Is Small Beautiful? Facing Challenges in the Assessment of Small Projects

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Abstract

Small environmental projects, accounting for a substantial share of environmental expenditures, seldom face cost benefit analyses (CBAs). Lacking a portfolio of previous small project CBAs, benefit transfer methods are difficult to apply, particularly for benefits that exhibit distance decay. We examine a small project in the southern interior of British Columbia, calibrating a Monte Carlo simulation by benefit transfer and identifying distance decay rates that lead to break even expected project net present value. We suggest that targeted valuation studies can be used to cost effectively calibrate the WTP landscape and contribute economic

valuation insights to project selection methods.

1 Introduction

In some nations, expenditures by government, industry and households related to environmental protection may exceed 2% of GDP (Broniewicz, 2011). The vast majority of this is accounted for by the management of waste and of wastewater, with the protection of water quality frequently the third largest component. Expenditures on the protection of biodiversity are only occasionally reported as a separate category, and when they are they account for amounts comparable to nonclassified environmental expenditures. Most of these expenditures are made by government and regulated firms, with household expenditures on environmental protection typically account for less than a ten percent share (Pearce and Palmer, 2001). Since many of these costs are the consequence of regulations, much of the analysis of the costs and benefits of environmental protection has focused on such regulations (for example EPA, 1997, 1999; Krupnick and Morgenstern, 2002).

Excepting 'charismatic megaprojects', expenditures on biodiversity protection and habitat restoration projects have typically not received rigorous analysis of costs and benefits. Many government programs, foundations, environmental and conservation groups, and business philanthropic activities include providing funds for small scale environmental projects. Some examples relevant to the province of British Columbia include local conservation funds like the Columbia Valley Conservation fund (Kootenay Conservation Program, 2021), the Real Estate Foundation of BC (Real Estate Foundation of BC, 2021), Ducks Unlimited Canada (Ducks Unlimited Canada, 2021) and the Patagonia company (Padagonia, 2021).

Elements of a landscape can provide a variety of goods and services, ranging from those that are purely private to those that are purely public (Brown et al., 2007). Purely private goods can be valued at their market price. Purely public goods are valued by summing the willingness to pay of each individual given standing. The greater the extent to which a good is public, the greater the challenges in estimating the benefit generated by increasing the level of that good. Many projects that affect the landscape modify combinations of public and private landscape services (De Groot and Hein, 2007; Antrop et al., 2013; Song et al., 2020). How people enjoy some of these services may depend on where they live relative to the location of the project.

The role of distance in the willingness to pay for amenities or public goods is quite well known. Many hedonic property valuation studies have established that the distance from an amenity or disamenity can be a priced characteristic. A review by Crompton (2001), recently updated by Crompton and Nicholls (2020), consider more than 60 studies, finding that in the vast majority that being near a park increases property value. Passive parks are found to increase value more relative to active parks, particularly for those properties closest to the park. Considering lakes and reservoirs, a review by Nicholls and Crompton (2018) finds consistent evidence that greater access to such water bodies increases property prices. Some water bodies, such as industrialized, dammed, and/or polluted rivers reduce prices for nearby properties (Lewis and Landry, 2017).

Bateman et al. (2006) show that if use value is higher than non-use value, then with increasing distance, the share of non-users in the population increases and average WTP for a resource should decrease with distance. They demonstrate this with a valuation study, showing that calculating value based on an economic jurisdiction, defined as the area around a project where the WTP from a spatially explicit valuation function is positive, produces a substantially lower, and they claim more accurate, measure of aggregate WTP than using at the mean estimates applied to a political jurisdiction. Bateman et al. (2011) refine this result, demonstrating for river water quality improvements that distance and proximity to substitutes is important, and that value function transfer is superior between dissimilar sites while mean value transfer has lower error between similar sites. Their evidence supports one of their central propositions, that simple value functions based on economic theory are superior to ad-hoc value functions using site specific variables. Bergstrom and Loomis (2017) review the results of more than thirty studies were nonmarket valuation was used to inform CBAs of river restoration. Only about one in eight of these CBAs were central to the decision to proceed with the restoration, with the remainder serving as part of larger information gathering efforts or focused more on valuation methodology than support of decision making. The authors note that more such studies are needed to support meta-analyses that can generate benefit transfer functions, particularly functions that can inform the valuation of small projects.

In many situations, particularly where small projects are concerned, it is impractical to directly estimate the nonmarket impacts (Bergstrom and Loomis, 2017). Transferring results from previous studies provides a potentially useful approximation. Rosenberger and Loomis (2017) provide a history and description of the benefit transfer approach, pointing out that benefit function transfer, when possible, is generally more precise than value transfer. Lewis and Landry (2017) use a difference in difference estimate to calculate the effect of removing a dam on the value of proximity to a river. The reduced disamenity of proximity provides a means to calculate the benefit of dam removal from the river reach where a dam remained in place. They cannot distinguish what aspects of the restoration are affecting willingness to pay. Schaafsma (2015) describes how spatial heterogeneity in ecosystem services, in the availability of substitutes, in the cost of access and use, and in the clustering of individuals with similar WTP can generate spatial patterns in WTP that should be considered in benefit transfer. Johnston et al. (2017) conduct a meta-analysis of WTP for water quality improvements, demonstrating a clear relationship between geospatial features and WTP across a variety of studies. Johnston et al. (2019) repeat the analysis in Johnston et al. (2017), using project size scaled by a population weighted distance as a spatial variable. Results are strongly significant. However, both these analyses consider improvements that could support swimming and boating, and are therefore not applicable for small projects on water bodies that have no water based recreation value. Logar et al. (2019) used pared CV and DCE surveys to estimate the WTP for two river restoration projects in Switzerland. While the empirical results documented a distance decay effect, in their application of the results to a CBA of the restoration projects, they opted to use the mean estimated benefit for rural residents with access to the river segments.

