Chapter 5

ESTIMATING SOCIAL BENEFITS OF ENVIRONMENTAL IMPROVEMENTS FROM REDUCED ACID DEPOSITIONS: A CONTINGENT VALUATION SURVEY

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1 INTRODUCTION

In Scandinavia, fish kills in connection with acidic waters have been observed since the turn of the century (Overrein et al. 1980). Populations of atlantic salmon (Salmo salar) were first affected, followed by brown trout (Salmo trutta) and other freshwater species. By 1980 fish populations throughout an area of 33,000 km^2 had been affected in Norway (see also map in Appendix 1). Today, although there has been no increase in annual acid depositions, the fish losses in acidified areas of Southern Norway continue and are spreading to the western coast (Rosseland, Skogheim & Sevaldrud 1986, Sevaldrud & Skogheim 1986).

Most European countries have now committed themselves to reducing their sulphur emissions by 30 % before 1993 (using 1980 as the reference year). International negotiations on further reductions in sulphur dioxide and other long range transported air pollutants are also in progress. In Norway, which imports about 90-95 % of its annual sulphur depositions of 191,000 metric tons (1985) (NMI 1987), reduced sulphur depositions are predicted to have a very positive effect on water chemistry and freshwater fish populations (Muniz et al. 1984, Seip et al. 1986).

This paper presents some results of a survey estimating the Norwegian population's willingness-to-pay (WTP) for these predicted increments in freshwater populations.[1] This

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[1] A recent nationwide survey of 1,005 lakes (NEMP 1987) supports these forecasts.

survey is the core of an empirical follow-up study based on a methodological "package" proposed in a pilot project (Navrud 1985). This package also includes a regional WTP-survey of a sample of 573 households in the most heavily affected area: Sörlandet (i.e. the four southernmost counties Telemark, AustAgder, Vest-Agder and Rogaland). Both these surveys use the Contingent Valuation Method (CVM) to estimate the social benefits of increased freshwater fish populations.

In addition, a mail survey of anglers in the River Vikedalselv in Southwestern Norway was carried out autumn 1987. Here, both the CVM and the Travel Cost Method (TCM) were employed. The Vikedalselv, once a prime sea trout and salmon river, is now recovering after being on the verge of losing its salmon stock. Sea trout, which is less sensitive to low pH-levels, has become more abundant. This situation is very similar to the expected development in restored salmon rivers in Southern Norway after reductions in acid depositions. The results from this case-study can be used as a consistency check of values extracted from the national and regional surveys. Large scale liming in this river started in 1987, and the mail survey together with annual recreation participation data collected since 1979 (before the effects of acidification became obvious), can also give important information on how different levels of acidification affect the recreational value of fishing. Similar surveys over the next few years will enable us to estimate the effects of liming on fish populations and their recreational value.

The total economic value to society of a marginal increase in this non-market environmental good (freshwater fish populations in Norway), can be estimated as the aggregate, maximum, total WTP for all people affected by this environmental improvement. They are here defined as all of the 1.52 million households in Norway (Central Bureau of Statistics 1987). This estimated value constitutes a very significant part of the welfare improvement to the Norwegian population obtainable through reductions in long range transported air pollutants.

2 METHOD AND DATA

2.1 Contingent Valuation Method

During the past two decades economists have applied a variety of techniques to reveal individual preferences for non-market environmental commodities. These can be divided into two major groups; indirect and direct methods.

The indirect methods assume either that private goods are complementary to environmental goods, or that the environmental quality is incorporated in the private good. The value of the environmental good can thus be calculated from the demand for the private good. The two most important of these methods are the Travel Cost Method (TCM), based on travel costs to visit a recreational area, and the Hedonic Price Method (HPM), usually based on property values.

The direct methods use interview techniques to make individuals express their subjective evaluation of the good explicitly in constructed hypothetical markets. The most promising of these methods is the Contingent Valuation Method (CVM). The CVM is used in this study and will therefore be described in more detail. The essence of this survey method is succinctly expressed by Randall et al (1983, p. 637) as follows:

> "Contingent valuation devices involve asking individuals, in survey or experimental settings, to reveal their personal valuations of increments (or decrements) in unpriced goods by using contingent markets. These markets define the good or amenity of interest, the status quo level of provision and the offered increment or decrement therein, the institutional structure under which the good is to be provided, the method of payment, and (implicitly or explicitly) the decision rule which determines whether to implement the offered program. Contingent markets are highly structured to confront respondents with a well-defined situation and to elicit a circumstantial choice contingent upon the occurrence of the posited situation. Contingent markets elicit contingent choices".

In the CVM, individuals are asked neither about their opinions nor about their attitudes, which may be poor predictors of actual behaviour. Rather, they are asked about their contingent valuation (If "this" happened, what would you be willing to pay?). While questions posed in the CVM are (arguably) not attitudinal, the "market", or the commodity and payment, as they appear in the CVM, are hypothetical.

Because of this hypothetical nature, several potential biases may occur. The major types of biases are: (1) strategic bias, i.e. depending on how respondents perceive the consequences of the hypothetical experiment, they may behave strategically and not reveal their true preferences (by acting as "free riders"); (2) information bias - potential biases induced by lack of, or type of, information given to the consumer in the contingent market, including: (a) instrument bias - introduced by the process or procedures employed to discover preferences (e.g. bidding games, payment card); (b) starting point bias, i.e. the mean final bid may differ with different starting points in bidding games; (c) vehicle bias, i.e. different forms of payment elicit different bias and the vehicle should therefore correspond reasonably well to how people actually would pay for the environmental improvement; (d) commodity specification bias, i.e. not explaining the commodity to be valued in a detailed way understandable to the respondents can distort the result; (3) hypothetical bias - the potential error induced by confronting the individual with an imaginary situation i.e. would people behave the same way in an actual market?; (4) constant budget bias, which originates from the hypothesis that each individual has a type of mental budget for environmental goods, i.e. an idea of how much money they want to spend on environmental quality. If they are asked about one particular environmental good they tend to give up all or a very large part of their environmental account; and (5) sampling, interviewer or nonrespondent bias.

In addition, disparities have been observed in empirical studies between using "willingness-to-pay" (WTP) e.g. for reduced air pollution and "willingness-to-accept" (WTA) compensation to accept that the pollution continues, i.e. the disparity between Equivalent Variation (EV) and Compensating Variation (CV). This is contrary to expectations from conventional welfare theory. However, experimental evidence supports an interpretation of the observed disparity in payment and compensation-based measures as both real and psychologically meaningful (Knetsch & Sinden 1984, Gregory 1986, d'Arge & Shogren 1988). In this study WTP was choosen as the appropriate measure.

Clearly, asking someone what they will do or pay a priori is not the same as confronting them with a recognized and wellunderstood market and observing what they actually pay. However, two recent state-of-the-art assessments of the CVM, which review the majority of empirical applications of the method, alternative methods, experiments with actual payments (auctions) and laboratory experiments, conclude that carefully constructed surveys give meaningful values for environmental goods (Cummings et al. 1986, Mitchell & Carson 1986). For well defined recreational goods with little uncertainty and with which people have had valuation/choice experience, CVM using WTP-measures appears to give value estimates with an accuracy of ± 50 %. Cummings et al. (1986) consider this accuracy to be sufficient to give an approximate size of the values involved.

