protection mechanisms, and housing has followed, whereas in the United States, canals have been built as primary

TABLE 2 Summary of hedonic studies of streams (in chronological order)

Author (year)	Study site/ location	Dependent variable, mean[b]	Year(s) analysed	Method, sample size, functional form, and (adjusted) R^2 (as applicable)	Key findings regarding water feature impacts on property values
Streiner and Loomis (1996) [a]	Contra Costa, Santa Cruz, and Solano counties, CA, United States	Assessed values of mostly SFH, mean $144,085	1983 to 1993	HPM, 999 properties, non-linear Box–Cox transformation, 0.54–0.55	Value of individual stream restoration projects calculated as follows: Maintain fish habitat, 11% premium; acquire land, 13%; establish education trail, 12%; stabilize streambanks, 3%; reduce flood damage, 5%.
Mahan et al. (2000) [a]	Portland, OR, United States	Sales prices of SFH, mean $123,109	1992 to 1994	HPM, 14,485 properties, log–log form, 0.76	Decreasing distance to nearest stream by 1,000 ft increased property value by $259 (relative to average house 1 mile from stream, sig. at 1%).
Mooney and Eisgruber (2001) [a]	Mohawk watershed, western OR, United States	Market-assessed values of SFH, mean $141,820	1996	HPM, 705 properties, non-linear Box–Cox transformation, 0.83–0.84	Stream frontage commanded premium of 7% (sig. at 1%); existence and increasing width of treed riparian buffer reduced value (by 3–11% for an average stream front house with a 50 ft buffer, sig. in four of six models tested).
White and Leefers (2007) [a]	Wexford County, MI, United States	Sales prices of SFH	2000 and 2001	HPM, 256 properties (split into two categories, subdivision and non), linear form, 0.47–0.65	Proximity to a stream insignificant in both models.
Sander and Polasky (2009) [a]	Ramsey County, MN, United States	Sales prices of SFH, mean $255,955	2005	HPM, 4,918 properties, log–log form, 0.79	Value of view of stream sig. at 5%. View of water more highly valued than view of grass or forest. Proximity to lake valued more highly than to park, trail, or stream.
Netusil et al. (2014) [a]	Johnson Creek, OR, and Burnt Bridge Creek, WA, United States	Sales prices of SFH, mean $264,194	2007	One traditional and two spatially explicit HPMs (applied to all data as well as by season), 10,479 properties, semi-log form, 0.71–0.72	Location within 0.25 mile of creek sig. at 1% in six of seven sets of results presented (insig. in other). Location within 0.50 mile sig. at 5% (5 times), 1% (1 time), insig. (1 time). Location within 1 mile sig. at 1% (1 time), 10% (1 time), insig. (5 times).
Bonetti et al. (2016) [a]	Milan, Italy	Bid (asking) prices of residential properties, mean €298,068	2011 to 2015	One traditional and three spatially explicit (spatial lag) HPM, 10,530 properties, semi-log form, 0.86 for OLS model	Increasing distance to stream sig. and positive (at 10% in OLS model and 0.1% in spatial models), though this effect was mitigated by stream quality. For average priced house, each additional metre from stream generated increase in value of €35.77.

Note. HPM = hedonic pricing model; insig. = insignificant; OLS = ordinary least squares; SFH = single family houses; sig. = significant; WTP = willingness to pay.

[a]refereed.

[b]Mean value of dependent variable listed for those studies in which mean stated by original author(s).

features within new residential developments, to facilitate the placement of docking facilities and hence boating access to larger water bodies. None of the studies reviewed included any kind of interaction with residents, to determine their uses of or opinions about the water features they reside by, suggesting an opportunity for additional research into these preferences and attitudes. More recent studies of other water feature types have demonstrated the variability of view premium with feature size and view extent, and these kinds of qualifiers would be especially useful to incorporate into urban river studies where partial views are most likely as a result of building heights and configurations.

