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Ecological and economic valuation of managed realignment sites, Humber estuary, UK: benefits for society.

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by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT

The valuation of ecosystem services through economic methods has exponentially increased in last twenty years. However these studies seldom incorporate the specific influence of the study sites' ecological development on the local populations' economic valuation. The primary aim of this thesis is to ecologically and economically value the societal benefits provided by four managed realignment sites on the Humber estuary, UK. Choice experiment and contingent valuation interview surveys were conducted with local residents, eliciting their willingness to pay (WTP) values for both maintenance of their closest site, and access to it. Results from the economic valuation for each site were then related to their ecological status, to see whether these two aspects were interconnected. Generalised Linear Modelling and Decision Tree Analysis, as well as exploratory techniques such as Pearsons Chi-square, coplot analysis and principal component analysis, were employed to determine which explanatory variables, such as socio-demographic details or details regarding the participants' interaction with the site, were significant influences on their WTP values. The main influencing explanatory variables proved to influence both WTP maintenance values and WTP access values in a similar manner. These included the distance that the participant lived from the site, the frequency which they visited, whether they had knowledge of the site prior to completing the survey, and their annual household income. Average WTP for maintenance values for the four sites were: £7.32, £3.13, £9.29 and £6.96. Average WTP for access values were: £4.64, £0.28, £6.20 and £4.43, suggesting that participants are willing to pay more for the non-use values that maintenance of the site provides, rather than use-values provided by access to the site. In addition, the sites with higher WTP values are also the sites which have a more developed ecological status, such as a wider area of vegetation coverage and higher diversity and abundance of fauna. Furthermore, the sites which offered supplementary facilities such as easier admittance for visitors through designated footpaths and disabled access, specialised apparatus for interaction with the fauna (such as bird hides), information boards or car parking areas; received a higher valuation from the local population than the sites which were difficult to access or had no facilities. These additional facilities are provided to enhance the participants' ability to appreciate the ecology of the site, therefore results show that the sites with a more developed and diverse ecological system will have a higher economic value than those which have a less developed ecology. The findings have implications for policy makers in terms of future managed realignment site creation. The results suggest that public involvement at conception through to implementation ultimately results in a higher ecological and economic value of the site. This also encourages a higher visit frequency through creating a site which is not only effective in its management purpose but also has a complex ecological status and is 'visitor friendly'.

CHAPTER 1

1. GENERAL INTRODUCTION.

1.1 Introduction.

Marine and coastal ecosystems are important to society in a number of ways, mainly through the multiple direct and indirect uses for services to society. It is well accepted that the coastal zone is subject to many and varied changes resulting from human activities as well as natural processes (Aubry & Elliott, 2006). As the human population is increasing and diversifying their use of the marine and coastal environment, marine life, habitats and landscapes are affected. Therefore the development of environmental policies that consider all members of the user community and that incorporate many aspects and disciplines is increasingly necessary (Atkins *et al*., 2011; Elliott in press).

There has been an increase in interest over the past 40 years in the analysis and valuation of the multiple benefits provided by ecosystems, often prompted by the realisation that these benefits were being underestimated in decisions to do with management and policy of the ecosystem (Hein *et al*., 2006). An understanding of the socio- economic and environmental value of these benefits is therefore essential for local, national and global policy, and integration into the decision making process is required to ensure it is sustainable, efficient and equitable (Daily *et al*., 2000; Turner *et al*., 2010).

This study builds on the rapidly growing field of environmental valuation, in this case specifically for areas of recreated habitat on the Humber estuary, UK. The research questions and study objectives are presented in this chapter, and the key terms and fundamental ideas for the overall rationale of the thesis are identified. Background information and a literature review are given on the central concepts, including the ecosystem approach to management and subsequent development of ecosystem services and benefits, which form the basis of the stated preference valuation techniques used in this research. The institutional setting behind the creation of the habitat sites studied is addressed, before an outline is given of the technique used when creating the sites, managed realignment, which involves breaching or removing an existing sea defence in order to allow an area to permanently flood

(French, 2006). The Humber Estuary main ecological, economic and historic characteristics are outlined, before finally the structure of the rest of the thesis is given.

1.2 Thesis aims and objectives.

The key aim of this thesis is to ascertain the ecological and socio- economic value of four areas of recreated habitat on the Humber estuary, UK. In order to do this, the following objectives will be addressed:

- Research the background information and present the findings in a literature review to put into context and provide a clear understanding of the key concepts involved in this study;
- Develop a methodology suitable for estimating the socio- economic value of the habitat sites; present the possible available methods, the chosen method for this study, and a full evaluation of this method in the methodology chapter;
- Collect the necessary data and conduct appropriate statistical analysis;
- In each of the results chapters, interpret and briefly discuss the results for all four sites;
- Discuss the interpretation of the results, including the reasons for the similarities and differences between the four sites;
- Discuss how the findings compare to other studies, and what this means in wider terms for ecological and socio-economic valuation of recreated habitat sites;
- Present a working management framework for habitat ecological and socio-economic valuation;
- Give possible examples for further work in this area and give a critique of all aspects of this study.

1.3 Background information and literature review.

1.3.1 COASTAL MANAGEMENT.

In England and Wales, there is environmental legislation in place to guide management strategies and safeguard scientific areas of interest. These include the Habitats Directive 92/43/EEC (1992) which prevents the loss of ecologically important habitat without any compensatory measures unless there is no alternative, with the aim of preserving and restoring estuarine and coastal habitats where necessary; and the Water Framework Directive 2000/60/EC (2000) which aims to protect the status of aquatic ecosystems, and their related water needs, terrestrial ecosystems and wetlands. There are several management techniques can be employed by environmental managers in order to manage the various pieces of legislation in these dynamic ecosystems. However, it is now generally acknowledged that management strategies need to be holistic in their approach, accounting for the wider system rather than concentrating on individual aspects (Elliott, 2010).

Despite protective legislation, many estuarine and coastal marine ecosystems have increasingly experienced degradation caused by multiple stressors. When natural ecosystems are altered due to anthropogenic pressures, the ecosystems are not considered to have recovered unless the ecosystem has returned to the pre-existing condition or state, such as secondary succession, which occurs after the initial colonisation of vegetation in an area has been disrupted (Borja *et al*., 2010). This, however, depends on time scale, severity and spatial coverage of the anthropogenic disturbance. Restoration of the ecosystem to its pre-exisiting condition could follow natural restoration, be re-directed through ecological restoration, or may be unattainable (Borja *et al*., 2010). In cases where natural restoration is not applicable, the lost habitat must be compensated for, through habitat recreation elsewhere (Elliott *et al*., 2007).

The practice of ecological restoration is being used increasingly worldwide to compensate for the loss of biodiversity values for any number of the reasons previously stated (Maron *et al*., 2012). This procedure of “biodiversity offsetting” essentially aims to generate ecologically equivalent gains elsewhere, and therefore assumes that restoration will recover lost biodiversity (Maron *et al*., 2012). Due to this assumption, the number of potential cases of biodiversity offset- led restoration

may increase, as the promise of effective restoration may increase the chance that damage to biodiversity is permitted. However, Maron et al., (2012) examined the effectiveness of restoration as an approach for compensation for loss of habitat, and found that there was insufficient information on recreated sites to be able to conclude whether biodiversity was truly restored. This highlights that for effective management plans to be implemented for areas such as these, as much information on the ecological, economic and social development of the site as possible is required.

1.3.2 MANAGED REALIGNMENT.

Over the past 20 years, the rate of global warming and so likelihood of sea level rise has increased. Together with this, the frequency of storms and tidal surges is also expected to increase (Edwards & Winn, 2006). Although exact levels of rise cannot be calculated, especially where other confounding factors such as isostatic rebound are included. Edwards & Winn (2006) suggest an estimated annual increase of 6mm for the Humber estuary on the North East coast of England alone, and the Environment Agency (EA) currently predict in the Humber Flood Risk Management Strategy an increase in sea level rise of up to 0.35m by 2060, and up to 1m by 2110 (EA, 2012). If this approximation is found to be true, the risk of flooding in coastal areas will significantly increase, and the role of coastal defences will become increasingly important.

In areas where large-scale land claim has occurred for urban purposes, coastal defence is particularly important as a way of protecting the residents and reducing the need for necessary financial payout from relocation costs and rebuilding fees. Within the past twenty years, there has been a significant change in the way coastal defence is being undertaken. Artificial defences are now being replaced by more cost effective and sustainable methods, such as managed realignment (Garbutt et al., 2006; Doody, 2012).

Managed realignment aims to develop and establish various habitats such as mudflat and saltmarsh, in a bid to stabilise sediments and reduce the rate of coastal erosion (French, 2006). The existing artificial sea wall is removed and rebuilt further in-land. The area of land that was previously protected by the old sea wall is allowed to permanently flood, and over time develops into areas of saltmarsh, mudflat, reed

bed and grassland, creating a new area of intertidal habitat for wetland species (Figure 1.2). It is a widely accepted concept that coastal wetlands, and saltmarshes in particular, absorb a lot of wave energy preventing water travelling too far inland, and alleviating the effect of eroding wave action on hard coastal defence structures (Doody, 2012; Moller et al., 2001; Morris, 2012; Pethick, 1992).

It has been shown that wave attenuation over salt marsh is 50% higher than over sand flat (Moller et al., 1999) and as salt marsh width decreases, the height of the sea wall must increase almost linearly to offer the same protection, which would increase the cost of the coastal defence scheme significantly (King & Lester, 1995; Dixon et al., 1998). As well as the economic benefits provided by replacing hard structures with coastal wetlands, their biodiversity value and functional value is lawfully recognised under the EU Habitats Directive (C.E.G., 1992). The habitat directive (together with the Birds Directive) forms the cornerstone of Europe's nature conservation policy (Council Directive 92/43/EEC, 1992). It is built around two key concepts: the Natura 2000 network of protected sites, and the strict system of species protection. These aim to maintain a 'no-net-loss' in total habitat area, and commit the UK Government via the UK's Biodiversity Action Plan (BAP), to develop strategies to conserve and if possible, enhance biodiversity (UK Biodiversity Group, 1999).

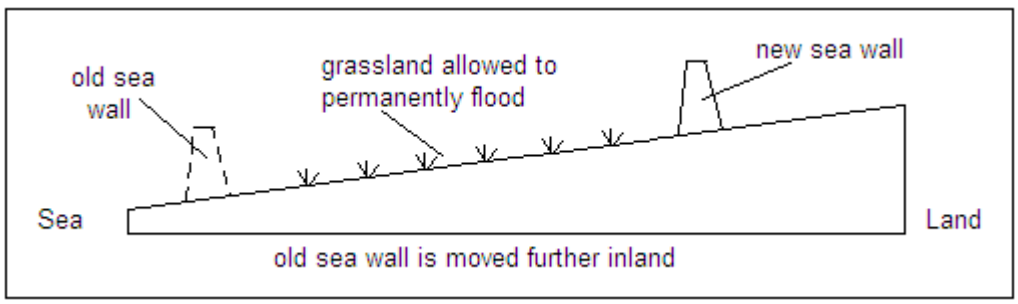

Figure 1.1 Process of managed realignment.

By using the natural defences to absorb the energy of the waves, areas further inland are essentially protected from flood damage (Doody, 2012; Morris, 2012). Managed realignment is considered a 'soft' engineering coastal defence strategy as it involves working with nature rather than concreting the coastline, and generally entails breaching the first line of defence, whether it is a sea wall or rock armour and replacing the defences further inland (Myatt *et al.*, 2003a). In addition, where protective artificial defence mechanisms exist, the inward migration of salt marsh in

response to sea level rise when sediment supply is limited is inhibited due to coastal squeeze (Hulme, 2005). In instances such as this, managed realignment can be used to mitigate the loss of intertidal habitat through removal of the artificial barriers and preventing coastal squeeze and, in the UK, this method of coastal defence has been the primary objective of intertidal habitat restoration (DEFRA, 2002; Pethick, 2002). As well as creating habitat and abating coastal squeeze, this practice is more cost-effective than simply trying to maintain permanent hard structures. Furthermore, areas of managed realignment are believed to significantly reduce the flow of water towards housing developments, as salt marsh naturally absorbs much of the wave power (Myatt *et al*., 2003).

Despite this, managed realignment is not without its problems. A suitable area needs to be identified, and the land then needs to be available to realign. There are also uncertainties about the implications for the wider estuary when disturbing land so close to the shore (Garbutt, 2009). Furthermore, since managed realignment has only been common practice approximately within the last decade, the lack of information readily available in Europe (there is considerably more literature available in the USA where the science of intertidal habitat creation is well advanced (Zedler, 2001)) to the public regarding the benefits of such a practice means that the media may be more likely to focus on constraints of the process, such as loss of land and the need for compensation, and disturbance or disruption caused by the process. The lack of access to information and general misconceptions arising from such media interest can present difficulties for policy makers, scientists and engineers to overcome (Myatt *et al*., 2003a).

1.3.3 THE HUMBER ESTUARY.

The Humber is one of the North Sea's primary estuaries, as well as being one of the largest in the UK, covering an area of around 24,472km² (Edwards & Winn, 2006). It has a tidal length of 147 km (Trent system) and a width of 15 km at its maximum point (Pethick, 1988). The estuary receives drainage primarily from the Rivers Trent and Ouse, catchments that drain close to a fifth of England (Neale, 1988). In parts of the outer estuary, the natural succession from marine to terrestrial environments progresses from mudflats to saltmarsh, and usually ending in mature saltmarsh found typically in front of clay embanked sea walls. This succession has been truncated however, by the construction of these seawalls and due to land

reclamation (Andrews *et al*., 2008). The Humber is a dynamic estuary with a tidal range of up to 7m, and is naturally a very turbid environment with suspended particulate matter of over 20 g l^{-1} recorded at the turbidity maximum in the tidal Ouse (Edwards & Winn, 2006).

1.3.3.1 Ecological Importance.

The Humber Estuary is of high ecological importance. It is a designated European Marine Site and proposed Special Area of Conservation (SAC) and Ramsar site. In addition, specified areas such as the mudflats at Saltend are classified as a Site of Special Scientific Interest (SSSI) and are designated Special Protection Areas (SPA) under the Habitats and Wild Birds Directives (79/409/EEC). Therefore, whilst flood defence can be seen as a priority in the area, it must be carried out in compliance with the requirements of the European Habitats Directive and the UK Habitats regulations set in 1994 (Edwards & Winn, 2006).

1.3.3.2 Economic Importance.

The estuary is of high economic and social value. It has the UK's largest complex of ports (by tonnage), the largest cluster of chemical and oil refining industries in England, and 11 electricity generating stations in the Ouse and Trent. The two main areas for this activity are between the city of Hull and SaltEnd on the north bank, and between Grimsby and North Killingholme on the south bank. Also close by in the town of Brough, British Aerospace has a major facility. Other areas of importance in terms of the industry located there include Goole and Flixborough, which are found beside the Ouse and the Trent respectively. The port facilities on the estuary are of major importance as they provide employment and wealth for the area. This in turn provides an attraction for other industries to locate in the area (Winn *et al*., 2003). These industries provide employment opportunities to the majority of the estuary's catchment, which is the largest in the British Isles with approximately 12 million inhabitants, with over 300,000 of these located on the banks. Although this appears a large concentration of industry, it only occupies 3% of the area protected by flood defences. The largest use for this area is farmed land, which uses around 85% of all the protected area, and around 8% being occupied by urban areas. The remaining land is used for a variety of other activities such as recreation and nature conservation (Winn *et al*., 2003).

1.3.3.3 Historic Importance.

It is also important to consider the historic environment of the Humber given that it and its floodplain contain many historic buildings, settlements, landscapes and archaeological sites that are important to the region's identity. They are also an important focus for the cultural services in the area, such as education, tourism and recreation (Ellis & Van de Noort, 2000). Some of these sites include prehistoric artefacts and Bronze Age boats found on the foreshore, as well as Iron Age, Roman, Anglo-Saxon and Viking settlements. As the estuary has long been an important trade route, there are features associated with navigation and ports, as well as military installations of interest from World War I and II e.g. defences at Spurn Point and Bull Island forts (Ellis & Van de Noort, 2000). The archaeological resource is particularly valuable due to its large scale wetland component, where the decay of organic materials is limited and remains are preserved in the waterlogged conditions (Ellis & Van de Noort, 2000). Some of the more important historical features are protected by statutory designations, which means before any defence works are planned, the management plan for the area must establish ways to protect these historical features, as well as fully surveying sites where works are proposed, in case any new discoveries are recorded (Winn *et al*., 2003).

1.3.4 INSTITUTIONAL SETTING.

1.3.4.1 Associated British Ports.

The Humber is the busiest trading estuary in the UK, and compared to north European ports, is surpassed only by Rotterdam, Antwerp and Hamburg. To ensure trading to and from the port can meet demand; the port and its hinterland have become an area rich in maritime expertise and well connected via road and railway (Marsh, 2012) (See Appendix I).

Associated British Ports (ABP) has the UK's largest port complex and is responsible for 14% of the UK's international trade. To accommodate the wealth of international trade the ports on the Humber manage, those at the Immingham and Hull locations were expanded in 2005. This expansion led to a conflict between the economic and ecological assets, both equally important on an international scale (Dodd, 2007). Conflict arose here as the expansion of the port lead to a loss of intertidal habitat

from areas of SSSI, and following an Environmental Impact Assessment (EIA), compensation measures were required to mitigate this loss. This resulted in the creation of new areas of habitat on the estuary, at Welwick on the north bank, and Chowder Ness on the south bank (Dodd, 2007) (Appendix I). This was an important process for the continued protection of the catchment area from flood damage, and to ensure the continued presence of intertidal and subtidal habitat, as it is estimated that over 700ha of intertidal habitat will be lost due to rising sea levels leading to coastal squeeze over the next 50 years on the Humber Estuary (Mander *et al*., 2007).

1.3.4.2 Environment Agency.

The Environment Agency (EA) is an executive non-departmental public body associated with the Department for Environment, Food and Rural Affairs. Principal aims are to protect the environment, improve environmental areas for the public where possible, and promote sustainable development. The organisation plays an important role in implementing any government approved environmental policies (EA, 2012).

The EA is predominantly responsible for flood risk management on the Humber, as outlined in the Humber Estuary Shoreline Management Plan (HESMP) (Winn *et al*., 2003). In line with EA principal aims, the HESMP considers the urban and industrial development on the flood plain, as well as the need to protect local residents from the potential flood threat from coastal erosion and sea level rise. Maintaining the flood defence system put in place by the EA, which protects 90,000 ha of land and 300,000 people on the Humber flood plain (EA, 2005), occasionally resulted in damage to areas of legislatively protected habitat, which requires compensation. In this instance, a compensation scheme was created on the north bank at Paull Holme Strays (PHS), to address the damage caused by previous schemes, to mitigate further predicted losses from sea level rise, and provide flood protection to the surrounding area (Environment Agency, 2002).

1.3.4.3 Natural England.

Natural England (formerly English Nature) is also an executive non-departmental public body responsible to the Department for Environment, Food and Rural Affairs,

and is described as the Statutory Nature Conservation Body for England. Natural England's overall aim is to protect and improve the natural environment, as well as raising public awareness and encouraging public use of their local natural environments.

ABP and the EA, together with Natural England, cooperate to reduce flood risk as well as compensation of already damaged habitats, and the mitigation of possible future habitat damage through a created habitat site at Alkborough on the south bank of the Humber. This presents the first of several compensation schemes, which are part of a 100-year strategy to implement the HESMP (Environment Agency, 2005). This collaboration between Humber-based organisations suggests willingness to accept responsibility when habitat compensation is required, and for reducing the effects of sea level rise and possible further industrial expansion.

1.3.5 THE ECOSYSTEM APPROACH.

There is a requirement for a multifaceted approach to the implementation of schemes with the need to consider former land use, soils, estuarine processes and changing environmental conditions such as sea level rise, ecology, socio-economics, and which consider all aspects (Atkins *et al*., 2011; Garbutt, 2009). The continuously changing nature of complex ecosystems requires an adaptive management strategy that can operate with diversity and conflict amongst stakeholders, who may differ in perspectives and opinions, whilst understanding both the ecosystem dynamics and the associated social-ecological interactions (Olssen *et al*., 2004; Widlock *et al*., 2012).

As the factors influencing changes in the environment intensify and increase in pace over local, regional and global scales, so does the risk that ecosystems will not have the resilience and integrity to respond to such changes. Therefore, policy has moved towards the adoption of an ecosystem approach towards management, which regards the ecosystem holistically and so is better placed to manage systems under threat of detrimental change (Balmford *et al*., 2002; Beard *et al*., 2011; Costanza *et al*., 1997; Daily *et al.,* 1997;).

Using the ecosystem approach to management ensures any decisions made involving the environment are efficient, equitable and sustainable, and both the short term and the long term social, economic and environmental impacts of a

development are identified and accounted (Daily *et al*., 2000). The main tenet of this strategy was defined by Grumbine (1994, pp. 31) as one which *'integrates scientific knowledge of ecological relationships within a complex socio-political and values framework towards the general goal of protecting native ecosystem integrity over the long term*'. The Fifth Conference of the Parties to the Convention on Biological Diversity (CBD) further defined the Ecosystem Approach in Decision V/6 (Annex A, section 1 pp. 103-104) as '*a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way'* (CBD, 2000). This philosophy understands and manages the human uses and effects on systems. As such, the term now appears in many management and policy documents such as from the Food and Agricultural Organisation (FAO), the Oslo and Paris Convention (OSPAR), the European Commission (EC) Directives and nature conservation reports (e.g. FAO 2003; ICES, 2005; Laffoley et al., 2004; Pope & Symes, 2000 a & b;).

Terminology has evolved since these Conventions and Directives, according to country, institution or discipline. For example marine management teams in America refer to 'ecosystem based management' (EBM) (Granek *et al*., 2010), or the 'Adaptive Ecosystem Management' (Heinimann, 2010). Central to all is the identification of the importance of human or social-economic interaction with ecosystems, recognizing that social, cultural and economic impact upon ecosystems, drive change, and feed back to affect human well-being (Holt *et al*., 2012). The ecosystem approach encourages the consideration and management of human activities and can be regarded as a philosophy for summarising the means by which the natural functioning of an ecosystem can be protected and maintained while still allowing and delivering sustainable use and development by society (Holt *et al*., 2012).

