APPENDIX A4.3

MONETARY VALUATION TECHNIQUES

A.4.3 MONETARY VALUATION TECHNIQUES

A.1 Overview

Section 4 of the main report provided brief summaries of six economic valuation techniques which were identified as being most relevant to the assessment of retreat options. These were:-

- change in productivity;
- preventative expenditure and replacement costs;
- damage costs avoided;
- travel cost techniques;
- contingent valuation methods;
- energy analysis approaches.

Each of these techniques is reviewed in more detail below, including an overview of the basic approach, potential for valuation of retreat, past applications and advantages and disadvantages.

It should be noted that discussion of past applications often gives the values estimated by a particular study. All information on parameters relevant to these estimates are given where possible but, in many cases, references did not provide details of, for example, discount rates used and/or time horizon adopted for discounting. The values are presented here for illustrative purposes only.

A.2 Change in Productivity

A.2.1 The Approach

Where there is a market for the goods or services involved, estimates based on the value of changes in productivity can be used to derive values representing the benefits or costs of changes in environmental quality or resource availability.

The change in productivity approach is based on determining the physical impacts resulting from actions affecting the environment. Market prices are used to value the physical changes, with benefits equal to the value of increased output and costs equal to the value of decreased output. There are three basic steps to application of this method:-

- identification and prediction of potential direct and indirect productivity effects stemming from a proposed action;
- determination of the "correct" prices to be used; and
- estimation of the value of the changes in productivity, where this involves combining information on predicted physical effects and on prices.

Prediction of productivity effects resulting from a particular action can be carried out through research either in the field or in a laboratory or through the use of statistical regression techniques. Care must be taken to ensure that any changes in level of output predicted stem directly from the impacts on environmental quality or availability and that these are wholly attributable to the action in question.

It is also important that the predictions represent the marginal productivity of the wetland or habitat area. This is one of the greatest difficulties in applying this method. The effects of human effort must be separated from the effects on output due to changes in the quality or availability of the system. Separating these effects is complicated in practice as data is based on total effects as reflected by harvests or other such variables. Determining the effects of environmental changes can be further complicated by the highly interrelated nature of different aspects of wetland or coastal habitat systems. Failure to separate out the different effects, however, may result in over-estimation of the contribution of the wetland or different wetland characteristics to productivity.

The second step involves determining the prices, or values, to be attached to changes in output. As used above, the term "correct" prices refers to price levels where the impact of subsidies or any other factors which may have distorting effects are removed. Additionally, any changes which might take place in the market structure (i.e. changes in supply) as a result of the productivity changes need to be taken into account in the determination of "correct" prices.

A.2.2 Potential for Valuation of Retreat

With regard to the valuation of benefits stemming from habitat restoration or creation activities, this method could be used to value changes in agricultural productivity (including reeds, sedge and willow production), effects on fisheries and shell-fisheries and effects on any other dependent industries such as water supply. Estimates of productivity levels for different types of habitat could form the basis for predicting expected productivity for the various managed restoration or creation options. The gain in productivity under restoration/creation would then form the measure of benefit accruing from the managed retreat option.

However, the predicted gains must be gains that would actually be realised. In other words, gains in fish/shellfish productivity would have to be of benefit to fisherman for these values to be attributed validly to the restoration/creation works.

A.2.3 Past Applications

Studies have been undertaken in the US to determine the value of wetland areas to commercial fisheries. A study carried out by Batie and Wilson (as reported in Shabman and Batie, 1988) derived a value for Chesapeake Bay wetlands for oyster production. Regression analysis techniques were used to determine the relationship between oyster harvests and wetland acreage, controlling for other variables affecting harvests. The predicted contributions of wetland area to oyster harvests varied widely, with marginal productivity values per acre ranging from $11 to $1,400. Although the study represents a valid application, the results were affected by limited information on the relationship between wetlands and oyster harvests.

A number of other US efforts to estimate the economic value of biological productivity and other natural functions have resulted in per acre estimates exceeding a hundred thousand dollars (see Shabman and Batie, 1988). These estimates, however, generally have little validity in economic terms as they are not based on estimates of the value of the functions that the wetland actually provides, but on estimates of their capacity to provide certain functions if called for. Frequently, inappropriate prices have been used and the costs associated with providing the services have been neglected.

Within the UK, change in agricultural productivity was used as one component in the estimates of benefits related to the Aldeburgh Sea Defence Scheme (Turner et al., 1990). The impacts of potential flood damage of marsh areas and saline intrusion in terms of changes in crop yields were estimated for irrigated and non-irrigated crops. The difference between the pre and post breach gross margins was then used as the value of flood protection services.

A.2.4 Advantages and Disadvantages

The change in productivity method is useful for valuing changes in environmental quality or availability when the impacts are on goods and services for which markets exist. This means that only use-related benefits can be measured by this method and total economic benefits would therefore be under-estimated if only this method was relied on for valuation purposes.

It is, however, a straightforward method given that markets do exist and that prices can be adjusted to reflect "correct" prices. The resulting estimates may also be considered more reliable than those derived from other techniques which use surrogate or hypothetical market data.