We contribute to this literature by applying a benefit transfer approach to a small project that impacts a multifunctional agricultural landscape incorporating a distance decay effect. Our work strongly corroborates the review by (Bergstrom and Loomis, 2017) that highlights the lack of small project analyses. Absent analyses of similar size projects, we had to apply large adjustments for differences in project size and population with standing. Rather than relying on single values from these adjustments, we implemented a Monte Carlo approach and report a distribution of net present values. We show that the choice of distance decay rate determines radii at which an average WTP can be determined. Aligning these radii with population centers within the area with standing may provide locations where quick and low cost valuation surveys can be conducted to provide insight into the value generated by a small project.

The remainder of the paper is organized as follows. In the next section we describe the restoration project that we focus on. In the following section we describe cost and the private and social benefits generated from the project, how we selected benefit transfer values, and how these vary over time. Herein we also describe the population with standing and how distance decay will be incorporated, and how this all will be operationalized as a Monte-Carlo experiment. This is followed by a discussion and conclusion.

2 The Restoration Project

Figure 1 locates the project site within the southern interior of British Columbia, and in relation to Fortune Creek, the main creek draining the watershed within which the project is located. The project itself involves a series of works in and around a reach of Alderson Creek. This reach is locally known as Alderson Creek, although the provincial Freshwater Atlas (GeoBC, 2010) locates the stream channel further east. This discrepancy reflects the fact that the stream channel network was mapped based on ground elevation data, while a significant share of the flow from the main channel of Alderson Creek was diverted into a ditch that terminates near the upper end of the project reach. The stream channels and various land uses sit on a large alluvial fan of material eroded from the hillsides to the southeast, with significant groundwater movement draining some streams, recharging others, and generating groundwater seeps at various places throughout the local landscape. The project itself is the latest example of the ongoing efforts by the land managers along the stream to adapt to and modify the stream in a way that allows them to achieve their objectives.

Along this stream reach, land uses are primarily livestock grazing and forage production. Vegetation, particularly large trees, along the stream channel take

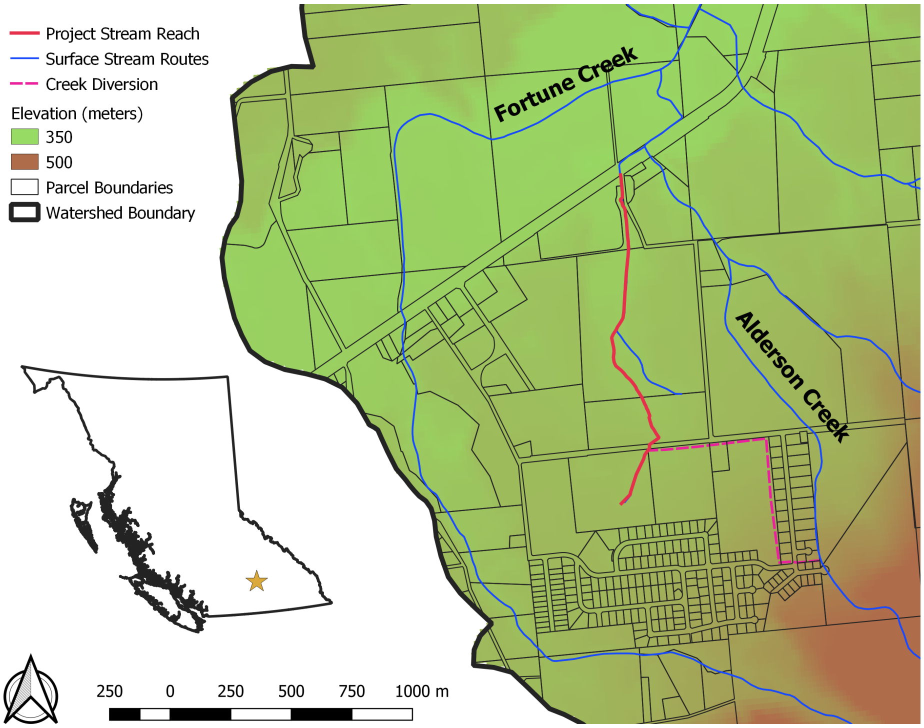

Figure 1: Alderson Creek restoration project location.

up space and shade adjacent land, reducing its productivity. Stream meanders consume land area and make it more difficult to operate large equipment. The stream itself provides a water source for livestock. Over the years, almost all natural riparian vegetation has been removed, portions of the stream channel straightened and relocated, and little effort taken to manage livestock access to the stream. Some undesirable consequences of these stream modifications include invasive sun loving watercress choking the stream channel and causing local flooding with heavy precipitation events with adverse health impacts on cattle from the muddy stream area they frequent. However, interventions, such as periodically digging out the stream channel with excavators and the periodic need to pay for veterinary care were not seen as unreasonable adaptations.

In recent times public concern about the environment has lead to the strengthening of environmental protections in many places. In British Columbia, one place this has manifested itself is in strict regulations governing works in and about a stream (Government of British Columbia, 2014). Shortly before to the initiation of this project, a land owner was charged and fined for conducing unauthorized works in the stream channel. Subsequent dialog between a government official and the land owner started a process that culminated in the formation of the Alderson Creek Restoration Society and the preparation of a Environmental Farm Plan Group Plan, an initiative under the provincial Environmental Farm Plan program at the time (of Agriculture, 2010). Completion of the plan enabled the land owners to apply for government funding to assist with undertaking the works set out in the plan.

