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Aggregating the benefits of environmental improvements: distance-decay functions for use and non-use values

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Abstract

One of the main problems in using environmental cost–benefit analysis is deciding on the relevant population: whose benefits should we count? This is important since aggregate benefits depend on both per-person benefit and the number of beneficiaries. Yet this latter term is often hard to evaluate. Distance-decay functions are one way of addressing this problem. In this paper, we present estimates of distance-decay functions for a particular environmental improvement, namely a reduction in low flow problems on the River Mimram in Southern England. We do this both for users and non-users, in the context of a contingent valuation study of the benefits of improving low flow conditions. We test whether distance-decay effects for mean Willingness to Pay are stronger for a single environmental good (the River Mimram, in this case) than for a more inclusive set (here, all rivers in Thames region which suffer from low flow problems). Finally, we explore the impact on part–whole bias, in terms of the relationship between WTP for an individual site and WTP for a more inclusive group of sites, of allowing for distance-decay effects.

Keywords: Aggregation; Environmental cost–benefit analysis; Distance-decay; Contingent valuation; Low flow problems

1. Introduction

One of the main problems in using environmental cost–benefit analysis is deciding on the relevant population: whose benefits should we count? This issue of 'standing' is important since aggregate benefits depend on estimates of both per-person benefit and of the number of beneficiaries. Yet this latter term is often hard to evaluate. For instance, when a river is improved, how many users will benefit? How does this divide up between anglers and informal recreational users? How many non-users will benefit? Errors made in estimating the number of users and non-users effected by an environmental change can easily swamp errors in estimates of per-person Willingness to Pay (WTP) when aggregate values are calculated (Bateman et al., 2002a).

For many classes of recreation, a common practice has been to make use of simple gravity models to predict participation rates, based on national surveys of participation per head of population in different recreation activities (e.g. FWR, 1996). This procedure can give misleading predictions of actual visits for many reasons, including variability in the availability of substitute sites, and variability in socio-economic characteristics by region. For instance, Gaterell et al. (1999) report results comparing visit predictions using a gravity model-derived approach with actual surveys. They found that the former under-predicted visits by a very significant amount, such that, for example, recreation visits to Dovercourt beach in Essex were 261,459 (actual) versus 46,000 (predicted): this produced an almost 10-fold increase in the present value of informal recreation benefits from an urban wastewater treatment improvement project. Similarly, Brainard et al. (1999) use GIS to compare predictions of visitor numbers to Forestry Commission sites, and found that predictions were within 25% of actual forest visitor numbers for 55% of sites. The prediction errors from the GIS-based model included both over- and under-estimates.

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Aggregate non-use values are more difficult to calculate, since such values may in principle be held by anyone. For instance, a significant improvement in water quality in the River Clyde could be a source of utility to people throughout Scotland, not just those who use the river or who live near it, since the river is nationally symbolic. Low flow alleviation schemes may likewise produce significant values to people who live far from the river, as the study by Garrod and Willis of the River Darrent showed (Garrod and Willis, 1996). Inclusion or exclusion of non-use values may have big impacts on the cost–benefit performance of individual improvement scheme, and in the ranking of alternative scheme (Gaterell et al., 1999).

Advice within FWR (1996) for aggregating non-use values in the specific case of water quality improvements is that the relevant population should be deemed to be the population of the relevant water company supply area. This is a simple rule, but clearly lacking in any empirical or theoretical justification. It was a source of much criticism in the River Kennet public enquiry, and was one of the main reasons why the case was found in favour of Thames Water and against the regulator, the Environment Agency (Moran, 1999). The approach was also used a recent, influential report on the costs and benefits of the Water Framework Directive to the UK (WRc, 1998). What alternative mechanisms for deciding on the aggregating population exist, however?

For certain types of use value, it seems reasonable to propose that WTP declines with distance from the site. This ‘distance-decay’ approach can be employed to identify the relevant population by including distance as an explanatory variable in contingent valuation bid curves. Bid curves seek to explain the variation in WTP across people (and sometimes across sites). If distance turns out to be a statistically significant determinant of value, then the mathematical relationship between distance and WTP can be used to estimate at what distance expected WTP goes to zero, or to some arbitrary small value (dependent on functional form). Some authors have argued that there is no reason to expect non-use values to be subject to such a distance-decay effect: for example, a person living in London *may* care just as much about the preservation of a wildlife habitat in Northern Scotland as someone living in Edinburgh, given that neither actually visit the habitat. However, this is a hypothesis which should be tested empirically.