The key limitation to the use of this method is that it necessitates good information on the relationship between environmental conditions and productivity. These relationships are rarely well established and making the link between cause and effect will require modelling work or the adoption of relationships developed in other studies. For example, the relationship between habitat characteristics and fish nursery potential is highly complicated and scientific uncertainty may make it difficult to determine how environmental changes would affect harvests.

A.3 Preventative Expenditure and Replacement Costs

A.3.1 The Approach

The preventative expenditure and replacement cost methods are related techniques for placing a value on a change in environmental quality or the loss of an environmental service.

The preventative (or defensive) expenditure approach is based on using actual expenditures incurred by individuals or a governmental body to determine the value or importance placed on a particular environmental good or service. In applying this approach, demand for environmental damage mitigation is viewed as a surrogate demand for environmental protection. That is, the willingness to accept the costs of mitigating adverse environmental effects is interpreted as the value of the benefits of a certain level of environmental quality.

The replacement costs approach is based on the principle that the work which would be incurred to restore the environment to its original state provides an estimate of the value of the environmental good or service threatened with damage or loss. Thus, through this approach, potential expenditures serve as a means of placing a value on previously unvalued functions (such as those provided by a wetland area).

Related to the replacement costs approach is the idea of mitigation works or shadow projects. A shadow project is one which compensates for the damages caused by a particular development by providing an environmental resource of equal or greater value. This may occur in a different location or even vary in nature from the damages caused. The costs of the "shadow project" can be used to place a minimum value on the damages caused.

A.3.2 Potential for Valuation of Managed Retreat

Within the valuation framework outlined in Section 4.3.3 of the main report, the preventative expenditure method could be used to provide "reference" values. Expenditure undertaken to prevent damage to existing coastal habitat areas could be used to provide estimates of the value of the areas protected. This site-specific data could then be used to develop estimates of value for different types of habitat areas. These values would provide second best estimates for restored or created wetland or habitat areas.

The replacement cost or "shadow project" approaches could also be used to place a value on restored/created habitats. In this case, the estimated costs of any management works would serve as the estimate of value; decision makers would then be left with using their own judgement as to whether or not the benefits gained would be greater than or equal to these costs.

However, the use of values generated through any of these techniques would have to be undertaken with care and treated very much as rough guides or second best only.

A.3.3 Past Applications

Several UK studies (such as that carried out for the Aldeburgh Sea Defence Scheme) have used payments made by MAFF to farmers under the Environmentally Sensitive Areas (ESA's) programme as measures of the value attached to low intensity versus high intensity agriculture. These payments represent a type of preventative expenditure.

The replacement costs approach has been used to value flood control and water quality enhancement functions and services. It also has been used to value the costs of replacing the groundwater recharge services provided by wetlands with other water supplies. There is considerable debate, however, about these applications as the relationship between wetlands and aquifers is uncertain.

One of the more widely quoted studies is that carried out by Gosselink (1974) into the water quality treatment capabilities of southeastern tidal marshes. This study argues that, due to the denitrification and nutrient removal capabilities of these marshes, they provide a form of natural tertiary treatment. The value of these services were estimated on the basis of the costs of replacing them with construction of a tertiary treatment facility. The estimated cost of such a facility was about $123,500 per hectare.

The replacement costs technique has also been used to value non-commercial species such as birds or rare fish. In estimates of the environmental damage resulting from an oil spill in Chesapeake Bay in the US, quotes were obtained from commercial breeders and biological firms to place a value on the costs of replacing lost birds. The average estimated cost was $30 per bird (Cohen, 1986).

Within the UK, the replacement costs approach was used as part of the cost-benefit analysis carried out for the Aldeburgh Sea Defence Scheme (Turner et al., 1990). Costs of purchasing and renovating a "replacement" Martello Tower were used as an estimate of the value of losses that would occur with a breach of the defences. Similarly, the costs of replacing yacht and sailing clubs with a new marina were used to value the loss of these facilities in the event of a breach.

The shadow project concept has been applied in the US to development of many wetland areas. For example, in the San Francisco Bay area, any development on wetlands must be compensated for by creation of wetland areas of a similar size and quality or by other environmental enhancement measures.

A.3.4 Advantages and Disadvantages

Preventative expenditure and replacement cost methods are straightforward and easily applied techniques, requiring data that is generally readily available. They are useful methods where the environmental change in question involves physical effects which are well perceived.

The preventative expenditure approach is based on the assumption of perfect substitutability of one good for another. If defensive expenditures are perfect substitutes for reductions in the level of pollution effects experienced, then an individual can effectively purchase the optimal amount of quality through defensive outlays. In practice though, perfect substitutability is rare. Thus, these expenditures form approximations of the minimum value to be placed on the good or service.

There are also likely to be several modes of averting behaviour and in many cases more than one mode will be used at a time. In these cases, the analyst must identify and measure the reductions in all modes if benefits are not to be underestimated.