Table 1 lists the main project works and their estimated costs. Estimates include the value of contributions by the land owners themselves. These works were meant to achieve two main objectives: restore natural functioning to the stream so that it would be better able to remove water from the area, and

Table 1: Project Costs

Activity	Cost
Stabilization stream bank to reduce erosion	$38,984.50
Fencing to exclude livestock from a riparian buffer	35,510.20
Planting native vegetation in a 5 meter riparian buffer	50,075.00
Constructing low impact stream crossings	4,267.16
Constructing off stream livestock watering	12,265.91
Installing drainage into water affected lands near stream	22,077.22
Total	$163,179.99

to enhance the agricultural value of lands adjacent to the stream by installing drainage to offset a high water table. The implicit justification for the government subsidizing these works is that they generate benefits to society at large that are commensurate with the investment society is making in the project. The aim of this analysis is to estimate a value for those social benefits, and compare those to the project costs.

The overall length of the stream reach where the works will occur is 1.50 kilometers. The costs in Table 1 apply to the project if the protected riparian buffer on each side of the stream will be five meters wide. Reducing the buffer width to three meters will reduce the planting costs, as less area needs to be planted. However, the changes in the other project costs are expected to be minimal with a change in buffer width.

3 Methods

For this project, the cost of a valuation study would likely be well within an order of magnitude of the total cost of the project. Conducting such a study may exhaust any project benefits. The cost effective approach to assessing the impacts of such a project is therefore benefit transfer. As noted in Rosenberger and Loomis (2017), ideally we would used a calibrated benefit function to transfer values to our project site from one or more study sites. However, our project site is very small, relative to the types of sites typically studied, pushing statistical predictions far away from the means of the study sites and the area where the prediction error is small. The key issues in this cost benefit analysis are identifying the external benefits and attaching appropriate values to those benefits. The total value generated by any particular benefit will depend on how they are distributed across the affected population. In this case, the small scale of the project and its isolation relative to significant habitats or connectivity corridors means that many of the benefits may not be pure public goods. We would therefore expect proximity to the project to be important to the value that a household would place on a substantial portion of the benefits generated by the project, consistent with the literature cited earlier.

3.1 Private Benefits

The project promised a number of benefits that were captured primarily by those managing land involved in the project. The two main benefits were the increased area of productive land after the installation of drainage and the reduction in the health consequences of livestock having wet hooves. There are 10.41 acres of land affected by a high water table that could be improved with drainage. With a five meter buffer, 6.23 acres of land will be improved for agricultural use, while 7.91 acres are improved when the buffer is only three meters wide. The assumed use of the improved land was production of an alfalfa and grass mixed hay, selling for \$7.00 per bale. Each bale is assumed to weigh 50 pounds. Assumed costs were \$2.00 variable and \$1 fixed. Yield would be 1.7 tons per acre for the first year and 2.5 tons per acre for the next four, with yield then declining to a long run average. Two cuts of hay would be produced each year. Price, cost and production values were chosen after consultation with project land owners and local hay producers. While yields, costs and prices are not in reality constant, for this analysis our emphasis was on variation in benefit values.

Conversations with project land owners also revealed that over the last decade two animals were lost to drowning in a small pond along the water course. These animals fell through thin ice on the pond in the winter and were not recovered before perishing. These conversations also revealed that there were hoof health issues that sometimes required veterinary attention. Consultation with the land owners and a veterinarian lead us to assume that an animal was worth \$2,000, and that the probability of an animal being lost was 0.10. Total cost of antibiotics, veterinarian visits, etc. was assumed to be \$480 per year, again based on consultation with land owners and a veterinarian. For simplicity, we used the \$200 expected annual cost of animal loss and one full treatment regime each year at \$480, with the corresponding benefit to the participating land managers being the avoidance of these costs. With our focus on the variation in the ranges of external benefits, for our Monte-Carlo analysis we did not include animal loss and illness as probabilistic events.

3.2 Social Benefits

Collecting primary data to assess the benefits generated by small projects is rare. The size of the project is unrelated to the number of observations necessary to achieve desired significance for statistical analysis, and as such the cost of a valuation study for a small project will not differ much from that for a large project. It is very difficult to justify spending more to analyze a small environmental project than the amount the project itself costs. Therefore, previous analyses that could support application of the benefit transfer approach would have to present results per household and per benefit unit (typically unit of land area). Few did so, and as shown below, those that did had vastly different values. To acknowledge this variation, we opted to use the ranges of values to parameterize a Monte-Carlo experiment. Table 2 cites the original studies, the ranges and units reported in those studies, and the scaled benefit values used in the Monte-Carlo experiment.

Seven benefit categories were settled on. Five of these, riparian habitat, landscape aesthetics, wildlife, erosion control and water quality, were taken to be environmental services where the size of the benefit depended on the area of the project. The studies used to generate value estimates reported values for one or more of these benefit categories. In some cases, such as Chen et al. (2014), specific value estimates were reported for more than one environmental service and therefore these were used for more than one of the categories we are using. In some other cases, including Loomis et al. (2000), the value estimate captured multiple environmental services. In these cases, the reported benefit value was divided by the number of relevant services, and the fractional service value assigned to the benefit category we used. In a couple of cases, specifically Angus (2012) and D'Souza et al. (2006), more than one estimation approach was used. We therefore included more than one range of values from these studies in our simulation.

For these area dependent environmental services, the consulted studies either reported results in per household per unit area per year terms, or they contained project descriptions that allowed a project area and a population with standing to be identified. We could therefore use the reported benefit to calculate an average per household per unit land area benefit value. One time values were divided by 20, the expected time before major repairs were expected to be necessary to fencing, etc., to generate an approximate annual value. These values were then used to calculate benefits by project scale, which consisted of a three or five meter buffer area on both sides of the stream reach.

