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Article *in* Regional Environmental Change · December 1999

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CSERGE Working Paper GEC 97-20

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Roy Brouwer[1]
Ian H. Langford[1]
Ian J. Bateman[1,2]
Tom C. Crowards[3]
R. Kerry Turner[1,2]

[1]Centre for Social and Economic Research on the Global Environment
University of East Anglia
and
University College London

[2]School of Environmental Sciences
University of East Anglia

[3]Caribbean Development Bank
St. Michael, Barbados

Acknowledgements

The Centre for Social and Economic Research on the Global Environment (CSERGE) is a designated research centre of the UK Economic and Social Research Council (ESRC).

This research paper is part of the European Commission Directorate General XII funded project 'Ecological-Economic Analysis of Wetlands' (ECOWET), contract number PL951491, co-ordinated by CSERGE.

ISSN 0967-8875

Contents:

Abstract

Recent years have seen a growing interest, both from academics and policy makers, in the potential for producing generally applicable models for the valuation of non-market environmental goods and services which do not rely upon expensive and time consuming original survey work but rather extrapolate results from previous studies of similar assets. This paper presents such a meta-analysis for the use and non-use values generated by wetlands across Europe and North America.

This study directly addresses two fundamental methodological issues: (i) whereas previous analyses have tended to examine valuation differences between various environmental goods, the present study focuses down a further level to assess the values attributable to the individual use and non-use values associated with the ecological, biogeochemical and hydrological functions provided by a given complex environmental asset; (ii) previous meta-analyses have been criticised for insufficiently addressing the potential problem of clustering within the multiple values derived from single valuation studies; this issue was examined through the application of advanced, multi-level modelling methods which allow for the hierarchical structure of data implicit in such clustering.

The study opens with a qualitative descriptive analysis of wetland functions. This is used as the basis of the subsequent quantitative meta-analysis of evaluations derived from a large number of contingent valuation (CV) studies of wetlands. These studies yield over 100 value estimates which our meta-analysis relates to the previously defined function variables and various CV design parameters.

Results from the meta analysis identify a number of distinct values for wetland functions. Interestingly, use values such as flood control, water generation and water quality attributes were found to exert a stronger influence over willingness to pay (WTP) than non-use elements such as the biodiversity functions of wetlands, a result which accords with the findings of recent mixed revealed and expressed preference studies of non-market goods.

A number of standard CV design effects were also shown to have a significant impact upon WTP including the choice of payment vehicle and elicitation method (the previously observed discrepancy between dichotomous choice and open ended formats being particularly noticeable). Routine considerations of issues such as inter-country effects were also conducted yielding interesting results. The analysis also included a number of novel elements such as a scope

test, an assessment of study quality and the aforementioned investigation of potential evaluation clustering due to identical survey design or sample population. Tests showed that this approach afforded a significant improvement in modelling of the data over that achieved by more conventional meta-analyses.

Although considerable effort has been put into specifying the characteristics of the environmental functions and correspondingly the environmental goods and services involved, many sample population characteristics remain unevaluated. Typically, in meta-analysis inferences are made on the basis of information on global statistics, such as the mean and standard deviations of parameter estimates. These may or may not describe individual behaviour adequately. In order to overcome this problem, a next step is to analyse individual data supplied by authors of the studies included in the meta-analysis. This provides an important test of the appropriateness of meta-analysis as an instrument to synthesise CV outcomes, for example for the purpose of benefits transfer.

1. Introduction

1.1 Meta-analysis[1]

Meta-analysis is the statistical analysis of the summary findings of empirical studies. In the relevant literature, a distinction has been made between primary analysis, secondary analysis and meta-analysis. Primary analysis is the original analysis of data in a research study. Secondary analysis is the re-analysis of data for the purpose of answering the original question with better statistical techniques or answering new questions with old data. Finally, meta-analysis refers to the analysis of analyses, that is, the statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings.

Meta-analysis has been developed over the last thirty years, mainly in the field of experimental medical treatment, psychotherapy, learning, education and skills. Typically, these experiments took place in rather well-controlled circumstances on the basis of relatively standard designs and standard measurement. Meta-analysis helps us to extract information from large masses of data presented in studies in order to quantify a more comprehensive assessment which can complement a narrative or more qualitative analysis. As such, meta-analysis is to be seen not as a substitute, but as an important supplement to qualitative analysis (van den Bergh and Button, 1997).[2]

Important advantages of meta-analysis are, first, that it does not prejudge research findings on the basis of the original study's quality and so is said to avoid selective inclusion. Secondly, it avoids a differential subjective weighting of studies in the interpretation of a set of findings. Thirdly, meta-analysis offers a transparent structure with which to understand underlying patterns of assumptions, relations and causalities, so permitting the derivation of useful generalisations without violating more useful contingent or interactive conclusions (Hunter *et al*., 1982).

However, a significant disadvantage of meta-analysis is that it is often biased towards including significant study results only, since it will be likely that insignificant study results will not be published. Furthermore, multiple results from the same study are often treated as individual, independent observations without explicit testing of the implicit assumptions of such an approach.

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[1] This first section draws heavily on Glass et al. (1981) and Wolf (1986).

[2] A qualitative analysis of the summary findings of empirical studies can also be called a meta-analysis. However, following the meaning given to the word in literature, in this paper meta-analysis refers to quantitative analysis.

1.2 The use of meta-analysis in environmental valuation research

Since the beginning of the 1990s, meta-analysis has started to play a more important role in environmental economics research, in particular in the field of environmental valuation. Analyses have focused on a range of environmental issues, from outdoor recreation to urban air pollution, based on single or multiple valuation techniques. The increase in meta-analytical research seems to have been principally triggered by: (1) increases in the available number of environmental valuation studies; (2) the seemingly large differences in valuation outcomes as a result of the use of different research designs; and (3) in view of the high costs of carrying out environmental valuation studies, the increasing demand for transferable valuation results.

An important criticism of the use of meta-analysis in the field of environmental valuation is that it compares findings from studies which are not the same. Including studies employing different standards of design or measurement will undermine the inferences made from a cross-analysis. There has to be a variation somewhere, besides statistical errors, in order to be able to explain differences in outcomes. The core question becomes therefore whether the analysis is appropriate for testing different findings derived by intrinsically different measures.

For the purpose of environmental benefits transfer, the importance of evaluating not only similar goods and services, but also similar value categories seems especially pertinent. Expressed preference approaches such as contingent valuation (CV) are the only valuation methods to date which are able, in principle, to measure a good's use and nonuse value. Conversely, revealed preference methods such as the travel cost (TC) method measure use value only. Use values are the values associated with the actual use of the environment, while nonuse values are generally associated with the benefits derived simply from the knowledge that environmental goods are preserved without any present or future use motives (Pearce and Turner, 1990). Significant differences between CV and TC estimates have for example been reported by Walsh *et al*. (1992) and Carson *et al*. (1996). In their benefits transfer study, Brouwer and Spaninks (1997) tried to account for the possible nonuse values associated with distance-decay effects found in CV estimates.

Table 1 gives an overview of meta-analytical research carried out in the field of environmental valuation. This has tended to focus on similar public goods or services, the values of which have been estimated using the same valuation technique. Hedonic property (HP) models have been used to detect the influence of air pollution on housing prices. TC based valuation studies focus on outdoor

recreation demand in general and fresh water recreational fishing demand in particular. The two CV based meta-analyses focus on improving the visibility at national parks in the United States and woodland recreation in the United Kingdom. Only two studies are based on a combination of valuation techniques, one of which moreover considers three broad classes of quasi-public goods (Carson *et al*., 1996). The values included in this study cover a wide range of environmental benefits, ranging from recreational fishing to occupational risks expressed in terms of statistical values of life.

Table 1: Meta-analyses carried out in the field of environmental valuation

Study	**Topic**	**Valuation technique**
Smith and Huang (1993, 1995)	air pollution	HP
Smith and Kaoru (1990)	outdoor recreation	TC
Sturtevant *et al*. (1995)	fresh water fishing	TC
Smith and Osborne (1996)	visibility at national parks	CV
Bateman *et al*. (1995[A])	woodland recreation	CV
Walsh *et al*. (1992)	outdoor recreation	CV, TC, (unknown) other valuation techniques
Carson *et al*. (1996)	recreation, environmental amenities, health risks	HP, TC, CV, defensive expenditures, actual market data

Results from these analyses suggest that differences in study design play an important role in explaining the variance between valuation outcomes. In the HP based studies, besides local property market conditions, the type of data and model specification employed in each study helped to reveal significant negative relationships between housing prices and air pollution measures. In the TC based studies, significant differences were found regarding (1) the overall statistical specification of the TC model, (2) the specification of the opportunity costs of time, and (3) the inclusion of substitute prices.

Differences in CV outcomes have been analysed in great detail in individual studies by looking at the effect of varying single research design elements on stated preferences. Significant differences have been found in valuation outcomes in individual studies with different survey design. But, these design

differences are addressed in a very narrow way in the very few existing CV based meta-analyses, i.e. investigating different elicitation formats only.[3] In the study by Bateman *et al*. (1995[A]), a dummy variable was also included to distinguish between use and option value.[4]

1.3 Contingent valuation of wetland functions

Wetland ecosystems account for about six percent of the global land area and are among the most threatened of all environmental resources. The wetlands found in temperate climate zones in developed economies have long suffered significant losses and continue to face an on-going conversion threat from industrial, agricultural and residential developments, as well as from hydro-logical perturbation, pollution and pollution-related effects (Turner, 1991).

Wetlands are complex ecological systems, whose structure provides us with goods or products involving some direct utilisation of one or more wetland characteristics, while wetland ecosystem processes provide us with ecologically related services, supporting or protecting human activities or human properties without being used directly. So, the stock of wetlands is a multifunctional resource with significant economic value, as the recent work by Costanza and others suggests (Costanza *et al*., 1997). Fifteen percent of the value of the world's ecosystem services and natural capital are generated by wetlands (ibid). Sustainable management of these assets therefore seems highly relevant. Since this management process is not costless, they require as precise and meaningful a valuation possible.[5]

Given the substantial (off-site) indirect use and nonuse values expected to be involved, wetlands have been the focus of attention in several CV studies (see

[3] The elicitation format refers to the way respondents are enabled to state a value. Four common elicitation formats can be distinguished: open-ended, payment card, dichotomous choice and iterative bidding questions (Mitchell and Carson, 1989). In the open-ended question, respondents are asked directly for their WTP and are free to give any answer, while the payment card is a card consisting of a range of WTP amounts from which respondents can choose their most appropriate amount. The dichotomous choice corresponds with a 'take it or leave it' or 'yes or no' format, similar to a referendum, but with regard to a set WTP bid level. Finally, in the iterative bidding game respondents are asked to move up or down from this starting bid level, depending on their original response.

[4] Option value refers to retaining the option of future availability of goods or services (Pearce and Turner, 1990).

[5] This does not necessarily imply monetary valuation. Non-monetary valuation in the sense of an explicit weighting procedure in a multi-criteria analysis of non-monetary environmental and monetary economic indicators is another way of helping decision-making in the achievement of sustainable development.

the review in Crowards and Turner, 1996). Many of these studies try to estimate the total economic value of wetlands. The total economic value of an environmental resource comprises use values, option value and nonuse values (Pearce and Turner, 1990).[6]

An important step towards the estimation of the total economic value of wetlands is the distinction between ecosystem structure, the characteristics of which provide humans directly with extractive (e.g. fish or reed) or non-extractive benefits (e.g. recreation), and ecosystem processes providing humans indirectly (often off-site) with extractive (e.g. clean water) and non-extractive (e.g. provision of biodiversity) benefits.[7] Although each of these benefits provides a distinct positive value to the overall system, the distinction is considered essential because it will ensure against possible double counting (Crowards and Turner, 1996).

1.4 Applying a systems approach in achieving the study's main objective

In this paper, we will investigate the main findings of contingent valuation studies of wetland functions in temperate climate zones in the developed economies. The main objective is to provide a combination of qualitative and quantitative analysis of possibly interacting factors underlying differences found in CV wetland studies. Given (1) the complexity of the natural system, the human system and the system of interactions between these two systems, and (2) the complexity of the data set considered in this paper, consisting of the findings of multiple studies, we will adopt a **systems approach** to analyse the value elicitation procedure of wetland functions. Such an approach involves placing as much emphasis on identifying and describing the connections between environmental good (i.e wetland functions) and study design characteristics as on identifying and describing the functions and design characteristics themselves. Formally, a system is a set of components that interact with each other. Changes in one component will induce changes in

[6] A more appropriate understanding of value in this context is given by Gren *et al*. (1994), who define the 'total system value' as consisting of the value of the ecosystem's self-organizing capacity (called 'primary value') and the value of life-support functions and ecological services that this capacity generates (called 'secondary value'). The total economic value concept does not correspond with this total system value. The secondary value encompasses use values and market revealed values, but the intrinsically different concept of value renders primary and perhaps some non-use values incommensurable with use values.

[7] Also called consumptive and non-consumptive benefits. However, although not actually 'eating or drinking' the specific service, walking in a forest or wild water rafting can also be seen as a consumptive use of the services provided by the natural system.

another component, which may in turn induce change in a third component (Clayton and Radcliffe, 1996).