Both the preventative expenditure and replacement cost methods provide lower limit estimates of benefits gained. Individuals will commit resources only if their subjective estimates of the benefits to be gained are at least as great as the costs. Observed expenditure therefore provides an indirect measure of the benefits as perceived by the individual. But because the willingness to incur costs is constrained by ability to pay, observed expenditures will be lower than levels that would otherwise occur.

Both methods also assume that the existing system is optimal. The question of the optimal level of environmental quality or services is not addressed by the preventative expenditure method; and current levels of expenditure may not be correct as they are based on incorrect subjective valuations of the benefits gained by the defensive measure. Similarly, the replacement costs method assumes that if the environmental good were removed or changed, then those currently benefitting from the good would replace all lost aspects. If beneficiaries were not willing to replace all aspects, then the values derived through this method would be greater than the benefits as indicated by willingness-to-pay. Conversely, if beneficiaries were willing to replace all aspects, then the value derived may be an underestimate of the true benefits.

Underlying both methods is the assumption that no secondary benefits are associated with the expenditures. If secondary benefits do arise, then these methods will over-estimate the value of the benefits provided by the environmental asset. For example, flood control works built to protect or maintain a given environmental habitat area (such as the Norfolk Broads) must not provide any other benefits for the costs of those works to be taken as the value of the habitat area protected. This will clearly not be the case in many instances as other benefits related to agriculture and recreation activities will also exist.

Finally, the replacement costs and shadow project methods both assume that re-creation of an environmental system is possible. As has been discussed in previous sections, however, this is a doubtful assumption when applied to wetland and coastal habitat creation as it may only be possible to partially recapture the value of goods and services provided by such natural areas.

A.4 Damage-Costs Avoided

A.4.1 The Approach

Related to the above methods is the use of damage-costs avoided as a measure of the value of a given function or service provided by a natural system. The concept underlying this approach is that the value of an environmental good or service is equal to the costs of damage to property or other assets which would occur if that good or service did not exist. The approach is most applicable to valuation of the physical functions and services of wetlands or habitat areas, where these provide benefits to individuals.

A.4.2 Potential for Valuation of Managed Retreat

This approach could be applied to valuation of flood protection or flood water storage, shoreline protection, erosion control and water quality enhancement benefits. It could be used to develop reference estimates for existing areas but, due to the site-specific nature of such estimates, they would be of limited reliability and validity when applied to managed retreat opportunities.

Development of values specific to enhancement and creation could also be undertaken using this approach. This would require prediction of the level of a particular function or service that would be provided by the enhanced or created service. The method would then provide an estimate of the benefits related to the creation activities (the "specific valuation" approach).

When using this approach, however, care should be taken to ensure that the value generated is not an over-estimate. For example, if the service or function could be provided by physical engineering works at lesser expense, then the costs of those works (the least-cost substitute) should be taken as the value of the environmental service, not the damage costs avoided.

A.4.3 Past Applications

There have been a number of past applications of this approach to the valuation of wetland functions and services. Most of these have been related to flood protection benefits. The approach has also been used to value the damage costs stemming from loss of water supplies resulting from the destruction of wetlands.

One of the better US illustrations of how this method has been used in the past, is given by work carried out using Corps of Engineers property damage estimates for different levels of flooding associated with wetland loss in the Charles River Basin in Massachusetts (Thibodeau and Ostro, 1981).

Using hydrologic data the Corps of Engineers predicted increased flooding levels given different levels of loss of the total wetland area. This information was combined with data on existing development and property values to predict the annual monetary loss given various amounts of reduction in wetland storage capacity. Under natural conditions (i.e. the existing situation) annual losses were calculated at about $467,000 rising to $3,193,000 with a 40% loss.

Thibodeau and Ostro extrapolated from this data to develop estimates of the losses that would occur if the entire wetland area were lost. Taking the Corps' estimates that the wetland provided 75% of the natural storage capacity of the basin, they predicted that total loss of the wetlands would produce expected annual flood damages of nearly $18 million, an increase of more than $17 million from the existing situation. On a per acre basis this equalled an annual average damage-costs avoided estimate of about $2,000. Discounted in perpetuity, the present value per acre was found to be $33,000 and this value was accepted as the flood control value of an acre of wetland in the basin.

Although this is one of the more valid applications of this method, concerns remain over the following assumptions. The extrapolation of damage costs assumes that property values in areas additional to those looked at by the Corps are similar to those considered in the Corps estimates. It also assumes that the 60% of wetland not considered in the hydrologic studies undertaken by the Corps provide the same services as the 40% initially considered. Finally, no discussion was given of the costs associated with the engineering works necessary to provide the same services.

A.4.4 Advantages and Disadvantages

The damage-costs avoided approach is a relatively easily applied method. It can only be applied, however, to cases where the "damage" can be valued in terms of market prices. Thus, if relied on as the only measure of benefit, the total benefits associated with the area are likely to be underestimated as non-use related benefits cannot be valued.

Most applications of the method involve consideration of systems where the protected area is heavily characterised by man-made structures or has high values related to agricultural productivity, etc. For example, wetland applications generally have associated with them highly developed downstream or upstream areas. If there were little man-made development or low value agricultural use, the values generated by this technique would be low, although this may be an appropriate valuation of the service provided.