The demand for marine natural resources is increasing with human population size, challenging conventional approaches to marine resource management that may not have been previously anticipated. Therefore the ecosystem approach is valuable, because when marine resource managers understand the complex ecological and socio-economic environments in which marine ecosystems must be managed, they may be able to anticipate the effects that management will have on the ecosystem. The ultimate aim of habitat restoration, for example through managed realignment, is to establish an area with a self-supporting and self-maintaining ecosystem, which

eventually does not require further management (Ruiz-Jaen & Aide, 2005). For this to be realised, both socio-economic and ecological aspects of the area have to be considered (Elliott *et al*., 2007). It is important to determine the value of habitat restoration across various scales, to allow the results of localised actions to be extrapolated to larger areas (Elliott *et al*., 2007). With this value, a cost-benefit assessment can be made of the restoration process, ensuring that the cost of restoring the proposed area is at least an order of magnitude greater than the cost of preventing damage to it initially (Holl & Cairns, 2002).

In essence, the Ecosystem Approach takes a holistic view when considering the effects of actions on every element of an ecosystem, based on recognition that all the elements of an ecosystem are intrinsically linked. It is based on the application of appropriate scientific methodologies, which focus on the levels of biological organisation (cell→ individual→ population→ community→ ecosystem) (McLusky & Elliott, 2004). This should encompass the essential structure, processes, functions and interactions among organisms and their environment, whilst recognising that humans and anthropogenic impacts are an integral component of many ecosystems. As ecosystem processes are often non-linear, the outcome of such processes may present temporal differences, resulting in discontinuities in those processes. This requires the ecosystem approach to apply adaptive management in order to address the dynamic nature of ecosystems even with the absence of complete knowledge or understanding of their functioning (CBD, 2008).

As such, the Ecosystem Approach also requires an understanding of the way in which society manages the adverse effects of its activities, including mitigation and/or compensation. In order to achieve this sustainable management, the CBD indicates that the implementation of the Ecosystem Approach should be based upon 12 guiding principles (CBD, 2000). Table 1.1 shows that the principles referring to the ecosystem approach are complementary and interlinked, and should be considered together when applying the ecosystem approach to a possible problem.

Table 1.1 Principles and rationale of the Ecosystem Approach. Adapted from CBD (2008) (Website 1).

Principle	**Rationale**
The objectives of management of land, water and living resources are a matter of societal choice.	Different sectors of society have different interests in regards to their stakeholders, and so will view ecosystems in terms of their own economic, cultural and societal needs. Therefore ecosystems should be managed for their intrinsic values and for the tangible or intangible benefits for humans in a fair and equitable way.
Management should be decentralized to the lowest appropriate level.	All stakeholders should be involved and local interests should be balanced with the wider public interest. The closer the management to the ecosystem, the greater the responsibility, ownership, accountability, participation and use of local knowledge.
The effects of the management's activities on adjacent ecosystems should be considered.	Management interventions may have an unpredictable effect on other ecosystems. Hence potential impacts of trans-boundary effects require careful consideration and analysis.
The priority target of the ecosystem approach should be conservation of ecosystem structure and functioning, in order to maintain ecosystem services.	The functioning and resilience of an ecosystem depends on a dynamic relationship between biological, chemical and physical reactions within the environment. The conservation and restoration of these processes is of greater significance for long term maintenance of the ecosystem, compared with the management of a single species.
Ecosystems must be managed within the limits of their functioning.	Attention should be paid to the environmental conditions that limit natural productivity, ecosystem structure, functioning and diversity. These limitations may be affected by temporary or unpredictable conditions and so management should be appropriately cautious.
The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.	The approach is based upon the hierarchical nature of biological diversity, and boundaries for management should be operationally defined by users, managers, scientists and local peoples.
Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives should be set for long term management.	As ecosystem processes are characterised by varying temporal scales, the tendency to favour short term management plans for ease will not benefit the ecosystem in the long term.
Management should recognise that change is inevitable.	Apart from their inherent dynamics of change, ecosystems are beset by a complex of uncertain situations. These situations may be important for the ecosystem structure and functioning, and so adaptive management should be used in order to anticipate and accommodate such changes.
An appropriate balance between conservation and use of biological	Instead of managing single components of biological diversity either as protected or non-protected, a more flexible situation

diversity should be prioritised.	where conservation and use are seen in context and a full range of measures is applied in a continuum from natural to human made ecosystems should be applied.
The approach should consider all forms of relevant information, such as scientific, indigenous and local knowledge.	For an effective management strategy to be formed, all relevant information regarding ecosystem functions and the impact of human use should considered and shared with all stakeholders. Assumptions behind management decisions should be checked against available knowledge and stakeholder views.
The approach should involve all relevant sectors of society and scientific disciplines.	Complex interactions within the management plan, as well as any side effects and implications, should involve necessary expertise and any stakeholders at local, regional, national and international levels.
Understand and manage the ecosystem in an economic context. This may involve reducing market distortions that adversely affect biological diversity, and aligning incentives to promote biodiversity and sustainable use	If natural systems are under valued, this may lead to the ecosystem being replaced with alternative land use that is deemed more valuable. This often occurs due to market distortions, which can provide perverse incentives and subsidies to favour the conservation of land to less diverse systems. An alignment of incentives allows those who control the resource to benefit and ensures that those who generate environmental costs will have to compensate those costs.

The need for this holistic approach is increasingly apparent in environmental policy. In addition to being adopted as an underpinning concept of the Convention of Biological Diversity, this now plays an integral part in relation to marine and estuarine governance, being endorsed in 2002 by the World Summit on Sustainable Development held in Johannesburg. It is also a primary concept in the European Habitats Directive and the OSPAR commission, which aims to stop the loss of biodiversity by 2010, and was held in Gothenburg by the European Union Heads of Government and the Ramsar convention (Laffoley *et al*., 2004).

A key objective of the ecosystem approach is the ability to maintain productive, resilient and healthy resources, the maintenance of natural processes and evolutionary potential, species, and habitat types, while incorporating the needs of humans and a realistic scientific and socio-political view of management. Some of the substantial changes between traditional resource management and ecosystem approaches to management are shown in Table 1.2. The differences between the ecosystem approach and a more traditional management mainly centre on the ecosystem approach's ability to function on larger geographical scales, and therefore encompassing whole ecological systems. The ecosystem approach is also

more adaptive to complex systems, integrating all influencing aspects of the systems, in particular social and cultural influences and human well-being that is influenced by the ecosystem.

The prerequisites in meeting this goal require a clear definition of both the components of the ecosystem to be managed and the desired end conditions for those components. The Interagency Ecosystem Management Task Force (IEMTF) in the US federal government established an ecosystem management initiative for public lands and waters to foster ecological and economic sustainability. Specifically, the IEMTF called for agencies of the federal government to adopt a proactive approach to ensure a sustainable economy and environment through principles of ecosystem management. At that time, the ecosystem approach was not fully implemented within many federal environmental management strategies even though the concept had been well used in scientific, state, and local resource management communities (Grumbine, 1994).

Table 1.2. Differences in ecosystem approaches to management. (Adapted from Lubchenco, 1994)

Traditional Management.	Ecosystem Approach to Management.
Localised geographic scale.	Multiple scales.
Individual species.	Multiple species and entire ecosystems.
Short to medium-term perspectives.	Long- term perspective and intergenerational sustainability.
Human impacts considered by individual sectors.	Humans an integral part of ecosystems.
Management not integrated.	Adaptive approach to the management of complex systems.
Managed commodities.	Sustaining production potential for goods and services.

From the IEMTF, the National Oceanic and Atmospheric Administration (NOAA) was one of 13 federal agencies that committed to the ecosystem approach in 1933. The NOAA, in the US department of commerce, conducts research and gathers data about the global oceans, atmosphere, space and sun. NOAA services are provided by five major organisations and numerous special programme units: the National Weather Service (NWS), the National Ocean Service (NOS), the National Marine Fisheries Service (NMFS), the National Environmental Satellite, Data and Information Service (NESDIS), and the Office of Atmospheric Research (OAR). Each of these divisions contributes towards the NOAAs execution of ecosystem

approach management techniques by conducting varying components of ecosystem research. The NOAA implementation of the ecosystem approach in 1933 represented a shift in the tools and techniques used to manage marine resources in the US, which consequently filtered throughout Europe (Grumbine, 1994).

The NOAA describes the ecosystem approach as differing from more narrowly focused management by a number of defining characteristics. The ecosystem approach is:

- geographically specified;
- adaptive in its development over time as new information becomes available or as circumstances change;
- takes into account ecosystem knowledge and uncertainties;
- considers the fact that multiple simultaneous factors may influence the outcomes of management (particularly those external to the ecosystem);
- strives to balance diverse societal objectives that result from resource decision making and allocation. Additionally, because of its complexity and emphasis on stakeholder involvement, the process of implementing the ecosystem approach needs to be:-
- incremental; and
- collaborative.

(Taken from NOAA strategic plan 2006-2011 (2005) & Murawski (2007)).

1.3.6 ECOSYSTEM SERVICES AND SOCIETAL BENEFITS.

Ecosystems can be defined as communities of living organisms together with the physical processes, abiotic and biotic components, all potentially interacting within an environment to form a functioning unit, distinguishable but not isolated from other ecosystems (Pullin 2002). As the definition does not offer any spatial scale or unit, ‘ecosystem’ can refer to any functioning unit at any scale, hence scale should be determined by the problem that needs to be addressed.

The valuation of ecosystems has received much attention, e.g. Beaumont *et al*. (2007 & 2008); Costanza *et al*. (1997); Daily *et al*. (2000); De Groot *et al*. (2002); Pearce & Turner (1990). It is important to integrate social, economic and environmental demands and pressures into the valuation technique, as all these

aspects are part of an ecosystem's dynamic nature. An effective method of doing this is to use the concept of ecosystem services (Hein *et al*., 2006).

The large amount of literature on the subject means that several definitions concerning the concept of ecosystem services are available, as well as different ways of identifying and classifying them. Some commonly cited definitions of ecosystem services include Costanza *et al*. (1997) who defined them as '*The benefits human populations derive, directly or indirectly, from ecosystem functions'*(pp. 253); Daily (1997) defined them as '*The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life'*(pp. 3); ecosystem services are defined by Beaumont *et al*. (2007) as '*The direct and indirect benefits that people obtain from ecosystems*' (pp. 254) and from the Millennium Assessment (MA) simply as '*The benefits people obtain from ecosystems*' (2005, pp. 2). Importantly, it can be seen that there is a broad agreement between the research papers on the general idea of ecosystem services. However, notable differences can be seen. Costanza *et al*. (1997) suggests that ecosystem services represent the goods and services derived from the functions and utilized by humanity, whilst in Daily (1997) ecosystem services are shown as the "conditions and processes" as well as the "actual life support functions". The MA (2005) and Beaumont *et al*. (2007) both refer to ecosystem services as purely the benefits society receives (Fisher *et al*., 2009).

The use of the concept of ecosystem services allows the dynamic nature of the environment and all its aspects to be translated into a series of functions. By assessing any ecological processes using the services provided by them, any benefits or losses to the ecosystem when development or exploitation takes place can be understood by all stakeholders involved which is useful for comparison (Beaumont *et al*., 2007). There are many attempts to classify ecosystem services into categories, (Ewel *et al*., 1998; Hein *et al*., 2006; Holmlund & Hammer, 1999; Moberg & Folke, 1999; the Millennium Ecosystem Assessment, 2003). One of the most commonly cited follows that of Hein *et al*., (2006) which divides ecosystem services into five main categories, and further developed by Beaumont et al., (2007), who identified the separate services within each category. Table 1.3 has been adapted from that given by Beaumont *et al*. (2007) to include Hein's five categories, and Beaumont's subsequent further identification of services.

Table 1.3. Services provided by the marine and estuarine ecosystem. (Adapted from Beaumont *et al*., 2007).

Category	**Service**
Production Services: Refers to products obtained from the environment.	Food Provision- extraction of organisms for human consumption e.g. fish, shellfish.
	Raw Materials- extraction of materials and organisms not for human consumption e.g. building materials.
	Transport and Navigation- use of waterways for leisure and industrial shipping.
	Energy generation- use of the estuary for wave and tidal power.
	Residential and industrial water supply- abstraction of water for e.g. drinking water, cooling towers.
Regulation Services: Benefits acquired from the regulation of ecosystem processes.	Gas and climate regulation- maintaining atmospheric homeostasis
	Disturbance prevention- flood and storm protection.
	Bioremediation of waste- removal of pollutants by storage, burial and recycling.
Cultural Services: Non- material benefits society gain from ecosystems.	Cultural heritage and identity- associated with historical dates or conservation value
	Cognitive benefits- research and education opportunities involving the ecosystem
	Leisure and recreation- non industrial or educational engagement and or exercise in the environment e.g. dog walking, angling.
	Feel good or warm glow- value derived from the environment without using it e.g. value from knowing it is there.
Option Use Services: Associated with safeguarding the ability to use the ecosystem in an uncertain future.	Unknown or speculative future uses of the environment.
Over Arching Support Services: These are necessary for the production of all other services, but have no direct benefits to society.	Resilience and resistance- support from the environment for the ecosystems living aspects.
	Biologically mediated habitat- habitat provided by living estuarine organisms.
	Nutrient cycling- storage, cycling and maintenance of nutrients in the ecosystem.

It is important to note that individual ecosystem services will change in use and value between different spatial and temporal scales in the ecosystem (Hein *et al*., 2006). As different estuarine and marine ecosystems function on different temporal and spatial scales, they will ultimately provide different ecosystem services. Larger habitats will produce physically more production service values, but may not produce more cultural services value than a smaller site (Hein *et al*., 2006). In temporal scales, an ecosystem that is well established may provide more or better services than an ecosystem that is not as established.

An established ecosystem can be defined as 'inhabitants such as microbes, plants and animals, in some cases humans, coexisting in a state of energy balance. Most living beings have found their niche in the ecosystem' (Gopalan, 1999). This stable environment may, for example, provide a more suitable nursery ground to fish species, and therefore will provide greater food provision, as well as possible leisure and recreation value compared with a less established ecosystem. As well as internal scales for the ecosystem, location can also have adverse affects on the volume and quality of goods and services available. If the ecosystem is close to a residential area for example, this could possibly lead to greater value being placed on cultural services, and less value placed on production services, leading to inconsistencies or site-specific variability within the same ecosystem. Therefore a holistic management approach, such as the Ecosystem Approach, should consider ways of identifying the impact of change and development on ecosystem services.

This study assesses the way in which the ecosystem services provided by the managed realignment sites deliver human welfare benefits, where the benefits may be realized, and the changeable nature of these scenarios. Fisher & Turner (2008) describe a slightly different classification scheme for ecosystem services, to accommodate a different application of the theory. They draw mainly from Boyd and Banzhaf (2007), proposing that ecosystem services are the aspects of ecosystems, actively or passively used, to produce human well-being. For this definition, three important characteristics are identified:

1. Services are not benefits.

It is argued that recreation is not a service provided by ecosystems, but a benefit of which ecosystems provide important inputs. A benefit is something that has an explicit impact on changes in human well-being, like more food, better hiking or walking, less flooding. Wallace (2007) and the MEA (2005) consider services and

benefits to be the same. For valuation, this is a problem and could lead to double counting. Adding values for primary production to values for recreational hiking would “double count” the value that a different environment such as forests, could add to the hiker experience.

2. Ecosystem services are ecological in nature.

This point is also similar to one made by Boyd & Banzhaf (2007) in that aesthetic values, cultural contentment and recreation are not ecosystem services. They are benefits as they are not just a function of ecosystems, but include other inputs such as human capital and built capital. Also, they are benefits because they directly relate to changes in human welfare- which for the MEA (2005) is classified as a service. Fisher & Turner (2008) differ from Boyd & Banzhaf here, in that they see functions and processes as ecosystem services as long as there are human beneficiaries, as opposed to ecosystem services just being ecological components, such as lakes or fish. Fisher & Turner (2008) therefore importantly connect human welfare to nature throughout the ecosystem, rather than just at the end point.

3. Ecosystem services do not have to be utilized directly.

It is argued that as long as human welfare is affected by ecological processes or functions at some point, they are services (Fisher & Turner, 2008). For example, carbon sequestration is an ecosystem service because there are net human benefits derived from this process in a world of changing climate. Similarly, pollination is an ecosystem service since it is an ecological phenomenon that we indirectly use in order to enjoy certain food benefits, so pollination would be classified as the service, and the direct food gained as the benefit (Fisher & Turner, 2008).

This differing classification system to the one suggested by Hein (2006), was discussed by Boyd & Banzhaf (2007), who first suggested that ecosystem services are not the benefits humans obtain from ecosystems, they are ecological components directly consumed or enjoyed to produce human well-being. Services are directly consumed components, so indirect processes and functions are not classed as ecosystem services, for example, leisure and recreation would often be classed as a service, but Boyd & Banzhaf classify it as a benefit of several ecological inputs, such as saltmarsh or reed bed (Boyd & Banzhaf, 2007).

Following Boyd & Banzhaf (2007), Fisher *et al*. (2009) propose that *‘ecosystem services are the aspects of ecosystems utilized (actively or passively) to produce*

human well-being'. The key points to this definition are that services must be ecological phenomena, and they do not have to be utilized directly (Fisher *et al*., 2009). In this sense, services include organization or structure as well as processes and/or functions if they are consumed or utilized by humans either directly or indirectly. This is further discussed in Luisetti *et al*., (2010), who suggest that ecosystem services are *'the link between ecosystems and things that humans benefit from, not the benefits themselves'*. Therefore, the functions or processes become services if there are humans that benefit from them. If humans do not benefit from them, they are not services (Fisher *et al*., 2009).

Ecosystem services that humans gain from the environment can be divided into intermediate and final services (Fisher & Turner, 2008). Intermediate services stem from interactions between ecosystem structures and processes, and lead to final services. Final services combined with other forms of capital can provide human welfare benefits (Fisher *et al*., 2009). This classification can be loosely based around intermediate services in association with indirect benefits, and final services in association with direct benefits (Atkins *et al*., 2011).

Atkins *et al*. (2011) further discussed the concept of intermediate and final ecosystem services and benefits. They suggest that intermediate services can be defined as *'the bottom-up physio-chemical processes and regimes which set up the fundamental ecological niches which are then colonised by organisms'* and therefore are better termed 'fundamental services. Final services are defined as *'the biotic processes whereby the communities set up under the fundamental niches then interact and modify the biota'*. Once the ecological system is fully functioning, it can be presumed that it will produce benefits required by society, or societal benefits. The fundamental services, final services and societal benefits relevant to the managed realignment sites on the Humber are described in Table 1.4.

Table 1.4 Ecosystem services and societal benefits (in relation Table 2) that are provided by the Managed Realignment sites on the Humber estuary. Adapted from Atkins *et al*. (2011).

Category	Ecosystem service	Description
Fundamental Services	Gas and climate regulation	Saltmarsh, mudflat and reed bed habitats can act as a sink for CO_2
	Physical habitat	Saltmarsh and reed beds provide habitats for many species of over-wintering waders and waterfowl. Mudflat provides habitat for invertebrate communities. Grasslands are habitat for many terrestrial species.
	Nutrient cycling	Communities inside the MR site develop over a few years to match those outside the site. Therefore the environments have a similar nutrient-richness.
Final Services	Bioremediation of waste	MR sites are typically built on ex-agricultural land, and so were subject to agricultural discharges in the soil when first breached.
	Biologically mediated habitat	Significant areas of saltmarsh and reed bed. Many littoral species of vegetation.
	Resilience and resistance	All sites are within the SSSI conservation area, amongst others and so are not disturbed to a significant extent. Resilience and resistance can be seen as good.
Societal Benefits	Food provision	Sites are important nursery areas for many commercial fish species and crustaceans.
	Raw materials	There is no extraction specifically from these sites.
	Transport and navigation	The MR sites are not in any shipping routes.
	Energy	There is no energy generation at the sites.
	Residential and industrial water supply	No water is abstracted from these sites for residential or industrial water supply.
	Disturbance prevention	All sites are intrinsic to flood protection in the area.
	Cultural heritage and identity	The Heritage coast only covers Spurn point, not the Humber MR sites.
	Cognitive values	Ecological monitoring and research is undertaken at the sites by relevant authorities.
	Leisure and recreation	The sites are used to a varied amount by local residents for a number of activities.
	Feel good/ warm glow	All sites are conservation sites and have areas of natural beauty, so existence values are likely to be high.
	Future unknown or speculative benefits	Option use values are likely to be high due to the user values at the sites.

1.4 Developed research questions.

The above discussion of the concepts gives the context to the present study and hence the rationale for the aims and objectives here. The literature regarding the advantages and disadvantages of MR as a general practice are extensive, and it is widely considered by the scientific community that MR is a positive addition to the coastline, as opposed to hard wall structures. It is agreed (e.g. Doody, 2012; French, 2006; Garbutt *et al*., 2006; Moller *et al*., 1999; Morris, 2012) that soft defences such as MR provide the same if not higher level of protection from flooding, as well as coastal squeeze abatement. It can therefore be accepted that scientifically, MR is successful. However, it is of note that on the Humber especially, the flood plains and areas close to the estuary are populated, and changes to flood defence will have an effect on communities near to the MR sites.

There have been several recent studies which address the issue of how local residents would react if a coastline near to them were selected for MR (e.g. Myatt-Bell *et al*., 2002; Myatt *et al*., 2003(a); Luisetti *et al*., 2008). The Humber estuary MR sites were created 6- 9 years ago, and have therefore developed in varying degrees into areas of natural beauty which can be appreciated by local communities. Hence, the overall aim of the present study is to determine whether the creation of the managed realignment sites on the Humber is justified in terms of the societal benefits that they provide. Hence, the first research question to be addressed is: can existing MR sites be valued based on their societal benefits? Previous studies have already shown several ways in which this is possible, and will be discussed in chapter 2. Following this, it is necessary to question how valuable are the MR sites on the Humber in terms of their societal benefits? This is the main research question to be addressed.

As with most research questions of this nature, there will be several questions that need to be addressed before and after the primary research aim is met. Firstly, the valuation should not be carried out on a single-site basis. Instead, either the valuation should be treated as if working with multiple coastal ‘cells’, or whole estuaries can be treated as a single project with the valuation in terms of the MR sites within it (Luisetti, 2010). However, the MR sites on the Humber are all different in terms of the benefits they provide, their aestheticism, and the social demographic of the residents that live near to them. In this case, to treat PHS, Welwick, Alkborough and Chowder Ness as a whole could lead to erroneous conclusions

being drawn about the value of MR sites as a concept on the Humber, therefore initially the analysis will be on a site by site basis, and differences or similarities between the sites will then be addressed in the general discussion (Chapter 7). The decision to treat the MR sites separately is noted as a key difference in methodology in comparison to some other studies. This methodology was chosen to compliment the differences between the MR sites and aid comparison between them, and to make full use of the data acquired within the given time-frame.