Only one study calculated the total value of river view or proximity to the entire study area (Kulshreshtha & Gillies, 1993 for Saskatoon). Once the premium(s) associated with frontage on, a view of, or proximity to a feature has been determined, it is now relatively easy to apply that/those premiums to an entire study area using electronic datasets and geographic information systems techniques. Given the relatively fixed supply of properties on the waterfront or with a view of water features in developed urban areas, this approach would appear to be especially valuable in places where new construction might reduce or eliminate existing properties' views. In such cases, addition to the tax base from newly constructed residences should be balanced against potential losses due to diminished or degraded views from existing properties.

Overall, the studies reviewed demonstrate that recreational and aesthetic amenity can be a major source of land value increase along linear water features. Given the fixed supply of naturally occurring rivers and streams, as demand for the packages of amenities offered by waterside properties increases, prices of and premiums for these properties are likely to rise. The current body of literature does not facilitate the examination of this inelasticity, suggesting the future utility of longitudinal analyses.

TABLE 3 Summary of hedonic studies of canals (in chronological order)

Author (year)	Study site/ location	Dependent variable, mean[b]	Year(s) analysed	Method, sample size, functional form, and (adjusted) R^2 (as applicable)	Key findings regarding water feature impacts on property values
Conner et al. (1973) [a]	Kissimmee River Basin, Florida, United States	Sales prices (total and per front foot) of vacant residential lots	1966 to 1970	Two linear regression models, 316 lots, 0.63–0.68	Lakefront lot premium $3,232 (64%, sig. at 1%); canal-front $809 (31%, sig. at 1%); lake and canal front $4,040 (69%, sig. at 1%).
Garrod and Willis (1994) [a]	Greater London and Midlands, England	Sales prices of houses	1985 to 1989	HPM, 1,787 properties in London and 275 properties in Midlands, linear Box–Cox transformation, 0.75–0.76	Canal-side location in London commanded premium of £1,909 (2.9%, sig. at 5%), adjacent location (within 200 m) £958 (1.5%, sig. at 20%); in Midlands canal-side premium was £1,589 (~5%, significance not stated), adjacent location insignificant.
Luttik (2000) [a]	Eight towns/ regions in the Netherlands	Sales prices of houses	1989 to 1992	HPM, nearly 3,000 properties	Location adjacent to canal (tested in one case): Insignificant. View of canal (two cases): Premiums of 4% and 5% (sig. though level not specified).
Nelson et al. (2005) [a]	Arlington, TX, United States	Sales prices of SFH over $99,999, mean $146,826	1998 to 2003	HPM, 795 properties, log-linear form, 0.85	Canal frontage commanded average premium of $16,298 or $175/front foot (11.1%, sig. at 0.01).
Bonetti et al. (2016) [a]	Milan, Italy	Bid (asking) prices of residential properties, mean €298,068	2011 to 2015	One traditional and three spatially explicit (spatial lag) HPM, 10,530 properties, semi-log form, 0.86 for OLS model	Increasing distance to canal sig. and negative (at 0.1%) in three models, insignificant in fourth model. For average priced house, each additional metre from stream generated decrease in value of €220.49.

Note. HPM = hedonic pricing model; OLS = ordinary least squares; sig. = significant; SFH = single family houses.

[a]refereed.

[b]Mean value of dependent variable listed for those studies in which mean stated by original author(s).

The papers were consistent in their application of the HPM, though were less uniform with respect to aspects such as functional form. This factor, as well as variations in the units of measurement employed and style of reporting (e.g., some studies listed monetary amounts, others only percentages), made direct comparisons of the exact magnitudes of premiums problematic. Some of the most recent studies demonstrate the analytical possibilities opened up by the employment of advanced geographic information systems and spatially explicit regression techniques, which account for the effects of spatial heterogeneity and generate highly detailed depictions of how property premiums can vary across even relatively small study areas. These latter studies illustrate the uniqueness of locations, in terms of their resources and housing markets. They thereby challenge attempts at generalization but also provide useful evidence of the highly contextualized and nuanced reality of the variations in values that humans place on the landscapes in which they live.