A.5 Travel Cost Method

A.5.1 The Approach

The travel cost method places a value on an environmental good, generally related to recreational activities, by using the costs of consuming the service as a proxy for price. The approach is based on the concept that people spend time and money travelling to recreational sites and that these expenditures, or costs, can be treated as revealing the demand for the site. These costs are assumed to be equivalent to an overall entry price to the environmental good.

The travel cost method involves developing a demand function for the site in question, relating visitation rates to the costs of travel and/or entry price for the site. The method can be used to determine the value attached to recreational activities at a single site, or to determine how changes in environmental quality would affect demand and therefore the valuation placed on a given site.

The method assumes that recreation is a divisible good and that a set of individual demand functions can be developed for different sites where quantity (number of visits) is a function of prices, incomes, travel costs and other characteristics such as quality. The number of visits to a particular site will also depend on the attributes of competing sites; thus as quality changes at one site, demand will change for other sites. This change in demand provides the measure of benefits resulting from the change in quality.

The general procedure followed in applying the travel cost method can be summarised as follows (Freeman, 1979):

i. The area around the site or area in question is divided into contours of equal travel distance for the purpose of measuring travel costs to the site.

ii. Visitors are surveyed to determine their zones of origin and to gather data on journey times, direct travel expenses, and socio-economic characteristics (such as income, education, etc).

iii. Visitation rates are calculated for each zone. These may be expressed either as visits made by a given individual (visits per annum) or visits from a given zone (visits per capita).

iv. A demand function is developed for the site, relating visitation rates to the costs of travel. The costs of travel are assumed to form the "entry price" for the site. Regression analysis techniques are used to determine the relationship between visitation rates and travels costs, socio-economic characteristics, etc.

The functional relationship used in the regression analysis will take a form based on the following:

$$V_ij = f(P_j, D_i, C_i, t_i, h_i, Q, M_i)$$

Where:

V_ij	number of visits by individual i to site j
P_j	vector of entry fees to the various sites
D_i	vector of distances from residence of individual i to the various sites
C_i	unit travel cost of individual i
t_i	vector of travel times to the various sites for individual i
h_i	opportunity cost of travel time for individual i
Q	vector of services of the various sites (quality, etc)
M_i	money income of individual i

v. The results of the regression analysis provide the basis for developing a demand curve for visits to the site. Once the demand curve has been estimated the effect on demand of, say, raising the entry fee to the site, or of changes in quality can be determined. Through this process a second stage demand curve is developed which provides an estimate of consumer surplus.

vi. Dividing estimated consumer surplus by the number of visits to the site gives a figure for average consumer surplus per visit for those surveyed. By combining this figure with estimates for the total number of people visiting a site (in a given time period) an aggregate estimate of value, as measured by consumer surplus, can be calculated.

A.5.2 Potential for Valuation of Managed Retreat

In the valuation of habitat creation or restoration activities, the value attached to an existing site of similar characteristics could be used to provide a "reference value" for restored or created areas. For example, the type of approach adopted in recent work undertaken by the Forestry Commission could be used develop these values (see 5.3). The reliability of this would, however, be questionable as the method is site-specific and a number of assumptions would have to be made concerning key variables such as visitation rates and the quality and nature of the created habitat.

Theoretically, the travel cost method could also be used to derive a value for a restored or created resource such as those developed under a managed retreat option. In practice though, its use in this manner may not be feasible. It would require that the sites where creation or restoration works were to take place already receive visitors for whom demand functions could be developed. This may not always be the case. Even where it is the case, current demand levels may not provide a good indication of future demand if the restoration or creation activities are to provide considerable improvements in quality. Further, data on sites of similar quality to that predicted for the created habitat areas would have to be included in the regression analysis.

A.5.3 **Past Applications**

The travel cost method has been used extensively in the United States, with some studies valuing the recreational services (e.g. fishing, hunting, bird watching, photography, walking, etc.) provided by wetland or coastal habitats. One example of such an application is that carried out for wetland areas in Terrebone Parish, Louisiana. A survey of recreational users was undertaken to determine willingness to pay to preserve the areas for recreational use. Questionnaires were placed on all vehicles parked at twenty seven boat launch facilities at different times during the year, including both weekdays and weekends. Out of over 7,800 questionnaires placed in this manner, only 1,126 were returned for a response rate of just over 14%.

Seven concentric rings of 35 mile increments were then constructed around the area. The study found that use of the wetland areas was highly localised with 78% of respondents coming from ring 1 and 98% from rings 1 to 3 (this localised use may invalidate the results of this study, and the relatively low values found for habitat are attributed to this factor). Total costs of travel time for the typical user group were used to measure the value of the resource. These costs were estimated to be about $27 (1985 values) for the typical user group. Aggregating these over Terrebone Parish (zones 1 to 3), provided a value of about $6 per acre per year, or $46 when discounted at 8% in perpetuity.