Using CVM to measure the benefits of less familiar goods such as air quality improvements or risk reductions of various kinds is more difficult. However, provided the respondents can be motivated to carefully follow the contingent market described in the scenario and find it sufficiently plausible, CV-surveys offer the possibility of obtaining meaningful information about consumer preferences for all nonmarket amenities (Mitchell & Carson 1986). CVM may in many cases also be the only way to estimate the value of an environmental asset. However, I agree with Mitchell & Carson (1987) when they say that we still have much of importance to learn about the CVM and that it is vulnerable to misuse. They assume that new methodologies progress along a learning curve consisting of several stages. Although the CVM has passed the experimental prototype stage, it is not understood well enough to have reached the routine application stage. Field applications should therefore always be combined with methodological research. The principal challenge facing the CV researcher is to make the scenario sufficiently understandable, plausible, and meaningful to respondents so that they can and will give valid and reliable values despite their lack of experience with one or more of the scenario's dimensions.

Provided a representative sample of all the affected individuals is used, CVM can potentially elicit both use and non-use values, held by people today. By *use value* we mean the value of actually using the environmental good; e.g. the recreational value of fishing. The *non-use values* include option-, existence- and bequest value. Option value is the value or "insurance premium" an individual would pay to ensure the existence of fish populations so that he/she could have the option of fishing in the future, even if he/she does not do so now. Existence value is the value people place on the simple existence of the fish populations. Their valuation of being able to deliver this existence to future generations is termed the bequest value. The different parts of the non-use values can often be difficult to separate. Both the use and the non-use values are needed to estimate the total WTP for an environmental good. Empirical evidence indicates that a large part of the WTP is due to other motives than recreational use of the good (Strand 1981, Greenly et al. 1981, Walsh et al. 1984). Therefore it is very important to include the non-use values. This may be particularly important in this study. In situations with a large degree of uncertainty (which characterizes the dose-response relationships between acid depositions and freshwater fish populations), large non-use values motivated by risk-averted behaviour can be expected. Large non-use values in this acid rain case may also be expected because non-users vastly outnumber users.

To conclude this short presentation of the CVM and to state the importance of valuing environmental goods, I would like to quote Schultze et al. (1981, p. 170). From a review of four CV-studies where alternative methods were also used, they concluded as follows:

> "In many cases decision makers quite simply have no idea as to the economic value of preserving environmental quality. All evidence obtained to date suggests the most readily applicable methodologies for evaluating environmental quality - hedonic studies of property values or wages, travel cost and survey techniques - all yield values well within one order of magnitude in accuracy. Such information in our view is preferable to complete ignorance".

2.2 Sampling method and questionnaire construction

This CV-survey consists of two independently drawn random samples from the Norwegian population, each of about 1,000 individuals over 15 years of age. The total survey size was 2,032 persons, each representing one household. They were interviewed in-person by interviewers from a professional opinion poll agency (Gallup/NOI). Both samples were tested against socioeconomic data of the Norwegian population and found to be representative.

The interviews were made in April and June 1986. This period began before the Chernobyl accident of April 26th, and ended before the large media coverage of the radiation effects on fish populations and the following recommended consumption limits and prohibition of sale of freshwater fish from affected areas in July. Furthermore, differences between the results from interviews made in April and June were insignificant. This incident therefore seems to have had no systematic influence on the results of the survey.

Respondents were asked to reveal their WTP for various intensities of lime application to the acidified water bodies. These intensities were described as enabling different increments in the freshwater fish populations in Southern Norway. These increments corresponded to the expected effects of 30, 50 and 70 % reduction in sulphur emissions in Europe (compared to 1980 levels). Different subsamples were confronted with different increments, and each respondent was asked about only one specific increment. In this way the respondents were not aware of the other possible improvements. This was done to avoid overwhelming the respondent with information during the relatively short interview. However, this can introduce biases. People may have difficulties in perceiving different marginal changes in environmental quality, and this problem may be exacerbated if not all of the possible improvements are presented. Paired comparison may therefore reduce this bias. (Paired comparisons of 30 and 50 % emissions reductions were used in the regional survey).

Division into subsamples was also used to test for instrumental bias. Payment cards may provide a lower, more conservative estimate of value than the bidding games technique. To test for starting point bias in bidding games six subsamples were given different starting bids, which they could accept or reject. Depending on the answer the next bid presented to the respondent was higher or lower. This procedure was repeated until their highest bid on the scale was found. (The different bidding schemes are shown in Table 1.) Then they

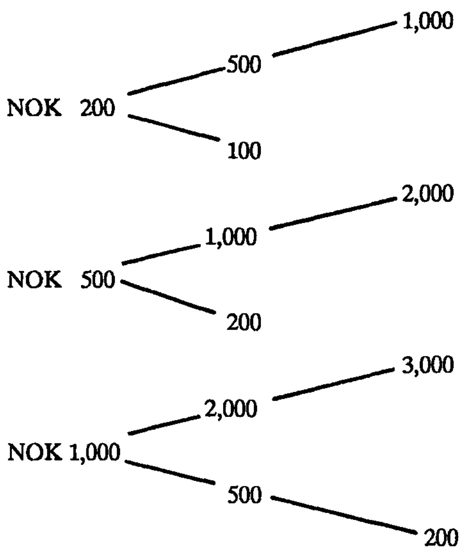
TABLE 1

Description of payment instrument and emission reduction used in the nine subsamples.

Subsample no.	Percent reduction in sulphur emissions	Payment instrument[1]
1	30	B.G. - f.b. = NOK 200
2	30	B.G. - f.b. = NOK 500
3	30	B.G. - f.b. = NOK 1,000
4	30	P.C.
5	50	B.G. - f.b. = NOK 200
6	50	B.G. - f.b. = NOK 500
7	50	B.G. - f.b. = NOK 1,000
8	50	P.C.
9	70	P.C.

1 a) B.G. (Bidding Games) - different bidding schemes

First bid (f.b.) Bid sequence



b) P.C. (Payment Card) (originally all amounts were on the sameline)

0 10 20 50 100 200 300 400 500 700

1,000 1,200 1,500 1,700 2,000 3,000 4,000 5,000 10,000 were asked the maximum, annual WTP for their household. The bidding technique was used only to establish a "learning process" for the respondents about their subjective valuation of this non-market good. The remaining three subsamples were shown a payment card with amounts ranging from 0 to 10,000 NOK (1 NOK = US $ 0.16) and were asked to pick the amount that reflected their maximum WTP.

Table 1 gives an overview of the different payment schemes and marginal changes in sulphur emissions used in the nine subsamples.

Because statistical analysis limits the possibility of using split samples, corrections were made in construction of the WTP-questions in an attempt to avoid other potential methodological biases. These WTP-questions for subsample no. 5 and a review of the background information collected is reproduced in Appendix 1. The corresponding questions in the other subsamples are identical except for payment scheme, degree of emission reduction and the resulting effect on freshwater fish.

In the following I will comment on the questionnaire and the potential biases involved. The contingent market was designed to be as realistic and credible as possible. A map of acidification damages to freshwater fish in Southern Norway in 1980 was shown (see Appendix 1). At the same time information was given about this pollution problem, its origin, and international commitments to emission reductions. To most Norwegians this environmental problem is well-known through widespread media coverage. Nevertheless it is important to give all respondents the same minimum amount of objective information.