Table 2: Sources for values used, values reported, and values after transferring them to scale of the Alderson Creek project.

	Original				Transferred		
Source	Min	Max	Cur.	Unit (WTP)	Min	Max	Unit (CAD)
Riparian Habitat							
Amigues et al. (2002)	7.00	25.00	USD	/per/yr	0.0934	0.334	/hld/ac/yr
Chen et al. (2014)	4.08	6.23	EUR	/hld/yr	0.00631	0.00963	/hld/ac/yr
Trenholm et al. (2013)	-1.38	12.88	CAD	/hld/yr	-0.00471	0.0441	/hld/ac/yr
Loomis et al. (2000)	50.40	50.40	USD	/hld/yr	0.000341	0.000341	/hld/ac/yr
Landscape Aesthetics							
Trenholm et al. (2013)	-1.38	12.88	CAD	/hld/yr	-0.00471	0.0441	/hld/ac/yr
Van Bueren and Bennett (2004)	0.02	0.14	AUD	/hld/yr	0.00000106	0.00000742	/hld/ac/yr
Chen et al. (2014)	3.62	5.94	EUR	/hld/yr	0.00559	0.00918	/hld/ac/yr
Wildlife							
Weber and Stewart (2009)	-12.89	25.05	USD	/hld/yr	-0.00500	0.00972	/hld/ac/yr
Angus (2012)	48.56	69.3	CAD	/hld/yr	0.000137	0.000196	/hld/ac/yr
Angus (2012)	50.20	75.69	CAD	/hld/yr	0.000142	0.000214	/hld/ac/yr
Robbins et al. (2009)	23.00	25.00	CAD	/hld/yr	0.00448	0.00487	/hld/ac/yr
Erosion Control							
Lantz et al. (2009)	10.90	23.38	CAD	/hld/yr	0.0930	0.200	/hld/ac/yr
Colombo et al. (2003)	18.32	35.43	EUR	/per/yr	0.000346	0.000669	/hld/ac/yr
Loomis et al. (2000)	50.40	50.40	USD	/hld/yr	0.000341	0.000341	/hld/ac/yr
Water Quality							
Angus (2012)	200.14	288.54	CAD	/hld/yr	0.000566	0.000817	/hld/ac/yr
Angus (2012)	198.14	291.92	CAD	/hld/yr	0.000561	0.000826	/hld/ac/yr
D'Souza et al. (2006)	48.59	89.32	USD	/hld	0.0000389	0.0000715	/hld/ac/yr
D'Souza et al. (2006)	31.61	61.7	USD	/hld	0.0000198	0.0000386	/hld/ac/yr
Loomis et al. (2000)	50.40	50.40	USD	/hld/yr	0.000341	0.000341	/hld/ac/yr
Salmon							
Payne et al. (2000)	13.20	16.40	USD	/hld	0.000151	0.000188	/hld/yr
Garber-Yonts et al. (2004)	51.00	67.00	USD	/hld/yr	0.0119	0.0157	/hld/yr
Stevens et al. (1991)	6.25	7.93	USD	/per/yr	0.00474	0.00601	/hld/yr
Carbon Storage							
Government of British Columbia (2008)					30.00	30.00	/tonne/yr

Two benefit categories were treated differently in scaling to the Alderson Creek project, the value of improvements to salmon productivity and carbon storage. For salmon, improvements to Alderson Creek were taken to impact the salmon habitat quality of Fortune Creek, the creek to which Alderson Creek is a tributary. The studies consulted reported willingness to pay to protect salmon populations, values taken to be relevant to the Fortune Creek system. These values were scaled by the area share of the Alderson Creek watershed to the Fortune Creek watershed. This results in a value per household that is not a function of the project area. Carbon storage was treated as a pure public good for the province, with the value of a tonne of stored carbon being the size of the carbon tax in 2017, the year when the project works were started. While the value of a unit of stored carbon was not varied, variation in the estimated amount of carbon stored created ranges for the total value of stored carbon (see Marton et al., 2014)

3.3 Costs

Most of the direct project costs are shown in Table 1. One additional cost is the opportunity cost of the land included in the riparian buffer. While the wider buffer increases the area contributing external benefits, it also consumes land that could be used for agricultural production. The value contributed by this land was taken to be the value of the forage that could be produced on this land. While some of this land is too close to the stream channel to be effectively worked with machinery, it could still provide feed for livestock able to graze there. We therefore see it as appropriate to use the net forage production value of this land as the opportunity cost. Due to variations in the local topography and natural soil conditions, one of the land owners was in a position to grow a higher valued type of forage, Timothy hay. For the portion of the riparian

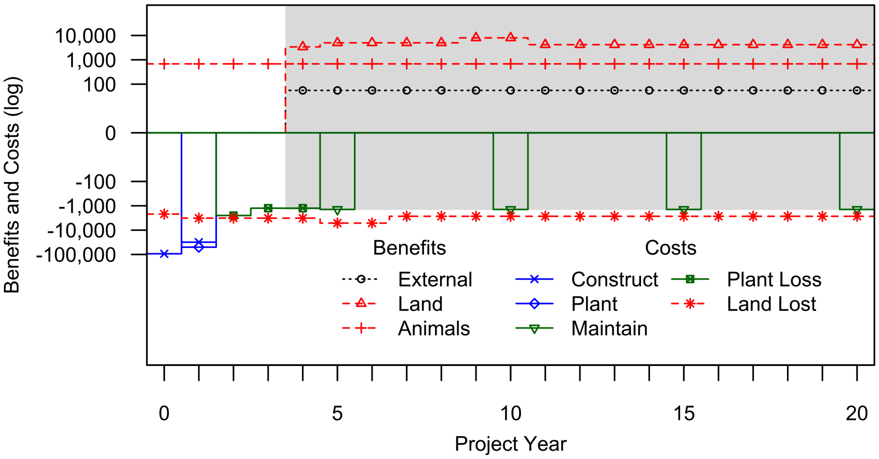

Figure 2: Timeline of costs and benefits. Greyed region reflects fact that the actual benefit values used in each simulation will vary.

buffer that took this land out of production, a hay price of $8.00 per bale was used instead of $7.00 per bale. The three meter riparian buffer has 60% of the opportunity cost of the five meter buffer.