Earlier US studies include those carried out by Kreutzwiser, and Miller and Hay (as reported in Shabman and Batie, 1988). Kreutzwiser calculated travel costs for Long Point Marsh on Lake Erie, where the wetland uses included nature viewing, photography, fishing, waterfowl hunting, canoeing and camping. The overall estimate of consumer surplus for the marsh was $191,361. Miller and Hay related hunter success to wetland acreage. Hunter participation was estimated as a function of habitat, socio-economic variables and travel costs. A 10% loss in waterfowl habitat was then assumed. Consumer surplus estimates of $29 per day of hunting were assumed, based on previous study results, and these were combined with the above model to calculate the average value for hunting at this site to be $82.00 per acre of habitat. This per acre value is unique to the assumption of a 10% loss in habitat.

Within the UK, no applications of the travel cost method to recreation services provided by wetland or coastal habitats have been documented. Use of the method has generally, been fairly limited but includes the valuation of nature reserves and forest recreation. A recent study carried out for the Forestry Commission (Benson and Willis, 1990) indicates, however, how the method can be used to derive an overall demand function for a given environmental asset.

Forestry Commission estate land was divided into fourteen clusters of districts, where lands incorporated into each district were considered to share common characteristics. A representative site was selected from each district and visitor surveys were carried out to produce estimates of recreational benefits. The results of these surveys ranged from £1.34 to £3.31 per site, with an average of £2 per person over all sites. District managers were then asked to provide "guesstimates" on the number of visitors and this data together with monitoring data were used to estimate total figures for each site. Site-specific results were then combined with the visitation rate estimates for all estate sites to develop a total value for open-access recreation. Total value was calculated at £53 million (1988 values) with an average value of £47 per hectare.

A.5.4 **Advantages and Disadvantages**

The main advantage of the travel cost method is that it relies on using observed behaviour. This gives the resulting values greater credibility than those derived from methods such as contingent valuation which depend on stated responses to hypothetical situations, or from indirect approaches based on engineering costs. It is a valuable approach at a site-specific level where areas are visited by a broad range of people specifically for recreational purposes and where adequate data on the characteristics of the area and the users are available.

On the negative side, data requirements for the travel cost method are considerable. Information is required on number of visitors, place of journey origin, duration of journey, direct travel expenses, value of travel time, socio-economic characteristics, and population for different zones. Where the aim is to predict how changes in quality would affect demand, information is also needed on the costs of travel to other substitute sites and on current site "quality" characteristics.

There are also a number of modelling and other assumptions which need to be considered when applying the method. A particular concern relates to the type of functional form to be adopted. Economic theory provides no guidance on whether the demand relationship should be linear, log-linear or take some other form, yet results may be sensitive to the form used. Further, care must be taken in comparing results of different applications as comparability will depend on the functional forms specified.

The travel cost method assumes that all users would get the same total benefit from use of the site and that the people in a given zone would make the same number of visits at given entry fee. There is no reflection of the quality of the recreation experience, unless congestion is specifically controlled for in the demand model. It is also assumed that people know how much enjoyment will be gained when deciding to take the trip.

In general, no recognition is made that travel to the site might form part of the benefits associated with the experience or that some trips may be multi-purpose. In the case of multi-purpose trips, assigning all the benefits to one site would result in an over-estimation as some of these benefits should be apportioned to other sites visited. This problem can be dealt with through either of two approaches. The first is to exclude multi-purpose users (known as "meanderers") from estimation of the visitation demand function and then to assume when calculating consumer surplus that these users value the site on average as highly as purposeful users. The second approach is to ask multi-purpose users to weight the relative importance or value of their trip to the site in question as compared to other sites.

There is considerable debate over what type of approach should be adopted for estimating the costs of distance travelled and the value of travel time. Some analysts base the costs of distance travelled only on fuel costs as these represent marginal costs. Others take the full costs of motoring including insurance, depreciation, etc as the basis. The difference in the estimates resulting from the two approaches could be significant. Similarly, in terms of the valuation of time, if individuals are giving up working time in order to visit a site, then the wage rate is the appropriate price as it represents opportunity cost. If recreation time is not at the expense of wage earnings, then this may not be the right value. In this case, the opportunity cost of other foregone activities might provide a more valid measure.

Determining how quality should be represented in the analysis can also pose analytical difficulties. The relationship between the recreational service provided and the change in habitat quality will have to be established. The units defined for measuring changes in quality should also be in a form that is easily understood by individuals using the site. Studies have shown wide discrepancies between objective expert measures of environmental quality and what users perceive and value. Given this problem, applying the method to gradations in quality may be complicated.

Statistical problems with the method stem from the fact that only data for visitors to the site are recorded. No information is provided on what determines whether an individual visits a site or not, nor on the entry fee at which visits would not occur.

Finally, the estimation of benefits relies on the concept of consumer surplus. This rules out direct comparability with valuation techniques such as contingent valuation which are based on the concept of willingness to pay. In studies where the travel cost method is complemented by methods such as contingent valuation, the travel cost estimates should provide upper limit indications of willingness to pay. On the other hand, the travel cost method also provides minimum estimates of benefits in the sense that it omits option and existence values, as well as any values attached to the good by those who never actually visit the site.