6.2 | Implications for policy and planning

Despite the generalization challenge just mentioned, case studies remain essential, both to describe specific settings and to build a larger body of comparable evidence from which broader understanding of linear water features' values as recreational and aesthetic assets might be established. This is especially true in light of the increasing recognition of natural resources as lifestyle amenities, not only as a result of their aesthetic benefits but also as settings for activities that encourage physical activity and help improve mental health, ultimately contributing to reductions in health-care costs and to more productive societies (e.g., Tzoulas et al., 2007 formulated a conceptual framework of associations between urban green space [including water] and ecosystem and human health.). Many of the studies reviewed indicate the need for the full spectrum of economic, social, and environmental natural resource values to be considered in urban and suburban areas where those resources are under continued threat from development and sprawl. As suggested in several of the studies reviewed, the advent of highly sophisticated electronic mapping and analysis systems now allows planners to assess trade-offs between different development styles, configurations, and densities in an attempt to maximize economic, social, and environmental benefits. In the rural United States, too, natural resources are increasingly recognized as important influences on individuals' and businesses' location decisions, with places that offer access to amenities such as water proving more successful in attracting and retaining young talent and footloose firms (e.g., McGranahan, Wojan, & Lambert, 2008).

As competition over finite water resources grows and the need for their equitable and efficient allocation between multiple consumptive and non-consumptive uses escalates, knowledge and understanding of the values attributed to water views and access by nearby homeowners holds much significance for resource planners and managers. The review has important implications for areas where the withdrawal or diversion of linear water features already occurs or is under discussion, where non-market values that might be detrimentally impacted when deciding whether or not to implement this practice upstream of residential communities should be considered. The value of view and/or proximity should also be considered in any decision relating to the preservation of a water-based amenity when its conversion to another use is being considered (Mahan et al., 2000; Tapsuwan, Ingram, Burton, & Brennan, 2009). Likewise, recreational and aesthetic benefits to nearby homeowners are an important value to consider in cost–benefit analyses of restoration programmes, that is, in addition to the reductions in property damages likely as a result of these measures. Accurate and reliable data that adequately represent the full range of benefits provided by ecosystems are a critical prerequisite to the development of the kinds of stakeholder-focused management efforts of increasing prevalence and importance in the water resource realm (e.g., Bell, Lindenfeld, Speers, Teisl, & Leahy, 2013; Snell, Bell, & Leahy, 2013). Similarly, engagement of local people in the assessment and management of resources has been associated with their future stewardship of natural features (Streiner & Loomis, 1996). Findings such as those of Mooney and Eisgruber (2001) that demonstrated the negative property value impacts of some restoration measures and suggested the need for incentives if homeowners are to voluntarily adopt them are especially critical.

Full accounting of the range of market and non-market values associated with linear water resources is especially significant for public resource managers; the ability to quantify a larger number and proportion of the benefits that they offer bolsters public agencies' abilities to demonstrate their worth to both residents and the governing bodies (whether local, county, state/provincial, or national) that oversee them. In urban areas still prone to the blight of abandoned buildings, or the current or former use of prime waterfront locations by commercial or industrial enterprises that do not require or make use of this amenity, local government might consider partnering with the private sector to convert these properties to residential use given the potentially substantial increases such redevelopment is likely to result in for the local tax base.

Understanding the impacts of water-related entities on property values becomes even more essential in light of the threat of climate change, which is projected to lead to an increase in the frequency and possibly the magnitude of droughts, extreme precipitation events, floods and storm surges, as well as to wide-ranging changes in ecosystems (e.g., lake, river, stream and wetland levels, and temperatures) and in the geographic ranges, seasonal activities, migration patterns, abundances and species interactions of terrestrial, freshwater, and marine species (Pachauri & Meyer, 2014). All of the aforementioned impacts influence the relative attractiveness, associated property price premiums and consequent tax base enhancements, or reductions of water-based amenities.

An additional influence of climate variability and change will be on water quality. Several studies have demonstrated the positive relationship between improvements in river quality and hedonic proximity effects (Epp & Al-Ani, 1979 for houses near rivers and streams in rural Pennsylvania; Bin & Czajkowski, 2013 for waterfront properties in Martin County, Florida; Chen, 2017 for apartments with Pearl River view in Guangzhou, southern China), though another resulted in more mixed and inconclusive results for rivers and streams in North Carolina and Tennessee (Cho, Roberts, & Kim, 2011). Though this review focused solely on proximity and view effects, a similar argument can be made with respect to the need to consider non-market values when considering the potential impacts of the implementation of pollution control measures on linear water features, because full quantification of all likely outcomes—positive and negative—is necessary in unbiased fair cost–benefit analysis.