3.4 Distribution Over Time

A twenty year time horizon was used, based on the expectation that degradation of fencing material, weather effects, and agricultural operating realities whereby damage is likely to be done to the fencing. The distribution of the costs and benefits over this horizon is illustrated in Figure 2. Construction costs are split between the first and second years of the project, with initial planting costs occurring only in the second year. Additional planting costs occur in the third through fifth years to replace loss of a share of the initial plantings. Some basic maintenance, amounting to 5% of the project construction cost, is included every five years.

The reduction in animal production costs is assumed to occur immediately, as a key initial task necessary for the success of the later parts of the project is keeping livestock out of the stream channel. The increased agricultural production due to the installation of drainage is not assumed to be realized until the fifth year. The increase in forage production is also assumed to begin in year five, with the profit in that year being lower, reflecting lower yields in the year that the forage crop established itself. Its peak production occurs in the second through fifth years after planting. Following this high production period, it is assumed to fall to a lower average, reflecting invasion by weeds, etc. Conversations with land owners and agricultural experts suggested that the improvement to the land from drainage may enable more valuable crops to be grown or justify irrigation. At the time the project was initiated, no land managers had plans to change crops. However, to reflect this option value, we added two years in the middle of the planning horizon where an additional forage crop is grown (three harvests instead of two in those years). The cost of land excluded from production was the negative of the increased production benefit, adjusted for the area lost, with the loss occurring from the date the project was initiated.

Figure 2 does not break out the individual external benefits into their components. For each simulation, the external benefit is assumed to remain the same in each year. The benefits are taken to not occur until the fifth year after the project was initiated. Some benefits may ramp up over a longer horizon, while others may start almost immediately. However, for simplicity, we did not add this additional detail. The position of the external benefit line will be different for each simulation run, a fact reflected by the gray range in the figure.

3.5 Population and Standing

The total value contributed by any benefit category depends on the number of people who have standing, and the value that each of those people places on the benefit. The small size of the project and its relative isolation suggests that many of the benefits should be less for people who are further from the project. To examine this, we apply a distance decay function to calculate a scaling factor for each household, based on its distance from the project:

$$s_i = \left[1 - \left(\frac{d_i}{1+d_i}\right)^{\alpha}\right]$$

where s_i is the scaling factor applied to household i which is d_i kilometers from the project. The parameter α controls the rate at which benefits decay with distance. When $\alpha = 0$, the only benefits that count are for those who are located at the project. As $\alpha \to \infty$, $s_i \to 1$ for any value of d_i.

Scaling the benefits by distance requires knowing where all the households with standing are located relative to the location of the project being evaluated. We began by considering the three closest regional districts, the Regional District of Columbia Shuswap, the Regional district of North Okanagan and the Regional District of Central Okanagan, and the incorporated municipalities within the regional districts. Household locations were approximated using the parcel boundary GIS layers and zoning layers available from the regional district websites and from most of the incorporated municipalities. Parcels within an area zoned residential were assumed to have residences, and the centroid of each of these parcels was taken to be a household.

Distributing the population of each regional district across the number of residential parcels would provide an estimate of the population distribution. However, multifamily residential housing typically appears as single parcels. To better reflect this aspect of the population distribution, we used the census dissemination areas reported by Statistics Canada. Each dissemination area had a population between 400 and 700 residents. Distributing the population of each dissemination area across the number of parcels in each dissemination

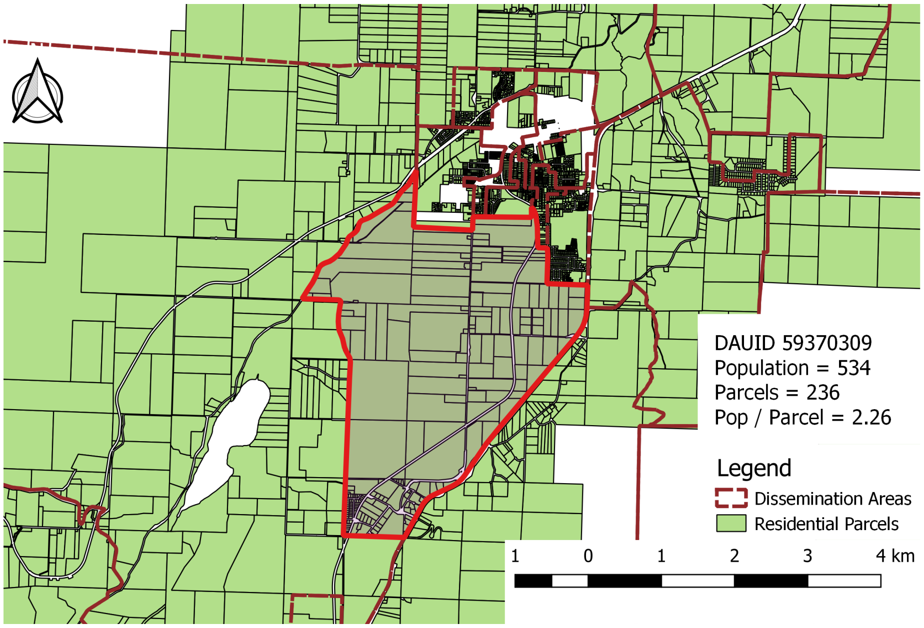

Figure 3: Example intersection of dissemination area boundaries and parcel boundaries used to approximate population distribution.

area provides an average per parcel population for each dissemination area. Dissemination areas with a large number of muli-family parcels will tend to have a higher per parcel occupant count than parcels in dissemination areas dominated by single family residential parcels. Figure 3 illustrates an example. The dissemination area #59370309 has a population of 534. There are 236 residential parcels with centroids inside the dissemination area. Each parcel is therefore assigned 2.26 persons.