Then it was stated that Norwegian authorities were considering starting large scale liming of the affected water bodies as a necessary first aid action while waiting for the effects of the international agreements on emissions reductions. This liming was assumed to have the same effects on the fish populations as emission reductions. This description was used to try to avoid "protest bids", i.e. people stating a WTP lower than their actual value because they believe the "Polluter-Pays-Principle" should be used. The setting was also realistic and appropriate since liming was already in progress and government grants for this purpose were (and are) very limited.

Next, diagrams of improvement in the brown trout stocks corresponding to reduced sulphur emissions, together with a verbal description of the effects on the atlantic salmon stocks were introduced. The diagrams are shown in Appendix 2. Originally both the map and the diagrams were in colour, different colours corresponding to different fishery conditions. These simple descriptions are based on the expected value of the improvements. Alternatively a probability distribution of different increments in the fish stocks based on experts' "best guesses" could have been used. However, no such data was available. Also, this more complicated, detailed and more uncertain delphi-technique does not guarantee a more perfect assessment, considering the low level of information about the dose-response relationship (Crocker 1985). Based on comments from the interviewers it seems the map and the diagrams were understood by the respondents and that the presentation in general worked well.

The wording of the question may be seen as a reasonable compromise to avoid both the hypothetical and strategic bias. To put the described situation into a "decision framework", it was stated that the answers to the questions would influence the decision to lime or not. This was done to motivate respondents to think carefully through their valuation of the environmental improvement, and to make the constructed scenario less hypothetical. A more realistic situation may, however, increase the possibility of strategic answers. The provision at the end of the question (that all Norwegian households would pay, and according to their income), was introduced to minimize the strategic bias. If respondents gave biased WTP responses, visual inspection of the frequency distribution may show bimodal clustering of values at abnormally high and/or low levels. This was not observed, suggesting there may be little or no strategic bias in the results. However, without knowledge of the true underlying values, visual inspection does not constitute a completely satisfactory test of strategic bias.

To avoid respondents basing their WTP on the actual costs of liming, these were said to be unknown. Such statements could have had the same anchoring effect as first bids. The period of payment was also made uncertain. In this way, the value estimate elicited can be assumed to approximate the annual WTP per household for all time to come.

The payment was to be collected as an annual income tax to a federal liming fund. Tax was used for two reasons. First, this is a just payment vehicle, i.e. everybody pays according to their income. Second, the results can be compared directly to the total WTP for all the freshwater fish in Norway estimated as increased income tax in a previous CV-study (Strand 1981). Paying into a special fund, to be used exclusively for the purpose of liming and restocking acidified lakes and rivers, is recommended as a relatively neutral method of payment (Water Resources Council 1979).

Respondents not willing to pay for increments in the fish population were asked a question designed to determine why (Appendix 1, question no. 3). This made it possible to find out how many of these individuals stated zero WTP because they rejected the payment vehicle or hypothetical market, although their "real" WTP was not zero (i.e.

"protest zero-bids"). To distinguish between use and non-use values, respondents were asked to estimate how large a portion of their stated amount was due to different motives (see Appendix 1, question no. 4).

To control for the "constant budget"-bias, the respondents were asked their maximum WTP for improvements in the quality/quantity of all the public goods affected by acid rain. A verbal description of the effect on these goods was given (see Appendix 1, question no. 5). This description is very rough due to the lack of empirical studies and large uncertainty about the dose-response functions. This accuracy should be sufficient to test for the specific bias, but one should be careful in interpreting the resulting value estimate as the social economic value of the total environmental improvements from reduced acid depositions. The question was not constructed for this purpose.

In addition to the above described WTP-questions, data on relevant predictor variables was collected (see Appendix 1 for a complete list). They were used to develop an appropriate econometric model of the WTP for increments in the fish stocks.

One of these explanatory variables is of particular interest. It is reasonable to assume that people will have less difficulty in describing how their behaviour would change in response to an environmental improvement, than in placing an economic value on the same improvement. Thus, all respondents, both anglers and non-anglers, were asked how many additional days they would fish in freshwater habitats each year as a result of the described increments in fish stocks. The statement of intended behavioural change, together with information on the recreational value per angler day (RVD) (collected from rivers and lakes of the same quality that can be expected in the restored water bodies), can be compared to the recreational value derived from question no. 4 in the survey (Appendix 1). This comparison provides a consistency check of the recreational value. However, of the rivers in Norway where the TCM has been used to derive RVD-estimates, none have the same quality as can be expected in restored rivers. Therefore the previously mentioned case study of the River Vikedalselv has to be completed before the consistency check can be carried out.

3 RESULTS AND DISCUSSION

In this chapter, I will first present the value estimates derived from the WTP-questions and discuss how the potential biases inherent in the CVM may have influenced these results. In the second section multiple regression is used to find those explanatory variables that are important in predicting the respondents' WTP. In the last section benefits per household are aggregated to produce total social benefits for the described increments in the freshwater fish stocks. This estimate is compared with benefit estimates from other studies, and with the costs of liming and re-stocking, which are first-aid actions to achieve this environmental improvement.

3.1 Benefit estimates and potential biases

Table 2 shows some statistical characteristics of the WTP-results for the different subsamples. Let us first discuss the results for the increments in fish stocks. A very high response rate to these questions and relatively low and constant zeroresponse indicate reliable and valid results.

The 95 % confidence interval for the mean value of the WTP for different subsamples was also constant around ± 15-25 %. The mean values vary from 278 to 603 NOK in the different subsamples. The payment card tends to give the lowest estimates, and the largest first bid the highest. Mean WTP increases as the first bid increases. One way classification analysis of variance was used to test for starting point bias. The results showed that the mean final bids corresponding to different starting bids in the bidding game for 30 % emission reduction were significantly different at the 0.05 confidence level. This statistical difference could not be observed in the 50 % emission reduction bidding game. For the 70 % reduction the starting point bias could not be tested, because only one subsample was shown a payment card. This was due to the survey's budget restrictions.

In spite of the highest, but still relatively small, zero responses, the payment card generally seems to work better than the bidding schemes. The payment card also produces more conservative value estimates.

The median values for WTP range from 100 to 300 NOK/household/year. This would be an important predictor of the maximum WTP that could be adopted if an actual referendum on this subject was taken. However, this is not common practice in Norway. Nonetheless, the median values show the maximum amount 50 % of the respondents are willing to support. Comparisons of mean and median values show that the frequency distribution of the WTP is skewed towards the left, i.e. the lowest bids.