A.6 Contingent Valuation Method

A.6.1 The Approach

Contingent valuation methods (CVM) are direct approaches toward the valuation of environmental goods. The methods consist of asking individuals what they would be willing to pay (or willing to accept by way of compensation) for a specified change in quantity or quality of an environmental good or service. The contingent valuation approach is appealing because it can be applied to a wide range of environmental issues and in almost any context. It is the only valuation method which can be used to derive estimates for option, bequest and existence values.

The first step in the contingent valuation (or expressed preferences) approach is the establishment of a hypothetical market for the environmental good in question. A sample of individuals (taken to be representative of the population of concern) are then questioned to determine the amount they would be willing to pay (or accept). The hypothetical or contingent market used should be as close as possible to a real market and should include the good itself, the institutional setting for its provision and the financing instrument (taxes, local community charge, entrance fee, etc.) that would be used. The sample surveyed should be familiar with the good and with the financial instrument (also referred to as the payment vehicle). They should represent a range of views on the issue of concern. Thus, if across-the-board values are needed, the sample should not be confined to a local population or users of a particular good as the values derived from these groups may not be representative of social values.

In addition to information on what individuals would be willing to pay (or accept), the surveys must also collect data related to socio-economic characteristics. This includes information on income, education, etc. This socio-economic data helps check the reliability of survey responses.

Surveys can be carried out using either direct interview techniques or bidding games:

- **Direct interview techniques** involve asking people to state what they would be willing to pay for a change in quantity or quality of an environmental good. The respondent may be given a "starting point" relating to current expenditure levels on the good, expenditure required for protection of quantity or quality, or some other relevant form of expenditure. Direct survey techniques can be carried out either through personal interviews, postal surveys, or telephone surveys.

- **Bidding games** are much more complicated. These involve setting out the contingent market for the respondent and describing how quantity or quality would be changed. The interviewer then sets a starting point bid and asks the respondent whether he would be willing to pay that amount for a specified improvement in environmental quantity or quality. This process is repeated until the interviewer finds the respondent's maximum willingness to pay. Conversely, this approach can be used to find the minimum willingness to be compensated.

Bidding games must be carried out through personal interviews but can take a range of forms. The interviewer can vary the process described above by using a reference device to determine when a respondent is indifferent between two outcomes. Alternatively, a trade-off analysis approach can be taken which involves determining the trade-offs the respondent is willing to make between changes in the quantity/quality of the environmental good and some other good (such as a lump sum payment).

The results of the survey are then analysed to determine an average willingness to pay per person. These figures are extrapolated to calculate the total value of the good or service to the whole population. This analysis will include the use of statistical regression analysis techniques to test the reliability of the responses and to test for potential bias in the results.

Because of the hypothetical nature of contingent valuation surveys, there are a number of potential sources of bias which need to be recognised and taken into account in both the design and evaluation of the survey.

- **Design bias**: The amount and quality of information, or the sequence in which it is provided may influence an individual's response to the questions. Similarly there are a range of different financing instruments or payment vehicles which can be used in the survey (taxes, community charge, entrance fees, special fund). Individuals may be more sensitive to one type of payment vehicle (such as taxes) than another, and it may be important to include more than one type of vehicle in the surveys to tests for this problem. The last form of design bias relates to the use of a starting point bid, which may lower or raise the individual's response. Again this can be tested for by using two different starting points and comparing the resulting bid levels.

- **Hypothetical bias**: Individuals are not likely to be familiar with placing a monetary value on environmental goods and some may find it difficult (due to the artificial nature of the question) or be unable. Further, if individuals know that no real payment is involved they may respond in an irresponsible manner. Respondents should therefore believe that their answers will affect the environmental change in question.

- **Operational bias**: Operational bias stems from a lack of consistency between the hypothetical market and the market in which actual choices are made. It is important therefore that the market be established so as to be as realistic as possible.

- **Strategic bias**: This bias arises from what is known as the "free-rider" effect. It is difficult to exclude people from enjoying an environmental good, and if an individual believes that he will benefit regardless of his actions then he may not reveal his true willingness-to-pay.

A.6.2 **Potential for Valuation of Managed Retreat**

As noted above, contingent valuation methods provide the most flexible means of deriving economic values for non-priced goods. Values can be developed which represent the total value of environmental resources such as wetland habitats, where this includes both use and non-use benefits. Its potential for application to the problem of valuing retreat options which benefit nature conservation is, therefore, greater than is the potential for any of the other techniques. Contingent valuation could be used to derive "reference" values, but could more usefully be used to predict values for specific retreat options.

Application of CVM to the valuation of habitat creation benefits will require that considerable attention is paid to the design of the survey instrument to ensure, for example, that individuals are given a clear understanding of the difference between natural evolution and evolution following restoration or creation works. Studies carried out in Canada found that the method could be applied most reliably to wetlands which had been the subject of considerable press attention or which were well known due to proximity. There was also a general lack of public knowledge about the differences between the functions and services provided by different types of habitat, and these may have had significant effects on survey results (Bardecki, 1988).