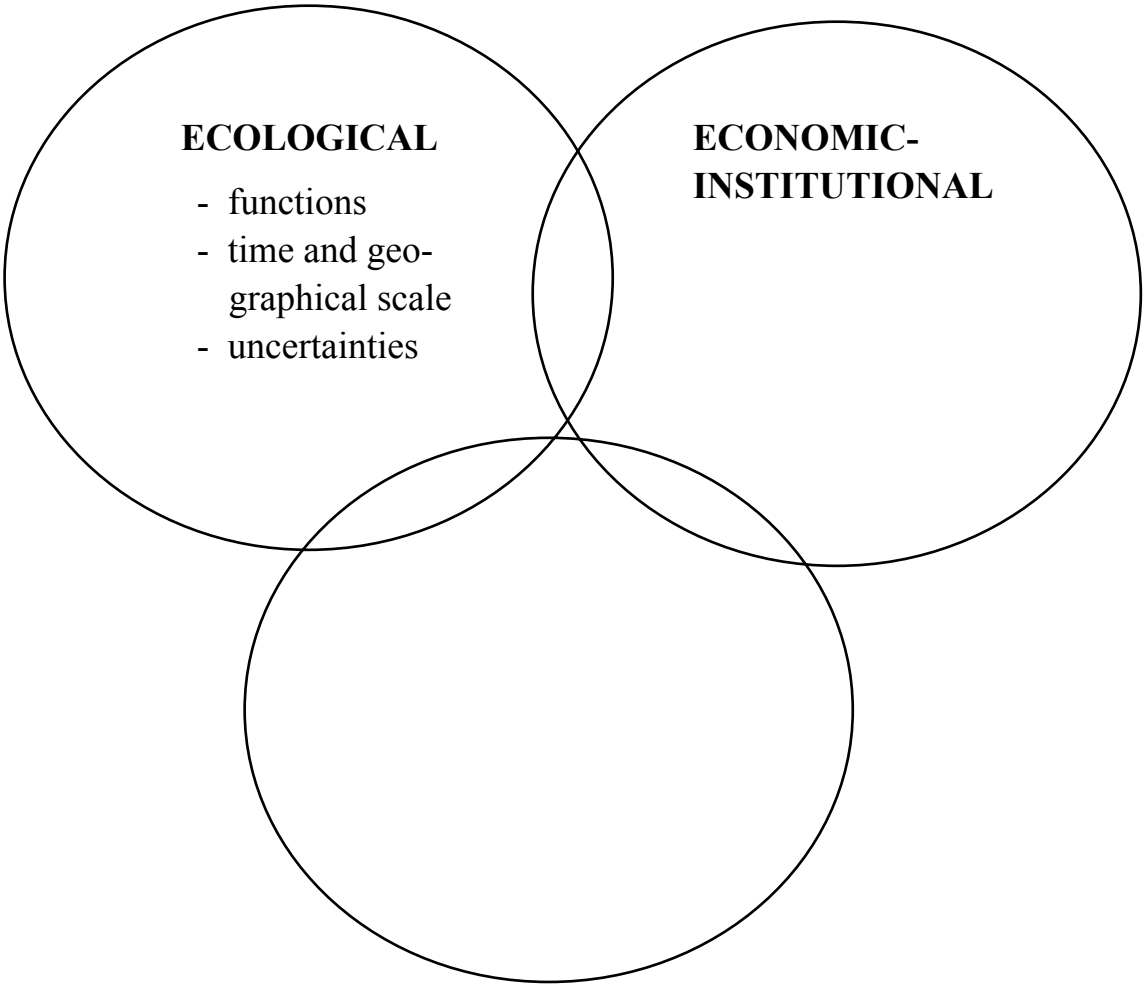
We will focus on the different wetland functions involved, the benefits derived from these ecological functions and the values attached to these benefits. At the same time we will try to link these values to the different contexts present or created in each study. The simple diagram in Figure 1 shows that contingent valuation can be understood as comprising three main dimensions: ecological, social and economic, all affected by different methodological issues. In this paper, we will be mainly addressing the ecological (wetland functions) and economic-institutional side (market construct) and their interaction as expressed in respondents' use and nonuse values.

Different presentations of environmental problems in CV surveys with respect to the (levels of) various attributes or ecologically related services in different methodological settings may result in different valuation statements, possibly by prompting different motivational orientations in respondents' mind which direct and help them to construct their stated preferences. That is, different combinations of the various elements found in CV surveys, like the environmental functions to be valued, the market construct, the payment vehicle or the elicitation format employed, may activate different motivations and corresponding underlying beliefs, and ultimately elicit different either well-articulated or constructed preferences.

The remainder of this paper is organised as follows. In section 2, an overview will be given of some important methodological issues presently underlying much of the CV debate. The essential elements in this critique will be briefly highlighted and partially incorporated into the meta-analysis. Section 3 presents the qualitative part of this analysis, giving a descriptive overview of the selected CV studies considered. Section 4 presents the quantitative part of the meta-analysis, while section 5 concludes and briefly discusses the possible implications of the study.

Figure 1: Main dimensions underlying the CV methodology

METHODOLOGICAL ISSUES



2. Essential Elements of the Contingent Valuation Method

The issue of what constitutes a valid and satisfactory CV design has received a lot of attention in CV literature. Starting with the state-of-the-art report by Cummings *et al.* (1986), it was argued that the use of the CV method should be restricted to situations which best emulate consumer markets. Subjects should understand and be familiar with the commodity to be valued and they should have had (or be allowed to obtain) prior valuation and choice experience with respect to consumption levels of that commodity. Meeting these conditions would clearly limit the use of the CV method to those environmental goods and services which are currently already being marketed, like emission or hunting permits (Mitchell and Carson, 1989). Alternatively, political markets such as referenda have been suggested as a more appropriate analogue for CV surveys that value public goods in a private market setting (e.g. Harris *et al.*, 1988; Mitchell and Carson, 1989).

Fischhoff and Furby (1988) argue that a 'satisfactory transaction', that is, one in the traditional neo-classical sense in which people are fully informed, uncoerced and able to identify their own best interests, can only take place if (i) the environmental good, (ii) the method of payment, and (iii) the constructed market are well defined and well understood by the individual. Similarly, based on the theoretical background of CV, Mitchell and Carson (1989) argue that CV scenarios must define and communicate to respondents (a) the reference level of utility, i.e. awareness of current disposable income and description of the property rights situation, (b) the nature of the public good, (c) the relevant prices of other goods, (d) conditions for provision of the good and payments for it, and (e) the nature of the WTP amount desired, i.e. the value of the good in question, not for example the 'purchase of moral satisfaction' (Kahneman and Knetsch, 1992) or 'stating a fair price'.

In their 'best practice' recommendations, the NOAA Panel (Arrow *et al*., 1993) provides an extensive list of guidelines for CV survey construction, administration and analysis. Some of the most important guidelines for value elicitation in order to assure reliability and usefulness of the obtained information include (i) a conservative survey design, (ii) the use of the willingness to pay format, (iii) the use of the referendum format, (iv) the provision of adequate and accurate information about the environmental program that is being offered, and (v) a reminder of substitute commodities. The Panel furthermore distinguishes a subset of items which it calls the '*burden of proof*' requirements. The Panel judges CV findings unreliable if it suffers from (a) a high non-response rate, either to the entire survey instrument or the valuation question, (b) inadequate responsiveness to the scope of the

environmental insult, i.e. stated choices should reveal a smaller WTP for smaller amounts of an environmental commodity provided by an environmental program, (c) lack of understanding of the task by respondents, (d) lack of belief in the full restoration scenario or (e) 'yes' or 'no' votes on the hypothetical referendum that are not followed up or explained by making reference to the cost and/or the value of the program.

Two main elements can be identified in the CV survey design recommendations: (1) the description of the environmental good or the environmental program delivering different provision levels of this good, and (2) the contextual setting of the environmental problem. This latter issue can be understood in a broad sense as the entire valuation task set out to respondents in the CV survey, i.e. including the social context in which the questions are being asked and answered. Since these elements are addressed differently in each CV study included in the meta-analysis, they will be discussed in more detail in the following subsections before turning to the meta-analysis self.

2.1 Description of the environmental good

Fischhoff and Furby (1988) distinguish between the environmental good's substantive and formal definition. The substantive definition refers to the identification of the valuable attributes of the good in question and is considered especially relevant to the functional approach adopted in this paper. Section 2.1.1 will briefly introduce a number of problems to be encountered in CV when applying the notion of attributes or functions to environmental goods or services. The formal definition refers to the target and reference level of each valuable attribute, i.e. the *with* and *without* situations in CBA, and will be discussed in 2.1.2.

2.1.1 Identification of attributes

The notion that a good is perceived by respondents as being made up of a bundle of attributes has its origin in consumer behaviour theory (Lancaster, 1966; Fishbein, 1967) and is widely used in marketing research.[8] It is suggested that consumers perceive a particular product in terms of where it lies in the space spanned by the set of attributes relevant to its product class. While these attributes may be of general interest, individual consumers vary as to which attributes they consider most relevant. Consumers' beliefs or perceptions may furthermore vary from the 'true' attributes because of consumers' particular experience and the way consumers gather and process information. So, it is

[8] For example, conjoint analysis is a widely used statistical tool to decompose and weight consumers' multi-attribute product preferences (Leigh *et al*., 1984).

consumers' perceptions of a product's characteristics that influence their behaviour, not necessarily the 'true' characteristics (Lilien *et al*., 1992). For the purpose of benefits transfer, an important implication of this may be that consumers may experience and hence value the same good differently at the study site (the site from which the estimated values are transferred) and the policy site (the site to which the values have to be transferred).

When applied to environmental goods and services, the notion that a good is perceived as consisting of a bundle of attributes seems to face a number of fundamental problems, which severely limit its use in CV research. Vatn and Bromley (1995) distinguish three relevant problems: *cognition, incongruity and composition*.

First, respondents may find it hard to observe and weigh the various attributes involved (cognition problem). On many occasions, the general public will be unaware of the various functions the environment provides ('functional transparency'). In the case of more complex flows of environmental services, like air or water quality, even natural science experts do not completely understand their ecological functioning and importance for sustaining human life. Only in a limited number of cases can environmental goods and services be defined comprehensibly and be broken down in units as is the case for most market consumer goods.

In circumstances where the public is basically uninformed about a good, it has been suggested that the information given about the good will be helping to form preferences rather than informing existing preferences (Spash and Hanley, 1995). In the case of unfamiliar products, the bench-marks that consumers use in perception formation are generally not applicable. For example, Johnson (1986 and 1988) suggests that the more consumers are faced with non-comparable alternatives, the more they resort to hierarchical processing. That is, in the case of unfamiliar products, consumers eliminate products by using a very general comparison rather than one related to a specific attribute. Similar suggestions are found in CV literature (e.g. Kahneman *et al*., 1982; Ready *et al*., 1995). The more ambiguity in one's preferences, for example due to a lack of familiarity with the goods in question, the more one's expressed preferences will be subject to procedural and descriptive influences (Schkade and Payne, 1994).

The information individuals have at hand seems to play a particularly crucial role in the case of eliciting nonuse values (Randall and Stoll, 1983; Shechter and Freeman, 1994). The use and nonuse typology of values is an important dimension underlying the description of the environmental good to be valued

(Brouwer and Spaninks, 1997). The actual measurement of nonuse values, especially attempts to break them down in various components (e.g. Walsh *et al.*, 1984; Loomis, 1988), has been a source of controversy. Mitchell and Carson (1989) argue that although nonuse values can be measured adequately by CV, they should not be decomposed. People seem to enter a CV survey with a vague holistic value judgment rather than with explicit decomposed value judgments.[9] [10]

The second and third problems distinguished by Vatn and Bromley (1995) represent two poles of the same spectrum: incongruity refers to the incommensurability of attributes (orthogonality), while composition refers to dynamically interrelated attributes (internally or with attributes of other goods). In the former case respondents are unable or unwilling (perhaps as a result of moral considerations) to weight or trade-off different attributes, while in the latter case the value of one attribute depends upon the level of another attribute.

Another problem is the context in which respondents perceive a goods' attributes. This has been labelled 'itemising' (Holland, 1995). Itemising means that goods can be given a value independently of their use context, which seems even in the case of many market goods to be hardly feasible. A screw or a nail, for example, has a particular function (or standard use) in any circumstance. But, in the case of a loaf of bread, another rather ordinary market commodity, one can already distinguish between different functions in different circumstances, e.g. everyday use, feast or ceremony (Holland, 1995). In the case of complex (dynamic and interrelated), multi-attribute environmental services, assuming a standard use context does not seem to be very realistic, especially when substantial off-site indirect use and nonuse values are likely to be involved.

2.1.2 Target and reference levels of attributes

[9] Others (e.g. Milgrom, 1993) consider the entire economists' utilitarian conception of non-use value too simple and therefore inappropriate.

[10] Contingent non-use values are usually distinguished from use values by sampling people who are living further away from the natural resource under evaluation and who have not visited it before. Use values are estimated by sampling for example visitors of a wildlife park or residents in or near that park and ask them for the valuation of their current and possibly future use of the services provided by the park. Hidden in their value statement on-site visitors may also attach value to the mere existence of the park and the services it provides. Perhaps because of the knowledge that it will be there for contemporaries to be seen ('philanthropic value'), for generations to come ('bequest value') or because of the believe that other (than human) living organisms have a right to live on this planet in their own, independent of any human related use, justifying the preservation of their habitats ('existence value').

The second step in describing the environmental good concerns the definition of the reference and target levels of each valuable attribute (Fischhoff and Furby, 1988). Based on what they called a reference-dependent theory of preferences, Tversky and Kahneman (1991) showed that, besides the description of the various attributes, the points of reference used in defining the CV scenario may also influence stated preferences. This theory states that people commonly perceive outcomes as positive or negative deviations relative to some reference point, usually the status-quo allocation of goods, such that changes in the reference points lead to changes in a given welfare measure. In a laboratory experiment wherein individuals were presented with a series of trading opportunities concerning well-known consumer goods and money, Bateman *et al.* (1997[A]) provided a rigorous test of reference-dependent preferences. Results typically failed to conform to Hicksian individual welfare theory, but were generally consistent with the expectations of reference-dependent theory. Reference-dependency is generally known as 'framing' and means in practice that stated preferences can for example be influenced by the description of the problem as 'is the glass half empty' or 'is the glass half full' (Brookshire and McKee, 1994), further adding to the information supply burden the CV researcher faces.

Another important aspect of framing is the level of embedding.[11] Previous studies have demonstrated that embedding a good within a more inclusive good lowers respondents' WTP significantly (Brown *et al.*, 1995). Embedding effects have received a lot of attention in CV literature. In effect, it is seen by many, including the NOAA Panel, as one of the most important issues in CV methodology research. Two important lines of thought can be distinguished (Cummings *et al*., 1994). The first one, proposed by Kahneman and Knetsch (1992), rejects the assumption that standard value theory applies to the measures obtained by CV. Embedding is considered a purely CV inherent phenomenon. The second line, proposed by Randall and Hoehn (1992), argues that embedding is a general economic phenomenon stemming from substitution effects induced by constrained optimization.

Recent empirical support for this second line of thought comes from Bateman *et al.* (1997[B]), who demonstrated that part-whole bias may not only exist for non-marketed goods valued in hypothetical markets, but also for private goods traded in real markets. They conclude that part-whole bias '*may not be confined to the*

[11] When the WTP value for some specific good is found to be similar to the WTP value for the more inclusive good, this is called perfect embedding or part-whole bias. Part-whole bias means that respondents are unable to distinguish between the specific good under analysis (the part) and the wider group of goods (the whole) into which that specific good falls (Mitchell and Carson, 1989; Bateman and Turner, 1993).

realms of hypothetical markets' but, *'may be a more widespread economic phenomenon'*. Holland (1995), on the other hand, instead of questioning the economic rationality of respondents, relates the embedding effect to respondents' inability to itemise complex environmental goods and services. As a result, they are unable to value a change in the provision of these goods and services like they can for some other commodities (e.g. more or less screws or nails needed to get a particular job done).