A comparison of the mean WTP for the increments in fish stocks with the corresponding estimate for the total increment in all the affected public goods (fish included), shows that 59-91 % of the latter is due to the fish stock improvements. The percentage seems to be lowest and most stable for subsamples using the payment card. The generally

TABLE 2

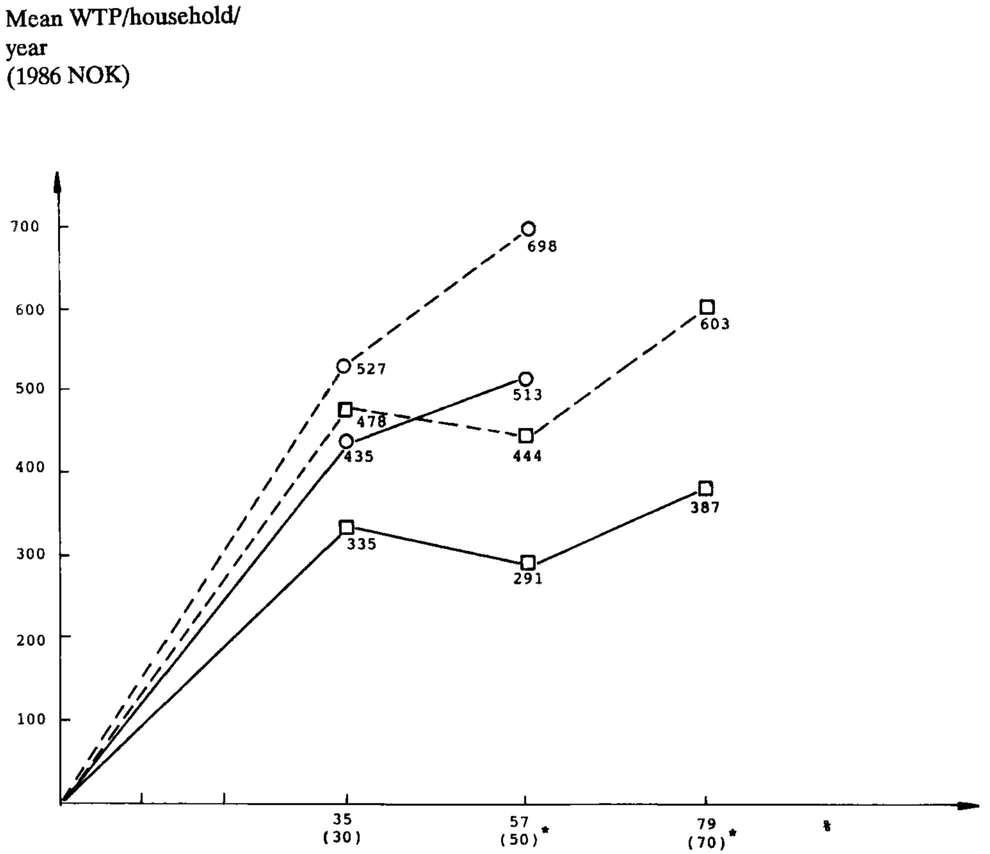
Maximum, annual willingness-to-pay (WTP) of Norwegian households for improvement in the freshwater fish populations (WTP-fish) and all public goods in Norway affected (WTP-public goods) by reduced European sulphur emissions. (In 1986-NOK).
(1 NOK = US $ 0.16 - exchange rate April 1988).

Subsample no. (emission reductions)	No. of obser-vations	Response rate fish/public goods	First bid	WTP - fish/ household/year			WTP-public goods/ household/year			Mean WTP-fish / Mean WTP-public goods (%)	WTP-fish: Percent zero-bids
				Mean	Median	Std. Dev.	Mean	Median	Std. Dev.		
1	288	98/97	200	278	200	338	375	200	652	74	23
2	270	97/95	500	455	200	826	537	200	1003	85	18
(30%) 3	238	99/96	1000	603	300	772	700	250	1285	86	23
4	239	97/99	0-10000 (payment card)	335	100	514	478	100	1130	70	29
5	206	99/96	200	366	200	660	617	200	1324	59	23
(50%) 6	206	98/98	500	578	200	1036	793	300	1883	73	17
7	204	97/97	1000	597	200	796	656	200	962	91	23
8	192	98/98	0-10000 (payment card)	291	100	492	444	150	998	66	28
(70%) 9	189	98/97	0-10000 (payment card)	387	200	648	603	200	1274	64	27

high percentage can be viewed as reasonable due to the fact that the current damage to public goods by acid rain in Norway is largest for the freshwater fish populations.

However, this result may also be due to the sequencing and the constant budget bias. The respondents were first asked their WTP for fish without being aware or thinking of the other public goods affected. They therefore could have overestimated their WTP for this particular environmental good. This would have given them less of their "environmental budget" to spend on the other public goods affected by acid rain. This bias could have been avoided if the respondents had been provided the opportunity to reconsider and adjust their bids for the fish stock increments. Results from the regional survey where such reconsideration was provided, showed that only 13 % of the respondents adjusted their bids and that the mean WTP for fish should be reduced by 6-13 % to correct for this bias. A CV-study of the WTP for increments in the fish population in Oslomarka (the recreational area surrounding Oslo), showed a 35-50 % reduction of the mean WTP for this good when environmental policy items other than acid rain were introduced (Amundsen 1987). This local CV-study used the same question format as the national survey, and was constructed with this comparison and transferance of results in mind. These results correspond well with the results obtained by Schultze et al. (1983). They found a tendency for the WTP for one separate environmental good to decrease by 10-40 % when other environmental goods were introduced.

Figure 1 illustrates the variation of mean WTP with different emission reductions and the corresponding increments in the fish populations. (Note that the dose-response relationship utilized is assumed to be linear). No emission reduction and no environmental improvements are assumed to give zero WTP, and the curves therefore pass through the origin. When looking at the mean of subsamples using bidding games the WTP appears to increase (but at a decreasing rate) with increasing improvements in the fish populations and for all affected public goods. This corresponds well with general welfare theory. However, the observed tendency is not statistically significant, and the same tendency can not be observed for the subsamples using payment cards. This indicates that the respondents have difficulties in perceiving the differences between the environmental improvements. The reason for this could be that the differences are so small that they are difficult to distinguish or that each respondent was asked about only one particular improvement. Results from the regional survey, where each respondent received descriptions of the effects of both 30 and 50 % reduction in the sulphur emissions, indicate that the



Percentage reduction in the number of lakes devoid of brown trout in "Sørlandet". Corresponding percentage reduction in the sulphur emissions in Europe in parentheses.

FIGURE 1

Mean, annual willingness-to-pay (WTP) of the Norwegian households for environmental improvements due to different reductions in sulphur emissions.

Key to symbols: - all subsamples with bidding games
O——O WTP for fish
O– – –O WTP for all affected environmental goods

- subsamples with payment card
□——□ WTP for fish
□– – –□ WTP for all affected environmental goods

*At these levels of sulphur emission reductions the salmon rivers in "Sørlandet" could also recover reproducing fish stocks.

latter explanation is more likely.[2]

Respondents not willing to pay for increments in the freshwater fish populations were asked a question designed to determine why. From Table 3 it can be determined that rejection of the payment vehicle or hypothetical market (i.e. "protest zero-bids") represented 14.5 % of the total sample of 2,032 households.

This is within the 15 % limit recommended in the guidelines for CV-studies by the Water Resources Council (1979). These individuals may actually place an economic value on the described environmental improvement, but object to the construction of the question. Therefore the aggregated, total WTP for all households estimated may understate the total value to society.

TABLE 3

Frequency distribution of the most important reasons for stating zero willingness-to-pay for increments in freshwater fish populations at different emission reductions. (Results from question no. 3, see Appendix 1).

Reason for zero bid	Emission reductions		
	30 %	50 %	70 %
A. "Real zero-bids" (1. Don't fish; 2. Can't afford it; 3. Other things are more important)	28 %	23 %	31 %
B. "Protest zero-bids" (4. I pay too much tax already; 5. The polluters should pay)	58 %	69 %	61 %
C. Other reasons	14 %	8 %	8 %
Sum	100 %	100 %	100 %
No. of observations of zero bids	237	183	52
Total sample size	1,035	808	189

[2] An approximated Student's t-test (Welch 1947) was used to test the hypothesis Ho: Mean WTP (30%) = mean WTP (50 %) versus Ha: Mean WTP (30 %) $\neq$ mean WTP (50 %). Ho was rejected at the 0.01 confidence level.