In this paper, we present estimates of distance-decay functions for a particular river improvement, namely a reduction in low flow problems on the River Mimram in Southern England. Here, ‘distance-decay’ is used to refer to the phenomenon whereby the mean value placed on a given environmental improvement falls, the further away an individual lives from this improvement. We do this both for users and non-users. We also test whether distance-decay effects are stronger for a single environmental good (the River Mimram, in this case) than for a more inclusive set (here, all rivers in Thames region which suffer from low flow problems). Finally, we explore the impact on part–whole ‘bias’ of allowing for distance-decay effects amongst non-users. The paper in intended as a contribution to the development of Cost–benefit Analysis procedures for assessing environmental improvements where significant use and non-use benefits are anticipated.

In what follows, Section 2 reviews previous work on distance-decay functions. Section 3 describes our study context and design, whilst Section 4 sets out four hypotheses to be tested, provides some descriptive analysis of the data, and reports test results for these four hypotheses. Section 5 offers some concluding comments.

2. Previous estimates of distance-decay effects

Examples of the use of distance-decay functions may be found in Pate and Loomis (1997), Bateman and Langford (1997), Bateman et al. (2000), Hanley et al. (2001), and Georgiou et al. (2000). In the Bateman and Langford study, WTP for protecting the Norfolk Broads declined from a mean value of £39/household/year at a distance of 20 km, to £13.90 at a distance of 110–150 km away from the Broads area. Moran (1999) reworks these numbers to come up with a critical distance of 214 km, beyond which mean WTP is predicted to go to zero. Bateman et al. (2000) use their own bid curve, including distance and income as independent variables, to estimate aggregate WTP for the Norfolk Broads. The equation they use is:

$$\mathrm{Ln}(\mathrm{wtp} + 1) = -0.671 + 0.371 \ln(\mathrm{income}) - 0.273 \ln(\text{distance in km})$$

In the Hanley et al. study, WTP bids were sought for protecting two Scottish habitats from change. These were heather moorland (where the prospective change was either to forestry or to improved pasture), and rough grazing, where the same prospective changes were employed. For each study site, the distance from the site at which WTP is predicted to go to zero was derived from the bid curve, and the populations within that distance found from census data. For the heather moorland area, this procedure suggested that the population within a circle of 25 miles radius be used. Using data from the 1991 census the number of households in this circle was approximately 48,000. A similar analysis for the rough grassland area suggested the relevant population lay within a radius of 30 miles. Within this area the number of households was approximately 17,000. These estimates of the relevant population were then used to produce figures for aggregate WTP to protect the existing landscape, which could then be converted into per ha. terms.

Georgiou et al. found a negative, significant relationship between WTP to clean up the River Tame in Birmingham, and the distance respondents live from the site in miles (parameter $= -0.544$ ($t = -2.17$)). This implied WTP declined to zero at a distance of 16 miles (for a ‘small’ improvement) and 36 miles (for a ‘big’ improvement).

Finally, Bateman et al. (2002b) find a national distance-decay effect for non-use values for reductions in acidity in Scottish mountain lochs across the Scotland–England border.

3. Study design and context

The River Mimram is a chalk stream flowing from Whitwell, Hertfordshire to the River Lee at Hertford. Over the recent past, it has suffered from many low flow incidents, due partly to the abstraction of water for agricultural and industrial use. However, the Mimram is only one of about thirty rivers in Thames region which suffer from similar low flow problems.