Following the two lines of thought, a distinction can be made between CV studies focusing on regular embedding and those focusing directly on the substitution question. Regular embedding means that the same good is given a lower value if the WTP for it is inferred from the WTP value for the wider class of goods into which the specific good falls rather than if that good is valued on its own (Whitehead and Blomquist, 1991; Magnussen, 1992; Hoevenagel, 1994). In the latter approach, respondents are asked to simultaneously value the good in question and goods that are relevant substitutes and/or compliments (Hoehn and Loomis, 1993; Cummings *et al*., 1994). Recent CV research (Brown and Duffield, 1995; Brown *et al.*, 1995) has highlighted the need for guidelines on what information about substitutes should be presented to respondents and how.

2.2 Contextual setting of the environmental problem

It has been suggested that CV surveys evoke constructed rather than well-articulated preferences (e.g. McClelland *et al*., 1992; Schkade and Payne, 1994; Spash and Hanley, 1995; Vatn and Bromley, 1995). If responses to CV questions are constructed, they are likely to be highly sensitive not only to the specific description of the environmental goods and services (previous section), but also the description of the economic-institutional context in the questionnaire in which their values are elicited and the social-psychological-cultural context surrounding the survey (Randall, 1986; Schkade and Payne, 1994). In order to be able to evaluate the usefulness and appropriateness of CV in cost-benefit or other decision-support analysis, like multi-criteria analysis, it is important to recognise the diversity of motivations underpinning valuations, the context of the contingent market and the psychological pressures of the interview situation. Three main contextual elements will be briefly discussed in the following subsections: the survey method, the market construct and the elicitation format.

2.2.1 The survey method

The NOAA guidelines prescribe face to face interviews as the survey method likely to yield the most reliable results. However, this method is said to result in possible compliance bias, like interviewer and/or social desirability bias (Hoinville and Jowell, 1977). Respondents may reveal a more positive willingness to pay (WTP) in the presence of the interviewer, because of their motivation to comply with the overall social-cultural beliefs and the perceived interviewer's expectations (Orne, 1962; Desvousges *et al.*, 1987; Boyle and Bishop, 1988; Mannesto and Loomis, 1991; Bateman *et al.*, 1995[B]).

Although avoiding possible compliance bias, mail surveys face another problem, namely high non-response rates which seriously invalidate the representativeness of the study. Unfamiliarity with the subject of the survey, the need to inform respondents and consequently lengthy explanatory texts are important potential contributions to low response rates (Brown *et al*., 1989). Evidence from mail surveys suggests that early, late and non-respondents all differ in several socio-economic aspects (Hoinville and Jowell, 1977; Dalecki *et al*., 1993). Loomis (1987) and Bateman and Langford (forthcoming[A]) found that respondents are better educated and earn higher incomes than the general population.

More recently, the environmental values people may hold have also been elicited via the use of focus groups. These are carefully planned discussions usually between 6 to 10 people, being either field experts, members of the general public or a combination of both. The groups are used to obtain people's views about a defined area of interest. Until now, focus groups have been used in CV research mainly to help determine the best way to present information and questions within a subsequent survey by exploring respondents' pre-survey knowledge. Burgess *et al*. (forthcoming) and Brouwer *et al*. (1997) have used focus groups to investigate people's perceptions of a particular survey and the appropriateness of CV surveys to elicit environmental values held by people after they participated in a survey. The latter argue that this type of research addresses the whole problem of eliciting environmental values in a social setting different to conventional CV research and consequently yielding a different kind of information. Group behaviour and the individual's role in a group become an important issue in this social setting.

2.2.2 The market construct

Different market constructs may activate different respondent motivations. An important distinction has been made between respondents acting as individual consumers in a market context and respondents acting as citizens in a social choice context (Sagoff, 1988). Blamey (1995) found that the CV referendum market format primes more citizen flavoured preferences than the private fund market format. It is argued that since CV builds upon the individual market

behaviour of neo-classical utility theory, citizen roles prompted in public environmental decision-making undermine the appropriateness of CV values in traditional cost-benefit analysis. When it comes to public programs, private goods market behaviour becomes less relevant (Mitchell and Carson, 1989; Jacobs, 1994; 1997).

In a study of woodland recreation, a general taxation payment vehicle which would maintain an open-access resource usage resulted in a substantial and significantly higher WTP than a private entrance fee which would exclude non-payers (Bateman and Langford, forthcoming[B]). Mitchell and Carson (1989) found evidence that the same respondents stated lower WTP amounts for a pollution control device installed and maintained in their homes by the city water company compared to the town's water plant installing and maintaining new equipment. The latter option would achieve the same risk reduction, but for everyone in the community. These respondents valued the public program more highly because they perceived that it protected others besides themselves.

However, Mitchell and Carson found no indication that private desires were subordinated when respondents took the broader public interest into account. It seems inappropriate to view CV respondents as adopting either citizen or consumer roles. Several dimensions may be used to differentiate citizens from consumers and each dimension presents a continuum of possibilities (Blamey, 1995). In this sense, the consumer-citizen continuum provides an interesting way to look at use and nonuse values. It will be most likely that respondents in the role of consumers will first and foremost take into account current use values, and more altruistically orientated nonuse values when adopting the role of citizens.[12]

The different ways respondents are asked to pay in constructed markets will not only evoke different motivational orientations (respondents acting to different degrees as consumers or citizens), but also bring into play underlying beliefs about fairness and trustworthiness. As a result of their different functions and responsibilities, the two types of institutions, the private goods market and the political public decision-making arena, will evoke different claims for justice.[13]

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[12] Although it is argued that all utilitarian thinking since Edgeworth (1881) published his '*Mathematical Psychics: An Essay on the Application of Mathematics to the Moral Sciences*' is based on pursuing self-interest. Also altruism.

[13] Contrary to private market decision-making, political public decision making is judged by the fairness of its outcomes, not its procedures (Lane, 1986). Rawl's (1971) procedural market justice and Pareto optimality (the latter being the heart of economic theory) are cases in point. In the latter case, the market divides the cake in the first place, while the government alters its distribution. By Pareto optimality reasoning, nothing the government can do is just, for changing the market induced distribution means taking away from someone in order to

The public market seems to be much more vulnerable to allegations of both unfairness and injustice than the private market (Lane, 1986). The distinction in vulnerability to claims of injustice is related to the general belief that in both arenas people pursue self interest (Lipset and Schneider, 1983). But while it is considered fruitful for competition in the private goods market, self-interested goal maximisation in the political process may result in a lack of public confidence in political leaders or a '*tragedy of the commons*'.

General taxation as a means of financing an environmental program may, for example, not only evoke a sense of public responsibility in respondents when they evaluate the program, but may also take away possible fears of free riding behaviour by others. The fact that most will pay for a public program funded by general taxation, possibly largely associated with nonuse values, may be in accord with the respondents' overall sense of fairness. Whether respondents believe the proposed funding scheme will actually be implemented, or trust the institution in charge of the collection of payments, is another question. On the other hand, if local beneficiaries can be identified, respondents may fall back on the Beneficiaries Pay Principle, an equity principle which states that those who benefit from public services should pay for them. In that case a private goods market context like the payment of an entrance fee or the purchase of a hunting or fishing permit may be considered more appropriate.

2.2.3 The elicitation format

The elicitation format is another element in CV surveys which, it has been reported, can evoke different stated preferences. Depending on the elicitation format being used, different cognitive responses might result (Bateman *et al*., 1995[B]). Four main elicitation formats can be distinguished (see section 1.2.): open-ended (OE), payment card, dichotomous choice (DC) and iterative bidding (IB) questions. In the studies in which the the impact of elicitation format on stated preferences has been investigated, usually OE versus DC and IB comparisons, significant differences have been found, with the OE format producing significantly lower estimates than the DC format (e.g. McFadden, 1994; Willis *et al*., 1995; Bateman *et al*., 1995[B]). Bateman *et al*. (1995[B]) found that respondents experienced more uncertainty in answering OE than DC questions.

The OE format tends to produce a large number of non-responses or protest (zero) responses compared to the other formats (Desvousges *et al*., 1983). As a result, the payment card (with or without benchmarks) was introduced to help respondents determine their WTP amount. The DC format was developed to

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give it to someone else. So, a fair procedure seems to be a sufficient justification in the private market, but not in the political market (Lipset and Schneider, 1983).

increase the incentive-compatibility of the valuation question. It matches the way consumers make choices in the market (they either decide to buy or not to buy a product at a given price) or, to a lesser extent, the way voters decide in political referenda. Kriesel and Randall (1986) showed that this format gives respondents the proper incentives to reveal their 'true' preferences. However, the DC format induces what has been called anchoring bias, i.e. it matters what sum is given to start off the bidding process (Kahneman, 1986).

The DC method does not reveal the maximum WTP amount, only a discrete indicator of maximum WTP. Moreover, different mean WTP values can be retrieved depending on the statistical specification of the valuation function (e.g. logit or probit function approaches and truncation strategies). In order to overcome the statistical inefficiency of the DC method, the follow-up (iterative) bidding game has been proposed. An important drawback of this approach is that respondents may feel pressured by the follow-up questions and activate other motivations in responding the follow-up questions than he or she did when answering the starting bid. Moreover, the IB format has been shown to have a strong starting point bias (Bateman *et al*., 1995[B]).

3. Qualitative Analysis of Wetland Contingent Valuation Studies

3.1 The data set

The initial data set for the analysis is taken from Crowards and Turner (1996). They describe a common framework for the evaluation of wetland management programmes, including the potential for economic valuation. Included in their report is a list of 132 wetland valuation publications, ranging from market analysis, productivity loss assessments, prevention and restoration cost assessments to HP, TC and CV studies.

As mentioned in section 1.3., a distinction can be made between direct and indirect, extractive and non-extractive benefits derived from wetland structures and functions. The direct extractive benefits of wetlands are generally assessed by means of market analysis if market prices for the products involved are available. Direct non-extractive and indirect extractive benefits have been estimated by a variety of valuation techniques, such as dose-response functions (simplified production functions), defensive expenditures, restoration or replacement costs, TC and CV studies or HP models. Finally, indirect non-extractive benefits have usually been estimated by CV, but are in some cases also approximated by replacement or restoration costs.[14] Since we will focus on CV studies only, it is the direct non-extractive and the indirect extractive and non-extractive benefits which have been valuated in the studies included in our analysis rather than the direct extractive benefits.

Forty-five percent of the 132 publications reviewed by Crowards and Turner (1996) are CV studies. After a first screening, a third of these sixty publications were omitted for one of the following reasons:

1. the study does not focus on wetland functions in particular, but on functions which could have been performed by other typical ecosystems as well;
2. the study focuses on a wetland in a humid area in a developing country[15];

[14] It is important to note that if benefits are estimated using hypothetical costs like restoration, replacement or compensation costs, the implicit assumption is that the benefits are at least as large as the costs involved. In cases where costs actually have been incurred, one could consider the expenditures involved as revealed preferences, similar to TC or HP studies.

[15] Only very few tropical wetland valuation studies exist (Barbier, 1993). A recent tropical wetland CV study has been carried out by Kumari (1995). However, the enormous differences between population samples in developed and developing countries regarding socio-cultural and demographic-economic characteristics leads us to exclude tropical wetland studies from our analysis.

3. the study is experimental in nature, using a very small sample of respondents;
4. the outcomes of the same study are presented in different publications;
5. the publication gives an overview of wetland or water-related recreation demand studies only;
6. the study was carried out long ago (1960s), using a very poor survey design;
7. two publications were untraceable.

In a second, more thorough screening, another eleven publications were removed from the analysis, because the environmental values appeared to be expressed in monetary units which cannot be compared with the monetary unit values found in the majority of studies (e.g. US dollars for different river flow levels in cubic feet per second, or US dollars per trip). This more than halved the list of publications. However, three new publications have been added to the list. The final list of publications included in the analysis is presented in Table 2.

Twenty-four of the thirty studies detailed in Table 2 have been published in journals, of which six appeared in the journal Water Resources Research. Two studies have been published as a section in a book, one is a University working paper and two studies are part of a MSc-thesis or dissertation. The first wetland CV study considered was published in 1981, followed by two publications in 1985. Most studies (77%) have been published in the 1990s of which 1990, 1991 and 1993 are peak years with five studies published in each of these years.

Besides the use of multiple results from single studies (section 1.1.), Table 2 illustrates another problem. As a result of the specialised field of work we are dealing with, a number of people have been involved in several projects or studies and related publications. This may result in an '*authorship*' bias. Learning from previous studies, authors may use similar, perhaps slightly adapted survey designs in different studies. In the analysis presented here, both Willis and Loomis helped carrying out four studies, resulting in four publications. In three of these four studies, Willis worked together with Garrod. Bishop and Boyle worked together in two studies, while Walsh worked together with different people on three occasions and Spaninks on two.

Table 2: Studies included in the analysis

No.	Authors	Type of publication	Year of publication
1	Bateman, Langford, Willis, Turner and Garrod	journal article (EE)	1995
2	Bergstrom, Stoll, Titre and Wright	journal article (EE)	1990
3	Bishop and Boyle	consultancy report	1985
4	Bishop, Boyle and Welsh	journal article (TAFS)	1987
5	Brouwer and Slangen	journal article (ERAE)	1997
6	Carson and Mitchell	journal article (WRR)	1993
7	Cooper and Loomis	book chapter	1991
8	Cummings, Ganderton and McGuckin	journal article (AJAE)	1994
9	Desvousges, Smith and Fisher	journal article (JEEM)	1987
10	Farber	journal article (JEM)	1988
11	Garrod and Willis	journal article (JEPM)	1996
12	Green and Tunstall	journal article (AE)	1991
13	Greenley, Walsh and Young	journal article (QJE)	1981
14	Silvander	dissertation	1991
15	Jordan and Elnagheeb	journal article (WRR)	1993
16	Kaoru	journal article (ERE)	1993
17	Kosz	journal article (EE)	1996
18	Lant and Roberts	journal article (EPA)	1990
19	Loomis, Hanemann, Kanninen and Wegge	book chapter	1991
20	Loomis	journal article (WRR)	1987
21	Olsen, Richards and Scott	journal article (Rivers)	1991
22	Phillips, Haney and Adamowicz	journal article (CJAE)	1993
23	Sanders, Walsh and Loomis	journal article (WRR)	1990
24	Schultz and Lindsay	journal article (WRR)	1990
25	Spaninks	MSc-thesis	1993
26	Spaninks, Kuik and Hoogeveen	scientific report	1996
27	Sutherland and Walsh	journal article (LE)	1985
28	Whitehead and Blomquist	journal article (WRR)	1991
29	Willis	journal article (AE)	1990
30	Willis, Garrod and Saunders	journal article (JEM)	1995

Clarification of Abbreviations

AE:	Applied Economics
JEEM:	Journal of Environmental Economics and Management
AJAE:	American Journal of Agricultural Economics
JEM:	Journal of Environmental Management
CJAE:	Canadian Journal of Agricultural Economics
JEPM:	Journal of Environmental Planning and Management
EE:	Ecological Economics
LE:	Land Economics
ERAE:	European Review of Agricultural Economics
QJE:	The Quarterly Journal of Economics
ERE:	Environmental and Resource Economics
TAFS:	Transactions of the American Fisheries Society
EPA:	Environment and Planning A
WRR:	Water Resources Research

3.2 Study characteristics (1): study year, study site and valuation question

Half of the studies have been carried out between 1985 and 1989. Most of these studies have been published in the first three years of the 1990s. Only one study was carried out in the second half of the nineteen seventies. Nineteen studies were conducted in the 1980s and ten in the 1990s (see Table 3).