The respondents asked about the 50 and 70 % emission reductions who stated a positive WTP were asked to distribute this amount among different motives. Table 4 shows how the aggregate, total WTP for all respondents was distributed between use and non-use values. As hypothesized, a very large part (88 %), of the total WTP was due to non-use values, and only 12 % was motivated by recreational use (angling). This is due to the fact that even the anglers, who constituted 27 % of the respondents, were also motivated largely by non-use values: only 27 % of their total WTP was due to recreational value. In addition the mean WTP stated by anglers was higher and differed significantly (at the 0.01 level) from the corresponding value for non-anglers (non-users).

The decomposition of use and non-use values used here, may be subject to bias due to people's difficulties in dividing their total WTP between these two categories. However, this strategy is considered preferable to describing each individual type of value to the respondents and then ask them separate questions about their WTP for the good motivated by use and non-use. In that way separate values for use and non-use are obtaineddirectly, and total WTP is estimated by simply adding the values (Mitchell & Carson 1987). Greenly et al. (1981) has used this latter strategy to obtain a use value comprising 39.8-51.9 % of the total WTP for preservation of existing water quality in the South Platte River Basin, USA. Strand (1981) used a third strategy to find a use value comprising 40 % of the total WTP for preserving all freshwater fish in Norway. He estimated the total WTP by using a

TABLE 4

Frequency distribution of aggregated, total willingness-to-pay (WTP) for increment in freshwater fish populations on different motives.*

Motives for WTP	Percentage of total WTP (%)
Recreational value	12
Option value	12
Bequest- and Existence value	76
Sum	100
No. of observations	733

* (Results from question no. 4; see Appendix 1. This question was used only in the subsamples asked about 50 and 70 % emission reductions).

nationwide CV-survey. This estimate was compared to a use value estimate derived from a TC-study of one river assumed to be representative of all rivers in Norway. Clearly, this is a strict and not very plausible assumption. Both these studies result in a higher use value than our study. This may be due to the different strategies used to separate use and non-use values. A comparison with results from a study using the decomposition strategy (Strand 1985) supports this hypothesis. Strand (op.cit.) concluded that most of the non-use values of the Norwegian population's WTP for improved air quality from automobile pollution abatement was due to uncertainty about current and future effects of air pollution.

A strategy of treating the WTP amounts given by the non-users as a relatively pure expression of non-use values and assigning all of the users' WTP amounts to use value has been suggested as a method of giving a lower boundary for non-use values (Fisher & Raucher 1984). Using the strategy in this study suggests a minimum non-use value of 63 % of the total WTP. Clearly, regardless of the strategy used, non-use values constitute the major part of the total WTP.

3.2 Multiple regressions

Multiple regression was used to produce statistical WTP functions. WTP for increments in the freshwater fish stocks due to emission reduction j for household unit i, was estimated as:

$$WTP_{ij} = f(I, S, F, B, S, A, P) \qquad (1)$$

where I = household income, S = socioeconomic variables, F = freshwater angling activity, B = intended behavioural changes in freshwater angling, S = substitute activity, i.e. saltwater angling, A = attitude towards environmental preservation and P = payment instrument. Previous empirical research (Strand 1981) and theoretical welfare economics served as a guide in preselecting these explanatory variables.

Table 5 illustrates the relationship between annual WTP and household income and other predictor variables thought to be important. The estimations are carried out separately for 30 % and 50 % emission reductions. Ordinary Least Square (OLS) regressions are estimated. Due to uncertainties inherent in the method and the fact that statistical estimation will therefore provide a very uncertain picture of the true preferences in the population, it seemed unnecessary to use more advanced statistical methods (e.g. generalized non-linear regression models).

The multiple regressions (no 2 and 4) are based on less observations than the corresponding simple regressions (no. 1 and 3) because some respondents did not answear all the questions. The simple linear regressions between WTP and household income (regression no. 1 and 3) show that the WTP increases with increasing household income. The regression coefficient is significant at the 0.01 level and is about the same size for

TABLE 5

Regression estimates of total willingness-to-pay (WTP) for increments in freshwater fish populations in Southern Norway due to 30 and 50 % sulphur emissions reductions [a].

Variables	Regression coefficients			
	30 % emis. red.		50 % emis. red.	
	1	2	3	4
. Income (1,000 NOK)				
- household income	1.464**	1.107**	1.447**	0.835**
. Age				
- 15-29		140.21**		176.98*
- 30-44		49.18		123.48
- 45-59		-40.12		-25.35
. Number of angler days in freshwater in 1985				
- 1-9		-22.00		182.40*
- 10-29		66.99		157.58
- 30 +		128.43		328.18*
. Number of additional angler days/year				
- 1-4		14.38		36.12
- 5-10		186.27**		60.96
- 11 +		353.87**		92.90
. Attitude towards environmental preservation				
- active in environmental issues		691.88		544.59
- greatly concerned about environmental issues		337.68**		427.71**
- less concerned		193.17		174.99
- little concerned		111.93		18.89

(TABLE 5 - continued)

Variables	Regression coefficients			
	30 % emis. red.		50 % emis. red	
	1	2	3	4
Payment instrument				
- first bid = 500 NOK		129.57**		194.47**
- first bid = 1,000 NOK		319.27**		236.70**
- payment card		71.68		-53.02
Education (years)				
- 10-12		60.87		15.46
- 13 +		54.49		162.65
Recreational fishing in saltwater in 1985				
- yes		87.79*		86.16
Place of residence				
- Oslo		-17.55		-154.05
- Bergen		150.01*		260.32*
- Trondheim		482.02**		563.91**
- town with more than 2,000 inhabitants		160.55**		88.00
- town with less than 2,000 inhabitants		16.87		-77.98
Living in "Sørlandet"				
- yes		115.04*		185.22*
Sex				
- man		39.9		-115.78*
Constant term	161.94**	-355.94**	169.75**	-208.02
Adjusted R^2	0.05	0.25	0.04	0.18
F-value	51.47	11.98	33.06	6.65
Significance level of F-value	0.0001	0.0001	0.0001	0.0001
Degrees of freedom	966	843	751	653
Number of observations	968	871	753	681

[a] Regression coefficients significantly different from zero at the 0.01 and 0.05 confidence level are denoted respectively ** and *.

WTP for effects from 30 % and 50 % emission reductions. These simple regressions are used to calculate the gross effect of income on WTP, i.e. not considering the effects of other explanatory variables. The Engel elasticity for freshwater fish populations, here defined as the relationship between the households WTP (as an expression of the demand for the good) and their money income, is estimated to be in the range 1.447 - 1.464. This means that the demand for this non-market good increases by 1.45 to 1.46 % when income increases by 1 %. This is in agreement with Biørn & Jansen (1982, Table 7.7), who estimated the Engel elasticity for recreational goods to be 1.260. This estimate was based on cross-section data on consumer demand in Norwegian households in the period 1975-77 (from the Central Bureau of Statistics). In USA Thompson & Tinsley (1978) found an Engel elasticity for recreational fishing of 1.39. However, both these studies are based on real expenditures and estimate the Engel elasticity of only the recreational part of the environmental goods. In addition these studies are also based on the gross effect of income, and are therefore subject to specification error.