In order to value the societal benefits they must first be identified and so identifying the societal benefits relating to MR sites on the Humber is the next objective. Chapter 2 explains how the societal benefits are identified and categorised. Once the societal benefits are identified, the suitable valuation techniques available should be addressed. Most of the societal benefits are valued using a survey based methodology sampling all villages within a seven mile radius of each site. The main stated preference method used is a choice experiment, but a contingent valuation and ranking benefits question are also included in the survey in an attempt to elicit as accurate a value as possible (Chapter 2). It is understood here that using a choice experiment to value disturbance prevention is not often seen in the literature, however this is justified as necessary considering the different stages of MR development on the Humber in comparison to previous studies based elsewhere. The MR sites have already been developing for 6-9 years (depending on the site) and the cost to create each site is already known. In this sense, we already know the value of disturbance prevention. However, this value is not indicative of the societal benefit that the sites hold in terms of flood protection, or rather how important the sites are to society. The survey is used to see whether local residents value the MR sites in terms of their benefits, which is expressed to the interviewer through a positive willingness to pay amount for the continued maintenance of or access to the MR site (Chapter 2).

Once the findings from the surveys have been analysed, both for each site in turn, and all sites together as a study on the estuary as a whole, conclusions can be made concerning the value of these sites in terms of their societal benefits, the possible reasons behind their value to society, why the sites may differ in their value, and ultimately whether managed realignment as a whole has benefits beyond its initial purpose (See Appendix I for map).

1.5 Thesis structure.

Chapter 2 gives a background to the valuation techniques available to use in a study such as this. The techniques that were used to gather data for this research are then outlined and described, as well as information on techniques used in the creation and development of the survey questionnaire. The statistical techniques used to analyse the data are also presented.

Chapter 3, 4, 5 and 6 present the results for each of the MR sites at Paull Holme Strays, Welwick, Alkborough and Chowder Ness respectively (Figure 1.2). Each chapter gives an overview of the site's ecological status including information on abundance and diversity of vegetation assemblages as well as invertebrate, bird and fish information. Results from the interview survey are then presented, initially with information on survey completion rates, before analysing the participant average values of the site, as well as reasons for visiting the site. Results from the data analysis using the statistical techniques described in chapter 2 are then described, and significant socio-demographic influences are identified for each site. The reasons are given behind particular economic values, as well as possible reasons for any socio-demographic influences.

Chapter 7 discusses the differences between the sites, including suggested reasons for these differences. The reasons behind separate values, and their influences are discussed, and a framework for discerning the ecological and economic value of an MR is presented. A critique of the study is given, as well as suggestions for further work and final conclusions.

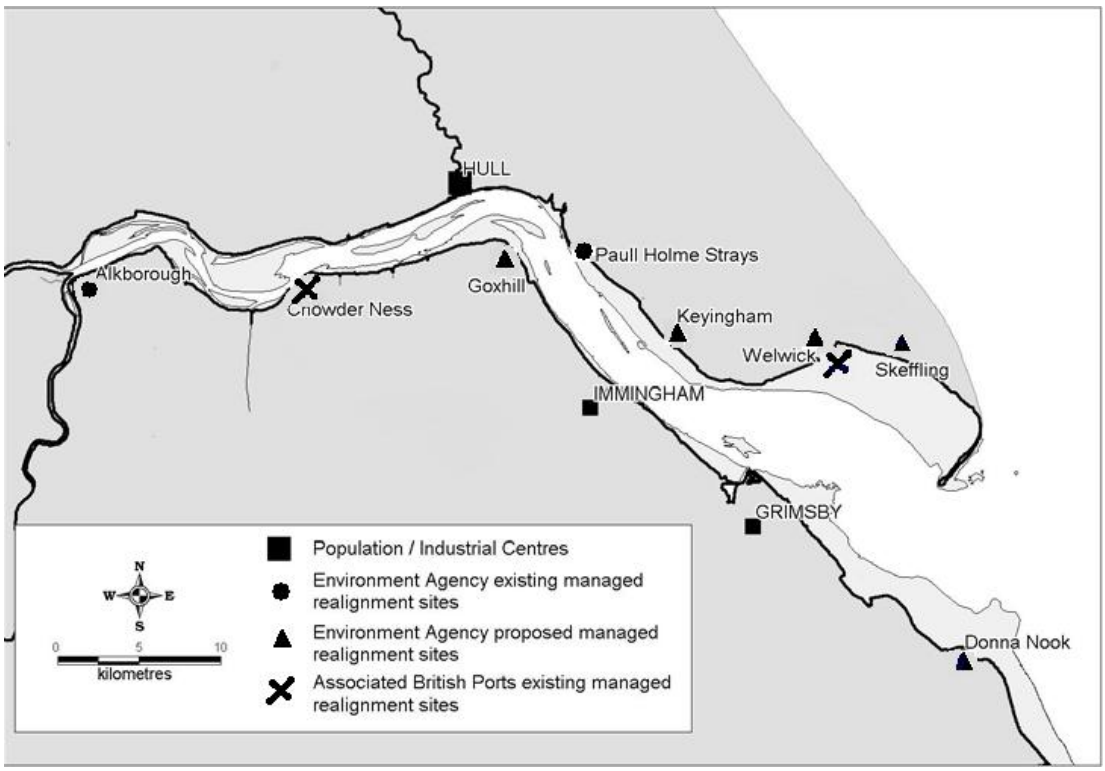

Figure 1.2 Existing and proposed managed realignment schemes on the Humber Estuary, UK. Adapted from HARBASINS report (2008).

CHAPTER 2

2. VALUATION METHODOLOGY.

2.1 Introduction.

This chapter reviews potential techniques for valuing the societal benefits associated with MR sites. A brief overview of the main methods employed in various valuation studies is given, as well as the services and/ or benefits they relate to. The ecological and economic valuation techniques that will be employed specifically in this study are then presented.

This chapter will briefly outline some of the more accepted methods of economic valuation of ecosystem services and societal benefits, to indicate the options available for such a study. The methods used in this study will then be described and the reasoning behind their use, as well as explanations of the field research specifics, including descriptions of the sample populations and reasoning behind the experimental design. The methods of statistical analysis of the socio economic data will be outlined, as well as the justification for the specific methods chosen. Information on the ecological valuation techniques will then be outlined. Due to time restrictions, and a desire to complement the socio economic data, the ecological valuation of the MR sites will be through expert opinion and previously collected data, rather than any primary field work.

The major pitfalls of all the valuation techniques used in the study are identified, and any attempts to try and remedy them will be described. The reasons behind using these methods will be further expanded on, and the author will attempt to describe how the different techniques will combine to create a holistic value picture of the four sites, individually and combined.

2.2 Important considerations in socio-economic valuation.

It is important to place the specific criteria that should be addressed when developing a socio-economic valuation methodology within a management context and framework. An example of such a framework is the DPSIR approach (Atkins *et al*., 2011; Ojeda-Martinez *et al*., 2009). The *driver* would be the cause of the

disturbance on the ecosystem, such as anthropogenic disturbance. This in turn would assert pressures on that system, and its functions and processes, which would eventually lead to a *state-change*, or a threshold effect. This would *impact* society as a change in the state of the functions and processes of the ecosystem may affect the ecosystem services and societal benefits provided by them. There may be numerous anthropogenic *responses* to the impacts, such as the new ecosystem services and societal benefits being accepted by society and management policies must adapt to accept the change, or management policies must change to try and regain the lost services and benefits.

Further to this, it is suggested that since *Impact* is defined to include effects on ecosystems, it is unclear where the distinction between *State* and *Impact* lies (Cooper, 2012). Therefore a redefinition of the *Impact* stage is given, so rather than referring to the consequences of *state change* for human and ecological systems, it instead refers to the consequences of *state change* for human welfare. Therefore, it proposed the approach be renamed DPSWR, *Driver- Pressure- State Change- Welfare- Response* (Cooper, 2012).

Within the DPSWR management framework, there are specific criteria in which the method can be tested. These should be considered before a valuation technique can be considered appropriate for its study (Turner *et al*., 2010). These are: Spatial explicitness, marginality, double counting, nonlinearities in benefits and threshold effects. It is important to consider these issues if the welfare estimates that result from the study (the monetary equivalents from e.g. WTP or travel costs) are to be taken seriously and be considered meaningful in terms of the wider research (Morse-Jones *et al*., 2011).

2.2.1 SPATIAL EXPLICITNESS AND SCALE.

The requirement for ecosystem valuation to be spatially explicit is important to counter the issue of the treatment of ecological systems at the scale of biomes, and the extrapolation of site specific values to an international or global importance (TEEB 2010). It is also important to recognise that ecosystem services are context dependent, and may form ‘socio-ecological mosaics’, or a patchwork of landscape units ranging in management issues or geographical variations in biophysical supply or demand, and service values may vary across the landscape. By using a model

that considers the spatially explicit and scale factors, we can move away from assuming all marginal values are constant, and instead use benefit transfer based on ecosystem type (TEEB, 2010; Morse-Jones *et al*., 2011). The way ecosystem services are produced and used, and subsequently the societal benefits they provide, vary spatially. Therefore, any costs associated with maintenance or implementation of these services will fall locally, making it important to society when and where these services are generated and to what extent.

In terms of this research, we could experience the "distance decay effect", which assumes that as distance from the site increases, visiting the site/ utility of the site/ willingness to pay for maintenance of the site would decrease. The 'distance decay effect' (Loomis, 2000) refers to the decline in WTP values the further away the respondent lives from the site. The effects of distance on WTP values has been widely studied within stated preference and CV literature (Bateman et al., 2006a; Johnston & Duke, 2009; Brouwer et al., 2010; Schaafsma et al., 2012). This point was shown by Luisetti *et al,* (2008), who researched the importance of spatial context in relation to the several benefits available from a new wetland habitat on the Blackwater estuary on the east coast of England. In this instance, the distance attribute was found to be significant and negative, supporting the distance decay effect (Luisetti *et al*., 2008; Morse-Jones *et al*., 2011).

2.2.2 MARGINALITY.

It is said that for economic valuation to be effective, the analysis should be conducted "at the margin", or when marginal environmental changes are being assessed. This means the focus of the study should be on relatively small or incremental changes rather than larger state changing impacts (Turner *et al*., 2010). However, it is often difficult to distinguish between a 'marginal' change or a larger one as smaller changes can be more difficult to detect in dynamic sytems, which is why former knowledge of the drivers and pressures of the ecosystem in question is important, as well as an understanding of the systems current or proposed state-changes (Luisetti *et al*., 2010).

2.2.3 DOUBLE COUNTING.

This widely recognised issue (de Groot et al., 2002; Millennium Ecosystem Assessment, 2003; Turner et al., 2003; Boyd & Banzhaf, 2007) is a problem that can cause uncertainty and poor reliability when estimating the value of ecosystem services (Fu *et al*., 2010). Primarily, double counting can be caused when competing ecosystem services are valued separately, but the values are then aggregated; or when a fundamental or final service is valued separately, and then is also indirectly valued through its contribution to the end societal benefit. This may be the result of ambiguous definitions and inconsistency when classifying ecosystem services, a poor understanding of the ecosystems complexities or failure to properly recognise how linked ecosystem services complement each other (Fu *et al*., 2010). A classic example of double counting is the value of a pollination service, which is already included in the market price of the crop, being counted separately unless the value of its input to the crop is deducted (Luisetti *et al*., 2010).

To avoid the issue of double counting, it is important to have an in depth understanding of the various overlaps that occur between the ecosystem services. Several suggestions have been made to ensure double counting does not compromise research analyses. Hein *et al*. (2006) suggest only including regulating services in valuations if their impact occurs outside the ecosystem being valued and/ or a direct benefit is provided to people living in the area, although not through sustaining or improving another service. This approach would be useful if the classification of ecosystem services were the same as Hein's paper. However, as discussed previously this thesis follows the ecosystem services classification scheme described by Fisher & Turner (2008) and developed by Atkins *et al* (2011), where a clear distinction is drawn between fundamental services, final services and societal benefits, and only the societal benefits are valued. Fu *et al*. (2010) build on this and they propose four steps for reducing double counting in ecosystem service valuation: (1) identifying the spatio-temporal scales of ecosystem services; (2) valuing the societal benefits obtained from ecosystem services; (3) establishing consistent classification systems for ecosystem services; and (4) selecting valuation methods appropriate for the study context.

2.2.4 NONLINEARITIES IN BENEFITS.

A major underlying assumption when valuing ecosystem services, is that the quantity of an ecosystem function varies linearly with other variables and characteristics of the environment, such as ecosystem size, change in season, disturbance (anthropogenic or otherwise), and species interactions. That is to say that the ecosystem service is assumed to change at a steady, unvarying rate (Barbier *et al*., 2008). It is important to note that the effects the independent variables can have on an ecosystem service, especially in dynamic environments such as coastal areas and wetlands, tend to be spatially and temporally non-linear (Farnsworth, 1998). In areas such as managed realignment sites, due to the nature of their creation the habitats and species diversity and abundance are in continual development. In addition, they are affected by seasonality just as much as other coastal environments, for example the function of wave attenuation by the suite of habitats developing at the site (saltmarsh/ mudflat/ grassland) may be more effective during Spring/ Summer when production rates are higher, and less effective during the Autumn/ Winter months when density and biomass are lower (Chen *et al*., 2007).

Because many different ecosystems typically respond to disturbances in a non-linear fashion, their functioning may appear unaffected by increasing disturbances, until they reach a point when the amount of perturbation will cause a dramatic system-changing response (Morse-Jones *et al*., 2011). Whilst it is important to consider all aspects of the environment being researched, in terms of this study the non-linear changes in the MR sites would not affect the potential the site has for flood protection at this time. However, there are several more proposed MR sites for the Humber, and nonlinearities should always be considered in management plans.

2.2.5 THRESHOLD EFFECTS.

Ecosystems in general are complex but adaptive systems, and can have varying levels of resilience. The resilience of an ecosystem refers to the amount of disturbance that system can experience (and adapt to) before it is forced to shift into a different state, which in turn may mean different structures or functions, and a shift in ecosystem services available. The point at which the ecosystem is forced to change is referred to as the threshold effect, and if the earlier DPSIR/ DPSWR

categories can be identified and classified, it may be possible to prevent unwanted threshold effects occurring in sites with similar ecosystem characteristics.

2.3 Economic valuation techniques.

The valuation of ecosystem goods and services has become one of the most important research fields in applied ecological economics (Jin *et al*., 2009). It is essential that the techniques used to value the environmental resources in the MR sites show a true representation of the values that society places on the ecosystem benefits in their area. An exact representation is important as where ecosystem services are marketable; their market price has the ability to represent their social worth. Therefore, it is imperative that the ecosystem services are valued in accordance with one, or many of the methodologies that have been developed for the specific reason of assessing these values (Birol *et al*., 2006). It is essential that the correct valuation technique is chosen for the specific situation that needs valuing.

Non-market economic valuation methods are regularly used to value environmental assets and services in monetary terms, by estimating the economic value that society receives from their use of their existence. Over the past 10 years, economic values of the environment have been under represented in market decisions, causing further need for non- market valuations and its development into an important source of information for environmental decision making (Freeman, 2003). In addition, it has been suggested that one of the primary motivations behind the development of environmental valuation is the need for public policy and management decisions to reflect an understanding of society's values relating to the environment (Cullinan, 2011).

Estimation of non-market environmental values usually relies on the employment of revealed preference or stated preference methods, which directly or indirectly estimate virtual or substitute market prices, and their associated individual economic values (Table 2.1). The values of the environmental benefits are subsequently aggregated into sample mean values of economic welfare, and then can be converted to a total value figure for an identified population (Hanley *et al*., 2007). It is noted that it is possible that the use of different methods could give different benefit or cost values once aggregated, as this is a complex process. The choice of

experimental design in this study means that stated preference methods were the only methods suitable.

Table 2.1 Identification of possible revealed preference of stated preference valuation techniques

Economic valuation method	Possible techniques
Revealed preference: Also known as indirect valuation methods. Examine related or surrogate markets in which the environmental goods are implicitly traded.	Hedonic Pricing
	Travel cost method
	Replacement/ substitution costs
	Defensive expenditures
	Production function analysis
	Net factor income
	Cost-of-illness
	Market analysis
	Damage avoidance costs
	Relocation costs
	Restoration costs
Stated preference methods: Direct valuation methods. Designed to estimate values of environmental resources not traded on a market. Used to estimate non-use values also.	Contingent valuation
	Choice experiment
	Contingent ranking

2.3.1 REVEALED PREFERENCE METHODS.

The hedonic price (or sometimes implicit marginal price) approach to the analysis of a market for a distinguished good examines the relationship between the price of a good, and the group of attributes possessed by the good in order to explore variations in prices of the goods (Clapp & Salavei, 2010). Using housing as an example, at its simplest a hedonic equation is a regression of expenditures (rents or values) on housing characteristics. The independent values represent the individual

characteristics of the dwelling, and the regression coefficients may be transferred into estimates of the prices of these characteristics (Malpezzi, 2003). This has implications for the creation or development of environmental areas near to houses, as it can affect the price of the houses in proximity to the environmental area (Gopalakrishnan, 2011; Waltert & Schlapfer, 2010).

The travel cost method aims to place a value on recreational sites by using consumption behaviour from similar markets, therefore the cost of consuming the recreational benefit of a particular site is used as a proxy for price. These goods can include travel costs, entry fees or any on-site expenditures, and therefore the recreational area can only be valued if the consumption expenditure is positive (Hanley & Spash, 1993). The time and travel cost expenses that people incur to visit a site represent the 'price' of access to the site. So the cost borne by visitors to a bird watching site may be interpreted as the minimum value they attach to that site. Costs differ between different sites, and over time for the same site, and so the method can be used to estimate the economic benefits or costs resulting from changes in access costs for a recreational site, elimination of an existing recreational site, addition of a new recreational site and changes in environmental quality at a recreational site.

The travel cost model can be divided into two different analysis techniques, an individual model or a zonal model, depending on the spatial scale of the study and the level of details required from the data. The key difference between them is that the individual models' response variable is the number of trips in a defined period of time by individual users of a recreational area; whereas the response variable for the zonal model is the visit frequency to the site by the population of a particular region or geographical zone. The former is a more appropriate method for frequently visited sites with a close local population, whereas the latter is more appropriate for infrequently visited sites, whose visitors live further afield (Fleming & Cook, 2008).

In terms of revealed preference methods, hedonic pricing and the travel cost method are the most widely used in the context of environmental resources valuation. The other techniques identified (Table 2.1) are not as widely used, but can still be useful in certain situations.

Replacement or substitution costs value the costs of replacing damaged assets (including environmental assets) by assuming these costs are estimates of the benefit flows from aversive behaviour. The method assumes that the damage is measurable and that the value of the environmental asset is no greater than the cost it takes to replace it. This concept was considered by Oliveri & Santoro (2000) who used this method on a case study in Palermo for valuing the costs of flood damage, and developed a concept through these valuations to be used a judgement tool for flood mitigation measures in urbanised drainage areas. They defined the replacement value as the total cost for replacing the structure with another or like utility, with the same characteristics as the previous one. However, although this is feasible for average houses, it can mean misleading results when considering buildings of artistic or architectural interest, such as churches. The substitution approach was also applied here, which considers the value of technically equivalent estates and produces a similar utility for which a market exists, and therefore the value can be conveyed, by combining procedures, values for historically important buildings can be estimated (Oliveri & Santoro, 2000).

Defensive expenditures refer to the costs incurred in mitigating the effects of reduced environmental quality. These expenditures are not borne to increase the overall welfare of the household, but rather to prevent or avoid the effects of worsening environmental quality, for example, the consumption of bottled mineral water rather than drinking tap water (Tiezzi, 2002). It represents a minimum value for the environmental function.

Production function analysis offers another surrogate market technique, in a similar way to how travel cost methods create a surrogate market in which to attempt to estimate the demand by households for environmental quality (Barbier, 2000). In general, it consists of a two step procedure. Firstly, it requires the identification of any physical effects of changes in a biological resource or ecological function on an economic activity. Secondly, the impact of any environmental changes identified is valued, by determining the corresponding change in the marketed output of the corresponding activity, i.e. the identified biological resource or ecological function acts as an environmental input into the economic activity. Therefore as with any other input, its value can be equated with its impact on the productivity of any discernible marketed output (Barbier, 2000).

Net factor income estimates change in producer surplus by subtracting the costs of other inputs in production from total revenue. The remaining surplus can be described as the value of the environmental input. This method is most appropriate when the environmental site provides a service (or services) that lead to an increase in producer surplus; which makes it possible to identify the increase in producer surplus associated with the environmental area (Woodward & Wui, 2001).

Conservative estimates of the benefits of improving the quality of environmental factors which directly influence the public's health, such as air or water quality, can be examined by deriving a cost-of-illness value. This is the sum of any medical expenditures or possible loss of earnings directly caused by a polluted living environment; or the estimated cost of averting the effects of the pollution, or attempts to control exposure, limiting illness (Alberini & Krupnick, 2000). Although this method is recognised as providing a simpler technique for data collection compared to questionnaire surveys, cost-of-illness or averting expenditure will only provide a lower bound for the correct measure of willingness to pay (Harrington & Portney, 1987). This is similar to Market analysis, which is also used to value the costs and benefits associated with changes in quality and quantity of environmental goods, but those which can be traded in functional markets, such as estimating the value of fisheries. This is often used alongside another revealed preference technique.

Damage avoidance costs refer to the costs that may be incurred if the environmental benefit were absent. For example, this could be seen in groundwater contamination damage. If groundwater treatment were not paid for, the subsequent increase in contamination levels of groundwater would inevitably deteriorate human health, increase fear and anxiety within a community, increased avoidance costs and property value loss, ecological damage and loss of recreational use of the area, and reduction or loss of non-use values (Abdalla, 1994). Therefore, this would encourage the local population to pay for water treatment in order to avoid these damages. More recently, natural disasters have highlighted the benefits of damage avoidance costs in preventing the impacts of adverse weather situations. For example, research is ongoing in South East Asia following the effects of the 2004 South Asian tsunami. Sanford (2009) presents findings which show the coastal protection value of mangroves in South East Asia presently exceeds the direct use values associated with them, such as forest harvesting and mariculture, by 97%.