Two thirds of the studies shown in Table 3 are from the USA, while the rest is from Europe, half of which are from the UK. Both the USA and the UK have experienced severe wetland losses in the past, and probably continue to do so albeit at a slower rate. In the USA, one third of the total wetland area had been lost by 1950 and one half by 1985 (excluding Alaska). Iowa, California, Michigan and Louisiana are some of the states which lost between 50 and 95 percent of their total wetland area. Losses are probably even higher in Europe, but data are not available, except for particular areas (Tolba and El-Kholy, 1992). In the UK, it has been claimed that agricultural drainage and land use intensification alone was responsible for the loss of some 150,000 acres of wetland every year during the 1970s and 1980s (Turner, 1992)

Table 3: Study year, study site and research questions

Nr	Study year	Study site	Wetland type	WTP question
1	1991	Norfolk Broads, U.K.	fresh water (riverine)	WTP to prevent flooding
2	1986	Coastal wetlands, Louisiana, U.S.A.	fresh and salt water	WTP for wetlands protection program
3	1985	Michigan Lake, Illinois Beach State Park, U.S.A.	fresh water (lacustrine)	WTP to maintain nature reserve
4	1985	Wisconsin, U.S.A.	fresh water (lacustrine)	WTP to preserve bald eagle
5	1994	Alblasserwaard, the Netherlands	fresh water (palustrine)	WTP for preservation of wildlife
6	1983	U.S.A.	fresh water	WTP for 3 water quality levels
7	1987	San Joaquin Valley, California, U.S.A.	fresh water	WTP for different levels of bird viewing
8	1992	Albuquerque, New Mexico, U.S.A.	fresh water	WTP to reverse decline in Colorado squawfish habitat
9	1981	Monongahela river, Pennsylvania, U.S.A.	fresh water (palustrine)	WTP for different water quality levels
10	1984	Terrebonne coastal wetlands, Louisiana, U.S.A.	fresh and salt water	WTP to retain opportunity of using wetlands
11	1993	River Darent, U.K.	fresh water (riverine)	WTP to maintain and improve river flow
12	1986	12 river corridor sites, U.K.	fresh water (riverine)	WTP for water quality improvement
13	1976	South Platte river basin, Colorado, U.S.A.	fresh water	WTP to postpone mining development to ensure recreation enjoyment
14	1989	Sweden	fresh water (palustrine)	WTP for cleaner ground water quality
15	1991	Georgia, U.S.A.	fresh ground water	WTP for improved ground water quality
16	1989	Martha's Vineyard, Massachusetts, U.S.A.	salt water (lagoonal)	WTP to raise water quality for shellfishing
17	1993	Donau-Auen National Park, Austria	fresh water (riverine)	WTP for a national park without hydro-electric power
18	1987	14 towns in Iowa and Illinois, U.S.A.	fresh water (riverine)	WTP for improvement of river quality
19	1989	San Joaquin Valley, California, U.S.A.	fresh water (riverine)	- WTP to maintain and expand wetland area - WTP to maintain and improve water contamination - WTP to improve salmon population
20	1985	Mono Lake, California, U.S.A.	salt lake	WTP for lower water diversion alternatives
21	1989	Columbia river basin, Washington, U.S.A.	fresh water (palustrine)	WTP to double salmon and steelhead runs
22	1991	Alberta, Canada	fresh water	WTP to increase and improve wildlife habitat

Table 3 continued: Study year, study site and research questions

Nr	Study year	Study site	Wetland type	WTP question
23	1983	Colorado, U.S.A.	fresh water (riverine)	WTP to protect rivers
24	1988	Dover, New Hampshire, U.S.A.	fresh ground water	WTP for groundwater protection
25	1993	Friesland, the Netherlands	fresh water (palustrine)	WTP for preservation of wildlife
26	1995	Waddenzee, the Netherlands	salt water (marine)	WTP to achieve a natural state
27	1981	Flathead lake and river, Montana, U.S.A.	fresh water	WTP for preservation of water quality
28	1989	Clear Creek wetland, Kentucky, U.S.A.	fresh water (riverine)	WTP to acquire and manage natural wetlands
29	1986	Derwent Ings, U.K.	fresh water (riverine)	WTP for wildlife conservation
30	1992	Somerset Levels and Moors, U.K.	fresh water (riverine)	WTP to maintain the ESA landscape

On the basis of the information provided in the publications and global wetlands literature (e.g. Finlayson and Moser, 1991), each case study area was categorised according to the seven main wet landscape units distinguished by Dugan (1990) (see the annex). Twenty-five of the 30 wetland studies relate to fresh water wetlands. The other five studies concern either salt water or fresh and salt water wetlands. Of the fresh water wetlands, 40 percent consist of riverine wetlands (i.e. wetlands fed by rivers) and 20 percent of palustrine wetlands (i.e. fresh water marshes and swamps on inorganic soils and peat land where peat bog can be found at or just under the surface). One third of all studies could not be classified in more detail and were listed as fresh or fresh and salt water wetlands. Two case studies focused on ground water quality related to wetlands.

Finally, although all studies included in the analysis focus on wetlands or wetland type areas[16], Table 3 shows that the specific WTP questions addressed in each study cover a large continuum of activities, actions or projects. These range from outdoor recreational activities like birdwatching or fishing, to ground water protection and complete wildlife habitat preservation. No studies were found in which respondents were asked for their WTA. Consequently, in all studies the property rights of the goods or services provided by the wetlands are assumed to lie in the hands of 'the provider' of these wetland goods or services, or the potential developer of these wetlands rather than the survey participants.

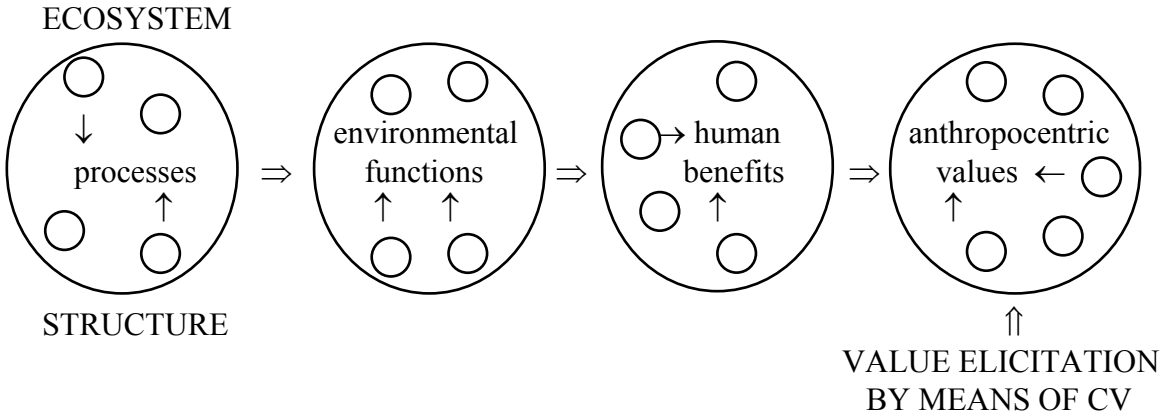
3.3 Study characteristics (2): wetland functions, benefits and values

In the systems approach adopted in this paper (section 1.4), ecosystems are understood to consist of a structure producing various processes. Both this structure and these processes provide functions from which humans benefit and to which they attach certain values. It is these values which are elicited by means of CV (see Figure 2). In the analysis, we have tried to identify the different wetland functions distinguished in each study, the benefits humans derive from these functions and the values attached to these benefits (see Table 4).

[16] Although there is little agreement among scientists on what constitutes a wetland, a workable definition is given by the so-called Ramsar Convention on 'Wetlands of International Importance Especially as Waterfowl Habitat' (1975): 'areas of marsh fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed 6m'.

In half of the studies included in the analysis, with some effort, the specific benefits humans derive from wetlands can be traced back to a single wetland function (Table 4). In the other cases it is very hard, if not impossible, to distinguish between different functions. For example, in the study carried out by Bateman *et al*. (1995[B]), visitors to the Norfolk Broads (UK) were asked for their WTP to prevent flooding of the area. One of the causes of flooding in this area is the deterioration of the river embankments by current recreation demand (boating). Clearly, the wetland provides a valuable buffer zone (water storage capacity) to prevent flooding of the area, but many of the resources considered valuable by society are amenities which have been supplied by the wetland in its function as provider of wildlife habitat. Moreover, a wetland providing wildlife habitat or controlling water quality ensures at the same time survival or maintenance of specific wildlife species, and hence helps to maintain biodiversity (see for example the studies by Cooper and Loomis, 1991; Whitehead and Blomquist, 1991; Brouwer, 1995). On the other hand, a wetland's ability to retain nutrients and sediments (water quality control), or to generate surface water may ensure the maintenance of the wetland as a wildlife habitat (see for example the studies by Loomis, 1987; Loomis *et al*., 1991; Olsen *et al*., 1991).

Figure 2: A simple framework relating wetland ecosystems to environmental functions, human benefits and anthropocentric values



Summarising, wetland ecosystem structures and processes provide various wetland functions. These are highly interrelated, making it very hard, and in some cases impossible, to distinguish between individual functions. They often go hand in hand and attempts to separate them, for example for economic valuation purposes in order to avoid double counting, are liable to be arbitrary. This implies that double counting is a real problem and attempts to aggregate up to

system level values is fraught with difficulties. Consequently, in the case of the human benefits derived from the wetland functions involved, complete separation of direct and indirect use and non-use benefits is difficult. Only in a third of all studies could a single benefit flow be identified, in all other cases multiple benefits resulted from actual wetland functioning. These are detailed on a study by study basis in Table 4. In more than half of the studies, both direct use and indirect non-use benefits are considered. Indirect non-use benefits are generally associated with the sheer knowledge that the wetland functions will be preserved. Direct use benefits are mostly related to the provision of recreational and clean drinking water benefits. In 5 cases indirect use benefits could also be detected, namely for reduced flooding and health risks.

Most studies (70%) asked respondents for the use and nonuse values attached to the benefits derived from wetland functions (Table 4). Five studies claim to have focused on current use values only. However, in two of these cases we also expect possible future use and nonuse values to have played a role in respondents' value statements. One study (Schultz and Lindsay, 1990), elicited future use value only (option value), while another (Greenley *et al*., 1981) focused, among others, on the *ex ante* 'option price' of being able to make a better informed judgement in the future based on more information becoming available regarding water quality.

Table 4: Wetland functions, benefits and economic values

No.	Wetland function	Human benefits	Estimated Value
1	- flood water control - provision of amenities	- indirect use: reduced floods - direct use: recreation (boating, walking)	current use value, but possibly including option and/or existence value
2	biomass export through harvesting	direct use: recreation (boating, waterfowl hunting, fresh and salt water fishing, recreational shrimping and crabbing)	current use value
3	- provision of wildlife habitat - provision of biodiversity - historic information - flood water control	- direct use: recreation (walking) - indirect non-use: knowledge that the reserve will be preserved	current and possibly future use value and non-use preservation value
4	provision of wildlife habitat	- direct use: recreation (bird watching) - indirect non-use: knowledge that bald eagle will be preserved	current and future use value, philantrophic, bequest, stewardship, existence value
5	- provision of wildlife habitat - maintenance of biodiversity - provision of scenic amenities	- direct use: recreation (walking, bird watching) - indirect non-use: knowledge that wildlife (habitat) will be preserved	current and future use value and non-use preservation value
6	water quality or pollution control	- direct use: recreation (boating, fishing, swimming) - indirect non-use: knowledge of clean freshwater	current and future use value, philantrophic, bequest, stewardship, intrinsic value
7	- provision of wildlife habitat - maintenance of biodiversity	direct use: recreation (bird watching)	current use value
8	provision of wildlife habitat	indirect non-use: knowledge that Colorado squawfish wll be preserved	non-use preservation value
9	water quality or pollution control	- direct use: recreation (boating, fishing, swimming) - indirect non-use: knowledge of existence	current and possible future use value and existence value

Table 4 continued: Wetland functions, benefits and economic values

No.	Wetland function	Human benefits	Estimated Value
10	- biomass export through harvesting - provision of amenity	direct use: recreation (boating, hunting, fishing)	current use value, possibly including future use and non-use preservation value
11	surface water generation	- direct use: recreation (walking, fishing) - indirect-non-use: knowledge of existence	current use value and non-use existence value
12	water quality or pollution control	- direct use: recreation (wildlife viewing, boating, swimming) - indirect non-use: knowledge of clean river water	current use value, possible future use, bequest and existence value
13	water quality or pollution control	direct use: recreation (boating, swimming, fishing, sightseeing, camping)	current use value, option price and non-use preservation value
14	water quality or pollution control	- direct use: potable drinking water - indirect use: reduced health risks	current use value
15	water quality or pollution control	- direct use: potable drinking water - indirect use: reduced health risks	current and future use value
16	water quality or pollution control	direct use: shellfishing	current and possible future use value, philantrophic and bequest (use) value
17	- provision of wildlife habitat - maintenance of biodiversity - provision of amenity - surface water generation	direct use: recreation	current and future use value, bequest and existence value
18	water quality or pollution control (nutrient retention)	- direct use: recreation (boating, fishing, swimming) - indirect use: public health - indirect non-use: knowledge of good water quality	current use value, option, bequest, stewardship, existence value

Table 4 continued: Wetland functions, benefits and economic values

No.	Wetland function	Human benefits	Estimated Value
19	- provision of wildlife habitat - water quality or pollution control - biomass export through harvesting	- direct use: recreation (bird watching, fishing) - indirect non-use: knowledge of preservation or potential to visit	current and possible future use value, bequest and existence value
20	- surface water generation - provision of wildlife habitat - maintenance of biodiversity - provision of scenic amenity	direct use: recreation	current use and non-use preservation value
21	- surface water generation - provision of wildlife habitat and biodiversity	- direct use: recreation (fishing) - indirect non-use: knowledge of existence	possible future use value, existence value
22	provision of wildlife habitat	direct use: recreation (hunting, fishing)	current and possible future use value, possibly including non-use preservation value
23	- surface water generation - water quality or pollution control	- direct use: recreation - indirect non-use: knowledge of preservation	current use value, option, bequest, existence value
24	water quality or pollution control	- direct use: potable drinking water - indirect use: reduced health risks	future use value
25	- provision of wildlife habitat - maintenance of biodiversity - provision of scenic amenities	- direct use: recreation (walking, bird watching) - indirect non-use: knowledge that wildlife (habitat) will be preserved	current and future use value and non-use preservation value
26	- provision of wildlife habitat - restoration and maintenance of biodiversity	- direct use: recreation - indirect non-use: knowledge of restored natural state	current and possible future use value, existence value

Table 4 continued: Wetland functions, benefits and economic values

No.	Wetland function	Human benefits	Estimated Value
27	water quality or pollution control	- direct use: recreation (fishing, boating, camping, swimming) - indirect non-use: knowledge of preserved water quality	current use value, option, existence, bequest value
28	- provision of wildlife habitat - maintenance of biodiversity	- direct use: recreation - indirect non-use: knowledge of wetland preservation	current and possible future use, existence value
29	provision of wildlife habitat	- direct use: recreation - indirect non-use: knowledge of conservation	current and possible future use value, non-use conservation value
30	- provision of wildlife habitat - provision of scenic amenity - provision of cultural-historic knowledge	- direct use: recreation - indirect non-use: knowledge of preservation and educational benefits	current and possible future use value and non-use preservation value

Source: Adapted from Crowards and Turner, 1996.