Inclusion of other important explanatory variables would give a more correct estimate of the Engel elasticity for freshwater fish populations. The lower Engel elasticity of 0.835-1.107 derived from regression no. 2 and 4 in Table 5 should therefore be used. In these regressions the pre-selected explanatory variables considered most important are included. With the exception of income, binary predictor variables are used. For the binary variables, the regression coefficients show the difference in WTP compared to the reference alternatives. The reference alternatives are defined as following:

- Age = 60 +
- Number of angler days in freshwater in 1985 = 0
- Number of additional angler days/year = 0
- Attitude towards environmental preservation = Thinks there has been too much environmental preservation
- Payment scheme = First bid equal to 200 NOK
- Education = 9 years or less
- Recreational fishing in saltwater in 1985 = No
- Place of residence = Rural area with less than 2,000 inhabitants in a cluster
- Living in "Sørlandet" = No
- Sex = Woman

The youngest age group was found to be willing to pay 140-177 NOK more than those over 60 years of age. This difference was statistically significant for both 30 % and 50 % emission reductions. For the 50 % emission reduction the WTP stated by anglers was higher than for the reference group that did not fish. This difference was significant only for those anglers that fished 1-9 or more than 30 days during the year before the survey was conducted. Such significant relationships were not found for the 30 % emission reduction. However, regression no. 2 shows that those stating they would fish an additional 5 days or more per year were willing to pay 186-354 NOK more than the reference group, who would not change their angling activity. This difference was significant at the 0.01 level. The pattern was the same for the 50 % emission reduction, but no significant differences were found.

Those greatly concerned about environmental issues stated a significantly higher WTP than those who felt environmental preservation had gone too far already.

The results from the payment instrument variable provide evidence of instrument bias in subsamples for both emission reductions. The respondent's education was found to have a small positive, but not significant, effect on the WTP.

Participation in saltwater recreational fishing, considered a substitute activity to freshwater recreational fishing, seems to have a positive effect on the WTP. This effect was significant only in the 30 % emission reduction case.

Residents in the large cities Bergen and Trondheim have significantly larger WTP than those living in rural areas. For Oslo, the capital and the largest town in Norway, the picture seems to be the opposite. This difference is, however, not statistically significant. People residing in "Sørlandet", the area most heavily affected by fish losses, were willing to pay 115-185 NOK more than those living in other parts of the country (a significant difference). The results also indicate that women state a higher WTP than men do.

In general, the relationships described above seem reasonable in regards to expectations from economic theory and a previous study of the WTP for all freshwater fish populations in Norway (Strand 1981).

R^2 adjusted for degrees of freedom for regression 2 and 4 indicates that respectively, 25 and 18 % of the total variation in WTP can be explained by the variables included in the functions. This is the same level that has been obtained in other Norwegian CV-studies using data from a cross section survey of households (Strand 1981, Hervik et al. 1987). The F values of the equations were significant at the 0.0001 level.

The mean, annual, total WTP per household to achieve marginal increments in the freshwater fish stocks due to 30-70 % reductions in the sulphur emissions was found to be in the range of 278-603 NOK (see Table 2). One way classification analysis of variance was used to test the hypothesis of no difference between the mean WTP for the three different environmental improvements. The hypothesis could not be rejected at the 0.01 level. Thus, one mean WTP-estimate for all the different increments in the fish stocks was calculated. This estimate was then multiplied by the total number of Norwegian households, to produce an approximation of the total social economic value of these effects of reduced sulphur emission.

Because of the observed starting point bias in subsamples using "bidding games", and because the payment card seemed to have the smallest "constant budget"-bias, gave conservative estimates and worked best in general, this latter method was used to produce a reasonable, least biased mean value estimate of 300 NOK/household/year (US $ 48).

3.3 Benefit aggregation and comparison with costs

The estimate of 300 NOK/household/year aggregates to a social economic value of 456 million 1986-NOK per year. This is the value of achieving reproducable brown trout stocks in 567-928 lakes (larger than 5 ha) in "Sørlandet", recovering "some atlantic salmon" or reproducable stocks in the same area, and halting further geographical spreading of the fish losses.

This estimate can be compared to the social economic value of preserving all freshwater fish populations in Norway from extinction. In 1980 Strand (1981) used a CV-survey of 4,400 persons over the age of 15 to estimate a mean annual WTP of 800 1980-NOK per person. This was considered a conservative estimate from the calculated interval 750-1,200. Adjusted by the consumers' price index and multiplied by the number of inhabitants over 15 years of age, this corresponds to an annual social economic value of 4,350 million 1986-NOK. This means that the economic value of the marginal change in freshwater fish populations from reduced acid depositions is about 10 percent of the value of all freshwater fish.

However, both the number and the area of lakes and rivers restored as a result of the emission reductions seem to be much less than 10 percent of the total (Central Bureau of Statistics 1981, 1983). The unproportionally large value of the marginal increment in the fish stock is assumed to be due to the fact that these fish losses are concentrated in an area where more than 1/3 of the Norwegian population lives. This effect may, however, be partly offset by methodological differences between the two surveys. Because Strand (1981) asked about the WTP to avoid extinction while in our survey WTP to recover fish populations was stated, loss aversion and the drastical extinction threat may have "biased" Strand's estimate upwards.

To my knowledge there have been no similar studies of the total WTP for marginal increments in freshwater fish populations due to reduced acid depositions. However, two Travel Cost (TC)-studies of the reduced recreational value of fishing due to acidification in the Adirondack Mountains in the state of New York, USA should be mentioned. Both studies (Mullen & Mentz 1985 and Violette 1986) are based on the New York Anglers Survey 1976-77. Mullen & Mentz (1985) found that if 5 % of the water acreage was devoid of fish this would reduce the annual recreational value of fishing to the New York resident anglers by 3.4 %. If the damaged water acreage increased to 10 %, the correspon-ding reduction in the recreational value was found to be 5.5 %. Thus, the incremental reduction in the recreational value was less than that associated with the initial habitat loss. This was found to be due to the increased importance of substitution as additional angling sites were lost. Mullen & Mentz op.cit. conclude that these estimates probably understate the loss in recreational value because of uncertainties about the assumptions made in the TC-model and the extent of the current acidification damages.

Violette (1986) uses a different TC-model not including any "substitution variables", because it might be argued that these threatened, high altitude brown trout ponds provide a relatively unique recreation experience with no perfect substitutes. Violette op.cit. tried to incorporate the uncertainty of the acidification damages by constructing four different scenarios. The results approximated those found by Mullen & Mentz (1985).

Because these studies reflect changes only in use value from decrements in the fish stocks they cannot be directly compared to the results from my study. In addition the scale of the problem is much larger in Norway. Due to these differences, it is difficult to draw any unambiguous conclusions from this comparison.

The benefit estimate of 456 million 1986-NOK per year for the increments in the Norwegian fish stocks from reduced acidification can also be compared to the costs of liming and re-stocking. From Matzow (1984) the annual costs of liming the run-off from the entire acidified area in Southern Norway can be calculated to be approximately 300 million 1986-NOK. Thus, this estimate can be viewed as the liming costs corresponding to a 100 % reduction in sulphur emissions. However, this estimate does not include labour costs, because current liming operations are voluntarily carried out by land owners and members of the local hunting and fishing organizations. In addition to the liming costs come the costs of re-stocking those rivers and lakes devoid of fish. No estimates of these costs exist, but it is reasonable to assume that they are not larger than the additional liming costs corresponding to the difference between 70 and 100 % reduction in emissions.