Allocating relocation costs is a form of defensive expenditure which refers to the cost it would take to relocate any agent or facility affected by environmental happenings. This could include the cost of re-assigning lost agricultural land after managed realignment. It could also mean a geographical shift of firm and industrial activities away from particularly low lying or high lying regions that may be highly affected by climate change; for example direct disruptions to operations due to drought or flood, or disruptions in a business's supplier, buyer or resource base causing adverse consequences for the firm (Linnenluecke *et al*., 2011). Relocation costs may also affect the individual or local population to an area susceptible to adverse climate effects, causing migration behaviour which would be the main source of any relocation costs (McLeman & Smit, 2006).

Restoration costs are expenditures involved in returning a degraded ecosystem to its original state. With regards to wetland ecosystems, this requires constructing the societal benefits of the ecosystem in a bottom-up approach, providing those who are paying for the restoration insight into the benefit improvements they will gain through payment. Examples of possible benefit improvement include greenhouse gas mitigation, nitrogen mitigation, and waterfowl recreation, each representing positive externalities from wetlands at different geographical scales, global, regional and local respectively (Jenkins *et al*., 2010).

2.3.2 STATED PREFERENCE METHODS.

Contingent valuation aims to elicit individuals' preferences, in monetary terms, for changes in the quality or quantity of non-market environmental resources. Valuation is dependent upon a hypothetical situation where a sample population is surveyed and asked to state their maximum willingness to pay (WTP) or willingness to accept (WTA) compensation, for an increase or decrease in the level of environmental quality or quantity (Mitchell & Carson, 1989). Although there are areas of controversy surrounding this technique in terms of its ability to deliver reliable results, and the correct design of the contingent valuation survey (Diamond & Hausman, 1994), it is one of the most widely recognised methods in eliciting economic values for environmental goods, and its use is increasing in this field (Whittington & Pagiola, 2012).

The choice experiment method is a discrete choice model which assumes the respondent has perfect discrimination capability. The method uses experiments to reveal factors that can influence choice, such as preference trade-offs. The preference trade-offs, or 'attributes' are presented in survey as multiple choices corresponding to different payment amounts in a survey format (Hanley *et al*., 1998). This technique, like contingent valuation, has increased in use both in the valuation of environmental goods, and also in other disciplines (Whittington & Pagiola, 2012).

Contingent ranking is also a choice modelling approach to valuation, which requires the respondent to rank a set of alternative options, each characterised by a number of attributes. Using contingent ranking valuation questions can allow trade-offs between the characterisitics being valued, rather than relying on an explicit elicitation of a willingness to pay amount (Foster & Mourato, 2002). The expressed trade-offs between respondent assessments can then be used to estimate the marginal utility the respondent places on each attribute. Valuation through ranking attributes is especially useful when valuing environmental programs or assets, as these tend to have several components and therefore contingent ranking is a more appropriate method (Bateman *et al*., 2006b).

In many cases, there is more than one valuation method that can be applied to the ecosystem services and societal benefits identified for the sites. Many of the techniques described above would require the collection of primary economic evidence, which in some cases would be costly to collect in terms of time and resources. Therefore it may be advantageous to observe the results from similar studies on other sites, as an insight as to what may occur in this study; although it is important to remember that differences between the sites may alter any results. Table 2.2, which has been adapted from Atkins *et al*., (2011) summarises the different techniques that can be used in valuing the ecosystem services and societal benefits that specifically relate to MR sites.

Table 2.2 Valuation techniques available for ecosystem services and societal benefits (Adapted from Atkins *et al*., 2011).

Category	Ecosystem service	Valuation technique
Fundamental Services	Gas and climate regulation	PF, RC, DAC, DEC
	Physical habitat	CVM, CEM
	Nutrient cycling	RC, COI
Final Services	Bioremediation of waste	RC, COI, DAC
	Biologically mediated habitat	CVM, CEM
	Resilience and resistance	PF, RC, DAC,
Societal Benefits	Food provision	MA
	Raw materials	*MA*
	Transport and navigation	*MA*
	Energy	*MA*
	Residential and industrial water supply	*PF, NFI, RC, MA,*
	Disturbance prevention	PF, RC, MA, DAC, PGL, DEC
	Cultural heritage and identity	CVM, CEM,
	Cognitive values	CVM, CEM,
	Leisure and recreation	TCM, HP, CVM, CEM
	Feel good/ warm glow	CVM, CEM,
	Future unknown or speculative benefits	CVM, CEM,

KEY: MA- market analysis; PF- production function; HP- hedonic pricing; TCM- travel cost method; CVM- contingent valuation method; CEM- choice experiment method; DAC- damage avoidance costs; DEC- defensive expenditure costs; RC- replacement cost; COI- cost of illness. Italics: Not applicable to MR sites, appear in the table for reference.

2.4 Stated preference techniques.

As stated previously, there is often more than one suitable valuation technique for each societal benefit. Therefore, when attempting to value an ecosystem holistically, using a suite of techniques ensures that the resulting values are as realistic as possible. Stated preference techniques rely on observing the individuals' behaviour in the market. They are particularly useful when estimating use values, as it assumed that if a person pays *x* for an ecosystem service, it can be assumed that *x* is at least the minimum WTP value for that individual.

For ecosystem services that are not market tradable, stated preference techniques are needed to identify a WTP value. These questionnaire based techniques are used to ascertain individuals' preferences and therefore how they monetarily value

services. Techniques such as these, either directly or indirectly obtain participant WTP or Willingness to accept (WTA) compensation for the loss of the service (Bateman *et al*., 2002). Stated preference (SP) techniques are useful in situations such as these as they allow the formation of hypothetical markets, and so habilitate the valuation of non-market ecosystem services. Hence, SP techniques are suitable for the estimation of non-use values. Non-use values in this context refer to the individuals' WTP to maintain a service that exists, but has no actual, planned or future use to the individual (or to anyone else). This could be the existence of an endangered species, or in the case of a wetland environment, a scenic view.

SP techniques can be divided into two main categories; contingent valuation (CV) and choice modelling (CM). Originally pioneered in the 1960s by Davis (1963) and Lancaster (1966) respectively, the methodology was introduced for using CV studies to get the total WTP for a specified service, and using CM studies to investigate the influence of the characteristics of that service and to ascertain a marginal WTP value for each characteristic.

CV studies can be divided into two further formats; either dichotomous choice or open- ended questions. An open- ended question format leaves the respondent free to give any value they think is their maximum WTP (or WTA) value. The dichotomous choice format or 'two- alternative referendum' offers the participant a definite choice in reply to a suggested WTP value (i.e. 'yes' or 'no'), essentially a closed question rather than the open- ended option. CM techniques can be divided into four further formats: choice experiments, paired comparisons, contingent rating and contingent ranking (Bateman *et al*., 2002). Choice experiments (CE's) require the respondent to make a choice between two or more options that are presented in a choice set, and each option is presented with its own description. In a contingent rating question a number of options, again with their own descriptions, are presented to the participant. They are then asked to rate all of the options individually- on a semantic or numeric scale. The paired comparison technique combines elements of both CE and contingent rating. Options in a choice set are presented to the participant in pairs; they are then asked which option they prefer in relation to a specific variable such as distance or size in relation to price. In a similar fashion, in a contingent ranking question the participant is shown several options. Each of the options has its own description, and they all differ from one another.

The participant is then asked to rank the options from most preferred to least preferred (Bateman *et al*., 2002).

Two or more of these techniques can be used in the same survey to strengthen the WTP/ WTA value and so add to the significance of the data gathered. Depending on the type of survey used, and the results the researcher is attempting to acquire, some techniques work particularly well together. The figure below shows the stated preference techniques, classified by the task required (Luisetti, 2010) (Figure 2.1).

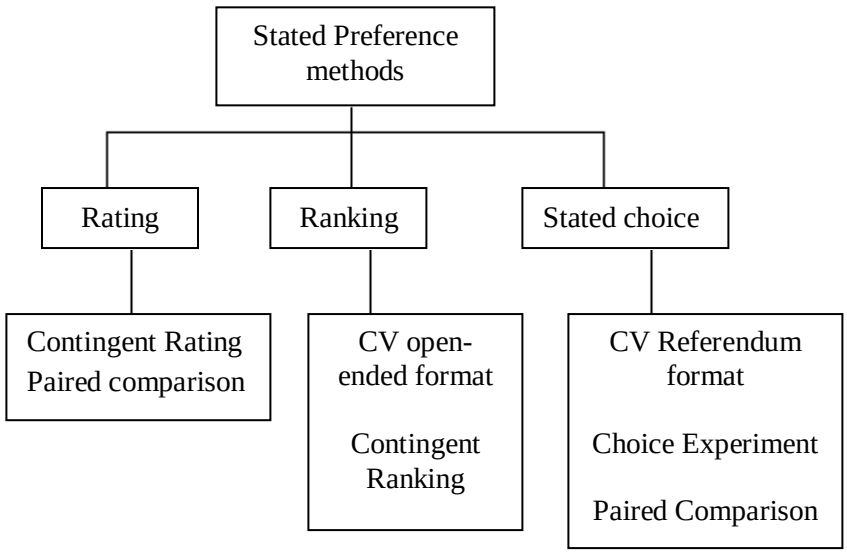

Figure 2.1. Classification for stated preference methods (from Luisetti (2010)).

Throughout the literature, it can be seen that CV and CE surveys are the most commonly used for valuing the environment, however which one to use depends on the type of information required for analysis. If the study is focussed on the ecosystem service or benefit as a whole, a CV study would yield the best results. However if the researcher is more specifically interested in the characteristics of the service or benefit, a CM technique would be better. CM studies tend to allow for a more direct valuation of the characteristics of an ecosystem service or benefit, and therefore can be used to study the changes in these characteristics. If welfare-consistent estimates are required, CE surveys are preferable to other CM methods (Luisetti, 2010).

As with all valuation methods, there are advantages and disadvantages. CE studies are occasionally deemed advantageous over CV studies because in a binary discrete choice CV survey, the different categories that are to be valued can only be

presented to the respondent as different scenarios for each aspect of the separate categories (Turner *et al*., 2010). This would be an inefficient way of valuing the separate categories. CEs however, can present the respondent with several choice sets, each with a different mix of attributes and levels to consider. For example, an attribute may be that there are bird species protected in the area, and levels may refer to different numbers of bird species. Although this means the participant can be asked to consider several choice sets in the same survey, increasing the number of choice situations to be evaluated can lead to an increase in the frequency of errors, as fatigue effects increase (Bradley & Daly, 1994; Czajkowski, 2012). Therefore, the number of choice sets presented in the survey should be carefully considered. If the study aims to value the societal benefits of a site that hasn't yet been created, for example to investigate the opinions of the local population on area size, distance from where they live and aesthetic appearance for a proposed nature site, the choice sets used will contain these parameters. However, if the nature site has already been constructed and the ecosystem services and benefits are developing or have developed, as in this case, parameters such as area or distance from their homes are already fixed, and so many different choice sets may not be necessary.

2.4.1 SOCIO-ECONOMIC EXPERIMENTAL DESIGN.

The survey in this research will be used to value the societal benefits for four managed realignment schemes that were all created between five and ten years ago. As the ecosystem services and societal benefits are already present, the survey will consist of a mix of principles, to elicit the best valuation possible for the values. Firstly, a binary choice experiment is used, which is a choice model version of the binary choice model used in CE. The respondent is asked to choose between two alternatives or policies, with different payment amounts corresponding to different scenarios for the MR site. Secondly, this is coupled with a CV 'willingness to pay' question, to derive their exact value for both maintenance of the site and access to it. Finally, a contingent ranking question is included to examine the level of importance the participant places on each of the societal benefits, in relation to each other.

The difficulty with presenting separate choice sets for each benefit available occurs because the sites were created between five and ten years ago and so many

residents have experience of the benefits available to them. If standard choice sets were to be presented to the participant excluding certain benefits, this would be unbelievable as a benefit cannot disappear. Therefore a hypothetical situation had to be constructed for the survey where the maintenance of the MR site, and so maintenance of the ecosystem benefits, was used as leverage. A situation was explained to the participant where the maintenance of the site had become the responsibility of the local council. The choice was then between whether they would hypothetically pay *X* for the maintenance of the site and therefore the services and benefits, or continue to pay nothing but the site would suffer from degradation which could potentially affect the quality and availability of the MR sites' societal benefits.

If the aim of the study was to value the benefits individually, choice sets could have been developed to indicate that the participant was only valuing one specific benefit at a time. However, it is considered that in many cases the benefits are interconnected at some stage of the ecosystem, whether it is at the fundamental service, final service or indeed the social benefit level. Asking the participant to value one benefit whilst disregarding another connected service would be unrealistic to their actual valuation views. Therefore, as well as valuing the site, the participant was asked to rank the benefits in order of importance to them. This way, emphasis can be put on a particular aspect of the site, whilst still valuing it as a whole system.

2.4.2 SURVEY QUESTIONNAIRE.

The research on stated preference questionnaires, and review of successful surveys that had recently been used in the field (examples from Ian Bateman, Sian Morse-Jones & Tiziana Luisetti), served greatly to highlight key aspects of a CE questionnaire and to inform the development of this survey, and informal focus groups were used in its further progress. The first focus group consisted of six adults aged from 23 to 42, all with a background in estuarine ecology but different interests within that field. All were familiar with at least one of the MR sites, some visited them regularly and some had never visited one. The second focus group involved 10 adults with an age range from 18 to 67. None of them had a background within the sciences, and whilst two were familiar with the concept of recreated habitat sites, they were not familiar with the term 'managed realignment'. None of them had ever visited an MR site.

After the initial results from the focus groups and the literature had been reviewed, and developed into a questionnaire, pilot surveys were conducted in the village of Humbleton in October 2010. Humbleton was chosen for the pilot study as it is near one of the MR sites, but its residents were not in the survey population. By combining findings from the literature, focus groups and pilot surveys, the details of this survey could be finalised. Key variables decided as a result of this process included the payment mechanism, application of the survey (i.e. postal survey, face-to-face interview, telephone survey or internet survey), a suitable time frame for survey completion, which pictures of the sites are most effective when describing the site, how the questions were worded or phrased, and the starting figures for the choice experiment questions.

The focus groups in particular were very instructive when considering the weather conditions when surveying, if it is particularly cold or raining, the public would be less likely to participate in a face-to-face interview. However, if the weather was dry and warm, the public would be more likely to participate in a five minute interview than fill in a questionnaire in their own time. They were also helpful when choosing the payment mechanism, a difficult task in these studies as the realism of the scenario has to be balanced against the potential for payment mechanism rejection (Mitchell & Carson, 1989). Several payment mechanisms were discussed at length with focus groups and the author's peers and superiors, and it was decided that an increase in tax was the most feasible.

Charitable donations were seen as untrustworthy, as members of the public may be wary as to how the donations were spent if not thoroughly regulated. Utility bills were unsuitable as the MR sites were created by EA, ABP and Natural England, and local utilities companies were not involved. National tax was considered, but it is well documented in literature that the response rate may be more positive than it actually is, because the participant does not actually believe that they will end up paying the proposed tax increase (Johnston *et al*., 1999; Luisetti *et al*., 2010). Council tax, however, is a more relevant and accurate mechanism as it involves a local situation that could feasibly be covered by council tax. Also as council tax can be paid monthly (over ten months), the 'annual fee' can be broken down into a cost increase per month, and so it can be quantified within the limits of their household income and budget.

The way that settlements have developed in the areas around the four sites means that the sample populations are clustered into small villages, predominantly separated by agricultural land. The village populations are spread over a large area, therefore every household within a seven mile travel radius of their respective MR site was included in the sample population, in an attempt to maximise the number of completed surveys, and so add greater validity when statistically analysing the data. By sampling both near to the site and further away, this allows any distance decay effects on respondent WTP values to be verified (Bateman *et al*., 2006a). The radius of seven miles was chosen because the MR sites on the south bank of the Humber, Alkborough and Chowder Ness, are approximately 11 miles apart so a larger radius would mean an overlap of villages being surveyed for each site. The seven mile radius (measured as travel distance) was applied to all the sites to reduce variability and aid comparison between sites (see appendix I for map).

The questionnaire was developed following the guidelines described in the NOAA Panel on Contingent Valuation (Arrow *et al*., 1993) and those used by Bateman *et al*. (2002, 2006). The date, location and weather conditions are recorded, and the survey begins with a brief introduction by the interviewer, followed by a brief introduction of the subject. It was suggested by the focus groups that the length of the questionnaire would greatly influence whether they would be willing to complete it. Therefore in order to elicit the maximum amount of responses, the questionnaire was designed to be as short as possible whilst still gathering the relevant information needed for analysis (see appendix II).

In some CEs of this nature, mainly when the site is yet to be created and parameters are being tested for the local residents' preferences, each separate proposed societal benefit is given a different choice option (Scarpa *et al*., 2007). However the MR sites have already been created in this study, and therefore the societal benefits have already developed somewhat. The concept of using 'maintenance' was decided upon because many of the societal benefits are very closely linked with one another, and it would be unrealistic to attempt to value one without it affecting another. The participant is also asked to give their WTP amount for access to the site; this distinguishes between users and non-users. There are three main sections in the interview survey.

Section 1: Knowledge and use of the nature sites.
Section 2: Valuing the site.
Section 3: Socio-demographic details.

Where possible all questions in the questionnaire are closed ended. This is both to be as clear as possible to the participant, and to simplify the interpretation of their answers. All the questions are the same for all four sites, but the respondent is asked if they have heard of the other sites and if they have visited them. The participant is asked to answer the questions in relation to their local, or nearest site.

The introduction section includes questions to ascertain whether the participant is suitable for the questionnaire, such as whether they are the bill payer, and information on what the MR sites were created for and their societal benefits. If appropriate, they are also shown a basic location map of the estuary with the four sites indicated.

Section 1 asks the participant if they are familiar with the site closest to them. Visual prompts are presented to the participant in the form of photographs of the site, both an aerial view, and an eye-level view so they are more likely to recognise the site in question. They are asked if they or any of their family visits the site and if so, how often their visits occur and the average length of time they spend there. They are also asked about the nature of their activities whilst at the site. If nobody in the household visits the site, they move to section 2.

Section 2 introduces the participant to the idea of valuing the site. The current situation regarding maintenance at the site and what this means in terms of benefits to them is explained in non-scientific language. They are told that maintenance at the site is currently paid for and conducted by the organisations that created the sites initially, either ABP or EA. Maintenance includes bank inspections and repairs; maintenance of all structures; clearance of any large debris and cutting the grass/ keeping a generally pleasing aesthetic appearance. Regular ecological monitoring of the site is also conducted, taking account of vegetation, bird and fish assemblages. The hypothetical payment situation is then presented, on which the valuation question was based. They are asked to hypothetically consider that the company that created the site had made other arrangements for its maintenance, and that the most likely outcome from this situation was that site maintenance would

become the responsibility of the local council. Although there were no immediate plans for the establishment of this scheme, it would be funded by a small increase in local taxes, such as council tax.

A distinction was made between two different payment options, *maintenance* of the site and *access* to the site, in an attempt to derive the difference between WTP for *non-use values*, and *use values* respectively. Asking these questions separately made it clearer when analysing the WTP answers, and meant that comparisons could be drawn between how the participant values the use and non-use values of the site.

Firstly, the respondent was presented with the choice experiment part of the survey. They where they are asked to choose between 'maintenance' and 'no maintenance'. The choice of 'maintenance' would cost them an annual increase in council tax by £10, so as council tax is paid over 10 months, would equate to a £1 increase per month. The amount of £10 as the initial cost was discussed in the informal focus groups, and was described as a realistic and 'unaggressive' start price. It was seen as unlikely that the respondent would be offended by a suggestion of £10 per year, and that the option would be there for them to express their desire to pay more if they so wished.

Choosing 'maintenance' also meant that all characteristics of the site would remain maintained to their current standard. Because MR site are dynamic ecosystems and are still developing, it was explained that maintenance would continue at the site to the exact standard that is currently employed, allowing for natural developments in the site to occur unhindered. By choosing 'no maintenance' the participant would have no increase in council tax due to site maintenance. However, the lack of maintenance could have a derogatory effect on the quality of the societal benefits the site provides, such as less effective flood protection or a decrease in the site's natural beauty. The value derived from this question was to be a reflection of how important the non-use values of the site were to the participant (Figure 2.2).

The participant was asked follow up questions in an attempt to extract their true WTP value. If they had answered the previous question with 'maintenance', they were then asked if they would be willing to pay double the tax amount they had agreed, ie an annual increase of £20, or £2 per month. If they agreed to this, they

were asked what would be the maximum amount they would be willing to pay. Conversely, if the participant had formerly chosen 'no maintenance', they were asked if they would be willing to pay half the suggested tax amount, a £5 annual increase or 50 pence monthly increase. If they chose not to pay again, they were asked if they would be willing to pay anything at all for the continued maintenance of the site.

	Maintenance	**No Maintenance**
Site characteristics	• Natural beauty of the site will stay the same. • Animal and plant species remain at the site. • The areas around the site are still protected from flooding. • There are education opportunities (for school children) to learn about nature and wetlands • All leisure and recreation activities currently available to the public will remain available. • The site will be available for future generations to enjoy.	• Decrease in the sites natural beauty. • Less effective flood protection. • Less education opportunities. • May lead to a decrease in available leisure and recreation activities. • Site may not be maintained to a level that can be enjoyed by future generations.
Annual increase in tax	£10 (As council tax is paid over 10 months, this is £1/month)	£0

Figure 2.2 The survey choice experiment question for the option of 'maintenance' or 'no maintenance'.

The participant was then asked to consider access to the site instead of maintenance. It was assured that the price they may have just agreed to for maintenance should be treated as a separate issue, and they would not be paying for both issues at the same time. This further distinguished their WTP amounts into use and non-use values.

The participant was then asked to choose between 'access' and 'no access'. By choosing 'access' this would mean an annual council tax increase of £6, equating to

60 pence per month, and they would have access to the site as often as they liked. If they chose to accept the 'no access' option, they would still receive flood protection to the current standard and the site would remain in place for future generations to use. However, the site would not be available to them for any leisure or recreational activities, or educational purposes. Access would be restricted through the use of hedges and locked gates, and any public rights of way such as public footpaths would be diverted around the site. The value derived from the 'WTP access' question was to be a reflection of how important the use values of the site were to the participant (Figure 2.3)

	Access	**No Access**
Site characteristics	• Site will be maintained to its current standard and all associated benefits will remain intact, such as flood protection, pleasant view, educational opportunities, and availability for future generations. • Access will remain available to the site for any reason, at any time, including all leisure and recreation activities.	• Site will be maintained to its current standard and all associated benefits will remain intact, such as flood protection, pleasant view, educational opportunities, and availability for future generations. • Access is restricted via hedges and locked gates, and public rights of way are diverted around the site. Site cannot be used for leisure and recreational activities.
Annual increase in tax	£6 (As council tax is paid over 10 months, this is 60p/month)	£0

Figure 2.3 The survey choice experiment question for the option of 'access' or 'no access'.