Similarly, considerable thought will have to be given to the population to which the survey sample should apply. Should only local and non-local visitors from the area surrounding the site be included in the survey as these are the individuals most likely to make use of the created area for recreational and other purposes? Or is the issue one of creating national resources using national funds, in which case the sample should be representative of the general population?

A.6.3 **Past Applications**

There have been a number of applications of contingent valuation methods in the UK. These include valuation of forest recreation, river quality improvements, coastal and beach amenity, and habitat creation.

Studies undertaken by the Middlesex Polytechnic Flood Hazard Research Centre between 1987 and 1990 used contingent valuation methods to determine the recreation benefits of coast protection. In particular, the studies focused on beach protection as this was considered to form the "front line" defence of the coast. Two surveys were carried out in 1988 and 1989 covering eleven coastal sites in England, and 1300 beach and promenade users. The aim of these surveys was to determine the economic losses likely to be associated with the loss of recreation through beach erosion at a particular site. The results of the surveys indicate values attached to beach and recreational experiences ranging from £3.60 to £10.50 per person visit. The economic losses from beach erosion and hence a degradation of recreational experiences were estimated to be about £4.37 on average per person visit.

Contingent valuation was also applied to the valuation of recreation assets in the cost-benefit analysis of the Aldeburgh Sea Defence Scheme (Turner et al, 1990). In this study, visitors to the Aldeburgh Sea Wall and Orford Quay were surveyed. Efforts were made in the development of the survey questionnaire to reduce bias problems. For example, hypothetical bias was minimised through the provision of information on local sea defences, tax and rates contributions, and environmental assets in the area. Payment vehicle bias was reduced by using taxes as the payment mode and an iterative bidding approach was adopted to reduce starting point bias. Strategic bias problems were recognised as a potential problem, but were considered to have had minimal impact on the results.

From the survey, three categories of individuals were identified: locals; non-locals who viewed the site as providing unique benefits; and non-locals who felt that equivalent alternative sites existed. For the latter category, the loss of the wall and its environs would not result in an economic loss as they could visit alternative sites without loss of enjoyment. They would, however, have to travel further on average to reach these alternative sites, and the costs associated with this travel were estimated. This cost data was combined with average per person willingness to pay estimates for the first two categories and data on the number of group visits per category to estimate the overall value for the recreational benefits of maintaining the status quo situation (i.e. preventing major change).

Similar work has also been carried out for Thames Region NRA with the aim of valuing the habitat creation benefits associated with riverine flood defence works. The findings of this riverine study should be valuable to the development of the contingent valuation method to the valuation of coastal habitats.

A.6.4 **Advantages and Disadvantages**

The main advantages of contingent valuation methods are that they are based on deriving maximum willingness-to-pay (or willingness to be compensated) and are flexible. The other key advantage is that, unlike the other techniques, contingent valuation can be used to derive option, bequest and existence values.

The key disadvantage lies in the hypothetical nature of the survey instrument and the potential biases which might consequently be introduced into the analysis. These problems are, however, related to survey techniques in general and considerable effort is being put into finding methods of reducing them. If these problems are controlled for, the results of CVM studies should provide valid and reliable benefit estimates. Tests can be carried out using statistical techniques to check reliability and the results can be compared to those derived through other techniques (although this will only provide a weak indication of reliability due to differences in the concepts underlying the techniques).

A second disadvantage arises from the level of resources that may be required in these studies. These requirements will depend on the number of people to be surveyed and the survey method, whether through postal surveys, personal interviews, bidding games, etc. In general postal surveys will be less costly, but savings must be traded against not having an interviewer present to help respondents answer what may be difficult and complex questions.

There is also considerable debate caused by the asymmetry observed between willingness to pay and willingness to accept estimates. Economic theory indicates that an individual should be indifferent between these two measures, but past studies have indicated that responses differ, sometimes significantly.

Finally, the question of whether or not individuals think in terms of a total "environmental budget" has also been gaining importance with regard to contingent valuation methods. The environmental budget is that proportion of disposable income which an individual is willing to spend on environmental protection/conservation. Some researchers claim that when answering questions on willingness-to-pay, individuals' responses reflect not only the value they attach to the good in question, but to their environmental budget as a whole. This results in the over valuation of willingness to pay, and thus of benefits gained. The degree to which this is a problem is not known. Careful framing of surveys, including questions on membership of environmental groups, for example, may help control for this problem.

A.7 Energy Analysis Approach

A.7.1 The Approach

The energy analysis approach is based on the principle that there is a fixed relationship between the energy embodied in a product and its market price. The method looks at the total amount of energy captured by a system and uses this as an estimate of its potential to do useful work for the economy. Once the level of energy embodied in a system is determined, the energy measurement is translated into money terms using a conversion factor that relates money (in the form of prices) to energy.

For a wetland or coastal habitat system, the Gross Primary Productivity (GPP) of the ecosystem is used to provide an index of the energy captured by that system. GPP provides a measure of the solar energy that is used by plants in the system to fix carbon into organic molecules. This primary production forms the life support for all of the plants and animals in that system which, in turn, also regulate water flow, sedimentation, etc. GPP therefore provides a measure of the energy inputs to the ecosystem. The energy value related to GPP is then converted into money terms, which provides an estimate of the total value of the wetland or coastal habitat system.