In eight studies an attempt was made to break down the stated total economic value *ex post* in the questionnaire into the various components distinguished in literature, e.g. use, option, philantrophic, bequest, stewardship and existence value (see section 2.1.1.). In two water quality studies (Carson and Mitchell, 1993; Desvousges *et al*., 1987), respondents were presented *ex ante* with a 'value card' which described the main reasons why water quality might be valued. In a further two studies use and nonuse values were elicited separately, either by the use of different questionnaires (Bishop *et al*., 1987)[17] or the use of separate questions for use and nonuse values in the same questionnaire (Greenley *et al*., 1981). This *ex ante* presentation of the main reasons why people might value environmental goods or services, and the *sequential* elicitation method differ from the usual *ex post* breakdown of total value statements.

3.4 Study characteristics (3): survey design

Table 5 provides information about the differences in each study's survey design. Most surveys were carried out by mail (53%) or personal interviews (37%). In one study (Loomis *et al*., 1991), respondents were sent a questionnaire first, followed up by a telephone call in which respondents were interviewed with the questionnaire in front of them. Giving people time to think about their answers can significantly influence their WTP (Whittington *et al*., 1992). Typically, telephone or personal interviews provide respondents very little time to answer each question and people may feel pressed for time (Brouwer *et al*., 1997).

Column 3 in Table 5 gives an overview of the different payment vehicles employed in each study. Almost a third of all studies used membership fees or contributions to private funds or foundations to elicit individual WTP and another third income taxation or a combination of income taxation and higher product prices. In 4 studies people were asked for their willingness to pay higher water bills. In two studies there was no mention of a payment vehicle.

The most frequently used elicitation format in the studies is the OE question, followed by the DC question. In two studies the effects of different elicitation formats were tested: OE versus DC and IB (Bateman *et al*., 1995^{B}) and OE versus payment card and IB (Desvousges *et al*., 1987). The former also tested the effect of analysing differences on the basis of the final bid only in the IB procedure (*single bound*), and the bids stated at each stage (*multiple bound*)

[17] One asking respondents for a total value and the other for a conditional, non-use only one. Another, slightly different approach was taken by Bateman and Langford (1997^{A}), who followed up their study of users (Bateman *et al*., 1995^{B}) by a study of non-users.

(Langford *et al*., 1996). Both studies found significant elicitation format effects on stated WTP, with OE formats producing significantly lower estimates than payment card and DC formats.

Table 5: Survey method, payment vehicle, elicitation format and main behavioural motivation likely to be prompted in each study

No.	Survey Method	Payment Vehicle	Elicitation Format	Behavioural Motivation (inferred)
1	personal interviews	income tax	- open-ended - dichotomous choice - iterative bidding	consumer and citizen
2	mail survey	not mentioned in questionnaire	dichotomous choice	consumer
3	mail survey	private foundation membership fee	dichotomous choice	consumer and citizen
4	mail survey	private foundation membership fee	dichotomous choice	consumer and citizen
5	mail survey	private fund	open-ended	consumer and citizen
6	personal interviews	income tax and increase in product prices	open-ended	consumer and citizen
7	mail survey	increase in trip expenditures	dichotomous choice	consumer
8	mail survey	income tax	open-ended	citizen
9	personal interviews	income tax and increase in product prices	- open-ended - iterative bidding - payment card	consumer and citizen
10	mail survey	not mentioned in questionnaire	open-ended	consumer and citizen
11	personal interviews	increase in water rates (charges by local water companies to households)	open-ended	consumer and citizen
12	personal interviews	increase in water rates	iterative bidding	consumer and citizen
13	personal interviews	increase in present sales taxes (product prices)	iterative bidding	consumer and citizen
14	unknown	income tax	open-ended	conumser and citizen

No.	Survey Method	Payment Vehicle	Elicitation Format	Behavioural Motivation (inferred)
15	personal interviews	increase in water rates (charges by local water companies to households)	payment card	consumer
16	mail survey	private fund	open-ended	consumer and citizen
17	personal interviews	income tax	open-ended	consumer and citizen
18	personal interviews	increase in state sales tax rates (product prices)	payment card	consumer and citizen
19	combined mail and tele-phone survey	income tax	iterative bidding	consumer and citizen
20	mail survey	increase in household water bill	dichotomous choice	consumer and citizen
21	telephone survey	increase in electric power bill	open-ended	consumer and citizen
22	mail survey	income tax	dichotomous choice	consumer and citizen
23	mail survey	private fund	open-ended	consumer and citizen
24	mail survey	property tax	dichotomous choice	consumer
25	mail survey	private fund	payment card	consumer and citizen
26	mail survey	income tax and increase in product prices	payment card	consumer and citizen
27	mail survey	private fund	open-ended	consumer and citizen
28	mail survey	private fund	dichotomous choice	consumer and citizen
29	personal interviews	private fund	open-ended	consumer and citizen
30	personal interviews	income tax	open-ended	consumer and citizen

Finally, on the basis of the payment vehicles employed in each study (Table 5) and the values elicited (Table 4), the last column of Table 5 attempts to categorise studies according to the behavioural motivation underpinning valuation responses (see section 2.2.2).

Considering the payment vehicles used in each study, most studies (60%) seem to prompt respondents to adopt a consumer role. Private membership fees, contributions to funds or foundations, increases in market prices, property tax or trip expenditures are expected to induce respondents to consider to a large extent their private interests first and foremost. However, based on the nonuse values respondents were asked to make explicit in certain studies, alongside use values, no single dominant type of behaviour, either consumer or citizen, could be distinguished in most studies (77%). Expliciting nonuse values is expected to induce respondents to behave more altruistically towards living organisms including human beings, now and in the future.

In only four cases are respondents restricted to a primarily private consumer role, social considerations remaining largely in the background. In these cases respondents were asked to elicit their use value in a private market setting. Conversely, in only one study (Cummings *et al*., 1994) is the combination of (i) payment vehicle, (ii) nonuse values and (iii) the explicit mention in the questionnaire of the role of each respondent's decision in a majority voting model expected to make people respond predominantly as a citizen.

3.5 Study characteristics (4): the NOAA's '*Burden of Proof*' requirements

In conducting the meta-analysis, special attention was paid to two important '*burden of proof*' requirements set out by the NOAA Panel: (i) the extent of non-response and (ii) the scope test. Response rates are used as a rough approximation of the validity of the studies included in the analysis, whereas the scope test can be regarded as an indicator of the validity of the meta-analysis. A high non-response, either to the entire survey instrument or the valuation question, invalidates the study's representativeness, and questions the validity of the survey design employed and the extent to which the valuation scenario constructed in the questionnaire was clearly comprehended by and credible to respondents. The scope test refers to whether or not WTP responses were sensitive to the extent and inclusiveness of the good under evaluation. Both issues are discussed below.

3.5.1 Response rates

Very few studies reported the extent of protest bids and other questionable responses in the survey. Although most studies mention the survey response rates, it is in many cases not clear what these response rates actually represent or which criteria have been used to exclude responses from further analysis. Where

such information was available, these responses were excluded from the response rates presented in Table 6.

Relating the response rates in Table 6 to the survey method employed in each study (as detailed in Table 5), personal interviews appear to show high response rates, perhaps as a result of the interviewer's presence and the possibility of clarifying problems encountered by respondents during the interview. Only in two cases is the response rate lower than fifty percent. Response rates in mail surveys range from 14 (Farber, 1988) to an unusually high 81 percent (Bishop *et al*., 1987). However, in the latter case it is not clear whether this percentage excludes non-usable responses. About a third of all mail survey response rates lie below 30 percent, a third between 30 and 50 percent and the final third above 50 percent. In 4 of the 5 cases below 30 percent, protest bids and other non-usable responses have been omitted, while in 2 of the 5 cases above 50 percent this is either not the case (Bergstrom *et al*., 1990) or is unclear (see above).

3.5.2 The scope test

In order to be able to carry out a scope test, one should consider both the size of the affected study site and the difference between the reference and the target levels of provision in the scenario, programme, project or action. However, in two thirds of all studies no information is provided at all about the size of the area involved. In about one third of all studies, the study site size has been roughly estimated by ourselves by reference to maps. In some cases estimating the study site size is a very difficult task, e.g. a region's fresh water bodies, river basins or the stock of ground water. Another problem is the comparison of these assets in terms of the units in which their size is measured (see Table 6).

Table 6: Response rate, study site size, scenario reference and target levels

No.	Response Rate	Study Site Size	Reference Level	Target level	Size Category
1	99%	coastal wetland (approx. 135,000 ha)	threatened by flooding	preserve wetland in present state	very large
2	55%	coastal wetland (1.32 million ha)	reduction of catch levels to zero because of continued marsh loss	- maintain current catch levels per day - preserve catch levels per day at 50% of current levels - preserve catch levels per day at 25% of current levels	large
3	64%	small (335 ha) State Nature Park along lake Michigan shore	threatened by flooding because of erosion of sand dunes	preserve present state by stopping erosion	very smalll
4	81%	Great Lakes (including Lake Michigan)	bald eagle will become extinct in state of Wisconsin	save the bald eagle	large
5	17%	peat meadow land, the Netherlands (16,000 ha)	reduction in habitat and number of peat meadow wildlife	improvement in habitat and number of peat meadow wildlife	medium
6	70%	nation's fresh water bodies (lakes, rivers, streams)	below boatable quality level	- boatable - fishable - swimmable	very large
7	44%	large national wildlife refuge and state wildlife management area (San Joaquin Valley; 35,000 ha)	current number of birds seen	- maintain current conditions - 1.5 times more birds seen - twice as many birds seen	medium
8	42%	unknown	reduction in habitat and number of breeding Colorado squawfish	reverse the decline in habitat that is essential for the survival of the squawfish	-

Table 6 continued: Response rate, study site size, scenario reference and target levels

No.	Response Rate	Study Site Size	Reference Level	Target level	Size Category
9	77%	the Monongahela river, streaming through different states (approx. length 200-300 km)	- boatable - boatable - fishable	- avoid decrease from boatable to below boatable - (raise quality from boatable to) fishable - (raise quality from fishable to) swimmable	medium
10	14%	Terrebonne wetlands, part of the Louisiana coastal wetlands (see Bergstrom et al., 1990)	wetland loss (not explicitly mentioned)	preservation of the wetlands	small
11	unknown	River Darent in South East England	low flow level	- water abstraction up to the maximum permissible limt below current flow level - maintain current flow level - increase current flow level	medium
12	unknown	12 river corridors in the UK	current water quality	water quality good enough: - for water birds to use the water - to support many fish and to allow many different types of plants to grow both in the water and on the edge - to be safe for children to paddle or swim	large
13	80%	South Platte river basin (approx. length 400-500 km)	own recreation experience	- no heavy metals present at the site - heavy metals present at site in excess of the amount recommended for fish and wildlife survival - heavy metals present at site in excess of the amount recommended for drinking water	medium

Table 6 continued: Response rate, study site size, scenario reference and target levels

No.	Response Rate	Study Site Size	Reference Level	Target level	Size Category
14	unknown	Gotland (Sweden) (approx. 405,000 ha)	current water contamination levels (not all respondents were aware of current water quality levels)	water quality of no more than 50 mg NO_3 /l in ground water	medium
15	35%	stock of groundwater in the state of Georgia, USA	increase in nitrate in private well or drinking water	avoid the risk of increasing nitrate in drinking water	large
16	26%	3 coastal ponds on the island of Martha's Vineyard, Massachusetts, USA	current situation in the ponds: closure for shellfishing for extended periods of time as a result of high coliform bacteria levels	raise water quality in the three ponds so they will be open for shellfishing all year round	small
17	50%	largest single riverside wetland and flood plain forest in Europe (11,500 ha in Austria)	not completely clear; probably park with hydro-electric power station	national park without any hydro-electric power station	large
18	41%	Cornbelt streams, rivers and reservoirs (in USA agricultural Midwest, Iowa and Illinois)	own experience (perception of river quality and recreational participation); poor water quality	- boating - rough fishing - game fishing - swimming	medium
19	51%	35,000 ha of wetland in San Joaquin Valley	no action: Wetlands habitat and Wildlife Program: loss of wetlands to 27,000 acres Wildlife Contamination Control Program: 95% of resident waterbirds exposed to contaminated water River and Salmon Improvement Program: unknown (graphical illustrations)	maintenance and improvement levels: Wetlands habitat and Wildlife Program: - maintenance of the current 85,000 acres - expansion to 125,000 acres Wildlife Contamination Control Program: - 70% exposure of waterbirds - 20% exposure of waterbirds River and Salmon Improvement Program: unknown (graphical illustrations)	medium

Table 6 continued: Response rate, study site size, scenario reference and target levels

No.	Response Rate	Study Site Size	Reference Level	Target level	Size Category
20	44%	Mono Lake (approx. 14,400 ha)	current maximum water diversion from Mono Lake	- substantial water diversion from Mono Lake (conditions similar to Lake's lowest level in 1982) - minimal water diversion from Mono Lake	small
21	72%	Columbia River Basin	the size of the fish runs before industrial development of the Columbia River Basin	double the size of the salmon and steelhead runs	medium
22	44%	province of Alberta, Canada	current wildlife habitat situation	increase in wildlife habitat of 120,000 acres	large
23	39%	rivers in the Rocky Mountains of Colorado (length 893 km)	current number of rivers protected	increase in the number of specific rivers protected	large
24	58%	groundwater stock in Dover, New Hampshire, USA	current situation (surrounding towns have recently had their ground water supplies polluted)	groundwater protection plan (reduction in the risk of ground water polution occurring)	very small
25	15%	peat meadow land, the Netherlands (500 ha)	reduction in habitat and number of peat meadow wildlife	improvement in habitat and number of peat meadow wildlife	very small
26	23%	Dutch Wadden Sea (280,000 ha)	present state (i.a. loss of salt marshes)	natural state (i.a. no more loss of salt marshes)	very large
27	61%	Flathead River, Montana, the largest freshwater body in the Western US (length more than 255 km)	current water quality at site	preserve water quality at site	medium

Table 6 continued: Response rate, study site size, scenario reference and target levels

No.	Response Rate	Study Site Size	Reference Level	Target level	Size Category
28	31%	Clear Creek wetland (approx. 2025 ha)	current natural wetland	- reclaimed surface-mined grassland without additional information about nearby located 10,000 acres of wetland - reclaimed surface-mined grassland with additional information about nearby located 10,000 acres of wetland - reclaimed surface-mined lake which functions as a wetland without additional information about nearby located 10,000 acres of wetland - reclaimed surface-mined lake which functions as a wetland with additional information about nearby located 10,000 acres of wetland	small
29	unknown	Derwent Ings, UK (flood plain)	current situation (Site of Special Scientific Interest)	maintain current situation	small
30	91%	peat meadow land, UK	current situation (Environmentally Sensitive Areas)	maintain current situation	small

Problems accumulate if we also look at the difference between the reference and target levels of the various attributes distinguished in the environmental scenarios, programmes or actions in each study. The multi-dimensional nature of these attributes makes a comparison between studies impossible.