Once again, the participant was asked further questions to elicit their WTP amounts. If they chose 'access' they were asked if they would be willing to pay double the amount, a £12 annual tax increase or £1.20 per month. If they agreed to this amount they were asked their maximum WTP amount for access. Conversely again, if they chose 'no access' they were asked if they would be willing to pay £3 per year, a monthly increase of 30 pence, and if not, if they would be willing to pay anything for access to the site.

The price increase of £6 was chosen (as opposed to using £10 again) for two reasons. The first was so the participant could see the distinction between the two questions; it reiterated that they required separate responses and represented two different types of value, *use* and *non-use*. Secondly, it was prudent for access to the site to cost less than maintenance, as maintenance is an ongoing process that would continue throughout the year, whereas organising restricted access to the site is a singular occurrence, although the funds needed to divert any footpaths and also for any maintenance the locked gates or hedges may need were taken into consideration.

The final question in the valuation section of the survey asks the participant to rank the societal benefits provided by the MR site 1 to 5 in order of importance to them. By answering a question such as this, preferences for a particular societal benefit over the others can be discerned. This is important to the study as up until this point in the survey, the WTP values for maintenance and access are known, which for example, can tell us if they value use values such as leisure and recreation over non- use values such as flood protection, but we do not know how the participant values the societal benefits provided by the MR site in relation to each other. This information will give a greater insight into why an individual may be willing to pay what they have stated, without assuming that they value all societal benefits equally.

Section 3 of the survey asks socio-demographic details. It was noted in the focus groups that most would not be comfortable with divulging sensitive information such as income and age to a stranger on their doorstep. Therefore a series of information cards were produced, whereby the participant was then asked to indicate the letter to which their age or income category corresponded (Figure 2.4).

It is noted that eliciting answers in this way will result in a less specific portrait of the sample population. However the alternative may have been the participant not answering the question at all due to the sensitive subject matter, which would have meant a much less specific overview of their socio-demographic details, and fewer responses. Participant gender was also noted, as well as the highest level of education they have received. They were asked about their occupation, if they were retired they were asked what their occupation used to be, and finally whether they were a member of any nature based interest groups.

This final section was imperative, as with this information different profiles for what may, or may not influence a participant to give money to this cause can be examined. For example, somebody in a higher position financially may be willing to pay a higher amount of money for maintenance or access to the site. They may be in this higher financial position due to a higher level of education, and a more educated person may have a higher awareness of political, social and ecological issues in their catchment or area. Therefore somebody with a higher level of education may have a higher WTP amount than someone with a lower level of education for various reasons. These points are generalisations that could be made about any participant, which reiterates why it is important to include socio-economic questions, so any generalisations made about those who may have higher or lower WTP amounts, can be guided by their information provided.

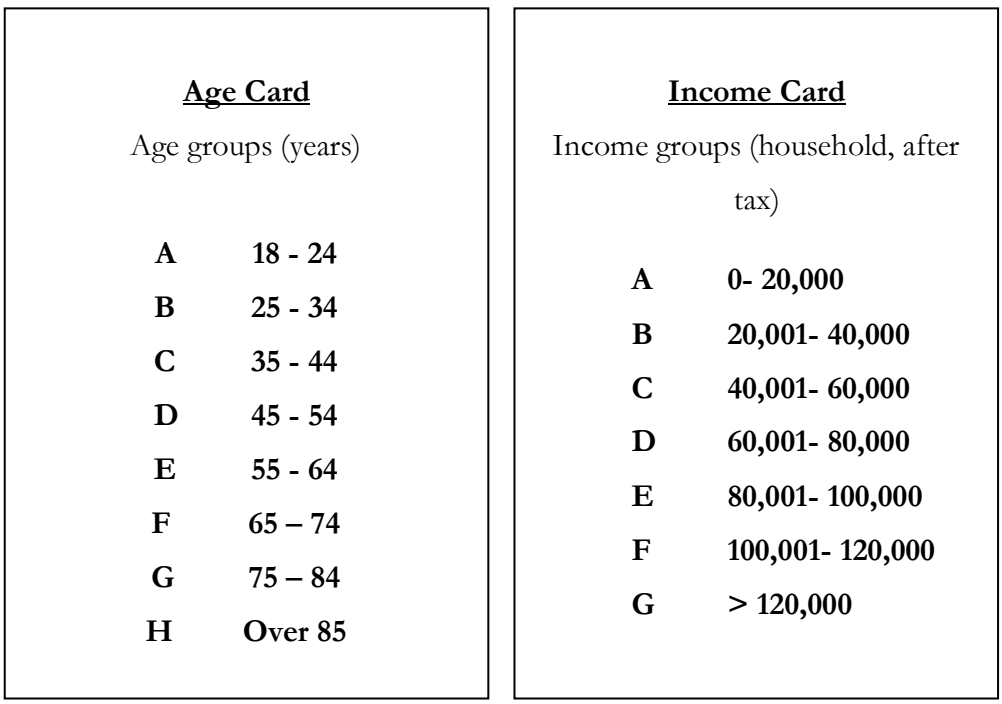

Figure 2.4 Age and Income category cards shown to participants.

2.4.3 SAMPLE SELECTION BIAS.

In this study, as in many studies of this nature, there exists the possibility for sample selection bias. In relation to this research, the selection bias manifests itself in the data collection process. During the process efforts were made to vary survey times, throughout the day and in the evenings in an attempt to collect responses from the population who either work during the day and so would be sampled in the evening, or work in the evening and therefore would sampled during the day. To eliminate sample bias regarding this issue, all houses should each have been sampled up to three times (until a response from a resident was gained), once during the day, once in the evening, and perhaps once at the weekend in order to sample residents who may work during the day but have an active social life in the evening, for example. However, time restraints and the large survey population (for all MR sites) meant that the author could only attempt to survey each household once. It is noted that the main cause of sample selection bias was the survey design. Although splitting the survey population with regards to the four MR sites was chosen for specific and valid reasons, the sample size could have been greatly increased by treating all the catchments as one population.

2.4.4 PROTEST ANSWERS.

When using questionnaires to gather information from the public, one must take into consideration that the answers that the participant gave may not be what they truly think, in this case, what they are truly willing to pay. Any deviation of a stated willingness to pay amount from an actual value, could be caused by a number of influences, these influences, or biases, can be grouped into three categories (Halstead *et al*., 1992):

1. Participant biases are in response to a mechanism in the survey itself (Morrison *et al*., 2000). This is most likely to occur if the participant objects to the payment method, rather than objecting to the reason for paying. The author attempted to mitigate this issue through the thorough research of appropriate payment mechanisms using focus groups. As previously stated, council tax was chosen for several reasons, one of them being that it is a widely understood concept. This could also have occurred in the form of ‘anchoring bias’. By suggesting a payment amount to the participant (i.e. £10 for Maintenance, £6 for Access) anchor bias may have occurred if the participant was influenced by the suggestion of a price

(O'Conor *et al*., 1999). An attempt to diminish anchor bias was made in the survey through the additional CV question; however it is still possible that bias may have occurred. This effect could have been eradicated by not suggesting an initial WTP price; however it did help to build a rapport between the interviewer and interviewee, which was also important.

2. A bias is caused because the participant is nonresponsive to the survey, either in part or in full. All surveys were conducted face- to- face partly to reduce the possibility of partially completed questionnaires, as opposed to postal surveys in which the completion of the questionnaire cannot be monitored until they are received. All partially completed surveys were discarded from the data set.

3. 'Protest' bias occurs, which refers to when a participant states a lower or higher price than their true value amount. A value of 0 (zero bid), and answering 'no' to the valuation questions could be seen as a protest bid. It is important in any survey involving the public that the participant has an option to say 'no' to any question asked of them. This causes problems in stated preference questionnaires, as zero bid responses could be interpreted as protest bids, rather than a genuine willingness to pay amount. However, not all zero bids were automatically excluded from the data set. It would be wrong to discard all zero bids from the data set on the assumption they are protest answers, as they may be genuine valuations. Therefore it is important from the interviewers' point of view to know why the participant may not be willing to pay anything. The researcher attempted to mitigate the potential confusion surrounding this issue. For each question that the participant answers 'no', they are given a card with a selection of reasons and asked to choose the one that most represents why they said 'no' (Figure 2.5) (Dziegielewska & Mendelsohn, 2007).

All the questionnaires with a zero bid were reviewed immediately after the interview was finished. A judgement was made by the author on whether to include the survey in the data set. This judgement was strictly based on: participant reasoning for not paying (Figure 2.5); the level of understanding of the questions and hypothetical scenario the participant showed; their income coupled with family dynamic (e.g. how many children they had); their prior knowledge and use of the site; their visit frequency to the site; and their geographical distance from the site. For example, non-protest answers were initially identified if they chose any of the

options A to E, and protest bids as those who chose option F, G or H. A respondent was identified as a protestor because choosing F, G or H suggests they have not understood the hypothetical nature if the question, and therefore their answer does not represent an accurate value for the societal benefits provided by the site. In addition to their reason for not paying, if a participant chose reason A and had used the site more than twice in the last twelve months, but showed good understanding of the hypothetical nature of the valuation technique, had a relatively modest income and children to provide for, their zero bid was accepted as a true value on the basis that they had understood the valuation technique and could not afford to pay anything.

Whilst conducting the interviews, the author also challenged any bid that was a lot more than the question suggested, as this may have been an example of the participant yea-saying. Yea-saying can occur if the interviewer is knowingly or unknowingly encouraging the participant to give a higher WTP amount than they would normally, because they want to please the interviewer. The author used the other information gathered in the process of the interview to make an informed judgement as to whether the participant was yea-saying, or if their valuation was genuine (Holmes & Kramer, 1995).

However if the participant is retired, their income may not reflect how much they would be comfortable paying each month, especially if they visit the site regularly or live in an area that may be of high flood risk, and so will value the sites highly for the flood protection they provide. In instances where the participant is of relatively modest income compared to their WTP value, does not visit the site on a regular basis or show a particular interest in the site, it may be concluded that their value can be accepted as 'yea-saying', and discarded from the data set. If the participant WTP amount was unusually high, but the participant was not yea-saying, the value was included in the data set.

'NO' options card.

A. I cannot afford to pay, but I would do

B. It is not a priority for me

C. I do not use or visit the site

D. I am not interested in the wetland environment

E. I do not value any of the benefits of the site

F. The organisation that created the site should not charge for access

G. I object to paying higher taxes

H. I do not trust the government to use the funds as intended

Figure 2.5 Options card shown to respondents if they chose 'No Maintenance' or 'No Access'

2.5 Ecological valuation.

This study recognises the inherent importance of understanding the ecological status of a site whilst deriving the economic value for its societal benefits. The concept of analysing the environmental status of a particular area takes into account the structure, functioning and processes of the ecosystem, together with natural physiographic, geographic and climatic factors (Borja *et al*., 2010). Borja *et al*. (2011) suggest that the development of an analysis strategy such as this should be aimed at the conservation of ecosystems, and through an integrated ecosystem-based approach should consider all protected areas, and the numerous influences that human activities have on the environment. Although this framework is specified for a marine environment, the concept of considering the human influences as well as the ecological characteristics when valuing an ecosystem is one that can be applied to many situations (Borja *et al*., 2008; Browman *et al*., 2004).

The importance of understanding the mutual influential effect between ecosystem function and human well-being are further discussed in Fisher *et al*. (2011). Although to date this subject has only been studied marginally in the field of economics, the number of articles regarding topics such as the benefit of ecosystem conservation and payments for ecosystem services has steadily increased in the past few years (Fisher *et al*., 2011). Ricketts *et al*. (2004) in their study into the benefits of the provisioning service of pollination on coffee production, found that an increase in this service directly resulted in positive financial returns, largely

exceeding the coffee farms present conservation incentive payments. The importance of incorporating ecological diversity and species composition into valuation models for ecological and economic valuation of environmental areas has also shown that increase biodiversity leads to an improvement in ecosystem service provision (Tilman *et al*., 2005); and greater biodiversity in environmental areas is essential, as it ensures the continuation of ecosystem services as spatial and temporal variabilities change, and therefore ensures the continuation of societal benefits (Hooper *et al*., 2005).

Within the time and monetary constraints of this project, the author was unable to conduct primary ecological research as well as socio-economic research; however an understanding of the sites' ecological status was required in order to value their societal benefits accordingly. Therefore, monitoring reports were obtained from ABPmer, EA, and from postgraduate students and fish ecologists in IECS who research several aspects of the MR sites. Although no statistical analysis will be conducted including the sites' ecological characteristics, subsequent discussion of the socio-economic results will discuss the influence that each of the sites' ecological characteristics has on both participant WTP values and the level of importance they place on each of the societal benefits, in the contingent ranking question.

2.5.1 VEGETATION ASSEMBLAGE.

The development of vegetation in an MR site is crucial in terms of the nesting habitat it provides for birds (Gonzalez-Gajardo, 2009), the nursery habitat it provides for juvenile fish (Fonseca, 2009), as a buffer to absorb wave energy (Moller *et al*., 1999, 2001), and is an important addition to the aesthetic qualities of the site. Therefore the speed of colonisation of wetland plants in MR sites after they have been breached inevitably will an important influencing factor on the other societal benefits supplied by the site.

In the past few years, studies have shown that it may take several years before the vegetation inside the MR site resembles that of a similar site or reference situation (Garbutt *et al*. 2002). Slow development can be caused by inefficient dispersal of the target species (Onaindia et al., 2001; Bakker et al., 2002; Bischoff 2002; Bissels et al., 2004; Wolters et al., 2005), unsuitable environmental conditions such as

sediment deficit which prohibit establishment of plant species (Morris et al., 2004), or bioturbation and herbivory caused by invertebrate species such as the polychaetes *Hediste* and *Polydora* which could also affect colonisation of pioneer plants (Hughes & Paramor, 2004). Some recreated wetlands may take just a few years before pioneer species are established at the site, and therefore show a relatively quick development time compared to terrestrial sites such as woodlands, which may need several hundred years before they reach a similar level of development (Morris et al., 2006).

Researching an MR site's vegetation cover involves mapping the area, usually using Geographic Information Systems (GIS) or Differential Global Positioning Systems (dGPS) techniques to obtain a clear view of the separate vegetation areas within the site. From this information, an informed overview can be made on how the site's habitats are developing, and predictions can be made on which faunal species can be expected and a time frame for colonisation. The biological monitoring of the vegetation and mapping of its progress is important when considering the overall value of the MR sites in terms of its societal benefits, as the benefits that are provided by these MR sites are a product of their ecological development, such as the importance of vegetation cover to the aestheticism of the site, and subsequent participant willingness to pay amount for this societal benefit.

2.5.2 BIRDS AND INVERTEBRATES.

Birds often represent the highest predator in the ecosystems food chain, and so can be an indicator of the overall health of the system. Invertebrates are the main diet of the majority of wetland bird species, and so in newly developing saltmarshes if there is an abundance of invertebrates, it is likely that birds will populate the site. The food source provided by invertebrate fauna in wetlands is thought to represent important stops for weight gain during wading birds' migration (Little, 2000). Therefore the use of birds and invertebrates to assess the health of a saltmarsh ecosystem can be a useful management tool.

Many studies have been conducted into the preferences of wetland birds and the factors which can affect their abundance and diversity, as well as their breeding and feeding. DeLuca *et al.* (2004) used assemblages of birds as indicators to show if increased human population affected the saltmarsh organisms. Their analysis

indicated that the integrity of the saltmarsh bird community was significantly decreased when the amount of urban / suburban development increased. It was also suggested by Stillman *et al.* (2005) that bird populations can be an indication of the wetlands' carrying capacity, although it is important to consider both prey availability and spatial restrictions; wetland birds are sensitive to changes in the size of the area they inhabit, and higher densities of birds will be found on wider marshes than narrow ones (Goss-Custard & Yates, 1992).

Burger *et al.* (1982) studied the differences in bird usage between impoundments, ditched marshes and natural marshes. Their results showed that although bird diversity was highest in the impoundments and lowest in the natural saltmarsh, the species that were present in the natural saltmarsh were those that would typically appear there, whilst these species were absent from the impoundments. This study suggested that conservationists should encourage the maintenance of natural saltmarshes, as they are necessary habitats for some species, even though diversity and abundance may be lower.

Variation in intertidal bird species richness at a site can be affected by the vegetation cover of the area (Gonzalez-Gajardo, 2009). Edwards & Otis (1999) studies the impact of vegetation cover specifically in relation to beaver ponds in South Carolina (US) and research suggested that in terms of vegetation, significant variables included vegetation interspersion, patch evenness, plant richness and total area coverage, with higher patch cover correlating to higher abundance of regional waterbird and waterfowl species, as well as neotropical migrants. In northern European intertidal areas, birds commonly seen such as widgeon will forage in vegetation for seeds, and so are attracted by vegetation coverage to feed directly. Other intertidal birds such as waders including redshanks and oystercatchers, will initially come to an MR site for the invertebrates provided in the mudflat, but will use the vegetation on the saltmarsh to nest and breed (Nick Cutts, IECS *pers comm.)* The reed beds that develop in MR sites are also of importance to marsh harriers and bittern. Both species breed in reed beds, and the provision of breeding space for these species is becoming increasingly important as both are included in Annex I of the EC Birds Directive, Appendix II of the Bern Convention, the Birds of Conservation Concern Red List, and are Protected in the UK under schedule 1 of the Wildlife and Countryside Act (RSPB).

The methodology for recording bird counts on MR sites is largely an accepted protocol throughout northern Europe. Depending on the size of the site, the researcher would divide the area into appropriately sized sections, based on habitat or using GIS techniques for larger sites. Using binoculars and telescopes, block counts of the number of birds in each section are taken, and different species are identified. The count is also divided into whether the birds are foraging or roosting. This provides the researcher with an overview as to how different species are using the site, and can help determine whether the site is meeting any expectations made prior to creation. Any disturbances at the site are recorded, such as the presence of members of the public, any aircraft in close vicinity, and the presence or absence of raptor species such as marsh harrier. Counts are taken at spring tide to ensure the maximum possible of birds are present, and depending on how many people are in the research team, counts are taken once an hour, so seven over one tidal period, or once each at low tide, mid tide and high tide. The former is mostly preferred and strived to by research teams, as a much clearer picture of bird use at the site is obtained (James Spencer (Consultant Ornithologist) *pers. comm*.).

2.5.3 FISH ASSEMBLAGES.

Food provision is a societal benefit, and although there is no direct fishing on a commercial scale at the MR sites, they are important nursery areas for the juvenile fish that will eventually join the wider estuary and become part of the fish catch. The importance of intertidal areas for fish species has been recognised for a number of years. For example, McHugh (1966) stated that '2/3 of the catch of commercially important fish is dependent on the inter-tidal estuarine habitat for the growth of young fish' and it was recognised in the late 1970s that 'saltmarsh provides important refuge habitat for fish larvae and early fry' (Shenker *et al.*, 1979). The majority of the available literature is based upon the North American wetlands, with less emphasis being placed on European estuarine intertidal systems (Stevenson, 2002), although it is recognised that these intertidal habitats play important roles for fish communities (Elliott & Taylor, 1989; McLusky, 1990; Laffaille *et al.*, 2000; Mathieson *et al*., 2000; Elliott & Whitfield, 2011).

In the UK, recent work undertaken by the EA and others has shown that saltmarsh provides very important functions (feeding, nursery and refuge areas) for fish species, particularly within managed realignment sites (see Colclough *et al.*, 2005;

Fonseca, 2009). Colclough *et al.* (2005) investigated the ecological benefit of MR habitat for fish species, by comparing the fish communities found within three sites in the Thames Estuary, and two sites within the Blackwater Estuary. Their study reported a positive relationship between the degree of fish utilisation and habitat heterogeneity using species richness, abundance and behavioural observations. This work was further developed by Fonseca (2009), under the European Interreg IIIb project, COMCOAST, who investigated fish utilisation of saltmarsh at three MR sites (Abbotts Hall, Tollesbury and Orplands) in the Blackwater Estuary, SE England between 2005 and 2007. Results showed that the sites were being used by three different fish assemblages, determined by the seasonal period the sampling was taken in.

Field sampling in a project such as this is typical of the methodology used widely. A suite of catch methods are usually used, both to ensure fish of all sizes and ages are caught, and to prevent gear bias. This also increases the range of species, and improves the overall quality of the dataset (Pérez-Dominguez, 2008). Initially, the site in question is divided into sections, and sampling stations within the sections are identified and marked, and GPS coordinates are noted on the first sampling trip, to aid subsequent sampling at the site and to mitigate the number of repeat sampling error due to sampling different areas. Gear types used include fyke nets, bottle traps and seine nets (Pérez-Dominguez, 2008).

2.6 Statistical analysis.

Both the socio- economic data and the ecological observations were analysed on a site by site basis. It was important that the MR sites were treated differently initially, as they differ from each other in their physical characteristics, and this was accounted for in possible reasoning for individual participant WTP amounts for both maintenance and access. By treating evidence collected from each site as a separate data set, we can see a clear distinction between what characteristics of that particular site may encourage someone to pay for maintenance or access, as well as taking into account what socio- demographic details may also have an effect. A suite of statistical techniques are used on the data set in order to gain a complex understanding of the reasons behind participant WTP, which will in turn inform the important elements in MR in terms of their societal benefits. It is expected that the information obtained describing the ecological status of each site will inform the reasons behind specific WTP amounts through the differentiation of the four

separate sites, developing a clear overview of the MR sites' values in terms of their societal benefits.

2.6.1 DATA EXPLORATION AND IDENTIFICATION OF OUTLIERS.

As with any statistical analysis, the data requires a thorough exploration before any models can be formed. It is important that several primary methods are used to look at how the data is distributed and existence of inherent assumptions, if there are any obvious relationships between variables, and to identify outliers or extreme variables in the data. An outlier is a data point that is significantly different from the rest of the data, and thus could potentially incorrectly influence any analysis conducted on the data set, for example if twenty people were each willing to pay £5 for an item, but one person was willing to pay £20 for the same item, this value would be considered an outlier. Outliers can also occur if a group of people are under-represented within a variable, such as if there is only one participant representative for a certain income bracket or age group, or if the wrong model is considered in terms of any skewness in the data.

The Kolmogorov-Smirnov and Shapiro-Wilk tests were performed on the data in its various different sets to tests for normality in the distribution of data. Non-significance ($p > 0.05$) suggests that the distribution of the sample is not significantly different from a normal distribution, and therefore the data set is likely to have a normal distribution. Conversely, if the test is significant ($p < 0.05$), it can be deduced that the data distribution is significantly different from a normal distribution, and is therefore non- normal (Field, 2000).