Following a series of stakeholder meetings (Jacobs-Gibb, 2002), questionnaire and survey development concentrated on (i) deciding an appropriate definition of use and non-use values; (ii) focussing peoples' valuations on the particular environmental good in question, thus addressing the issue of 'part–whole bias' (see Section 4) and (iii) sampling at sufficient distance bands to be able to estimate a distance-decay function. With regard to the first of these issues, use values were defined as accruing to those who have visited the river at some point in the past for recreational purposes, whether this was an actual use of the river itself (e.g. for fishing) or as part of a recreational experience (e.g. walking beside the river). With regard to (ii), respondents were first told about low flow problems for all rivers within Thames region, and were asked to say whether they were willing to pay (by way of an increase in water rates) for a programme which alleviated this problem for all low flow rivers in Thames region. Information was provided on show cards as to the implications of low flows for river health. The exact wording used in the questionnaire was as follows:

> "As mentioned earlier, the Thames Region Environment Agency is currently assessing all the low flow river problems within the Thames region. For any low flow alleviation scheme to be implemented, it is likely that households in the region would have to pay additional water rates to help finance it. The scheme costs may relate to water companies having to obtain water from a more expensive source, or to provide additional pumping or another technical solution. In principle, would you be in favour of paying increased water rates to reduce the low flow problem on any of the affected rivers in the Thames region? All money raised would be used directly to implement the scheme."

For those respondents who were willing to pay in principle, the questionnaire then asked for their maximum WTP for three scenarios:

A. To fully alleviate low flows in all 30 Thames region rivers so affected.
B. To fully alleviate low flows on the River Mimram only.
C. To partially alleviate low flows on the River Mimram only.

Scenario C was included as a scope test for the Mimram. The questionnaire continued:

> "Now, I would like you to consider *how much* you and your household would be willing to pay in increased water rates for three different real life situations or scenarios. Please read the different scenarios on these cards (the content of these cards is summarised in Appendix A). When answering the following questions about how much you would be willing to pay for each scenario, please bear in mind that:
>
> - Any money you pay in increased water rates towards the low flow alleviation scheme you will be unable to spend on other things you might want.
> - There are other rivers in the region that you can enjoy anyway.
>
> How much would your household be willing to pay *each year* for *five years* towards improving the worst low flow problems in the Thames region? Remember this should include any amount you may want to pay towards improving the River Mimram. To help you answer this question please look at this card which shows different amounts of money ranging from nothing to £300 (SHOW PAYMENT CARD 1). I would like you to first go down the list and tick all those amounts your household would *definitely be willing to pay*. Then, proceed up the list and put a cross against all those amounts that you would *definitely not be willing to pay*. For each amount that you are not *sure* of paying, simply leave it blank. If you would be happy to pay more, feel free to say how much."

Respondents were then asked to focus on the Mimram only, and to state how much of the amount they were WTP for all Thames rivers should be allocated to the Mimram under scenario B. A map of the Mimram was provided, along with photographs of the river in 'normal' and 'low flow' conditions. The exact wording was:

> "I would like you now to concentrate on the river Mimram only. What proportion of the amount your household would be willing to pay for all the Thames low flow rivers, would you want to go towards *full recovery of the natural flow* on the River Mimram? This card may help you to decide what proportion of the first sum you would be willing to pay (SHOW PAYMENT CARD 2). If you want the payment split evenly between all sites then say so. That would be roughly 3% for the Mimram." (This question was then repeated for scenario C).

Table 1
Distance distribution of survey respondents

Distance category (km)	Number of respondents interviewed	Percentage of respondents inside Thames Region
0–0.5	71	100
0.6–5	96	100
6–15	100	65
16–30	80	75
31–50	82	80
51–70	104	53
71–100	75	51
101–150	42	31
Total	650	71

As is implied above, WTP for scenario A was elicited using a payment ladder ('PAYMENT CARD 1', above), which we reproduce in Appendix B. This way of asking the WTP question is a development of payment cards, and may suffer from the same type of dependence on the amounts shown on the ladder as payment cards: however, it generates more information then dichotomous choice formats, and also allows for uncertainty over values (Bateman et al., 2002a). In this design, respondents indicate the maximum they are sure they would pay, and the minimum they are sure they would not pay. Responses can be analysed both semi-parametrically and non-parametrically (see, for example, Maddison and Mourato, 2002; Hanley and Kristrom, 2002). Here, we use respondents' maximum sure WTP-the highest value they tick which they are sure they would pay-as a lower bound point estimate of their valuation of scenario A. Equivalent valuations for scenarios B and C are then inferred as described above.