In order to control to some extent for differences in programme size between studies, a simple, arbitrary distinction is made between 'very small', 'small', 'medium', 'large' and 'very large' changes in wetland size, based on the relative size of each study site and on the discrepancy between the reference and target level (Table 6). The relative size refers to the share of each study site in the country's total stock of wetlands, which was taken from literature on wetlands (e.g. Finlayson and Moser, 1991; Tolba and El-Kholy, 1992).

4. Quantitative analysis of wetland contingent valuation studies

4.1 Making money amounts comparable

An important first step in the meta-analysis is to make the stated average WTP amounts in each study comparable. As mentioned in section 3.1., eleven publications were removed from the analysis, because the WTP amounts were expressed in unique monetary units, for example US dollars, for different flow levels in cubic feet per second. These money amounts could not be converted into a common monetary unit, i.e. average WTP per household per year. In the thirty studies included in the meta-analysis, a number of problems still came up in the conversion process, requiring arbitrary decision-making on our part

First, a few studies asked respondents for their individual WTP, not WTP on behalf of their household as in most studies. We decided to keep these studies in the analysis. Secondly, five studies asked respondents for their monthly WTP instead of their annual WTP. Although significant differences have been found in stated monthly and annual payments (e.g. Kahneman and Knetsch, 1992; Echeverria *et al*., 1995; Spaninks and Hoevenagel, 1995), we also decided to keep these observations in the analysis and multiplied the monthly amounts by twelve to get annual payments. Thirdly, one time donations were omitted from one study.

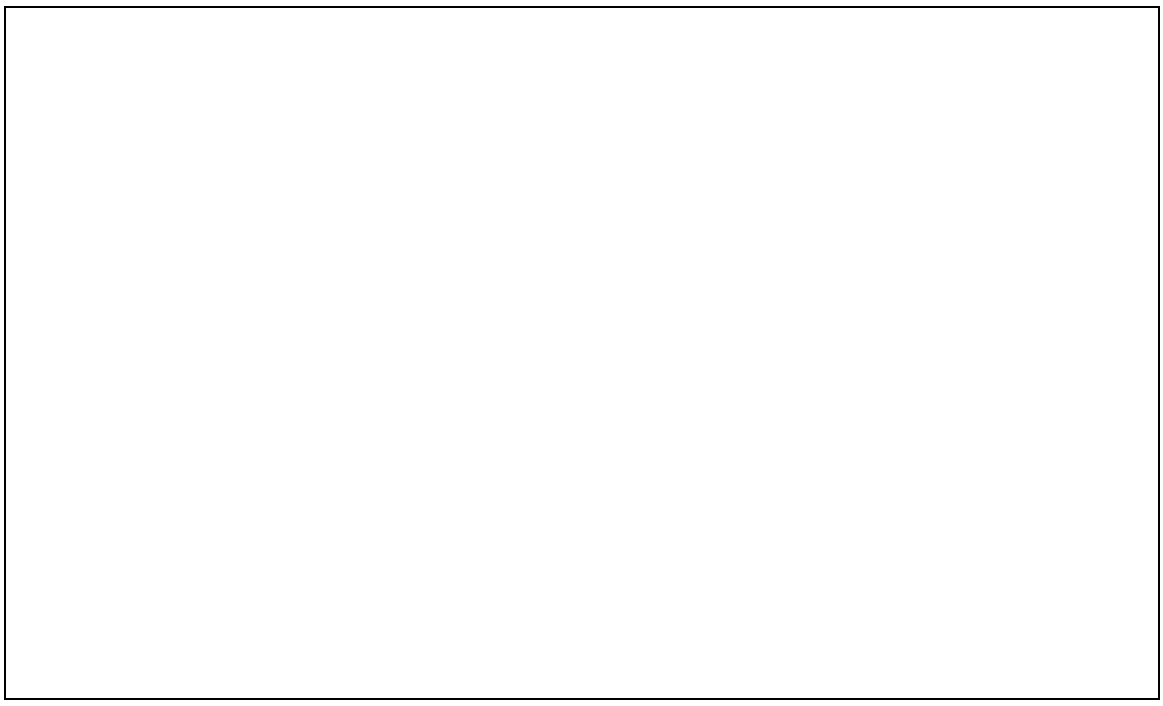
National currencies were subsequently expressed in their countries' 1990 purchasing power by dividing them by the Gross Domestic Product (GDP) deflator index, i.e. the GDP at current prices divided by the GDP at constant prices.[18] The last step was to convert these national currencies into one single currency, the International Monetary Fund's (IMF) Special Drawing Rights (SDRs), which is the Fund's official monetary unit of account (IMF, 1996). The value of the SDR is determined on the basis of a basket of currencies with each currency assigned a weight in the determination of that value.[19] The distribution

[18] One could argue not to deflate WTP amounts stated at different points in time in order to account for the possible increase in scarcity of environmental functions and hence the increase in the 'real' costs of living, i.e. including the loss of environmental functions. However, most of the environmental functions considered here remain outside the actual market transactions.

[19] The currencies in the basket are valued at their market exchange rates for the U.S. dollar and the U.S. dollar equivalents of each of the currencies are summed to yield the rate of the SDR in terms of the U.S. dollar. The method of calculating the U.S. dollar per SDR exchange rate remains the same, but the number and weights of currencies in the SDR basket do change over time. The rates for the SDR in terms of other currencies are derived from the market exchange rates of these currencies for the U.S. dollar and the U.S. dollar rate for the SDR.

of average WTP amounts is presented in the histogram in Figure 3. The distribution is clearly skewed to the right. Average WTP found in all studies taken together is 62 SDRs. By the end of 1995, one SDR was approximately one and a half US dollars. The median is considerably lower, namely 34 SDRs.

Figure 3: Histogram of the average WTP amounts (in SDRs/household/ year) found in the studies included in the meta-analysis



103 observations were distilled from the thirty studies (Figure 3). This corresponds, on average, to three or four observations per study. The number of observations taken from studies are presented in Table 7. More than half of the studies provided us with one or two observations. Outliers are the studies by Loomis *et al*. (1991) and Desvousges *et al*. (1987), providing ten and twenty-one observations respectively. The former presented respondents with three different wetland or wetland related conservation programmes, each programme consisting of two or three different levels, while the latter asked users and nonusers for their WTP for four different water quality levels using different bid levels.

Table 7: Number of observations from studies

Number of observations	Number of studies
1	7
2	10
3	6
4	2
more than 4	5

4.2 Summary statistics

In this section, we will present the summary valuation results from the studies included in the meta-analysis by cross reference to a number of possible explanatory variables. These variables can be grouped into four main categories: (1) wetland characteristics, (2) survey characteristics, (3) value types, and (4) sample population characteristics (Table 8).

Table 8: Cross reference factors and factor levels

Wetland characteristics	
wetland class	1. salt water marine 2. salt water lagoonal 3. salt water lake 4. fresh water riverine 5. fresh water lacustrine 6. fresh water palustrine 7. fresh water groundwater 8. fresh water unknown 9. fresh and salt water
wetland function	1. flood control 2. water generation 3. water quality maintenance 4. biodiversity maintenance
wetland size	1. very small 2. small 3. medium 4. large 5. very large

Survey design characteristics	
survey method	1. personal interviews 2. mail survey 3. telephone survey 4. combination of 2 and 3
payment vehicle	1. income tax 2. private market instruments (private fund or entrance fee) 3. product prices 4. combination of 1 and 3 5. other 6. none (not mentioned in questionnaire)
elicitation format	1. open-ended 2. dichotomous choice 3. iterative bidding 4. payment card
Survey design characteristics (continued)	
influential methodological publications	1. studies carried out before Cummings *et al*. (1986) 2. studies carried out after Cummings *et al*. (1986) and before Arrow *et al*. (1993) 3. studies carried out after Arrow *et al*. (1993)
Value types	
estimated economic value	1. current and possible future use value 2. nonuse value 3. use and nonuse value
Sample population characteristics	
region	1. Illinois, Iowa, Wisconsin, Kentucky 2. Montana, Alberta (Canada) 3. Colorado, New Mexico 4. New Hampshire, Massachusetts, Pennsylvania 5. Washington, Oregon 6. California 7. Georgia, Louisiana 8. United Kingdom 9. the Netherlands 10. Austria 11. Sweden

The first group of factors consists of three sub-group variables, i.e. wetland class, wetland function and wetland size. Wetland size reflects the size of a wetland relative to the total area of wetlands present in a country (Table 6 in section 3.5.2). The second group of factors consists of five sub-group variables, i.e. survey method, payment vehicle, elicitation format, time of publication and response rate. The penultimate variable attempts to account for the impact of two influential publications on CV research design: the work published by Cummings and colleagues (1986) and the recommendations of the NOAA Panel in 1993 (section 2). As mentioned previously, the response rate is used as a quality indicator.

The third and fourth groups of factors are both represented by one variable. In the third group this variable reflects whether use or nonuse values have been estimated or both use and nonuse values. Given the controversy surrounding the breakdown of nonuse values into various underlying motives, we refrain here from distinguishing between the various motives underlying nonuse values, e.g. philanthropic, bequest or existence motives (see also Table 4, section 3.3). The lack of summary statistics in the publications regarding sample population characteristics, e.g. respondents' average household size, age, gender or household income, led us to approximate average differences in population sample characteristics very roughly by including a variable for the region in which the population sample resides. The studies carried out in the United States are arbitrary divided into 7 main regions of adjoining states.

4.2.1 Wetland characteristics

Table 9 presents the summary of valuation outcomes by wetland characteristics. Average WTP per household per year is more or less the same for salt and fresh water wetlands. However, the number of observations for salt water wetlands is very low. Almost all observations are related to fresh water wetlands. Within the class of fresh water wetlands, the value of wetlands fed by rivers (riverine) is twice as high as the value of lakes or ponds (lacustrine) and marshes or swamps (palustrine). Ground water is valued highest, although the number of observations is also in this case very low.

In the case of wetland functions, WTP appears to be highest for flood control. Especially for respondents who live in the areas affected by possible flooding, this seems to be a logical result. Again, however, one has to keep in mind the relatively low number of observations, originating from one study only. Truncating the top and bottom of the data set, i.e. omitting the maximum value of 177 and the minimum value of 24 SDR/household/year from the analysis, a statistically more stable average value results which corresponds with the median value of 87 SDR.

Table 9: Summary statistics by wetland characteristics

wetland characteristic	mean (SDRs)	standard error	minimum (SDRs)	maximum (SDRs)	*n* *
wetland class					
salt water	56.2	27.2	19	137	4
marine	22.7	3.7	19	26	2
lagoonal	136.6	-	-	-	1
lake	42.8	-	-	-	1
fresh water	58.9	6.1	1	267	97
riverine	71.7	13.7	1	267	38
lacustrine	36.8	9.4	12	88	9
palustrine	36.9	4.3	9	117	31
ground water	125.7	24.3	99	174	3
unknown	71.2	10.1	2	115	16
fresh and salt water	237.5	106.2	131	344	2
wetland function					
flood control	92.6	24.4	24	177	5
water generation	21.5	6.8	3	59	9
water quality	52.5	5.9	9	174	43
biodiversity	76.1	12.8	1	344	46
wetland size					
very large	86.9	17.6	19	177	8
large	70.3	21.6	12	344	16
medium	67.0	8.9	3	267	58
small	29.5	13.2	1	137	13
very small	53.4	13.8	24	105	6

* The number of observations does not sum up to 103 in all cases as a result of missing values.

The supply of biodiversity is the second highest valued wetland function, followed by water quality maintenance. However, in the case of biodiversity supply, the range of values is wide. The median value is more than half the value of the mean (median=31.2), indicating that half of all the observations are more than half the average value presented in Table 9. Truncating the top six percent of the biodiversity supply data, i.e. omitting the three highest values from the analysis, a nineteen percent decrease of average WTP results to 61.6 SDR.

Overall, average WTP increases with increasing relative wetland size. At first sight, without controlling for other possible influences, this means that the study seems to pass the scope test. The only inconsistency found is between the 'small' and 'very small' wetland size categories, the latter displaying a higher value than the former. However, the median value of the 'small' wetland size class is more than three times smaller than its average value (median=8.6), while median values in the other size categories are found much closer to their average values. Taken together, the average value of the two smallest size categories is still considerably smaller than the average value of the larger wetland size classes, namely 37 SDR per household per year.

Table 10: Results of the Kruskal-Wallis test

Hypothesis	**wetland class**		**wetland function**		**wetland size**	
	χ^2	*p*	χ^2	*p*	χ^2	*p*
H_0: equality of average WTP in all groups	15.2	0.05	7.8	0.05	13.1	0.01

Statistically, the differences found in average WTP in each category are confirmed by the outcome of the non-parametric Kruskal-Wallis test statistic (Table 10). χ^2 refers to the test-statistic for the Kruskal-Wallis test which has, under the null hypothesis, approximately a chi-square distribution. *p* is the two-tailed probability of the type I error. Table 10 also shows the test results for wetland class and wetland function. Also in these two cases, the null hypothesis of equal average WTP in all groups is rejected at the conventional significance levels.

4.2.2 Survey design characteristics

In the case of the survey method employed, personal interviews yield a lower average WTP than mail surveys (Table 11), also after truncating the top value found in each subgroup data set.

Although it is not possible to check whether mail survey respondents actually permit themselves more time to complete the questionnaire and consider the issues involved at ease at home, we expected average WTP from mail surveys to be lower than average WTP from personal interviews where people might feel pressed, either for time or to say yes to the WTP question and state a considerable money amount (see section 2.2.1.). The combination of mail survey and follow-up telephone interview results in a very high average WTP. However, this outcome is based on one study only (see Table 5 in section 3.4.).