Boxplots were used to visualise the mean and spread of each univariate variable, and conditional boxplots were used to show relationships between the continuous response WTP variables and the nominal and ordinal explanatory variables. Extreme variables and outliers were identified through the boxplots, and removed gradually to test the differences in the mean and spread of the data set without them. However, the extreme variables and outliers identified in this process (shown on the graphs as * and º respectively) were not excluded from the data set on this basis alone. Cleveland dotplots (Cleveland, 1985) are primarily used to identify outliers and homogeneity, which is an important assumption for many statistical methods. The profile of the dots within the plot can easily identify those categories

with few, or singular cases and would perhaps then qualify as outliers. The boxplots alone may identify some values as outliers, when they should not be classed so, therefore it is useful to compare boxplots and dotplots, as this can explain why boxplots may have identified some points as outliers (Zuur *et al*., 2007).

Outliers in the response variable can be complicated to resolve. Although transforming the data is an option, the response variable is of primary interest and therefore it is considered more appropriate to choose a statistical method that uses a probability distribution that allows greater variation for large mean values (e.g. Poisson or negative binomial generalised linear modelling for count data) as this means analysis can continue with the original data (Zuur et al., 2009).

The nature of the data gathered in this study means that there are a number of explanatory variables that could have a significant relationship with the response variables. Because of this, it was important to use techniques that could accommodate the use of more than one variable. Coplots (or bivariate scatterplots) were used initially, as they are a conditional scatterplot which can show the relationship between the response variable *x* and an explanatory variable *y*, for different values of a second explanatory variable *z*, or even third explanatory variable *w*. The conditioning variables can be nominal or continuous, which is useful when a data set has different forms of values in it (Zuur *et al*., 2007), for example in the data set used in this study, coplots were designed to look at the relationship between WTP values and distance, for a nominal or ordinal explanatory variable such as income, age or gender. Regression lines were added to the graphs, if all boxes within the coplot showed a similar negative trend, it could be deduced that there was no, or very little, relationship between the explanatory and response variables. For data sets such as this one, knowing which variables did not have a significant relationship is just as important as knowing those which have a significant relationship (Zuur *et al*., 2007).

2.6.2 PEARSON'S CHI SQUARE (X^2) ANALYSIS.

Once it was established through the initial exploratory analysis that certain variables had a relationship, X^2 analysis was used to test whether these relationships were statistically significant. As X^2 tests the significance of relationships between categorical variables rather than continuous ones, the response variables (WTP

Maintenance and Access) and the explanatory variable 'Distance' were converted manually into ordinal measurements. To validate the X^2, all expected counts were checked to make sure they were over 5. As these tables can be classed as larger contingency tables, it is seen as acceptable to have up to 20% of expected frequencies below 5 and none below 1. The result is a loss of statistical power, but the solution is to collect more data so more observations are available for the categories with low expected frequencies. However, the collection of more data was beyond the time scope of this study. If any of the expected frequencies did not fall within the criteria, a Spearman's Rank Order (ρ) was used to check the significance level of the relationship between the two variables being tested.

2.6.3 PRINCIPAL COMPONENT ANALYSIS.

Following the initial exploratory analysis, Principal Component Analysis (PCA) was used in order to reduce the dimensionality of the data set, whilst retaining as much of the variation as possible (Jolliffe, 2002). The main reasons for using PCA are to extract the most important information from the data, compress the size of the data set by only keeping the most important information, simplify the description of the data set, and analyse the structure of the observations and the variables (Abdi & Williams, 2010). These goals are attained by transforming the variables into principal components, a new set of variables which are uncorrelated but ordered so that the first few retain most of the variation present in all of the original variables (Joliffe, 2002). It does this by extracting the important information from the data and representing it as a new set of orthogonal variables called principal components (Abdi & Williams, 2010).

Not all factors are retained in the analysis, and to decide which factors would be suitable to keep in the analysis, both scree plots made from the data, and Kaiser's (1960) recommended criterion of retaining all factors with eigenvalues greater than 1 were observed, and a judgement made for each data set. The scree plots graph the eigenvalues, and allow a visual representation of the relative importance of each factor, and a decision on how many factors to include can be made based on the point of inflexion on the graph. However it is always prudent to judge such decisions on more than one determining method, and Kaiser's rule is based on the idea that the eigenvalues represent the amount of variation explained by a factor, and an eigenvalue of 1 represents a substantial amount of variation (Kaiser, 1960).

Therefore, both these methods are used in the initial stages of the PCA to determine how many factors should be included.

2.6.4 GENERALISED LINEAR MODELLING.

Generalised Linear Modelling (GLM) is a particularly useful technique with regards to this data set, as it a technique used to model the relationship between a response variable and several explanatory variables. It has been likened to multiple linear regression (Zuur *et al*., 2007), however in multiple regression the observed response variable and the values predicted by the multiple regression model are linked linearly. In GLM a link function is defined which allows the predicted values to be transformed to a variety of distributions. This means that many different types of response and explanatory variable involved may be continuous, ordinal or nominal, in any combination of both types. This was a crucial factor in the decision to use GLM, as all three types of variable measurement are included in the data sets, and it was important to be able to analyse them all together in order to examine the statistical significance of the several explanatory variables on the response variable (WTP). GLM was used in conjunction with PCA, as although PCA can be used to analyse data of different measurement types through the use of eigenvalues, it lacks the predictive power of GLM and therefore it was important that both techniques were used to model the data (Atkinson *et al*., 1998).

Akaike's Information Criterion (AIC) was used for the model selection in the statistical package 'r', as already stated, in order to estimate the initial adequacy of the Poisson model (Mazerolle, 2006). The response variables are continuous, and therefore for this analysis the data are classed as Poisson distributed, and therefore the Poisson model is most appropriate. As the majority of the explanatory variables are ordinal or nominal, they were factored in 'r'. The Poisson model was tested for overdispersion, and if the AIC value was >1-1.5, the model was classed as overdispersed and was modelled again with a dispersion parameter, and Quasi-Poisson GLM was used. Ignoring overdispersion can lead to erroneous conclusions, as introducing an overdispersion parameter means that all estimated standard errors are multiplied with the square root of the dispersion parameter. The estimated regression parameters in this model are less significant, as the *t*-values are divided by the square root of the dispersion parameter; however ignoring overdispersion frequently results in wrongly identifying a variable as significant (Zuur *et al*., 2007).

2.6.5 DECISION TREE ANALYSIS.

Classification and regression trees are a further tool to analyse the relationship between one response variable and several explanatory variables. The procedure creates a tree based classification model, which classifies cases into groups or predicts values of a response variable based on values of explanatory variables. Classification and regression trees provide validation tools for exploratory and confirmatory classification analysis. This procedure has several uses, it can be used for segmentation of the data, to identify those who are likely to be members of a particular group; stratification, where cases are assigned to one of several categories, for example a high, medium or low risk group; prediction, where rules are created which can be used to predict future events, such as the likelihood that a person will default on a loan, or whether they are likely to pay for maintenance of a managed realignment site; data reduction and variable screening, where a useful subset of predictors can be selected from a large set or variables in order to build a formal parametric model; interaction identification, where relationships can be identified that relate only to specific subgroups and can be specified in formal statistical models (Zuur *et al*., 2007).

As with GLM, this technique is particularly useful in this study because both ordinal and nominal measured explanatory variables can be used in the same analysis (De'Ath & Fabricus, 2000; Venables & Ripley, 2002; Maindonald & Braun, 2003; Zuur *et al*., 2007). Classification and regression trees were originally most prominent in the medical profession, where they were used to assess whether a patient was high risk or not, in relation to approximately 19 different health variables that were measured during the first 24 hours of admission, e.g. blood pressure and age (Breiman et al., 1984). This analysis technique has since been used in many different fields, as the tree models handle non-linearity and interaction between explanatory variables better then regression, GLM and generalised additive models, and can be used to find interactions otherwise missed by other methods. They are also of great use in this study, as they indicate the relative importance of each explanatory variable in relation to the response variables, and also the importance of each category within ordinal variables (Zuur *et al*., 2007). Although decision trees may be better suited to handling the interaction between response and explanatory variables than traditional regression or GLM techniques, they are less suited for hypothesis testing and are less predictive. Therefore decision trees serve as a useful tool to use alongside GLM, providing a full analysis of the data set.

Decision trees analyse the data by sorting through the explanatory variables and progressively splitting each variable into subgroups in order to give the best classification or prediction of significance to the response variable, in this case the willingness to pay values for maintenance and access. So the first variable identified and split in the tree analysis will also be the best variable to split the cases. The degree of success in the 'split' is defined by the impurity level of the subgroups, and in addition to selecting the best variable to split the cases by; the tree analysis defines cut-off rules which define the split. This process is applied by the tree analysis at each stage, defining the sub-groups, until the designated stopping criteria for the model are met and the analysis is finished (Atkins *et al*., 2007). The decision tree analysis package for SPSS allows a lot of choice in terms of growing methods for the model and pruning criteria. For growing methods, Chi-squared Automatic Interaction Detection (CHAID), Exhaustive CHAID, and Classification and Regression Trees (CRT) (a specific growing method) were all considered (Quick, Unbiased, Efficient, Statistical Tree (QUEST) was ruled out initially as response variables must be nominal). There are benefits and limitations with each model, as summarised in Table 2.2.

Table 2.3 Key features of the two primary decision tree growing methods (SPSS decision tree guide, 2012).

	CHAID and Exhaustive CHAID	CRT
Chi-square based	X	
Surrogate explanatory variables		X
Tree pruning		X
Multiway node splitting	X	
Binary node splitting		X
Influence variables	X	X
Prior probabilities		X
Misclassification costs	X	X
Fast calculation	X	

For the analysis of this data, CRT was selected as this method is a binary tree algorithm, which means the data is divided into two subsets and the samples within each subset are more homogenous than the previous subset. This process repeats until a predefined measure of homogeneity is met, with variables sometimes being

used a number of times within the same tree with emphasis on different categories within the variable. This means that the results are very specific to not only the variables that have the largest predictive power, but also the categories within the variables that have the largest predictive power, for example a specific age group or income bracket.

2.6.6 MODEL VALIDATION.

Validation of any statistical model is always essential (Zuur *et al*., 2010). Validation in a tree model allows the assessment of how well the tree structure generalises to a larger population. This can be accomplished through split sample validation, or cross-validation. Cross validation was used for these decision trees, which involves dividing the sample into a number of subsamples, or folds. The decision tree models are then generated, each time excluding the data from one fold, therefore the first tree is based on all of the cases except those in the first sample fold, and the second based on the all of the cases except those in the second sample fold, and so on. The misclassification risk for each tree is estimated by applying the tree to the subsample excluded when it was generated (Atkins *et al*., 2007). Cross validation is preferred in this case to split-sample validation, as cross validation produced a single, final tree model (Murtaugh, 2009). The cross validated risk estimate for the final tree is calculated as the average of the risks for all of the trees. Split sample validation was not used for the purpose of keeping the model standardised across the four MR sites, as it is not advisable to use split sample validation on smaller data files. The data set for Welwick MR site has less than 75 cases, and therefore a ten-fold cross validation was used for all the MR data sets.

It is also important to apply stopping and growing rules, and to specify options for pruning the tree, so the size of the final tree is controlled, and does not produce nodes (final branches) that are not required or are not important to the data set (Zurr *et al*., 2007). For this study, the maximum tree depth was set to 5 and the minimum number of cases for parent nodes and child nodes were 100 and 50 respectively. The CRT growing method attempts to maximise within-node homogeneity. The extent to which a node does not represent a homogenous subset of cases is an indication of its ‘impurity’. The least-squared deviation (LSD) measure of impurity is used for continuous response variables. It is calculated as the variance within each node, and is adjusted for any frequency weights or influence values. The tree model

was also ‘pruned’ to avoid overfitting. After the tree is grown to its full depth, pruning trims the tree down to the smallest subtree that has an acceptable risk value. The risk value is expressed in standard errors, the maximum acceptable difference in risk between the pruned tree and the subtree with the smallest risk is entered on a scale of 0-1, 1 creates a simpler tree, 0 creates a tree with the smallest risk (Zuur *et al*., 2007).

Model validation for GLM is based on analysis of the residuals. The residuals are an estimate of the unobservable statistical error; it is typically the difference between a sample and its estimated value from the data (Cleasby & Nakagawa, 2011). The models’ extracted standardised residuals are plotted against the fitted values, the theoretical quantiles, and in a histogram to check for homogeneity of variance and whether they are normally distributed or not (Zuur *et al*., 2009).

2.7 Conclusion.

This chapter has presented the possible techniques that can be used to value MR sites in terms of their societal benefits. It has also outlined the techniques that were used for this research, and the reasons why they were chosen for this study, as well as possible problems that could occur from using these techniques. The important points taken from this chapter are the importance of using a suite of techniques in the methodology in order to value the sites fully both ecologically and economically, the importance of validating any statistical methods used, and to acknowledge possible limitations of the experimental design, so they can be addressed accordingly where possible.

CHAPTER 3

3. VALUATION OF SOCIETAL BENEFITS: PAULL HOLME STRAYS.

3.1 Introduction.

This chapter will attempt to ecologically and economically value the societal benefits provided by Paull Holme Strays (PHS) MR site. The main socio-demographic influences on willingness to pay responses will also be analysed, as well as the possible reasons for their influence.

The MR site will be described; including its position within the Humber estuary and the main reasons it was created, followed by a summary of the site's ecological characteristics including vegetation assemblages and bird, fish and invertebrate abundances and diversities. This will give a comprehensive overview of the site's ecological status, with the aim to better inform the reasons behind participant WTP values for both maintenance and access.

Various statistical techniques are used to thoroughly analyse data obtained from the interview survey questionnaires, to examine which socio- demographic factors may influence participant WTP values, as well as how much they are willing to pay on an annual basis for both maintenance and access to the site. The relative importance of the societal benefits in question will also be explored through the analysis of the contingent ranking data. This will offer insight into why a participant is willing to pay their stated amount.

Finally, a summary and discussion of the results will be provided, revealing the statistically significant characteristics which influence WTP values, which societal benefits are considered the most important, and possible reasons behind specific WTP values.

3.2 Site description.

PHS is situated on the North bank of the Humber, approximately 10 km east of the city of Hull, and around 35 km from the North Sea at Spurn Point, giving it a middle estuary position (see Appendix I). PHS was breached in 2003, as the first major managed realignment site established by the Environment Agency on the estuary.

The main objectives of the PHS managed realignment site were to primarily provide a cost effective method for flood risk management in the area; create intertidal habitat to compensate for the loss of implementing this process and other flood defence schemes in the middle estuary area; and to address additional habitat losses arising from coastal squeeze, which was identified in the EAs Coastal Habitat Management Plan (CHaMP) (Hemingway *et al*., 2008).

Two breaches in the flood embankment were made below the lowest natural ground level within the site; this ensured drainage in the first year of creation, the rest of the flood embankment remained in its original position, approximately 2100m. Before the site was breached in 2003, it was anticipated that approximately 45ha of mudflat and 35ha of saltmarsh would be ultimately created. The area is directly behind the vast Paull Holme Sands mudflat, and is adjacent to the Humber Estuary Special Protection Area (SPA); Ramsar site, and candidate Special Area of Conservation (cSAC) which is involved in forming part of the Natura 2000 network of European sites.

The site cost a total of £7.4 million to create, and called for a 5 year management programme to monitor accretion and erosion rates at the site, as well as assess the progression of specified flora and fauna. Specific targets were set by the EA detailing the species and numbers of birds required to use the site in order to ensure the site is providing a functioning intertidal habitat (Hemingway *et al*., 2008). Initial results from the accretion and erosion monitoring programmes showed that the sediment accretion within the managed realignment site was ongoing throughout the time frame, although the rate slowed as time passed (Boyes & Allen, 2007). The first 5 years of monitoring revealed that the habitats and communities within the site were still at an early stage of development, therefore the monitoring programme was extended to 2013 in order to fully assess whether or not the site will meet its objectives (Mazik & Cutts, 2012).

PHS has become increasingly ‘visitor friendly’ since it was created. There is a small car park nearby available to visitors, and limited disabled access, encouraging different types of people to visit the nature site. The Yorkshire Wildlife Trust also organise gatherings at the site, where the public can be lead on a nature walk, and taught to identify species they are likely to see at the site.

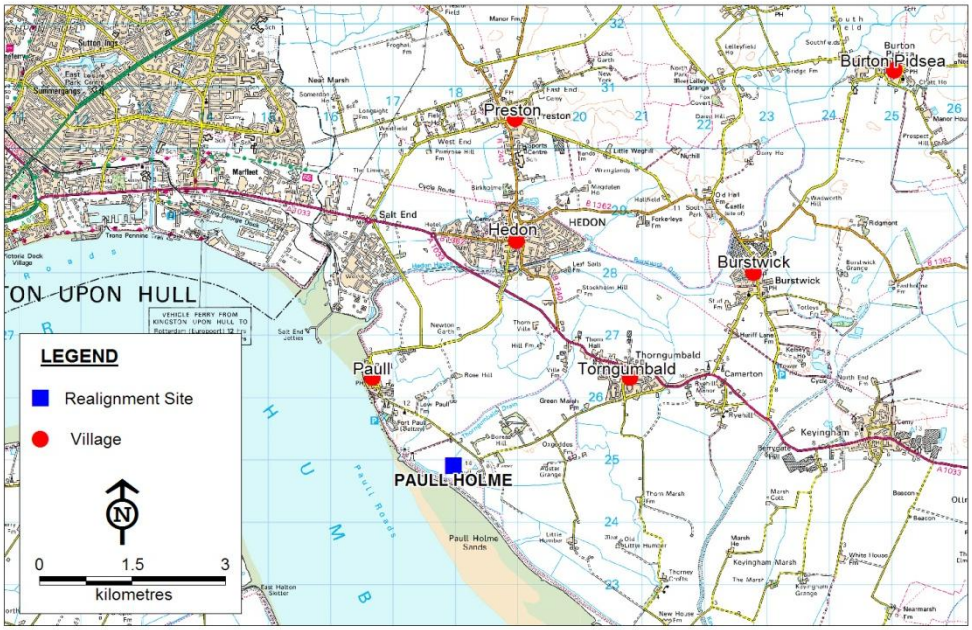

Figure 3.1 Map showing PHS MR site and surrounding villages within 7 mile travel distance.

3.3 Ecological overview.

It is important to give an ecological overview of the site, because how the site develops ecologically over time may affect its importance in terms of birds and other nature, its efficiency for disturbance prevention, and its aesthetics. As well as the overall objectives facing MR sites, PHS has an individual objective to create functioning inter tidal habitat and achieve 3000 individual and 30 species of birds (EA, 2010), and therefore an idea of the site ecological status will inform as to whether the site is fulfilling its individual objective or not, and whether it is likely to have an effect on the valuation of the sites societal benefits.

3.3.1 VEGETATION COVERAGE.

The initial 5 year monitoring programme revealed that by 2007, all plant species that were recorded outside the MR site were also recorded inside the site, approximately 23 species in total. In addition, very few of the species present before the site was breached still remained, and those that did were in low abundances (Hemingway *et al*., 2008).

In general, vegetation cover (i.e. colonisation by saltmarsh plants) has shown to increase both as elevation increases (elevation is a function of the frequency and

duration of tidal inundation, water depth and sediment accretion rate), and with the time since the site was breached/ created (Brown, 2009). At lower elevations (2.21-2.8 m), areas were mostly dominated by *Spartina anglica* with smaller patches of *Puccinella maritima* also present, *S. anglica* and *P. maritima* also showed a high abundance at the elevation between 3.01- 3.2m, in addition to patches of *Aster tripolium*. In elevations above 3.2m, these three species were present again, along with *Atriplex prostrata*, *Elytrigia atherica*, *Spergularia media* and *Cochlearia* sp (Mazik & Cutts, 2012).

Accretion rates are important to the development of vegetation assemblages. The initial rapid accretion rates that are seen in the lower elevations in areas such as PHS result in the development of areas that are suitable for colonisation by pioneer satlmarsh vegetation, which spread as the slower accretion rates gradually mean more areas are suitable for saltmarsh colonisation (Brown, 2009)

3.3.2 INVERTEBRATES.

In the monitoring reports conducted in 2004, a year after the site was breached, the oligochaete Paranais litoralis dominated the benthic fauna, however by 2006 and 2007 there had been a distinct shift in dominance from early colonising species to those more typical of an estuarine environment, such as *Hediste diversicolor*, *Hydrobia ulvae* and Collembola (Mazik *et al*., 2007). By 2007, a general shift had occurred from many small invertebrates to an increased number of larger invertebrates, meaning the overall biomass inside the site now resembled the biomass outside the site (Hemingway *et al*., 2008).

The results from monitoring at the site from 2009 and 2010 showed that the distribution of key species was now closely related to their elevation in the site. Nematoda and Enchytraeidae were recorded at all elevations, but in the highest abundances below 2.4m. Species such as *Macoma balthica, Abra tenuis, Streblospio shrubsolii, Pygospio elegans, Tubificoides benedii* and *Heterochaeta costata* were generally not recorded at elevations above 2.6 m (Mazik & Cutts, 2012).

3.3.3 BIRDS.

Water birds were also observed, and during the first three years of the project a total of 34 species of waterfowl were recorded, including 19 species of wader and 11 species of wildfowl including Golden Plover, Teal, Curlew, Dunlin, Mallard, Redshank and Shelduck. Of these species, golden plover make up 39% of the total bird abundance per hectare. Initial colonisation of the site by wildfowl was quicker than by waders, although now the wildfowl usage is at a lower level than the waders. It is also notable that the bird assemblage has been modified over time towards one that is more characteristic of a middle estuary (Mander *et al*., 2007). Therefore, although the increase in saltmarsh will result in a decrease in the mudflat habitat for benthic invertebrates and foraging birds, an increase in saltmarsh will provide nesting sites for birds and high tide refuges. As a result the colonisation seen here will provide an important basis for the design and monitoring of further realignment schemes along the estuary (HARBASINS report, 2008).

There are seasonal trends in bird use at PHS, with more birds using the site in the winter months than the summer months, which follows patterns also seen outside the realignment site. The differences in habitat means birds tend to use the site for different things, feeding on the mudflat and roosting on the vegetation of the saltmarsh. Between June 2004 and June 2005, feeding and roosting were both observed within the realignment site and outside it. 60% of the feeding took place within the realignment site, and a few species such as Dunlin preferring to roost inside the realignment site. The large diversity of invertebrate fauna found on the productive mudflats at PHS means the site lends itself to colonisation by feeding birds.