Questionnaire development was assisted by focus groups of users carried out in Wellwyn in June 2001; with one-on-one interviews with non-users at a variety of locations in Thames region in June 2001; and through a pilot survey. The fact that extensive stakeholder analysis of the Mimram had already been undertaken in an earlier phase of the project made this development task easier. The main survey was conducted over a five-week period in late summer 2001. Some 650 responses were obtained using face-to-face interviews in people's homes. Table 1 shows how sampling was divided over distance bands.

4. Hypotheses, econometric procedures and results

4.1. Hypotheses to be tested

We seek to test four hypotheses in this paper. These are stated, and then explained, below:

H1: a significant distance-decay effect exists for WTP to reduce low flows on the River Mimram. Our a priori expectation is that this will *not* be rejected.

H2: a significant distance-decay effect exists for a programme to alleviate all low flow problems in Thames region. Our a priori expectation is that this *will* be rejected.

H3: a stronger distance-decay effect exists for use values than for non-use values for the Mimram. Our a priori expectation is that this will *not* be rejected.

H4: even allowing for distance-decay effects, a significant part–whole effect will be found for non-use values. Our expectation is that this will *not* be rejected.

Hypothesis H1 implies people care more about an environmental good (here, the Mimram) the closer they live to it. H2 implies that this, however, does not hold for a general class of environmental goods (here, all rivers), since in this instance the distance/benefit relationship is diffused by the varying distances between each of the 30 rivers and the respondent's home. H3 implies that those who directly use the environmental good will show a stronger distance-decay effect than those who are non-users; but a significant distance effect for non-users is not ruled out. If benefits from an environmental asset are related to use, then given a positive cost of access which depends on distance, WTP will also depend on distance. For non-use, there is no reason within standard utility theory to suggest such a relationship. However, a sense of 'ownership' or spatial identity may be important for some environmental assets: I may have stronger non-use values for Scottish wildlife sites if I am Scottish than for English wildlife sites. A distance decay relationship for non-use values is thus feasible.

Finally, hypothesis H4 relates to the impact on potential 'part–whole bias' of allowing for a distance-decay effect on values. Part–whole bias refers to the phenomenon whereby WTP for one good valued in isolation exceeds WTP for the same good when valued as part of a more inclusive set. Mc Fadden (1994) has argued that such part–whole bias can arise when researchers try to value environmental improvements in just one member of a larger set of environmental goods, when what respondents really care about is the state of the set as a whole (since each member of the set is a close substitute for every other member). Non-use values may be particularly susceptible to this part–whole bias, since lack of actual use means people are unlikely to care as much about a given member of the set as distinct from the set as a whole; whereas use values should be more closely tied to the value of individual sites.

An alternative explanation is put forward by Carson, Flores and Hanemann (1998) in the context of 'sequencing': they find that the sum of independent valuations for a set of environmental goods will exceed the value of the set valued as a whole, due to substitution effects. These authors argue that the phenomenon whereby the value of a given river (in our case) depends on whether it is valued in isolation, or in the context of a more inclusive set (all rivers in the region), is one of the many examples of the value of public goods being dependent on context. Interestingly, Bateman et al. (1997) find that such part–whole effects ('effects' here, since in this light 'bias' is perhaps misleading) also exist for private goods.

Hypothesis H4 is thus that, over the whole region, the sums of WTP for each partial river improvement is equal to WTP for all n improvements together. This null model can be formulated as

$$\sum_{j=1}^{n} \mathrm{WTP}_j = \mathrm{WTP}_{\mathrm{all}} \quad (1)$$

or, assuming that all n partial improvements have equal benefits (an admittedly strong assumption), that

$$\mathrm{WTP}_{\mathrm{all}} = n\mathrm{WTP}_{\mathrm{j1}} \quad (2)$$

where $j1$ is one member of the set. As a simple way of aggregating stated benefits allowing for distance decay, we approximate a WTP 'volume' V over the relevant region of beneficiaries by:

$$V = \left(\int_{r=0}^{R} f(r)\mathrm{d}r \right)^2 \pi k \quad (3)$$

where $f(r)$ is the empirical distance-decay function, R is the radius of an arbitrarily defined beneficiary area, and k is the population density.[1] We thus test whether this WTP volume, when using the distance-decay function for the individual site, is indeed approximately n times smaller than WTP volume based on stated WTP for improving all n affected rivers in the region.