At a simplified level, the steps involved in the approach can be described as follows (Costanza, 1988):

i. Either through field measurements or laboratory experiments, the GPP of the natural system is determined. In the case of habitat creation, this would involve determining GPP for both the existing system and the restored or created system. These estimates are generally produced in terms of carbon fixed or heat equivalent energy content of the carbon.

ii. The GPP measurements are then converted to fossil fuel equivalents on the basis of the fuel efficiency of the ecosystem as compared to other fossil fuel sources.

iii. The fossil fuel equivalent estimates are then converted into monetary values using an economy-wide ratio of economic value per unit of energy (i.e. the ratio of Gross National Product to total economy energy use, as measured in fossil fuel equivalents).

GPP is generally measured by an analysis of gas exchange which detects carbon dioxide concentrations in different plants (or oxygen for aquatic plants). The estimates are stated in grams of carbon or calories of plant biomass per unit area per unit time.

This measure is then converted into fossil fuel equivalents either by determining the amount of energy needed to upgrade biomass to fossil fuel (e.g. through biogas), or by considering the relevant number of calories of biomass that would have to be burned to produce the same amount of electricity as a given quantity of fossil fuel (e.g. oil or coal). Either method provides an indication of the "energy quality factor" of biomass relative to fossil fuel. An approximate average value is .05 Cal biomass/1.0 Cal fossil fuel, indicating that it is 20 times less energy productive than fossil fuel.

A.7.2 Past Applications

The energy analysis approach has been applied to a number of different wetland sites in the United States. One example is given by work carried out for Louisiana wetlands and aquatic habitats (Costanza, 1988). Table A.7.1 provides estimates of GPP and of the loss in value for conversions of wetlands from marsh to open water systems. In preparing these calculations the following assumptions were made: a conversion factor of 0.05 coal equivalent kcal/GPP kcal was used; and the economic value per unit of energy was assumed to be 15,000 coal equivalent kcal per US$ (1983). As there are 4,047 m2/acre, the estimated economic value per acre per year is:

$$(0.05 \times 4047)/15000 = 0.013.$$

As can be seen from Table A.7.1, the estimated economic value of losses incurred from the transformation of marsh to open water resources are $6,700 for salt marshes, $10,602 for brackish marshes, and $6,400 for fresh marshes. If the process were reversed, in other words the conversion was from an open water resource to marsh, these values would represent the benefits gained from the restoration or creation of the marsh areas.

Table A.7.1 GPP and Economic Value Estimates for Louisiana wetlands and marine habitats

Habitat Type	Gross Primary Production (kcal/m2/yr)	Annual Equivalent Value ($) ($/acre/yr)	Net Marsh to Aquatic Change in Annual Value ($/acre/yr)	Present Value at 8% Discount Rate ($/acre)
Salt Marsh	48,000	624		
Salt Aquatic	6,600	86	538	6,700
Brackish Marsh	70,300	914		
Brackish Aquatic	5,100	67	847	10,602
Fresh Marsh	48,500	630		
Fresh Aquatic	9,300	121	509	6,400

Updating the above figures to 1990 terms gives values of $8,800, $13,900 and $8,100 per acre for the three marsh types respectively. These results compare to those found in other studies carried out for Florida and the Gulf of Mexico (unsourced reference, updating work by Gosselink and Costanza). A general wetland value for Florida was found to be $209,100 (1990 values). The valuations for the Gulf of Mexico involved further work on salt marshes, brackish marshes and fresh marshes; the values estimated in this study were $10,000, $14,600 and $10,000 (in 1990 values) respectively for the different marshes.

A.7.3 Advantages and Disadvantages

With regard to the valuation of restoration or creation activities, the energy analysis approach could be applied to most proposals and would provide a means of valuing the enhanced or new habitat. Proponents of the method claim that it has advantages over other valuation techniques in that it provides a comprehensive valuation. Detailed listing of the specific functions and services being provided by a given area and the subsequent valuation of each of these is not required. It is not clear, however, whether this comprehensiveness applies only to use related benefits, or whether it is considered also to include non-use benefits.

The comprehensiveness of the approach may also result in an over-estimation of values, as not all of the functions and services provided (as measured by energy) may be either useful or valuable to society. Given this, the approach should be considered to provide an upper bound estimate of value.

A further problem with the approach is that, unless detailed analysis is carried out for each site, application of general GPP estimates will not account for inter-dependencies between habitat types, nor for differences in productivity within the same habitat type. All salt marsh, for example, is assumed to have the same GPP, regardless of site-specific conditions or the nature of adjoining land uses.

The strongest argument against the use of the embodied energy approach, however, concerns the derivation of the prices used to convert the measure of energy into a monetary value. The approach is based on the assumption that prices for all goods are tied to the amount of energy required to produce that good. Although there is undoubtedly some relationship between market prices and embodied energy, prices also reflect a number of other considerations. Thus, inputing a good's value on the basis of energy alone (or calorific value) will provide an incorrect valuation.