This collection of the existing literature concerning the impacts of proximity to and views of linear water features also provides a useful summary for community planners, property tax assessors, and real estate appraisers. For property developers, better enumeration of water-related premiums could encourage them to maintain and promote the existence of features already present in their project areas and to create artificial features to add further value in locations that allow the landscape to be manipulated in this manner. As noted by Nelson et al. (2005), although the supply of waterfront property on natural waterbodies is fixed, artificial waterways can be designed and built into new residential communities. The integration of home sites into golf courses, to generate an additional source of revenue for developers, is a well-established phenomenon (Nicholls & Crompton, 2007). The evidence presented here suggests that developers also stand to gain from the inclusion of artificial waterways in their housing schemes, that is, from deliberate increase in the supply of waterfront property. Should these features then pass into public hands as green spaces in similar projects often do, it is quite feasible to expect the increase in property tax revenue attributable to their presence to more than cover ongoing maintenance costs, thereby representing a benefit to private homeowners at no cost to public authorities.

Although the evidence with respect to the impacts of water-based amenities on residential property prices does continue to grow, little if any attention has been paid to commercial property prices/rents. As waterfronts continue to be targeted for redevelopment and revitalization, the ways in which river front/view and canal-side locations positively influence tax revenues via, for example, the attraction of new food and beverage outlets to locations offering waterfront dining opportunities, and premiums on hotel rates for rooms with river views, are worthy of investigation.

7 | LIMITATIONS

Though the hedonic approach does capture the price that surrounding homebuyers or renters are willing to pay for proximity to or a view of a water resource, it does not include three important elements of value: (a) aesthetic and recreational benefits accruing to non-resident day and overnight visitors to the area; (b) option, existence, and bequest values, that is, the passive values placed on resources by individuals who might never visit them but who nevertheless place value on their presence, in and of itself and for the benefit of others (see Loomis, 2006 for the argument in favour of including passive use values when calculating the benefits of lake and river restoration); and (c) any amenities or services that are not (fully) recognized by homebuyers and therefore not capitalized into prices. Thus, the hedonic approach underestimates the total recreational and/or aesthetic value of any amenity. Other methods such as travel cost, WTP, and contingent valuation exist to measure some of these benefits; however, their use with respect to the value of water is less prevalent than hedonic pricing, and their inclusion was beyond the scope of this synthesis. Similarly, the hedonic approach does not capture direct spending and associated sales tax generation by residents or visitors on water-based recreation activities, for example, on equipment purchases and rentals, entrance fees, and other spending associated with leisure trips (lodging, fuel, food and beverages, and so on).

The preponderance of significant findings does raise the potential of publication bias, "the tendency on the part of investigators to submit, or the reviewers and editors to accept, manuscripts based on the direction or strength of the study findings" (Scholey & Harrison, 2003, p. 235). Social science research projects with significant results are substantially more likely to be written up and published than those with null results (Franco, Malhotra, & Simonovits, 2014; Peplow, 2014). The extent of this bias with respect to the discussion presented here is of course indeterminable, though its potential existence should nevertheless be acknowledged.

Finally, as noted by an anonymous reviewer, the notion of linear water features serving as pleasant visual amenities may be a "western" perception. Further, that perception may vary over time, especially in relation to chronic or occasional hazards such as pollution and floods, and with respect to waterborne threats to human health, particularly in less developed nations. Though beyond the scope of this review, these varying perceptions and the hazards associated with locations in proximity to water features are of course critical to recall and have been addressed in other papers. The relationships between property values, location in a flood zone, and insurance premiums have been assessed in a coastal context by Bin, Kruse, and Landry (2008), whereas implications of flooding for homes proximate to linear features have been addressed in at least two reviews (Chao, Floyd, & Holliday, 1988; Daniel, Florax, & Rietveld, 2009).

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