4.2. Descriptive sample statistics

Table 2 shows some simple descriptive statistics for WTP, based on the 'maximum sure bid' (highest tick) values from the payment ladder. A protest rate of 24.9% was found. The main reason for protesting related to the unpopularity of the bid vehicle (water rates), and perceptions that water company profits are already excessive. Unfortunately, higher water rates was the only realistic choice of bid vehicle here. Other reasons for protesting included that the government should pay, and that only those living near the river should pay. As may be seen, mean WTP is highest for scenario A, where low flow problems on all 30 Thames rivers is the good. For the Mimram only, mean WTP is greater for a 'full alleviation' scheme than for a partial alleviation scheme, although not significantly greater.

Table 3 shows how mean WTP values for the Mimram alone (full alleviation) vary with distance, for both users and non-users. As may be seen, mean WTP does fall for both as respondents become more distant from the river. This suggests a distance-decay effect is present. To test for this more carefully, we ran a series of Tobit regressions. In all cases, distance from site is included as one of the regressors. We also included as right-hand side terms household income, education level of the respondent, respondent's age and a dummy for whether their house bordered the river (since such people might expect an increase in property values were the river's condition to improve). Table 4 gives the Tobit regression results for four models: for scenario A (dependent variable = WTP for improvements to all low flow rivers in Thames region) and scenario B (WTP for improvements for the Mimram only), for both users and non-users of the Mimram. These allow tests of hypotheses H1–H3 set out above.

Table 2
Simple mean WTP by scenario in £/household/year

	Mean WTP, users	Mean WTP, non-users
All low flow rivers in Thames region	40.45	29.76
Full alleviation scheme for Mimram only	12.90	2.78
Partial alleviation scheme for Mimram	11.51	2.20

Notes: Based on sample of $n = 488$, which excludes protest bids but includes genuine zeros.

4.3. Results of hypotheses tests

Hypothesis 1 is not rejected, since highly significant, distance-decay effects exist for improvements to the Mimram for both users and non-users. However, no significant distance effect exists for the general environmental good, namely improvements to all Thames region rivers ($p = 0.62$ and 0.39, respectively, for users and non-users). Hypothesis 2 is thus rejected. It can also be seen that a slightly stronger distance-decay effect for the Mimram exists for users than for non-users. This result is robust to an alternative, non-logarithmic specification of the distance variable where distance parameters of -0.20 ($p = 0.11$) for users and -0.043 ($p = 0.002$) for non-users are obtained. This means hypothesis 3 is not rejected, which again accords with a priori expectations.

As distance from the Mimram appears to be the predominant household characteristic determining WTP for low flow improvements (besides income), it is worthwhile to search for a simple distance function. This was achieved by re-estimating the model as a function of distance only in a double log form. This gives the following constant elasticity formula for positive bids:

$$\mathrm{WTP} = 4.1\mathrm{DIST}^{-0.332}$$

where WTP is WTP (£) for improvements to the Mimram alone and DIST is distance the household lives from the Mimram in km (Fig. 1). This simplified model explains 17%

[1] For the present comparison of WTP volumes, the precise value of k does not matter, as it is the same in the computation of the WTP volume for all rivers combined.

Table 3
WTP estimates by distance band, and by use/non-use split, positive bids only

Distance category	Sample size	Mean	S. Dev	95% confidence limit-lower	95% confidence limit-upper	Mean (5% trim)	Median
WTP summary statistics for users							
0–0.5	43	17.27	26.90	8.04	25.31	9.23	13.59
0.5–3	50	13.20	16.26	4.51	17.71	8.69	11.03
3–12	16	4.12	6.92	3.39	7.51	0.73	3.10
12–130	5	–	–	–	–	–	–
Sum	114						
WTP summary statistics for non-users							
0–0.5	1	–	–		–	–	–
0.5–3	21	12.78	20.19	8.64	21.42	4.14	10.18
3–12	45	3.73	8.95	2.61	6.34	1.12	1.87
12–130	233	1.71	3.57	0.46	2.17	1.25	1.16
Sum	300						