The approximated population distribution is shown in Figure 4. Each household point is a centroid of a residential parcel. The project itself is located within the Regional District of North Okanagan (RDNO). If the project were funded through a local initiative, then the population of this regional district would be the appropriate group with standing. The project is funded through a federal and provincial partnership. Given the small size of the project and the likely decay with distance for the value from many of the services, the population distribution for the entire province or country was not considered. The two adjacent regional districts along the axis of the Okanagan Valley were included as this reflects the main transportation direction, and therefore people along this corridor stand the largest chance of being exposed to the impacts of this project. The largest population center is the city of Kelowna, in the Regional District of Central Okanagan (RDCO). The RDCO population is almost 195,000, with the RDNO population at almost 85,000 and the Regional District of Columbia Shuswap (RDCS) being just over 61,000 (Statistics Canada, 2017). The RDCO population may play an important role in determining the total benefits generated by the project. The limited and remote populations at a distance in the RDCS would be expected to enjoy little benefit from the project.

Procedurally, once the spatial distribution of households is known and the distance decay function has been parameterized, a scaling factor can be calculated to multiply the benefit and cost category by. In principle, the distance decay can depend on the benefit or cost being evaluated. Environmental services that are local in nature, such as aesthetics, would decay quickly, while those that are more public in nature, such as existence values for rare species, would decay more slowly. Without any empirical basis to choose different decay rates, we applied the same distance decay to all local benefits. Carbon storage, however, was treated as a pure public good.

3.6 Monte-Carlo Experiment

Only a few of the studies used to parameterize our Monte-Carlo experiment reported distributional information such as standard errors for their estimates. Our parameterization information therefore consists of a set of ranges for each benefit category, as show in Table 2. We have no information that would suggest

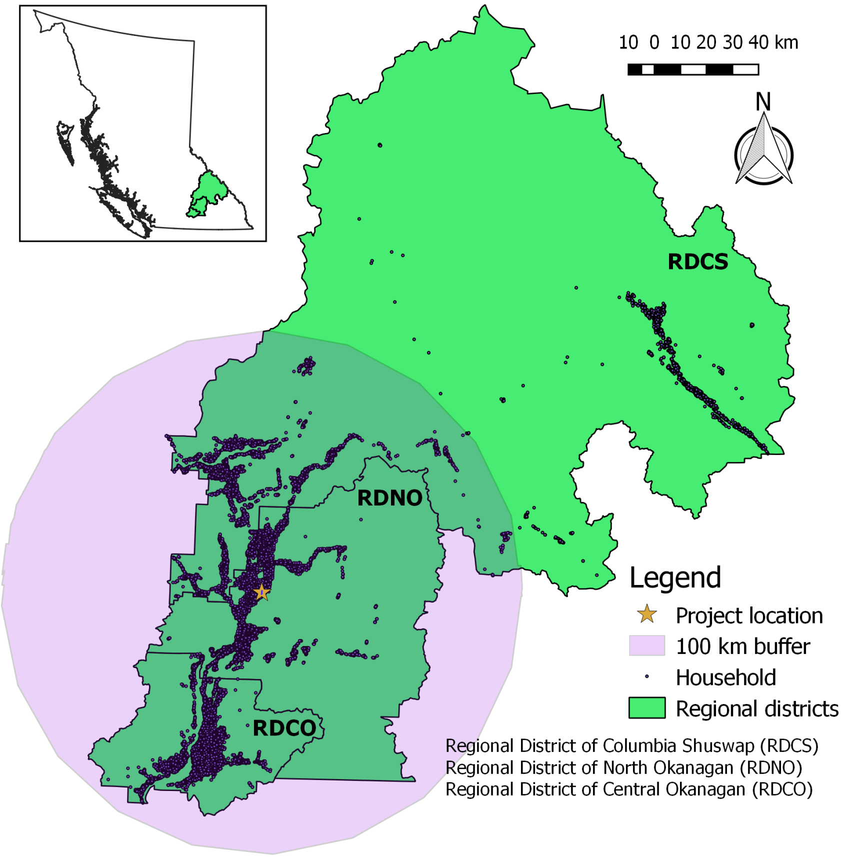

Figure 4: Approximated population distribution.

the superiority of any single study, and didn't have any strong reason to choose a particular distribution over the parameter ranges. For each simulation run, for each benefit category, we randomly selected one of the study's ranges. The value of the benefit category for this run was then chosen as a draw from a uniform distribution over that range.

The benefit value sampling process results in a set of values for each benefit category. This benefit was then multiplied by the population distance scaling factor to generate an aggregate benefit value, and scaled to reflect the three or five meter buffer width. The values for all benefits were next aggregated to arrive at an annual benefit. This aggregate benefit value was included in the time path of costs and benefits for years five to twenty (see Figure 2). Those further costs and benefits, such as land productivity changes, were similarly scaled to reflect the buffer width for the experiment and placed into the time path of costs and benefits. Once the time path of costs and benefits was determined, the net present value was calculated. The two discount rates, 3% and 5%, effected a limited sensitivity analysis beyond that embodied in the Monte-Carlo experiment.