Due to the lack of cost estimates, present values of these liming and re-stocking efforts can not be calculated. However, the existing information and the considerable size of the benefit estimate indicate a positive net present value.

Liming and re-stocking of water bodies are first aid actions, and only large international emission reductions can provide a final solution to this pollution problem. Thus, since Norway is a net-importer of long range transported air pollutants and the Polluter-Pays-Principle is internationally accepted, the benefit estimate should be used to document the economic value of repairing the currently most important environmental damage from acid rain in Norway.

4 CONCLUSION

The annual social economic value of marginal increments in the freshwater fish populations in Southern Norway due to a 30-70 % reduction in sulphur emissions, is estimated to be approximately 450 million 1986-NOK (or about US $ 72 million). This is 0.009 % of the Norwegian GDP in 1986 (Central Bureau of Statistics 1987).

The value estimate illustrates the size of the welfare improvement to the Norwegian population, expressed as their aggregated subjective, total willingness-to-pay (WTP) for this environmental improvement. A Contingent Valuation (CV) survey of two independently drawn random samples of the Norwegian population, each of about 1,000 households, was employed to derive this estimate.

The potential biases of the Contingent Valuation Method are addressed, and the CV survey was designed to control for the most important biases. The results indicate that this CV-design worked reasonably well. Nevertheless, there remain uncertainties in the method and the damage estimates on which the valuation is based.

In addition, the derived value is based on two important assumptions. First, the valuation is based upon present income distribution and the welfare change induced is assumed not to influence this distribution. Second, WTP of people today is assumed to reflect the value of the change in the environmental good, because unborn future generations can not be asked. The WTP for environmental improvements may, however, vary substantially with potential changes in the income distribution, and change over time as preferences for environmental goods change and new information becomes available.

Using the conservative estimate of 450 million NOK reduces the possibility of overestimation. But due to the above described uncertainties, this estimate should be interpreted only as an approximation of the values involved. This is especially true since it is difficult to control the accuracy of the large non-use values observed.

However, this study indicates that the economic value of environmental improvements due to reduced acid depositions is large. For the Nordic countries, as net-importers of sulphur dioxide and other long range transported air pollutants, it is important to document these values and use them in negotiations about further emission reductions.

To compensate for the lack of data and empirical studies on this subject, Navrud (1988) proposes and describes a Nordic research program on valuation of public goods affected by long range transported air pollutants. Such studies should, however, also be done in cooperation with other countries, which are differently affected by acidification damages. This would produce comparable results of considerable interest to policy makers.

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APPENDIX 1

QUESTIONAIRE - NATIONAL SURVEY, SUBSAMPLE NO. 5
(Instructions to interviewers in parentheses)

Question 1
(Show map)

This map shows the acidification damages to our freshwater fish populations. This acidification is largely due to long range transported air pollution from other countries in Europe. To reduce this acidification most of the European countries have agreed to reduce their sulphur emmissions by 30 % within 1993, and negotiations on further reductions have started.

In anticipation of these reductions, the Norwegian govern ment is now considering large scale liming of our water bodies. The lime will neutralize acid depositions. This liming, together with re-stocking of lakes and rivers devoid of fish, is a necessary first-aid action to maintain fisheries in the damaged areas and prevent spreading of acidification damages to other vulnerable water bodies.

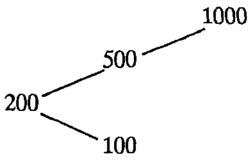
(Show diagrams)

These diagrams show the considerable increase in trout populations in the four southernmost counties (Telemark, AustAgder, Vest-Agder and Rogaland) that can be achieved by lime applications corresponding to a 50 % reduction in acid depositions. Similar effects could be expected in the rest of the affected area. This liming will also have a positive effect on salmon rivers. All of the rivers in the four southernmost counties, where salmon are now nonexistent, can be re-stocked and will again give rise to good salmon fishing. This liming would also stop fish losses from spreading north along the western coast of Norway, where there are still rich salmon rivers.

The costs of any liming and re-stocking program must be paid by the Norwegian society (i.e. taxpayers). The government is therefore interested in determining the value the Norwegian population places on the described increase in fish populations and on preventing the further spread of fish losses. An important question is whether this value outweighs the costs of liming and re-stocking.

One way to measure this value is the people's willingnessto-pay to achieve this environmental improvement. The answers to the following questions may therefore affect the decision to undertake these actions. We don't know exactly how much these actions will cost, or how many years it will be necessary to lime.

Suppose that the costs will be distributed among all households in Norway by payment of a special, annual tax to a federal liming fund. If all households pay equally in relation to their income, and this tax was NOK 200 each year for an average household in the years to come, would you then be willing to support these actions?



(Bidding scheme)

Question 2

What is the largest amount your household is willing to pay annually, if that should be neccessary to implement the liming program?

NOK ____

Question 3

(To those that answered NOK 0 to question 2 ask:)

What is your primary reason for answering NOK 0?

(Show card with these alternatives):

1. I don't fish and therefore see no reason to pay for increased fish populations.
2. My living costs are already too high; I can't afford it.
3. Other things are more important; e.g. hospitals, schools etc.
4. I think I pay too much tax already.
5. I think that those countries that produce the pollutants causing the damage, also should pay for actions taken to repair these damages.
6. Other reasons: ________________________

Question 4

People are willing to pay for this increase in the fish populations for different reasons. How large a portion (% of 100) of the amount you stated would you say is motivated by these different reasons?

(Show card with these alternatives):

1. I am an angler myself and pay to continue this recreational activity. _____ %

2. I am not an angler, but I will pay to secure the option to fish in the future. _____ %

3. Payment to preserve the freshwater fish populations due to other reasons than being an angler or wanting to keep the option to fish in the future; i.e. payment to preserve the existence of freshwater fish, and being able to deliver this existence to future generations. _____ %

Total: 100 %

Question 5

If acid depositions were reduced by 50 % in Norway, this would also entail other environmental improvements. In addition to effects on freshwater fish this would reduce the danger of forest dieback, the accumulation of toxics in plants and animals, the corrosion of historical buildings and monuments and the possibility of long term effects on people's health and wellbeing. The government is also interested in finding the value the people place on this total environmental improvement. One way of measuring this value is the people's willingness-to-pay to get this improvement.

Suppose that all households pay the same amount in relation to their income. What is the highest amount your household is willing to pay annually to achieve this total environmental improvement?