Table 4
Tobit estimates of distance-decay effects

	Use values						Non-use values					
	All Thames rivers			Mimram only			All Thames rivers			Mimram only		
	Coeff.	Std. Err.	*P*-value	Coeff.	Std. Err.	*P*-value	Coeff.	Std. Err.	*P*-value	Coeff.	Std. Err.	*P*-value
Constant	30.4167	27.7732	0.2734	5.7353	13.2079	0.6641	0.6541	15.2267	0.9657	5.2009	2.5657	0.0427
INCOME	0.2822	0.2413	0.2421	0.2070	0.1145	0.0706	0.5875	0.1249	0.0000	0.0808	0.0210	0.0001
EDUC	−0.6188	5.3938	0.9087	−2.1072	2.5646	0.4113	4.3921	2.9410	0.1353	0.3041	0.4974	0.5410
AGE	−0.0288	3.7935	0.9940	1.3944	1.7999	0.4385	0.3659	1.6707	0.8267	0.0357	0.2827	0.8994
LOGDIST	−1.4387	2.9300	0.6234	−2.7997	1.3979	0.0452	−2.0497	2.3736	0.3879	−2.0248	0.4016	0.0000
RIVBOUN	9.3744	15.4294	0.5435	5.9328	7.3063	0.4168	−17.4262	11.6293	0.1340	−3.6546	1.9514	0.0611
Sigma	47.2735	3.5870	0.0000	22.3654	1.6868	0.0000	43.8234	1.9837	0.0000	7.3341	0.3309	0.0000

of the variation in WTP, which is a high proportion for a single explanatory factor in contingent valuation data. A simple distance-decay function for all bids (i.e. including zero bids) is $\ln(\text{WTP}+1) = 1.70 - 0.244 ln(\text{DIST})$, or

$$\text{WTP} + 1 = 5.5\text{DIST}^{-0.244}$$

Our ‘distance elasticity’ is thus similar to the value of −0.273 reported in the Norfolk Broads study (Bateman et al., 2000).

With regard to hypothesis H4, integrating over a quadratic distance-decay function for WTP of non-users $f(r)$: $\text{WTP} = 5.79 - 0.121\text{DIST} + 0.00082\text{DIST}^2$ ($R^2 = 0.04$, $p = 0.000$), and using a relevant stakeholder radius R of 100 km and uniform population density k of 200 km^{-2} yields a WTP volume of £25.6 million for the single site improvement (scenario B).[1] Aggregation over all n rivers, assuming that stakeholder numbers and their WTP are comparable, yields a figure of £769 million. WTP bids for the improvement of all 30 Thames tributaries in need of improvement was unaffected by the distance from the Mimram. The average WTP for all sites was £29.76 (scenario A, Table 2), which, multiplied by $R^2\pi k$ yields a WTP for the improvement of all 30 sites of £187 million. Aggregate WTP based on the single-site values was thus approximately 4.1 times higher than aggregate WTP for the all-Thames scenario. At the aggregate level, then, even allowing for distance-decay effects, a substantial part–whole effect seems to exist.

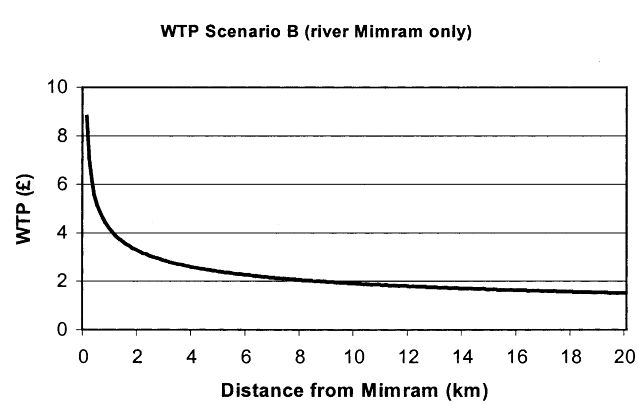

Fig. 1. Household WTP as a function of the households’ distance from the river Mimram.