Variation of the distance decay parameter α constituted the main treatments of our experiment. We chose two bracketing values for α, no distance decay ($\alpha \to \infty$) and a halving of the benefit value for each kilometer from the project ($\alpha = 1$). With the latter decay rate, households beyond a ten kilometer radius of the project value the benefits at less than 0.01% of those immediately adjacent to the project. With $\alpha = 1$, in effect only people very close to the project gain any benefit from it. Between these brackets, we also searched for that value of α which would result in an expected break even for the project. This was done for both the larger standing area - the three regional districts - and a smaller standing area defined by the population distribution of the households within

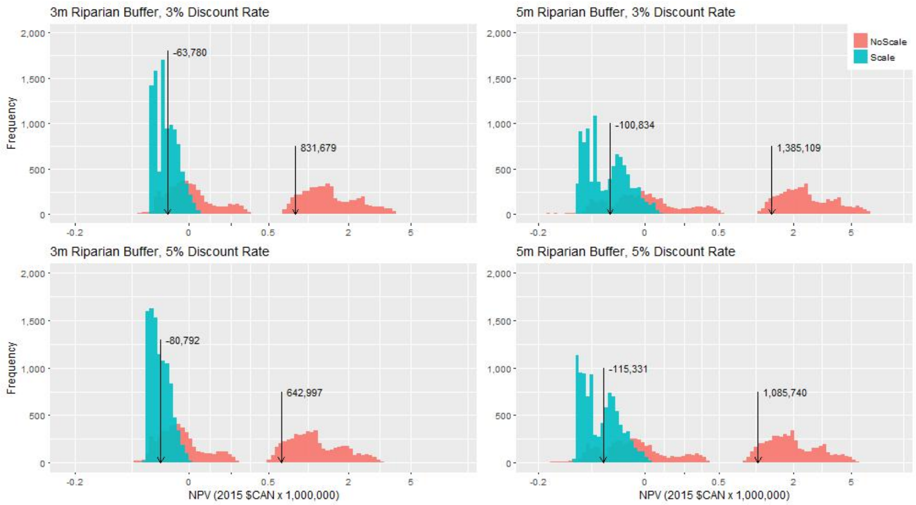

Figure 5: Results for bracketing distance decay parameterizations.

RDNO, the regional district containing the project.

4 Results

Figure 5 shows results for the bracketing distance decay parameterizations, $\alpha = 1$ and $\alpha \to \infty$. For all four cases, the average NPV is large and positive when household benefit does not decline with distance over the population with standing ($\alpha \to \infty$), while when it decays by half with each kilometer, the average NPV is negative. In all four cases, for both decay parameterizations, both positive and negative NPVs occur in some of the simulation runs.

We argue that it is reasonable to expect the benefits a household receives from this project to decline with the distance the household is from the project. However, we have little basis to choose the way that those benefits decline with distance. We therefore turn to considering how to parameterize our distance decay function such that the project has a zero NPV. Table 3 presents the values for α that result in an average NPV of zero, together with the several measures

Table 3: Break even project forms, scaling factors, and willingness to pay for various distances.

Standing	RDNO, RDCO and RDCS				RDNO			
Buffer	3 m		5 m		3 m		5 m	
Discount	3%	5%	3%	5%	3%	5%	3%	5%
α	4.261	6.132	3.926	5.190	12.199	20.178	10.430	15.089
d (km)								
$s_i = 0.50$	5.66	8.36	5.18	7.00	17.10	28.61	14.55	21.27
$s_i = 0.01$	424	610	390	516	1213	2007	1037	1501
Household i Benefit Scaling Factor								
$d = 25$	0.154	0.214	0.143	0.184	0.380	0.547	0.336	0.447
$d = 75$	0.055	0.078	0.051	0.066				
$d = 100$	0.042	0.059	0.038	0.050				
Household i Willingness to Pay (CAD)								
$d = 0$	4.66	6.07	7.90	10.13	4.66	6.07	7.90	10.13
$d = 25$	0.72	1.30	1.13	1.86	1.77	3.32	2.65	4.53
$d = 75$	0.26	0.47	0.40	0.67				
$d = 100$	0.20	0.36	0.30	0.50				

that describe the distribution of willingness to pay across the population with standing that results in a zero NPV. When the population with standing is large, when all three regional districts are included, the value of α ranges from 3.926 to 6.132. Reducing the population with standing to those that are resident in the RDNO increases the value of α for all the cases. It now falls between 10.430 and 20.178. When less people have standing, the value of the project benefits to them cannot decline as quickly if the project is to break even.

The distribution of values can be characterized by how far away from the project a household can be before the benefit it receives from the project falls to a particular level. In Table 3 we consider two levels. The benefit scaling factor s_i can fall to a half in about six kilometers or less and the project will break even when all households in the three regional districts are included. There are 2,779 household points of the 117,727 household points identified for the three regional districts within ten kilometers of the project. If only the households in the RDNO are considered, then the radius within which households need to value the project at least half as much as those immediately adjacent to the project is about twenty kilometers or less. This translates into 9,892 household points of the 26,394 in the RDNO, close to 40% of the household points in the regional district.

Another perspective is to consider the size of the scaling factor for various distances from the project. The center of the city of Vernon is approximately 25 kilometers from the project, while the center of the city of Kelowna is approximately 75 kilometers away. The scaling factors for the RDNO exclusive situation lie between 0.336 and 0547. When only the benefits to residents of the RDNO have standing, the benefit value to typical resident in Vernon needs to be at least one third of the value at the project location. If we consider all residents of the three regional districts to have standing, then the typical Kelowna resident, at 75 kilometers from the project, need only value the benefits at between 5 and 8 percent of the value at the project.