In terms of location in the MR site, Dunlin, knot and bar-tailed godwit showed a clear preference for the lower elevation, mudflat habitat and were recorded only at low densities in the higher elevation vegetated areas, suggesting these species are at the site to feed rather than roost. There were no spatial patterns noted in the distribution of balck-tailed godwit, curlew or redshank, all three species were recorded throughout the area. Although shelduck were recorded in all areas between 2004 and 2006, since then their abundance has decreased in more elevated areas, and they have now shown to favour lower elevations. This may be a result of gradual colonisation by plants in the higher elevation areas making the

habitat less favourable for shelduck; or it could be that the higher elevations are areas of hard and dry mud, which are not used by shelduck.

3.3.4 FISH.

A total of 11 fish species were recorded (when using fyke nets) as using Paull Holme Strays for nursery and feeding grounds after three years of development since the site was breached. Species included bass, cod, eel, flounder, goby, herring, place, sole sprat and whiting, with flounder (*Platichthys flesus*) dominating the fish community overall (Swig, 2009). Fish species were found to have similar catch rates inside and outside of the managed realignment site, showing that colonisation has been successful, although the sizes of the fish were significantly smaller inside than outside the realignment zone (Perez-Dominguez, 2008). A seine net analysis during the same time frame revealed that although abundance of fish both inside the realignment site and outside at a reference natural habitat site were similar, the diversity of fish species was higher inside the MR site (Swig, 2009).

3.4 Survey population and response rates.

The survey population for PHS involved sampling all households within a seven mile travel radius of the site (Figure 3.1). All households in this area are grouped into six separate villages, mostly connected by only one or two roads, and surrounded by agricultural fields. All households were included in the sample population in an attempt to maximise the number of surveys completed, and provide a solid basis for statistical analysis (Table 3.1).

Table 3.1 Summary of survey population statistics (PHS).

Village	Number of households	Number of complete surveys	% complete surveys
Paull	337	35	10.39
Hedon	2692	135	5.01
Thorngumbald	1235	49	4.0
Burstwick	722	42	5.82
Burton Pidsea	390	23	5.9
Preston	1348	36	2.67
Total	6724	320	4.76

The percentage of completed surveys is relatively low in comparison to other research projects using surveys to elicit their data (Myatt-Bell et al., 2002, 2003a, 2003b (postal surveys); Luisetti et al., 2011 (interviews at a fixed location)), however in these studies the percentage of completed surveys is based upon slightly different ratios than this project.

In the postal studies, the researcher posts copies of the survey to all households in the sample population, return rates are based upon the percentage of completed surveys that are returned to the researcher. When the survey is conducted at a fixed location, the researcher stands in a public place such as a train station and attempts to interview people in the train station. The number of surveys attempted is taken as the total, and then the number fully completed is taken as the percentage of complete surveys. During this research, the author attempted to elicit a survey from every household in all the villages (all households were approached via knocking on the door/ ringing door bell). As a result, the total number of attempted surveys includes the households in which nobody answered the door, which in this case is the majority. There were 1402 households in which the owner answered the door but then refused to participate in the survey (Paull: 114; Hedon: 506; Thorngumbald: 342; Burstwick: 131; Burton Pidsea: 79; Preston: 230), and there were no instances of only partially completed surveys. Unfortunately, time constraints limited the researcher from revisiting each of the houses where there was no answer at the door. If the percentage of completed surveys were calculated according to every household who answered the door, the survey completion rate is 20.85%.

3.5 Data preparation.

As already discussed in chapter 2, the identification of outliers is essential when trying to explore and model the data. The main tools employed for the detection of outliers were dotplots and boxplots (Chapter 2). Three outliers were identified from the box plot and dotplot analysis, in each case they were the only observation in a particular category, therefore could not objectively represent that category and were removed from the data set. 5 respondents were also identified as giving ‘protest bids’ (Chapter 2) and therefore were also removed from the data set (Section 3.9).

As the surveys were interview based, quick and concise transcription of participant answers was essential to ensure all relevant information was recorded correctly. As

a result some variables were recorded in binary or continuous format, which then required them to be aggregated. A full summary of the variable definitions is given below (Table 3.2). The scale values WTP maintenance, WTP access and distance were aggregated into ordinal values for the purpose of performing Chi square analysis on them. For all other statistical analysis, they remain as scale variables.

Table 3.2 Summary of variable definitions.

Variable	Aggregation key	Description
WTP Maintenance (£)	1= 0 2= < 10 3= 10 4= > 10	The maximum increase in council tax the participant is willing to pay for maintenance of the MR site.
WTP Access	1= 0 2= < 6 3= 6 4= > 6	The maximum increase in council tax the participant is willing to pay for access of the MR site.
Distance from the site (miles)	1= < 2 2= 2- 5 3= > 5	The distance the participant lives from the site.
Visit Frequency	1= Daily 2= Weekly 3= Fortnightly 4= Monthly 5= Yearly (once) 6= Never	How often the participant visited the site in the past 12 months.
Age (years)	1= 18- 24 2= 25- 34 3= 35- 44 4= 45- 54 5= 55- 64 6= 65- 74 7= > 75	How old the participant is.
Income (£)	1= < 20,000 2= 20,001- 40,000 3= 40,001- 60,000 4= 60,001- 80,000 5= 80,001- 100,000 6= 100,001- 120,000 7= > 120,001	The household's annual income, after tax.
Education	1= Primary 2= Secondary 3= Vocational Training 4= Further 5= Higher 6= Postgraduate	The highest level of education the participant has acquired.
Gender	1= Male 2= Female	Participant gender.
Previous Site Knowledge	1= Yes	Whether the participant is

	2= No	already aware of the MR site prior to the survey.
Time Spent At Site (Hours)	0= None 1= < 0.5 2= 0.5- 1 3= 1- 1.5	The average time the participant spends at the site.
Children	1= Yes 2= No	Whether there are children (under 18) in the household.

3.6 General characteristics of the respondents.

The survey contained a brief section to gather information on participant socio-demographic details. In surveys such as this, information on the general characteristics of the survey population is useful as they can help explain why a participant gave the bid that they did, as well as helping with identification of protest bids. A summary of the general characteristics of the respondents from the PHS sample population is given below (Table 3.3). It should be noted that it was not possible to ensure that the demographic characteristics of each site's sample population were the same, however they are presented for each site.

Summarizing the socio-demographic details in this way highlights any obvious trends in the survey population. For example a large majority of the survey population live between two and five miles from the site, there are slightly more female perspectives than male perspectives, the majority have A-levels or equivalent qualifications, and just over 82% of the survey population have a yearly household income of between twenty and sixty thousand pounds. This is slightly higher than the average annual income for this area, which is approximately £41,520 *before* tax (as stated by the National Housing Federation, 2011). However, this correlates with the information given here, as the average education level is higher than you may expect for this area, and therefore would suggest a higher average income. Although formal statistics on the average education level are unavailable, performance at GCSE level (Secondary) or equivalent qualification and continued study to Further and Higher education in Humberside and the East Riding of Yorkshire have been continuously below the national average for some years (Dept. for Education).

The majority of the categories within the variables are represented, which shows the survey sample covered most social backgrounds. Notably, there are no participants

within the top two income brackets, however this is a product of the area the surveys were administered in, as the area is not particularly affluent.

Table 3.3 General summary of respondents' characteristics (PHS).

Question	Answer	N	No of responses	% Response
Age	18- 24	312	1	0.3
	25- 34		53	17.0
	35- 44		91	29.2
	45- 54		86	27.6
	55- 64		28	9.0
	65- 74		49	15.7
	75- 84		4	1.3
Income	< 20,000	312	34	10.9
	20,001- 40,000		127	40.7
	40,001- 60,000		130	41.7
	60,001- 80,000		19	6.1
	80,001- 100,000		2	0.6
	100,001- 120,000		0	0
	> 120,001		0	0
Gender	Male	312	147	47.1
	Female		165	52.8
Education	Primary	312	4	1.3
	Secondary		41	13.1
	Vocational		47	15.1
	Training		89	28.5
	Further		131	42.0
	Higher		0	0
	Postgraduate			
Children	Yes	312	93	29.8
	No		219	70.2
Distance	< 2 miles	312	44	14.1
	2- 5 miles		209	67.0
	> 5 miles		59	18.9
Visit Frequency	Daily	312	2	.6
	Weekly		22	7.1
	Fortnightly		103	33
	Monthly		151	48.4
	Yearly (once)		6	1.9
	Never		28	9
Time spent at the site	None	312	29	9.3
	< 0.5 hours		15	4.8
	0.5- 1 hour		235	75.3
	1- 1.5 hours		33	10.6
Previous knowledge of the site	Yes	312	276	88.5
	No		36	11.5

3.7 Knowledge and use of the site.

88.5% of the participants had knowledge of the MR site previous to completing the survey, and just over 90% of the participants had visited the site at least once in the last twelve months. Of those that had visited the site, just under 90% of these visited on either a fortnightly (36.3%) or monthly (53.2%) basis, the majority spending between 30 minutes and an hour there (83%) (Table 3.3).

The survey respondents were asked what they used the site for, or what activities they participated in whilst there. This information is important to the study, as the reasons that a participant uses the site may affect how often they visit, how long they spend at the site, how far they are willing to travel to reach the site, and ultimately how much they are willing to pay to access the site or maintain the site in its current state. None of the participants in a seven mile radius of the site had an occupation which would cause them to visit the site for reasons other than for recreational reasons; therefore all visits to the site were specifically for one or several of these reasons. The two most common uses of the site are walking to enjoy the scenery (83.33%) and relaxing (89.42%), however these uses often occur whilst also participating in other activities, such as dog walking (23.72%), bird watching (16.99%) and nature watching (48.72%). 16.35% of participants visit the site for fitness, either walking or jogging (Figure 3.2).

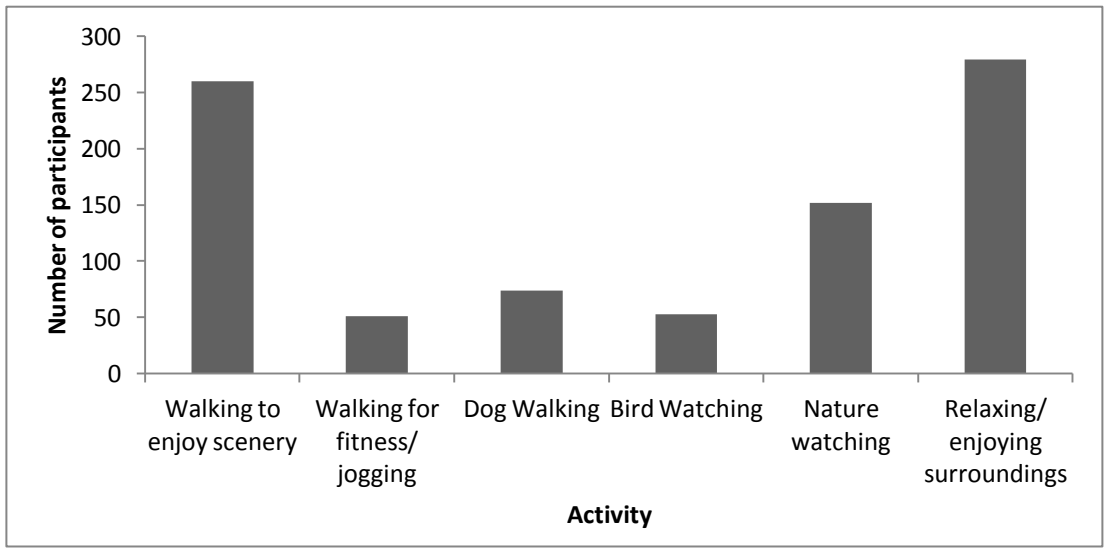

Figure 3.2 Uses of PHS MR site. Count does not equal the total number of respondents, as respondents were allowed to choose all activities they participate

3.8 Willingness to pay responses.

For both willingness to pay for continued maintenance of the MR site, and willingness to pay for access to the MR site, the participants were asked to choose between two options: either to pay nothing and the MR site would receive no maintenance and would not be granted access to the site; or to pay something, and maintenance would continue at the site, and access would be allowed. The results of the initial choice question are summarised below (Table 3.4). The suggested amount for those who wanted to pay 'something' were set at £10 for maintenance and £6 for access, although a series of follow up questions discerned the exact amount that the participant was willing to pay.

Table 3.4 Summary of choice experiment results for PHS.

Willing to pay for MAINTENANCE?	Number of Participants	% Response
Yes	283	90.7
No	29	9.3
Willing to pay for ACCESS?		
Yes	263	84.3
No	49	15.7

3.9 Distribution of bids.

A bimodial distribution showed that approximately ninety percent of the survey participants were willing to pay an annual amount of at least £1 towards the cost of maintenance for the site. Of those who chose not to pay anything, 20.7% stated that they could not afford to pay, but they would if they could; 24.1% said that maintenance of the site was not a priority. 34.5% gave the reason that they did not use the site and therefore should not be required to pay, whilst one participant (3.4%) was not willing to pay because they do not value any of the sites benefits and another participant chose not to pay because they do not trust the government to only use the tax increase for this reason. Two participants each chose the reasons 'the organisation that created the site should pay' and 'I object to paying higher taxes'. None of the participants chose the reason 'I do not value any of the sites benefits' (Figure 3.3).

Approximately 84% of the survey participants were willing to pay an annual amount of at least £1 specifically for access to the MR site. Of the fifty participants that chose not to pay for access: 19% stated their reason as “I cannot afford to pay, but I would do”; 6% chose “It is not a priority for me”; “I do not use or visit the site” was chosen by the majority of participants (50%); 12% stated they had no interest in the wetland environment; and 7% believe that the organisation that created the site should not charge for access. 6% objected to paying higher taxes, and as with the reasons for not paying for maintenance, none of the participants chose not to pay because they do not value any of the sites benefits or because they do not trust the government to use the taxes as intended (Figure 3.3).

Those who chose option F, G or H were identified as protest bidders (Chapter 2), and therefore were removed from the data set. For those who agreed to pay for maintenance of the MR site, they were then asked what the maximum amount was that they would be willing to pay as an annual increase in council tax. The bids offered by those participants that were willing to pay for maintenance ranged between £1 and £30 per year. The average willingness to pay amount for maintenance (including all bids) is £7.32 (SD= 4.67), with median and mode of £5 and £10 respectively (Figure 3.4).

For the participants who chose to pay for access to the MR site, the distribution of their maximum WTP bids are shown below (Figure 3.4). The range of bids for those participants willing to pay for access, were between £1 and £20 per year. The average WTP amount for access (including all bids) is £4.64 (SD= 3.59), with median and mode both £3.

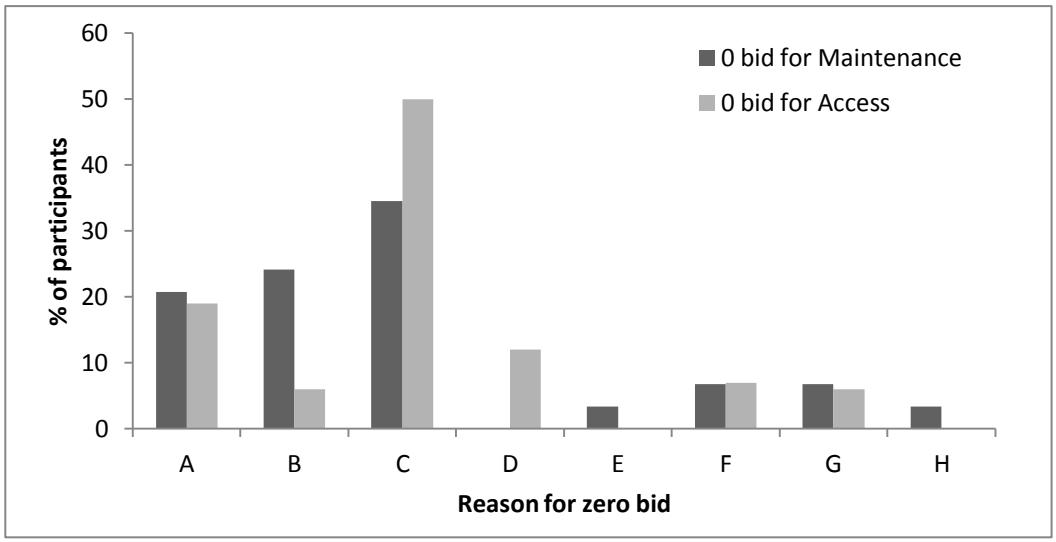

Figure 3.3 Participants' reasons for choosing NOT to pay for maintenance of or access to PHS MR site. (A= 'I cannot afford to pay, but I would do; B= 'It is not a priority for me'; C= 'I do not use or visit the site; D= 'I am not interested in the wetland environment; E= 'I do not value any of the site's benefits; F= 'The organisation that created the site should pay; G= 'I object to paying higher taxes'; H= 'I do not trust the government to use the taxes as intended'.

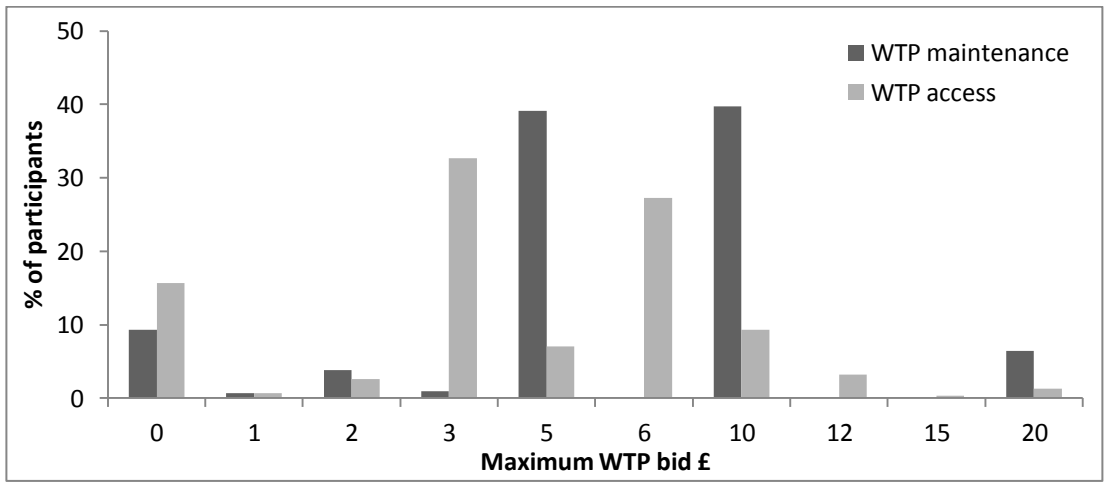

Figure 3.4 Distribution of WTP bids for PHS MR site.

To determine which characteristics possessed by the participants had significant relationships to their WTP for maintenance value, all the variables were analysed in a number of ways.

3.10 Exploratory and chi square analysis.

The distance that the participant lived from the site was analysed against their WTP maintenance value. The scatterplot showed a partial negative correlation, the further away the participant lived, the less they were willing to pay for maintenance (Figure 3.5). The statistical significance between these two variables was also tested, and it was found that distance had a statistically significant effect on WTP values for maintenance (X^2= 0.002), and therefore distance should be included within any aggregation of the results. Participant distance from the site did not have a statistically significant effect on how much they were willing to pay for access (X^2= 0.39)

Another variable that we may expect to have a significant effect on WTP maintenance is visit frequency, it is reasonable to think that the more often a participant visits the site, the more they would be likely to pay to maintain it (Figure 3.6). The chi square value was significant (X^2 p<0.05), however 44% of these cells had an expected count of less than 5, and therefore in this instance there is a loss of statistical power. To help increase the validity of the statistical significance of this test, Spearman's rank order (r_s) test was used to test the statistical significance of the same correlation, and was found statistically significant (0.00). Therefore the correlation is significant at the .01 level, and can be included in any aggregation of the variables.

In relation to their maximum WTP amount for access to the site, those who visited fairly often, such as weekly, fortnightly or monthly were willing to pay more on average than those who visited yearly, or had not visited in the last year at all (including the participants who had never visited the site). Considering the general trend the graph, it would perhaps be expected for 'Daily' to have higher WTP access values, however the number of cases for this category is relatively low compared to the other categories, and therefore this may account for the discrepancy (Figure 3.7). WTP access and participant visit frequency were tested to see if they were statistically significant, and had a X^2 value p<0.005, and is therefore significant.

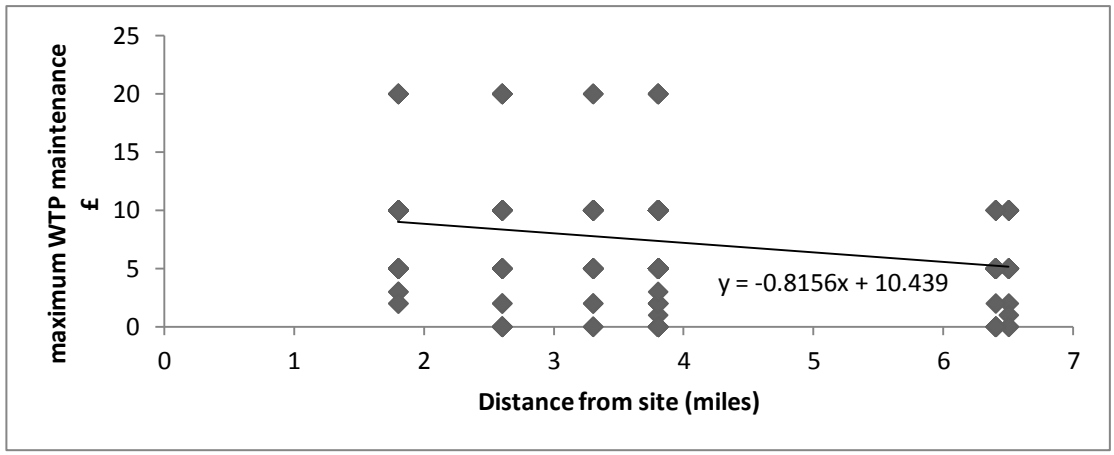

Figure 3.5 Relationship between the distance that the participant lives from PHS MR site, and their maximum WTP maintenance value. Points may represent more than one case. The trendline reflects this.