NOK ____

OTHER INFORMATION COLLECTED:

1. Recreational fishing activity
   a) No. of angler days in freshwater habitats in 1985 (divided into salmon fishing and fishing for other freshwater fish species)
   b) No. of additional days in freshwater habitats if we achieved the described increase in the fish populations; even if you do not fish today (i.e. intended behavioural change)
   c) No. of angler days in saltwater in 1985 (i.e. substitute activity)
2. Attitudes towards environmental issues in general
3. Socioeconomic variables:
   a) Personal income
   b) Household income
   c) No. of persons in household
   d) Sex
   e) Age
   f) Marital status
   g) Place of residence
   h) Education

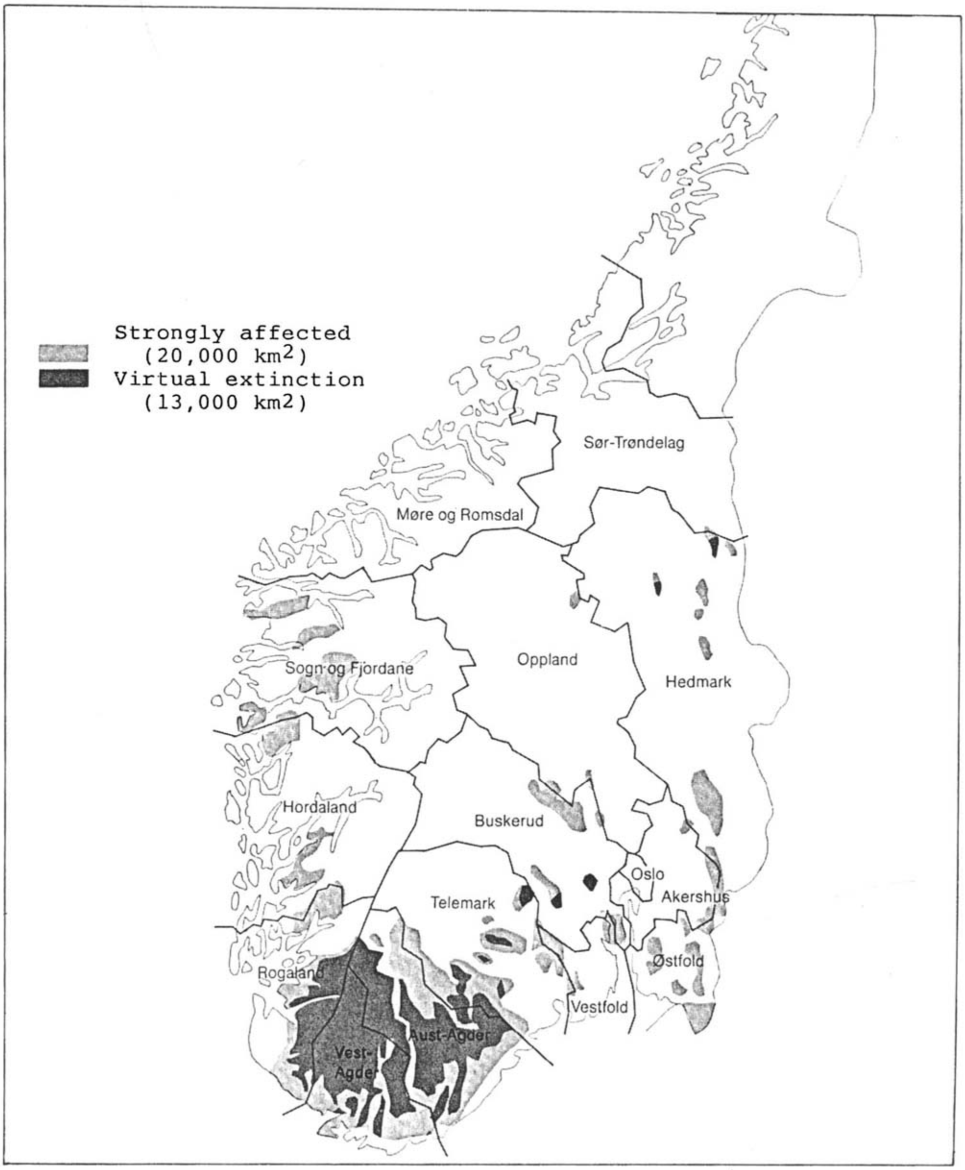
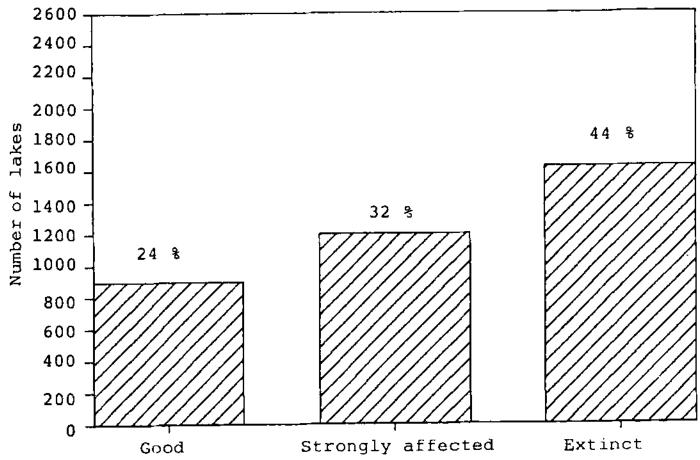


Fig. 1.1. Regional distribution of areas in Southern Norway where fish populations are affected by acid depositions. (No fish losses due to acidification have been observed in the three northernmost counties which are therefore left out of this map).
From: Sevaldrud et al. 1980.

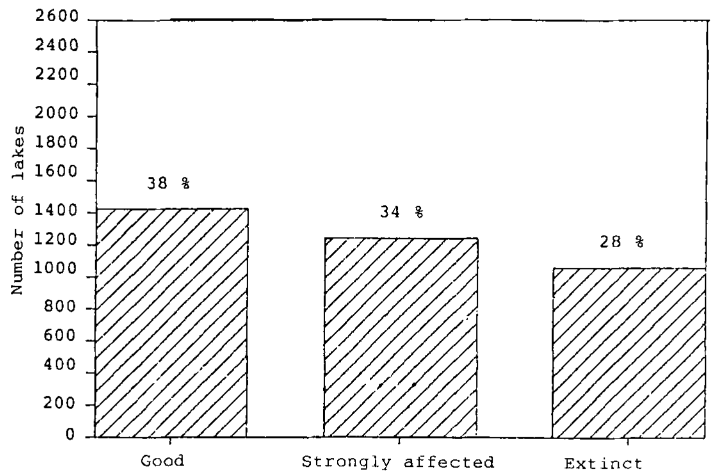
APPENDIX 2

THE CONDITION OF BROWN TROUT POPULATIONS IN THE LAKES IN THE FOUR SOUTHERNMOST COUNTIES OF NORWAY (TELEMARK, AUST-AGDER, VEST-AGDER AND ROGALAND) UNDER DIFFERENT REDUCTIONS IN ACID DEPOSITIONS.

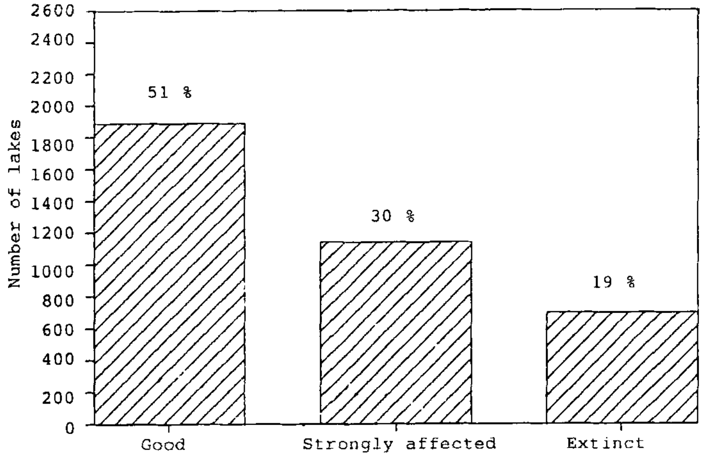
(a) Reference situation (1980).



(b) The situation after a <u>30 percent reduction</u> in acid depositions.



(c) The situation after a 50 percent reduction in acid depositions.



(d) The situation after a 70 percent reduction in acid depositions.