The difference between average WTP amounts is confirmed by the outcome of the Kruskal-Wallis test statistic (Table 12).

Table 11: Summary statistics by survey design characteristics

survey design characteristic	mean (SDRs)	standard error	minimum (SDRs)	maximum (SDRs)	*n* *
survey method					
personal interview	41.9	5.5	1	177	47
mail survey	55.1	10.0	2	344	41
telephone survey	42.1	11.1	21	59	3
combination 2 + 3	194.8	15.2	121	267	10
payment mode					
income tax	121.3	18.1	2	267	22
private market†	28.6	5.7	1	137	28
product prices	47.8	8.9	3	174	22
combination 1 and 3	42.8	6.3	9	117	26
trip expenditures	102.9	6.8	89	112	3
none	237.5	106.2	131	344	2
elicitation format					
open-ended	37.4	6.5	1	137	35
dichotomous choice	91.2	17.1	3	344	29
iterative bidding	78.5	14.9	9	244	20
payment card	47.1	8.4	10	174	19
time of publication					
before 1986	45.2	5.1	9	131	43
between 1986 and 1993	90.1	12.3	1	344	47
after 1993	18.7	3.4	3	40	13
response rate					
less than 30%	47.5	14.6	16	137	10
between 31 and 50%	46.9	9.2	2	174	25
more than 50%	78.3	9.9	9	344	59

* The number of observations does not sum up to 103 in all cases as a result of missing values.

† private fund/entrance fee

Table 12: Results of the Kruskal-Wallis test†

Survey design characteristic	χ^2	p
survey method	24.8	0.00
payment mode	27.4	0.00
elicitation format	10.1	0.01
time of publication	12.3	0.00
response rate	4.3	0.11

† H_0: equality of average WTP in all groups

As expected, the use of income taxation as a payment vehicle results in a higher average WTP than private market oriented instruments like private funds or entrance fees, again also after truncating the top value found in each subgroup data set (Table 11). General income taxation is expected to prompt respondents more into a citizen mode, considering the implications of the environmental issue involved for society as a whole as well, including possible philanthropic and bequest motives underlying nonuse values. Also the 'Polluter Pays Principle', reflected in the use of product prices as the mode of payment, yields a considerably higher average WTP than private market instruments. Combining the latter with general taxation, an almost similar value results. Also in the case of payment vehicle, the differences found in average WTP amounts are confirmed by the Kruskal-Wallis test in Table 12.

As previous studies also showed, the use of the OE elicitation format results in a considerably lower average WTP amount than any other format (Table 11). The DC format shows the highest average WTP, followed by the IB procedure. However, in both cases the range of values is wide, the highest values having a substantial impact on average WTP. Truncating the top three percent of the DC bids, i.e. omitting the top value from the analysis, a ten percent decrease of average WTP results to 82.1 SDR/household/year. In the case of the IB format, truncating the top five percent of the bid amounts, i.e. omitting the top value of 244 SDR, results in an eleven percent decrease of average WTP to 69.8 SDR. The differences in the untruncated average WTP amounts found in the four different elicitation formats are confirmed by the outcome of the Kruskal-Wallis test statistic (Table 12).

The studies carried out after the publication of the NOAA recommendations show a much lower average WTP than the studies carried out before 1993 (Table 11). Average WTP in the period between 1986 and 1993 is substantially higher than average WTP found in the other two groups, also after truncation of

the top two percent of the data set, resulting in an eleven percent decrease in average WTP to 80.5 SDR. The Kruskal-Wallis test confirms the differences found in average WTP statistically (Table 12).

Finally, average WTP at response rates higher than fifty percent is much higher than average WTP at lower response rates (Table 11). However, the differences found in the three groups are not confirmed by the Kruskal-Wallis test (Table 12).

4.2.3 Value types

On average, the use value of wetlands appears to be higher than the nonuse value (Table 13).

Table 13: Summary statistics by value type

value type	mean (SDRs)	standard error	minimum (SDRs)	maximum (SDRs)	*n*
use value	68.1	8.4	9	344	50
nonuse value	35.5	4.8	12	78	13
use and nonuse values	63.8	12.9	1	267	40

Remarkably, studies in which both use and nonuse values have been estimated show a lower average WTP than studies in which the use value has been estimated only. This does not make sense. After truncating the top value, average WTP in both groups converges slightly, but further truncation shows that the average use value remains considerably higher than the average use and nonuse value. The outcome of the Kruskal-Wallis test confirms the differences found in the three groups statistically (Table 14).

Table 14: Results of the Kruskal-Wallis test

Hypothesis		
	χ^2	*p*
H_0: equality of average WTP in all groups	6.1	0.04

4.2.4 Sample population characteristics

After truncation of the top values, average WTP appears to be highest in California (156 SDR/household/year), followed by Georgia and Louisiana (138 SDR/household/year) (Table 15).

Table 15: Summary statistics by region

region	mean (SDRs)	standard error	minimum (SDRs)	maximum (SDRs)	*n*
1. Illinois, Iowa, Wisconsin, Kentucky	28.6	5.0	3	88	21
2. Montana, Alberta (Canada)	70.6	19.7	22	112	4
3. Colorado, New Mexico	35.4	11.7	2	106	9
4. New Hampshire, Mass., Pennsylvania	43.9	7.4	9	137	23
5. Washington, Oregon	52.7	6.2	47	59	2
6. California	164.3	17.6	43	267	14
7. Georgia, Louisiana	187.0	54.5	99	344	4
8. United Kingdom	34.9	15.8	1	177	12
9. the Netherlands	25.9	3.0	16	40	8
10. Austria	17.6	-	17.6	17.6	1
11. Sweden	55.6	23.2	32	79	2

On average, wetland functions are valued more than twice as high in the USA than in Europe (70 SDR in the USA versus 32 SDR in Europe). After truncation of the top value, average WTP in the UK (22 SDR) appears to be almost the same as in the Netherlands. The differences found in the different regions are confirmed by the Kruskal-Wallis test statistic (Table 16).

Table 16: Results of the Kruskal-Wallis test

Hypothesis		
	χ^2	*p*
H_0: equality of average WTP in all groups	46.7	0.00

4.3 ANOVA results

In a systems approach, the interaction of components receives as much as attention as the components individually (section 1.4). Hence, in a first attempt to test the main and possible interaction effects of the factors discussed in the previous section on the summary findings of the studies included in the meta-analysis, an analysis of variance (ANOVA) has been carried out. In this section, only those statistically significant results will be presented which comply with the underlying normality condition of equal cell variance.

Only significant second order effects are found. Higher order effects could not be detected as a result of the remaining small number of observations in each cell. Although significant interaction effects are found between the various wetland and survey design characteristics, only the payment vehicle and elicitation format and their interaction pass Cochran's C test for homo-scedasticity.[20] We will analyse these results in more detail below. The ANOVA results are presented in Table 17.

The effects of the different payment vehicle and elicitation format levels on WTP are tested individually and jointly in terms of their sums of squares (SS) against the pooled within cells and residual sum of squares (the first source of variation in Table 17). The mean square (MS) for this latter category is the estimate of variability derived from the individual cells and the residuals and is used in the denominator in the F test in the ANOVA. The source of variation 'payment vehicle by elicitation format' provides a test of the interaction between both variables.

Based on the various levels distinguished in both variables (Table 8 in section 4.2), differences in average WTP can be explained, individually and jointly, as indicated by the significance levels of the F test statistics (Sig of F). Adjusted for degrees of freedom, the specified model accounts for more than two thirds of the overall variability around the dependent variable's (WTP) average.[21]

[20] The other standard test for homogeneity of variance, the Barlett-Box test, could not be performed because 4 cells contained only one observation. These cells are omitted from the Cochran test.

[21] The full model underlying Table 17 is: $E(Y_{jkl}) = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk}$, where the terms α_j and β_k refer to the main effects of the variables and the term $(\alpha\beta)_{jk}$ to the interaction effect (see for example Dobson, 1990).

Table 17: ANOVA results

Source of variation	SS	DF	MS	F	Sig of F
within and residual	125042.50	87	1437.27		
payment vehicle	96790.72	5	19358.14	13.47	0.000
elicitation format	56166.56	3	18722.19	13.03	0.000
payment vehicle by elicitation format	95617.44	7	13659.63	9.50	0.000
model	326264.78	15	21750.99	15.14	0.000
total	451307.27	102	4424.58		
R Square	0.723				
Adjusted R Square	0.675				

The ANOVA table provides summary results about whether or not there is a main and/or interaction effect. In order to see which factor or variable levels are different, one can, for example, look at the difference between the mean for each level and the overall mean, called contrasts. Table 18 presents the parameter estimates of the linearized contrasts between the factor level means and the factor's overall mean. Only the statistically significant (at at least the five percent significance level) results are shown. The null hypothesis that the parameter value is zero is tested by means of the *t* test. The last column in Table 18 shows the power of the differences found in the analysis. This power depends on the magnitude of the true differences and the sample sizes. If the true differences are very large, even small sample sizes should detect them. If, on the other hand, true differences are small, large sample sizes are needed to detect them (Norusis, 1992). Based on the sample size and the selected *p* level of a type I error, i.c. one percent, power reflects the probability that the null hypothesis will be rejected when it is actually false. So, the higher the power, the more confident one can be that the parameter estimates presented in Table 18 are different from zero and the observed differences between groups are true.

From the parameter estimates in Table 18, it appears that the payment vehicle income tax has a contrast score which is significantly better than average, while the private market payment vehicles private fund/entrance fee and trip expenditures show significantly worse contrast scores than average. This means that average WTP in the income tax group, which is expected to prompt more citizenship roles and hence elicit to a larger extent nonuse values as well, is significantly higher than average WTP in the sample as a whole, while the

private market payment constructs result in significantly lower average WTP. This corresponds with the results found in section 4.2.2. Moreover, the probability that the observed differences between the income tax and private market payment modes are true is quite high.

Table 18: Contrast results

Parameter	coefficient estimate	standard error	*t* value	Sig *t*	Power
Payment vehicle					
1. income tax	124.12	24.75	5.01	0.000	0.990
2. private fund/ entrance fee	-43.03	11.74	-3.66	0.000	0.845
3. trip expenditures	-44.18	21.12	-2.09	0.039	0.304
Elicitation format					
4. open-ended	-19.29	8.84	-2.18	0.031	0.334
5. dichotomous choice	83.39	14.68	5.67	0.000	0.999
6. iterative bidding	-29.88	12.57	-2.37	0.019	0.405
Interaction effects					
1 and 4	-137.53	27.17	-5.06	0.000	0.991
1 and 5	-87.32	30.39	-2.87	0.005	0.596
2 and 4	31.10	13.21	2.35	0.020	0.396
2 and 5	-79.30	15.30	-5.18	0.000	0.994
3 and 5	-61.93	20.99	-2.95	0.004	0.624

In the case of the elicitation format, only the power of the dichotomous choice format indicates that the significantly higher WTP found in this group reflects a true difference. The use of a dichotomous choice format results in a significantly higher average WTP than any other elicitation format. Although the probability of having found a true difference is small, the outcome of the coefficient estimate for the open-ended group confirms the results found in previous studies. On average, WTP is about 20 SDR per household per year lower when using an open-ended question format.

When looking at the combined effects of survey design elements, we find that asking respondents in an open-ended question for their WTP to pay higher income taxes results in a significantly lower WTP than using any other combination of payment vehicle and elicitation format. Finally, with a

probability of 60 percent of having found true interaction effects, employing an increase in income tax and a dichotomous choice format a statistically significant lower average WTP results.

4.4 Regression results

The structure of the data used in the meta-analysis is quite complex. WTP values are generated by different studies, carried out in different geographical locations using different valuation formats. Using the summary statistics of these different studies in a pooled sample, the usual conditions required for Ordinary Least Squares (OLS) regression are likely to be violated. The ANOVA shows that the assumption of equal variance is only met when looking at the combined effect of the variables payment vehicle and elicitation format. In order to account for heteroscedasticity, a Generalised Least Squares (GLS) regression technique was used (Goldstein, 1995).[16] Given the shape of the distribution of the WTP amounts, a logarithmic transformation was used.

Hence, for log(WTP) amounts for the studies Y, we have the GLS model:

$$Y = X\beta + Z\theta$$

where $X\beta$ consists of the design matrix X and associated parameters β and represent the mean or fixed effects of the explanatory variables on the dependent variable Y. However, whereas in OLS regression there is a single vector of error terms or residuals, here we may have a more complex variance structure where the values of residuals are dependent on explanatory variables included in the design matrix Z for the random part of the model. For example, for a single continuous explanatory variable x_1, we would have in an OLS regression:

$$y_i = \beta_0 + \beta_1 x_{1i} + e_i \ , \ \ e_i \sim N(0, \sigma_e^2)$$

whilst in a GLS model we have:

$$y_i = \beta_0 + \beta_1 x_{1i} + u_i + v_i x_{1i} \ , \ \begin{bmatrix} u_i \\ v_i \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_u^2 & \sigma_{uv} \\ \sigma_{uv} & \sigma_v^2 \end{bmatrix} \right)$$

[16] The GLS regression was carried out using the package MLN (Rasbash and Woodhouse, 1995).

where u_i is the residual associated with the intercept β_0, and v_i is the residual associated with the slope parameter β_1 of x_1. In the OLS regression, the variance of the responses is determined by the single residual term σ_u^2, so that:

$$\text{var}(y_i) = \sigma_u^2$$

whereas in the GLS model we have a variance which is dependent on the explanatory variable:

$$\text{var}(y_i) = \sigma_u^2 + 2\sigma_{uv}x_1 + \sigma_v^2 x_1^2$$

This can be done for any number of variables, hence making the variance of the responses a complex function of the explanatory variables, accounting for heteroscedasticity. This turns out to be highly relevant, as there are large differences in the variance of responses between Europe and the United States, for example, as well as for other variables. The results for the basic GLS model are presented in Table 19. Only those variables are included which are statistically significant at the 0.1 level.

The fixed part of the model represents the fixed or mean effects of each variable, as for an OLS regression model. The random part displays the variance and covariance parameters that model heteroscedasticity. The interpretation of the random effects is as follows: the variance of the constant in the model is the variance associated with the baseline case, i.e. where the value of all the explanatory variables is zero, and this turns out to be 0.059. The variance of, for example, North American studies is (0.059 + 2*0.689) = 1.437, and hence North American studies are more variable than European ones. In this way, one can construct any required function of the variance. For example, for North American studies which use income taxation as a payment vehicle, the variance is (0.059 + 2*0.689 + 2*0.020 - 2*0.707) = 0.023. The last term in this equation is the covariance between payment vehicle and country. We can conclude that wetland CV studies based on income taxation in the US have a particularly low variance. If we regard low variance as an estimate of quality in the sense that study results are better suited for comparison and hence can be more readily put together into a meta-analysis, then we can conclude that *on the whole* studies using income taxation as a payment vehicle are better suited than other payment vehicles, and that studies valuing wetland biodiversity tend to be less variable than studies valuing wetlands in their capacity of generating water or maintaining water quality.