5. Conclusions

One of the main difficulties in using environmental, non-market values in policy and project analysis is deciding on the size of the benefiting population. Decisions over this population are crucial in terms of the calculation of aggregate benefits and costs. In this paper, we have empirically tested the performance of distance-decay functions as a way of addressing this aggregation problem. In accord with a priori expectations, we find that a more rapid distance decay exists for use values than for non-use values. We also find no distance significant effect for a general class of environmental good, where a significant effect exists for a specific local example of this class. Our main conclusion is that distance decay relationships may well prove very useful in applied valuation work, since they provide a natural way of conceptualising the question "who benefits?".

However, we also suspect that distance decay relationships will vary across different resource types (rivers, national parks), and spatially within a type. For instance, we might expect a faster falling away of WTP on the part of local residents in areas where there are many substitutes for the resource in question, than in cases where there are few substitutes. This means that separate distance decay relationships will need to be estimated in each application of environmental CBA where their use is required: testing for the transferability of distance decay relationships across different environmental resources would thus seem an important avenue for future research. Distance-decay relationships based on the proportion of the population willing to pay for an environmental improvement could also be investigated. The design of the contingent valuation survey used here could be improved on. For example, the incentive compatibility of the payment ladder approach is unproven: testing the four hypotheses used here using a referendum approach might yield different results (although it is not clear, a priori, why we should expect this). Another feature of our survey design is that the payment scenario stated that only those living in Thames region would pay for the improvement in low flows: testing for distance decay under alternative assumptions about "who pays" would be useful.

This paper also found a substantial part–whole effect in aggregating non-use values, in that WTP for improving all Thames rivers was much less than WTP for the Mimram multiplied by the number of rivers, once distance effects had been allowed for.[2] Whilst from theory we expect a part–whole effect to occur due to substitution effects, this is a sizeable difference in value from a policy or asset management perspective. This may suggest that a top-down approach to non-use value estimation for individual environmental assets within some more inclusive class should be preferred to a bottom-up approach. A practical implementation of this would be to suggest that non-use value estimates for local projects be inferred from breaking down non-use values for more inclusive regional projects. However, this possibly begs more questions than it answers: how to define 'regional' and 'local', and how to decide which wider set a given environmental asset is a member of (in other words, where to start the top-down evaluation).

[2] Note that, due to survey design, we were not able to carry out comparable calculations for use values.

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Appendix A. Information given to respondents about the three scenarios

A.1. Scenario A. Thames Region—low flow alleviation at 30 sites

This scenario involves the Environment Agency making sure that all 30 worst low flow river and wetland sites in the Thames Region would be improved.

- Each river or wetland, *including the River Mimram*, would have their water levels returned as far as possible back to their natural levels.
- They would dry out less frequently, perhaps once every 20 years compared to say once every 3–4 years.
- They would also generally have more water in them all year round and would not silt up so much.
- There would be more wildlife, the visual attractiveness would be improved and there would generally be greater use of the sites.

A.2. Scenario B. River Mimram—full low flow recovery

This scenario involves returning the water flows and levels on the Mimram as far as practically possible back to their natural levels.

- Instead of parts of the river drying out for a period of months, say once every 3–4 years, the Mimram may dry out severely only once every 25 years.
- The water flows in the river would also generally be reasonably good for most of the year, but would not lead to increased flooding.

- There would be a significant increase in the number and different types of animals and plants living in and along the river.

A.3. Scenario C. River Mimram—partial low flow recovery

This scenario would achieve a smaller improvement, only partially returning water flows and levels back to their natural levels.

- Instead of parts of the river drying out for a period of months, say once every 3–4 years, sections of the Mimram may dry out severely say once every 10 years.
- The water flows in the river would not generally be as good as under the full recovery scenario, and would not lead to increased flooding.
- There would be an increase in the number and types of animals and plants living in and along the river, but this would not quite be as good as with the full recovery.

Appendix B. Paycard 1

(WTP for alleviating low flows on all 30 Thames Region rivers)

Amount (£ per hsld per year for five years)	Amount definitely prepared to pay (Tick)	Amount definitely NOT prepared to pay (Cross)
0		
10p		
25p		
50p		
£1		
£2.50		
£5		
£10		
£15		
£20		
£30		
£40		
£50		
£75		
£100		
£150		
£200		
£250		
£300		
Any other amount		

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