Finally, the scaling parameters can be used to adjust the willingness to pay at the project to that at the chosen distances. Notice that the WTP at the project location depends on the case being considered. The WTP to make the project break even is higher when the discount rate is higher, reflecting the fact that future benefits count for less. Similarly, when the buffer is wider, the project costs are higher, and residents must have a higher WTP to make the project break even. When the RDNO alone is considered, the average WTP for the typical Vernon resident, at 25 kilometers from the project, needs to be between \$1.77 and \$4.53 for the project to pay. When all three regional districts are included, the typical Kelowna resident, at 75 kilometers away, needs to have a WTP between \$0.26 and \$0.67 for the project to pay. The contribution by residents outside the RDNO to the overall WTP means that the typical Vernon resident needs to pay between \$0.72 and \$1.86, less than half of the

WTP required by the typical Vernon resident when only RDNO residents have standing.

5 Discussion

Small projects account for a substantial portion of expenditures on environmental project. Given growing interest in the role of green infrastructure (Benedict et al., 2002; Brown et al., 2007), which are often small projects, recognizing the multiple services that such infrastructure provides and providing an estimate of the value of these services can help demonstrate their return relative to more traditional built infrastructure. However, the net economic benefits of such projects are seldom evaluated. In many cases, the cost of conducting a CBA that involves collecting primary data will exceed the net economic benefit of the project. Analyzing small projects using a benefit transfer approach would have much lower costs. However, the questionable cost effectiveness for CBAs of individual small projects means that there does not exist a database of small project CBAs and/or benefit valuation studies to inform benefit transfer based analyses.

Our analysis focuses on a small stream restoration project that is expected to generate a mix of public and private benefits. The studies consulted to inform our benefit transfer were for substantially larger projects. We applied the simplest possible benefit value function (Bateman et al., 2011) - scaling by population and/or by project area - to adjust for differences between the benefit being valued and that reported in the literature. The large difference in project scales left us questioning the suitability of even this scaling, as we are far outside the range where prediction accuracy from regression analysis is considered reasonable. We therefore used a Monte-Carlo approach to generate a distribution of net benefits. We used ranges of value estimates reported in each study to parameterize a uniform distribution over parameter values, taken as a more conservative approach than assuming a distribution with a stronger central tendency.

We also incorporated a distance decay effect for a portion of the benefits (Bateman et al., 2006). While there are a number of studies that have demonstrated distance decay, there are none that we felt would reasonably represent an appropriate distance decay for the project being studied. Instead, we inverted the process, exploring the interaction between distance decay and jurisdiction size that would generate a zero expected net benefit (see also Johnston et al., 2017, 2019). This allows us to identify WTP values as a function of distance from the project.

In many cases, including ours, there are population concentrations within the region where people have standing. It may be relatively simple to conduct a 'rapid valuation study' at a small number of these population centers to both validate the distance decay and to establish if the average values at the distance of these population centers achieves the break even threshold for the project. Conducting a small number of valuation surveys at population centers within the potentially relevant jurisdiction can be used to parameterize the distance decay, establish an estimate of the relevant jurisdiction and whether the net benefit of the project is positive for this relevant jurisdiction. Using a choice experiment with attributes reflecting the environmental services most impacted by the project could also reveal which services people within the jurisdiction most value. Using at least one pure public good attribute - e.g. biodiversity protection - and one use based good - aesthetics, hiking, fishing - could further parameterize the distance decay, where that decay would asymptote towards the WTP for the pure public good.

Sample selection and survey design for such focused valuation studies could build on the Rapid Rural Appraisal (RRA) literature (Chambers, 1981; Gow, 2019). Chambers (1981, p.95) describes applying " ... optimal ignorance - knowing what is worth knowing - and proportionate accuracy - recognizing the degree of accuracy required." as central to developing effective rapid appraisals. While RRA has generally been applied in developing economy situations, where rapid, low cost appraisals of project outcomes or local needs are required to match project or funding timelines, Chambers' insights would also seem applicable to effective rapid, low cost appraisals to inform the distribution of budgets for small environmental projects. For example, using census data to select neighborhoods within the identified population centers that are representative of the potentially relevant jurisdiction on important variables would control for things that are likely not worth knowing, while choosing those neighborhoods to provide variation in distance from the project would heighten the accuracy of the distance decay estimate.

More participatory approaches, such as adaptations of participatory rural appraisal (Chambers, 1994; Robinson, 2002) and deliberative valuation (Howarth and Wilson, 2006; Kenter et al., 2016; Vargas et al., 2017) could also be adapted to provide insight on aspects of distance decay and aggregate valuation of the services generated by one or a collection of small projects. Participants in these participatory processes would represent the demographic variation of the potentially relevant jurisdiction, and be grouped so as to capture variation in distance from the project(s). The options participants deliberate over would enable assessment of the relative importance of the environmental services - non-use/public and use - generated by the project(s). Such participatory approaches are better at ensuring participants have a common and thorough understanding of the issues and are thought to elicit citizen preferences (Sagoff, 2007; Font et al., 2015). Some argue that participants in these processes are not necessarily representative of the population, either through their selection, or as a result of the influence of the participation process itself. However, relative to an expert panel focusing exclusively on ecological factors, a participatory process will bring into the analysis the social values important to the population in the relevant jurisdiction.

There is clearly scope for much further work how best insights from cost benefit analysis can contribute to the evaluation of small, local environmental projects. Expanding the portfolio of small project CBAs, allowing more effective calibration of benefit value functions is the most obvious area for future research. However, since such analyses are costly relative to the scale of the projects being evaluated, they may also be the least likely to occur. Exploring how to best adapt rapid, participatory and/or deliberative processes to enhance the community net benefits resulting from project choices is therefore a particularly important area to investigate. This is a space where economists with expertise in valuation can collaborate with those expert in engagement to support effective, local decision making.

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