Table 19: GLS-results for the basic model

Fixed effects			
Parameter	**Parameter Definition**	**Estimate**	**Standard Error**
constant	intercept	3.356***	0.100
payment vehicle	dummy: 1 = income tax 0 = other	1.880***	0.265
elicitation format	dummy: 1 = open-ended 0 = other	-0.411**	0.130
country	dummy: 1 = North America 0 = other	1.861***	0.217
response rate (1)	dummy: 1 = 30-50 percent 0 = other	-2.253***	0.326
response rate (2)	dummy: 1 = > 50 percent 0 = other	-1.904***	0.333
flood control	dummy: 1 = flood control 0 = other	1.477***	0.240
water generation	dummy: 1 = water generation 0 = other	0.691*	0.342
water quality	dummy: 1 = water quality 0 = other	0.545†	0.282
Random effects between average WTP amounts			
Parameter	**Parameter Definition**	**Estimate**	**Standard Error**
$\sigma^2_{constant}$	variance	0.059*	0.029
$\sigma_{payment\ vehicle,constant}$	covariance	0.020	0.043
$\sigma_{country,constant}$	covariance	0.689**	0.222
$\sigma_{country,payment\ vehicle}$	covariance	-0.707**	0.226
$\sigma_{flood\ control,constant}$	covariance	-0.013	0.050
$\sigma_{water\ generation,constant}$	covariance	-0.637**	0.227
$\sigma_{water\ quality,constant}$	covariance	-0.424†	0.231
$LL_{unconstrained}$		-83.907	
Pseudo R-squared		0.365	
n		92‡	

‡ As a result of missing values for explanatory variables, the number of observations is reduced from 103 to 92.

† $P < 0.10$ * $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

The estimates for the regression results are obtained through Maximum Likelihood techniques (see for example Maddala, 1983). The outcome of the

likelihood ratio test, based on the Chi-square statistic ($\chi^2_{14} = 96.51; p < 0.01$), rejects the null hypothesis of zero slopes for all explanatory variables. A pseudo R-squared can be calculated from the log likelihood (LL) ratio where only the constant term is included, called the *constrained* model, and the log likelihood from the final model where all explanatory variables are included, called the *unconstrained* model.[17] The order of magnitude of this pseudo R-squared corresponds with the goodness of fit measures usually found in this type of cross-sectional data analysis. However, this pseudo R-square lacks the straightforward explained variance interpretation of true R-square in OLS regression (Hamilton, 1993).

For the fixed part of the model, the estimated coefficients in the semi-log function represent the constant proportional rate of change in the dependent variable per unit change in the independent variables (Johnston, 1984). The coefficient estimated for the dummy variable payment vehicle reflects in this case, *ceteris paribus*, an almost twice as higher average WTP for an increase in income tax than for any other payment vehicle. A possible explanation for this substantially higher average WTP may be the social relevance of the problem prompted by this payment vehicle and the general understanding that most people will pay, avoiding possible feelings of unfairness or injustice and hence avoiding lower bid amounts or even protest bids. Corresponding to previous research results, the open-ended elicitation format yields a significantly lower WTP than the dichotomous choice format (with or without follow-up bidding) and payment card formats. On average, WTP is reduced by 41 percent (*ceteris paribus*) when using an open-ended WTP question.

Also the location of the wetland site and the sample population has a significant impact on average WTP. The dummy variable has a value 1 if the research took place in North America (USA and Canada) and zero if in Europe (UK, the Netherlands, Sweden and Austria). Average WTP appears to be substantially higher in North America than in Europe. Higher response rates, a rough indicator of the overall study quality, appear to result in significantly lower average WTP than low response rates. Although not much can really be said about this outcome, it does correspond, coincidentally, to two of the NOAA Panel's recommendations for reliable CV results, namely a high response rate and the use of a survey design resulting in a conservative estimate.

Of great interest are the outcomes of the parameter estimates for the wetland functions. The wetland functions distinguished play a statistically significant role in explaining the variance in average WTP at the conventional significance levels.

[17] Pseudo $R^2 = 1 - LL_u / LL_c$

Moreover, the size of the estimated parameters is as expected. *Ceteris paribus*, average WTP appears to be highest for flood control, followed by water generation and water quality. The wetland function 'biodiversity supply', the baseline category, is valued lowest. So, as can be expected, people seem to be willing to pay, on average, most for flood control. Only after controlling for this function, the supply of water plays a significant role, followed by the water's quality and finally the provision and maintenance of biodiversity.

As mentioned before, an important drawback of meta-analysis is that multiple results are used from individual studies. One should account for the possibility that results from the same studies may cluster together, for example as a result of identical survey design or sample population, and that results from some studies may be more variable than others. If we use the subscript *j* to label different studies, then we can rewrite our basic GLS model (again using one explanatory variable for simplicity) as:

$$y_{ij} = \beta_0 + \beta_1 x_{1ij} + u_{ij} + v_{ij} x_{1ij} + s_j \ , \ \begin{bmatrix} u_i \\ v_i \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_u^2 & \sigma_{uv} \\ \sigma_{uv} & \sigma_v^2 \end{bmatrix} \right) \ , \ s_j = N(0, \sigma_s^2)$$

where σ_s^2 is the variance parameter that describes the differing variability of estimates within different studies. The results of this model, where we account for study effects, are presented in Table 20.[18]

The reduction in sample variance or standard deviation of average WTP by accounting for possible study effects in the basic model is statistically significant $(\chi_1^2 = 4.066; p = 0.0438)$, meaning that study clustering effects significantly explain some of the variation around the mean dependent variable. The multi-level modelling approach (see Rasbash and Woodhouse, 1995) hence provides a significant improvement on conventional meta-analysis by allowing for the hierarchical structure of data implicit in clustering of multiple results from single studies.

Table 20: GLS-results when accounting for study effects

Fixed effects			
Parameter	**Parameter Definition**	**Estimate**	**Standard Error**

[18] Smith and Osborne (1996) used a Huber-White consistent covariance estimator which treats each study as a sample cluster with the potential for heteroscedasticity. In this approach, the standard errors are adjusted for the number of observations in each subsample.

constant	intercept	3.311***	0.247
payment vehicle	dummy: 1 = income tax 0 = other	1.576***	0.362
elicitation format	dummy: 1 = open-ended 0 = other	-0.376*	0.183
country	dummy: 1 = North America 0 = other	1.629***	0.363
response rate (1)	dummy: 1 = 30-50 percent 0 = other	-1.722***	0.451
response rate (2)	dummy: 1 = > 50 percent 0 = other	-1.461**	0.450
flood control	dummy: 1 = flood control 0 = other	1.134*	0.456
water generation	dummy: 1 = water generation 0 = other	0.441	0.479
water quality	dummy: 1 = water quality 0 = other	0.659*	0.327
Random effects between studies			
Parameter	**Parameter Definition**	**Estimate**	**Standard Error**
$\sigma^2_{constant}$	variance	0.160*	0.071
Random effects between average WTP amounts			
Parameter	**Parameter Definition**	**Estimate**	**Standard Error**
$\sigma^2_{constant}$	variance	0.045	0.028
$\sigma_{payment\ vehicle,constant}$	covariance	0.001	0.036
$\sigma_{country,constant}$	covariance	0.351**	0.129
$\sigma_{country,payment\ vehicle}$	covariance	-0.345**	0.134
$\sigma_{flood\ control,constant}$	covariance	0.027	0.060
$\sigma_{water\ generation,constant}$	covariance	-0.266†	0.153
$\sigma_{water\ quality,constant}$	covariance	-0.188	0.135
$LL_{unconstrained}$		-81.874	
Pseudo R-square		0.380	
n		92‡	

‡ As a result of missing values for explanatory variables, the number of observations is reduced from 103 to 92.

† $P < 0.10$ * $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

In this new model, all the fixed effects parameter estimates have decreased somewhat in size. As expected, having explained some of the variance in the model by study level effects, the random effects between log(WTP) amounts have decreased, except for the covariance between flood control and the intercept. In

fact, the variability among the WTP amounts for flood control has tripled (σ^2 = 0.099).

At the same time, the significance level of half of the explanatory variables (excluding the intercept) has decreased. Only the significance of the wetland function water quality has increased. The wetland function water generation has become statistically insignificant and has switched place with the function water quality supply in the order of size. Nevertheless, our analysis shows that we are able to link stated preferences for a large number of wetland conservation projects or programmes in different countries to the main wetland functions involved. This provides us average economic values for different wetland functions after controlling for important issues like population sample and procedural characteristics in contingent valuation.

5. Discussion and Conclusions

In this paper, an attempt has been made to compare CV results for both the use and nonuse values attached to different wetland functions by complementing a qualitative, descriptive analysis with a quantitative meta-analysis. Studies are categorised according to (i) the wetland types distinguished by Dugan (1990), (ii) the main hydrological, biogeochemical or ecological wetland functions addressed in each study, (iii) the countries in which the studies were carried out, (iv) the use and/or nonuse values estimated and (v) a number of CV survey design characteristics like payment vehicle and elicitation format. Because of lack of information, other important aspects which may help to explain differences in valuation outcomes could not be included in the analysis, such as sample respondents' socio-economic and psychological characteristics.

An important starting point in the analysis is to meet the criticism that meta-analytical work frequently compares findings from studies which focus on different environmental goods and services or even different economic-environmental value types. In the analysis presented here, we concentrate on wetland specific functions and benefits. However, wetlands are complex eco-systems, providing us with a number of attributes or functions which are difficult to disentangle from a natural science perspective, let alone from the limited information processing capacity in the public's mind. People's perceptions of the various wetland attributes or functions depend upon their own experience, for example of the recreational use of wetlands, and do not necessarily correspond with the scientifically measured functions.

In those cases where this experience is missing, people may construct preferences on the basis of the information provided in the CV survey, especially when nonuse values are expected to be involved. To what extent this is the case in the studies included in the meta-analysis is unknown. Constructed preferences and subsequently people's stated WTP may still be valid indicators of how strongly people feel about the issue involved, even though such preferences do not correspond with the core of neo-classical economic theory, which starts from existing preferences. However, it is debatable whether or not immediately constructed preferences remain constant in time and can hence be used in discounted cost-benefit analyses or can be made comparable to other value statements at different points in time as in the underlying meta-analysis.

In the qualitative analysis, we discussed some of the problems encountered in attempts to break down environmental values in the various components of use and nonuse values, and also our attempts to ascribe environmental values to the various wetland attributes or functions and the corresponding benefits derived

from these attributes or functions. With some effort, we managed to come up with an arbitrary distinction between these environmental value components and wetland functions by splitting them up into indicator variables which were subsequently used in a quantitative meta-analysis of the CV wetland studies. One could argue that we 'itemised' the environmental functions wetlands perform (see section 2.1.1) and in this sense disconnected the wetland goods and services supplied by these functions from the underlying wetland ecosystem structure.

In the quantitative analysis, we found that the distinction into four main wetland functions significantly helped to explain differences in average WTP. Moreover, the size of the estimated parameters is as expected. Average WTP appears to be highest for flood control, followed by the supply of water and the water's quality and finally the provision and maintenance of biodiversity. The distinction between use and/or nonuse values does not have a significant impact on average WTP, perhaps because the corresponding variance is already accounted for by the distinction in wetland functions.

Another important issue in the analysis is the important drawback of most previous meta-analyses that multiple results are used from individual studies. In our analysis we account for the fact that results from the same studies cluster together, for example as a result of identical survey design or sample population, and that results from some studies are more variable than others. We found that North American studies are more variable than European ones, whereas no statistically significant differences in variability could be detected between CV studies using different payment vehicles. On the other hand, wetland CV studies based on income taxation in the US have a particularly low variance. Regarding low variance as an estimate of quality in the sense that study results are better suited for comparison and can hence be more readily put together into a meta-analysis, we conclude that *on the whole* studies using income taxation as a payment vehicle are better suited than other payment vehicles, and that studies valuing wetland biodiversity tend to be less variable than studies valu-ing wetlands in their capacity of generating water or maintaining water quality.

As expected, survey design characteristics also help to explain differences in average WTP, especially the study's payment vehicle. When using income taxes as the mode of payment, average WTP appears to be substantially higher than any other way of paying for wetland-related protection or enhancement schemes. This result seems to be in line with speculations about the degree to which possible consumer and/or citizenship roles are prompted in studies using different payment vehicles. Corresponding with previous CV research results,

the open-ended elicitation format yields a significantly lower average WTP than other elicitation formats.
In the meta-analysis, response rates have been used as an indicator of overall study quality, whereas the scope test can be regarded as a validity indicator of the meta-analysis itself. The response rates significantly explained differences found in average WTP in different studies: higher response rates resulted in significantly lower average WTP than low response rates. Low response rates may be biased towards including a relatively large number of sample respondents with a greater interest than average in environmental protection and corresponding WTP. The size of the wetland study sites relative to the country's total stock of wetlands did not play a statistically significant role in the regression analysis. Nevertheless, without controlling for other possible influences, average WTP does increase with increasing relative wetland size. Another interesting finding is that studies carried out after the publication of the influential NOAA recommendations show a much lower average WTP than the studies carried out before the publication of these recommendations, and could be an indication that the Panel's recommendations to use a survey design resulting in a conservative estimate are taken to heart.

Finally, we started off quite ambitiously by trying to integrate ecological, economic-institutional and social-psychological aspects surrounding the CV method in a systems approach (see Figure 1). Although considerable effort has been put into specifying the characteristics of the environmental functions and correspondingly the environmental goods and services involved, many of these aspects, especially sample population characteristics, clearly remain undefined. This is a common problem in meta-analyses as a result of insufficient and/or inadequate information provided in published wetland CV studies. In most wetland CV studies, important information about socio-economic indicators like average household income, education level, household size etc. are collected, but only average relationships with WTP are reported, if at all. Possibly relevant information about the samples' social-psychological characteristics or even cultural characteristics is missing in all studies.

In meta-analysis, inferences are made on the basis of information on global statistics, such as the mean and standard deviations of parameter estimates. These may or may not describe individual behaviour adequately. In order to overcome this potential problem and to increase the study's validity and reliability, our next step has been to gather more information about sample population characteristics by asking the authors of the studies included in the analysis for their entire data set (Brouwer, Langford, Bateman and Turner, forthcoming). We believe this will provide us with an important test of the

appropriateness of meta-analysis as an instrument to synthesise CV outcomes, for example for the purpose of benefits transfer.

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Annex

Natural wetland classification (modified from Dugan, 1990)