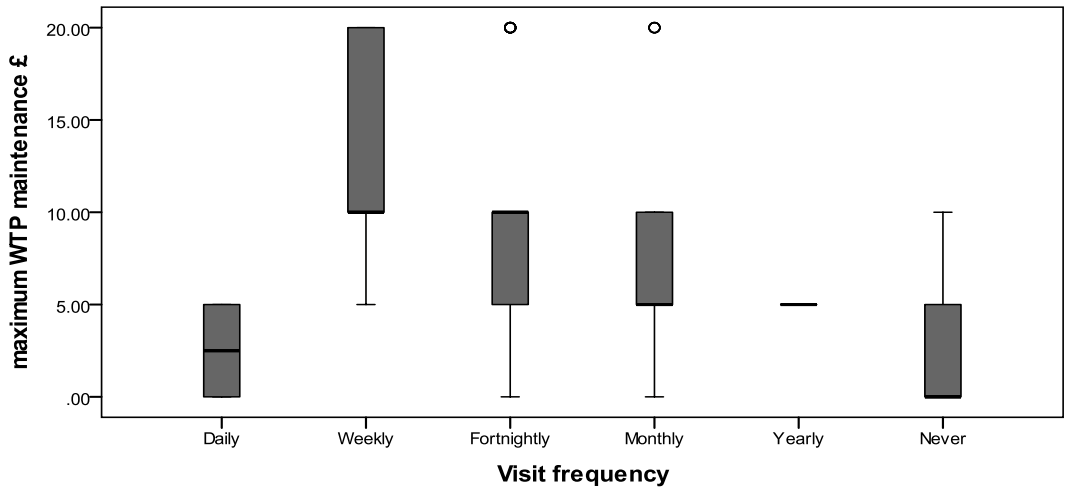

Figure 3.6 Relationship between visit frequency to PHS MR site and maximum WTP maintenance value (**o** = outliers, ***** = extraneous variables).

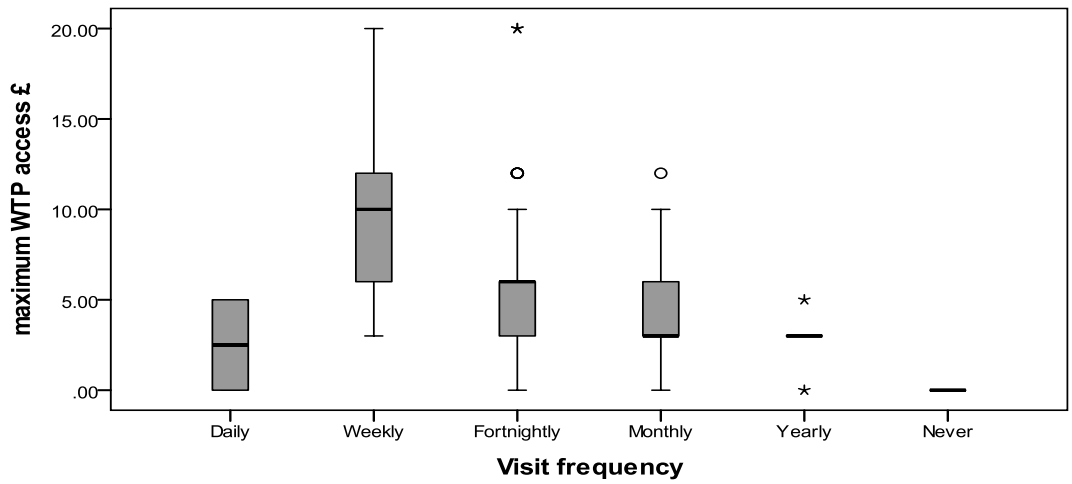

Figure 3.7 Relationship between visit frequency to PHS MR site and maximum WTP access value (**o** = outliers, ***** = extraneous variables).

A relationship of this nature may also be expected of the amount of time that a participant spends at the site, and the amount they would be willing to pay for its maintenance. A box plot depicting this relationship is presented below (Figure 3.8). The statistical significance between the two variables was tested, and a X^2 value of 0.00 was found, however 25% of the cells had an expected count of less than 5, and so r_s was also performed on the data. A significance of 0.00 was also found using this test. Therefore this variable should be included in any aggregation that occurs. The amount of time that the participant spends at the site is also indicative of the amount they would be willing to pay for access. Those who spent no time at the site were willing to pay considerably less than those who did spend time at the site (Figure 3.9). The relationship between visit time spent at the site and WTP access has a X^2 value of 0.00 ($p<0.005$), and therefore can be conserved highly significant.

The effects of income on participant WTP amounts for maintenance also yielded statistically significant results. The relationship has a X^2 value of 0.00, however 33.3% of the cells have an expected count of less than 5. Therefore a further statistical test was undertaken, and the same data had a r_s value of 0.00, the correlation is significant at the 0.01 level. We can see that income has an effect on WTP, and should be included in any aggregation (Figure 3.10). The annual income per household also had statistically significant effect on WTP access, X^2 value 0.00 ($p<0.005$), which is graphically shown below (Figure 3.11). Although there are a range of WTP values present for each income category, the boxes reveal a higher upper range as the income categories increase in amount. The exception of the 80,001- 100,000 bracket has likely not followed the pattern as there are fewer cases representing this bracket compared to the others.

The participants were also asked whether they had previous knowledge of the MR site, before they were given any information on the site or its benefits. There was a positive relationship between those who have prior knowledge of the site, and the amount they were willing to pay. If a participant was not aware of the site prior to the survey, they were less likely to be willing to pay for its maintenance (Figure 3.12) This relationship had a X^2 value of 0.00, but there were 33.3% of cells that had an expected count of lower than 5, therefore a r_s value was also calculated, this was also 0.00, and therefore the correlation is significant at the 0.01 level, and the

variable should be considered in future aggregations. There is a clear difference in WTP values for access when analysing whether the participant has previous knowledge of the site or not (Figure 3.13). If the participant has knowledge of the site prior to answering the survey, their maximum WTP values are higher than if they do not have knowledge of the site. This relationship was tested again using X^2 , and had a value of 0.00 (p<0.005) and therefore can be considered statistically significant.

Not all the socio demographic variables had an effect on the participants WTP amount for maintenance. Significance was tested for using X^2, where X^2 was not a sufficient test, such as when more than 20% of cells had account less than 5, r_s was also used to confirm the variables significance. The participants age (X^2= 0.227, r_s = 0.716; p> 0.05); their level of education (X^2= 0.566, r_s =0.416; p>0.05); their gender (X^2= 0.568; p>0.05); and whether there were children in the household or not (X^2= 0.410; p>0.05) were all statistically insignificant in terms of their relationship to WTP maintenance values.

As with the WTP maintenance values, there were some variables that were tested to see if their relationship with the WTP access values had any statistical significance. Unlike with WTP maintenance, participant age category and level of education were also found non-significant in terms of their WTP access values, with X^2 values of 0.089 and 0.458 respectively. This was also the case with participant gender, and whether there were children in the household or not as both variables were found statistically insignificant (X^2= 0.760 and 0.030 respectively).

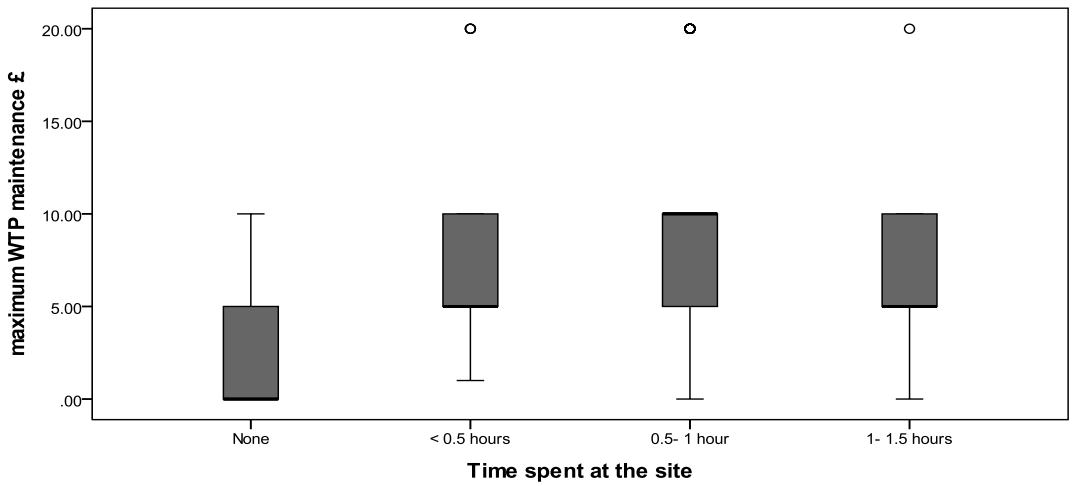

Figure 3.8 Relationship between time spent at PHS MR site and maximum WTP maintenance value (**o** = outliers, ***** = extraneous variables).

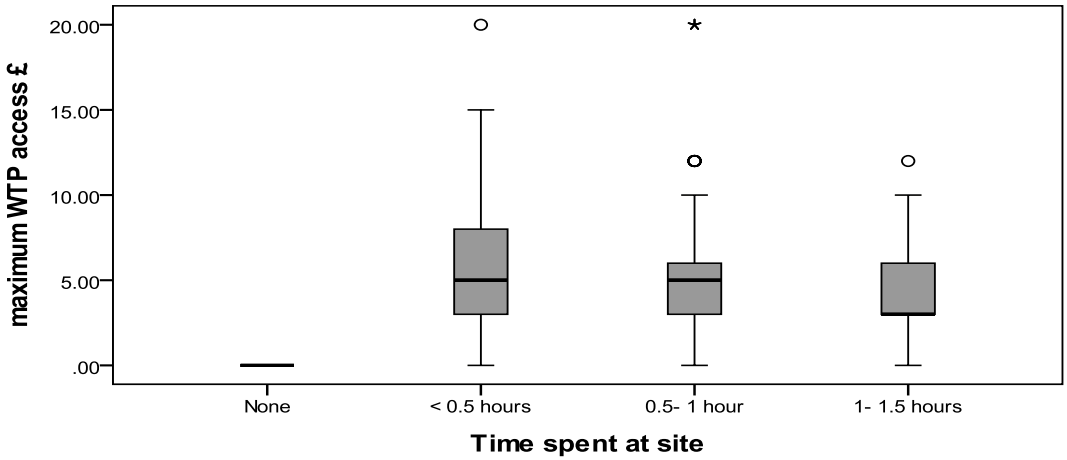

Figure 3.9 Relationship between time spent at PHS MR site and maximum WTP access value (**o** = outliers, ***** = extraneous variables).

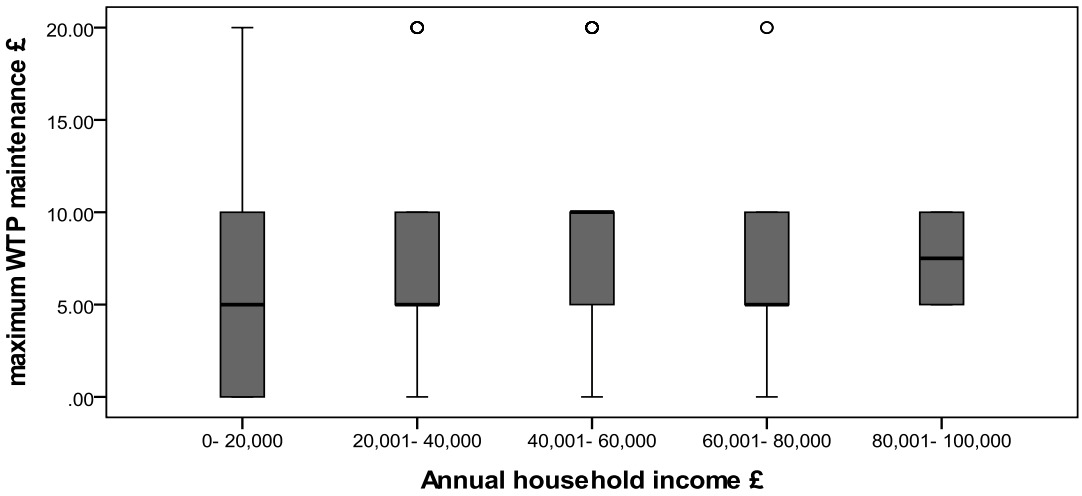

Figure 3.10 Relationship between household income and maximum WTP maintenance value for PHS MR site (**o** = outliers, ***** = extraneous variables).

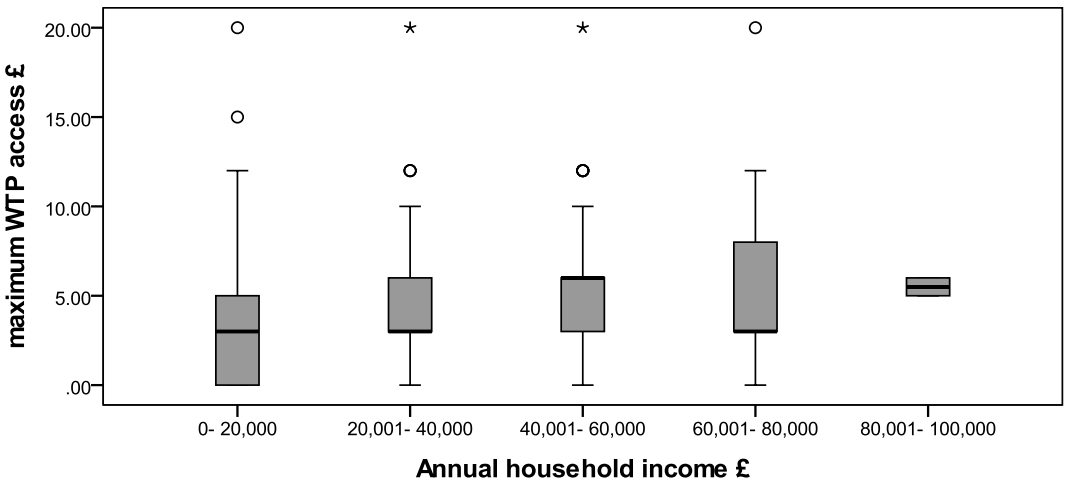

Figure 3.11 Relationship between household income and maximum WTP access value for PHS MR site (**o** = outliers, ***** = extraneous variables).

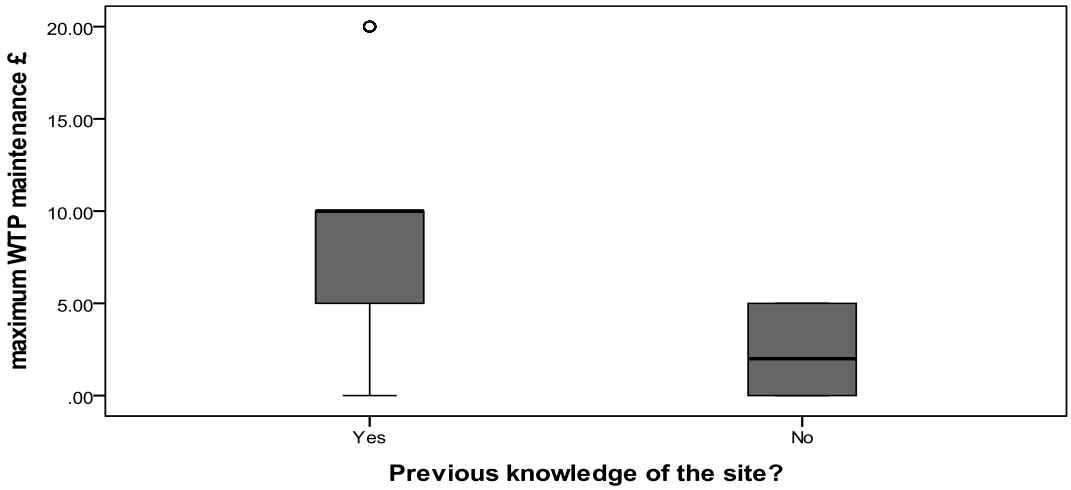

Figure 3.12 Relationship between whether the participant had knowledge of PHS MR site prior to survey, and maximum WTP maintenance value (**o** = outliers, ***** = extraneous variables).

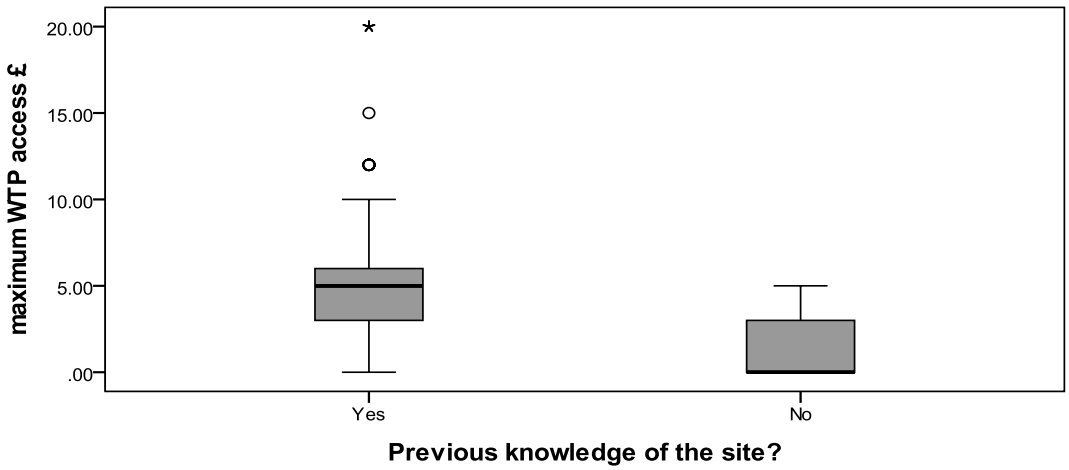

Figure 3.13 Relationship between household income and maximum WTP access value for PHS MR site (**o** = outliers, ***** = extraneous variables).

The results from the initial exploratory and X^2 analysis show that the statistically significant influencing variables on WTP maintenance are the distance that the participant lives from the site, the frequency in which they visit the site, the amount of time they spend at the site per visit, whether they had previous knowledge of the site and their household income. Main variables influencing WTP access are time spent at the site, visit frequency, previous knowledge and household income. Therefore, these variables will be considered in any further aggregation.

3.11 Coplot analysis.

Whilst relationships between the response variable (WTP) and one explanatory variable have been tested, it is also important to see how the interaction of two explanatory variables can affect WTP. Coplot analyses were used to analyse this.

The distance the participant lives from the site has a different relationship with their WTP maintenance values depending on whether they have previous knowledge of the site or not. If the participant has previous knowledge of the site, they are willing to pay less the further away they live, whereas if they do not have previous knowledge of the site, the coplot indicates that the further away the participant is, the more they are likely to pay for maintenance of the site (Figure 3.14).

The relationship between income and WTP maintenance values is largely similar whether the participant has previous knowledge of the site or not, in that the higher their annual income, the more they are willing to pay annually. However, if the participant had previous knowledge of the site, the coplot suggests they were willing to pay more on an annual basis than those who did not have previous knowledge (Figure 3.15).

Similar relationships were found with Age as the conditioning variable, whether the participant had previous knowledge of the site or not, those with a higher level of education were willing to pay a higher amount annually than those with a lower education, however if the participants did have previous knowledge of the site, their WTP value was higher than those with no previous knowledge (Figure 3.16).

When the explanatory variables age, visit frequency, education, time spent at the site, and income were analysed against participant WTP access values with previous knowledge as the conditioning variable, these variables all tended to show a clearer pattern to the WTP access values if the participant did have previous knowledge of the site. Using visit frequency as an example, the higher the frequency of visit, the higher the WTP access values. This was true for whether the participant had previous knowledge or not, however if they did have previous knowledge, the relationship was exacerbated (Figure 3.17).

However this pattern is slightly different when looking at the relationship between WTP access and the distance that the participant lives from the site, with previous

knowledge of the site as the conditioning factor (Figure 3.18). For participants with previous knowledge of the site, the data points seem to show that the closer the participant lives to the site, the more they are likely to pay for access to it. However for those who do not have previous knowledge of the site, the regression line on the graph shows that those living further away are prepared to pay more for access than those living closer to the site. Although this is true, it must be taken into consideration that those living further away are less likely to have previous knowledge of the site due to their lack of proximity to it, and therefore there will be more cases in this category which could affect the strength of the relationship between previous knowledge and distance, because more cases in one category may cause a larger range in values, affecting the relationship strength.

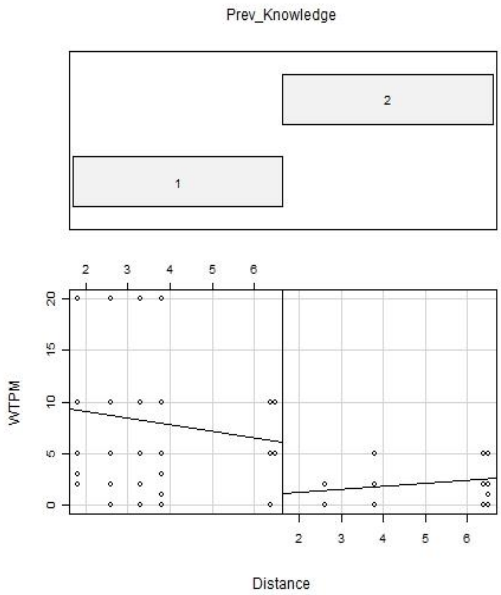

Figure 3.14 Relationship between distance from PHS MR site and WTP maintenance, with conditioning variable of previous knowledge. (WTPM= £ values; Previous knowledge 1= yes, 2= no; Distance= miles from the site)

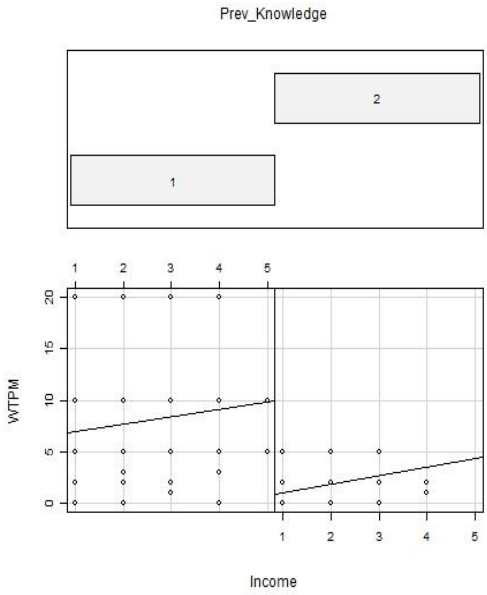

Figure 3.15 Relationship between the participants income and their WTP maintenance values, conditioning variable of previous knowledge. (WTPM= £ values; Previous knowledge 1= yes, 2= no).

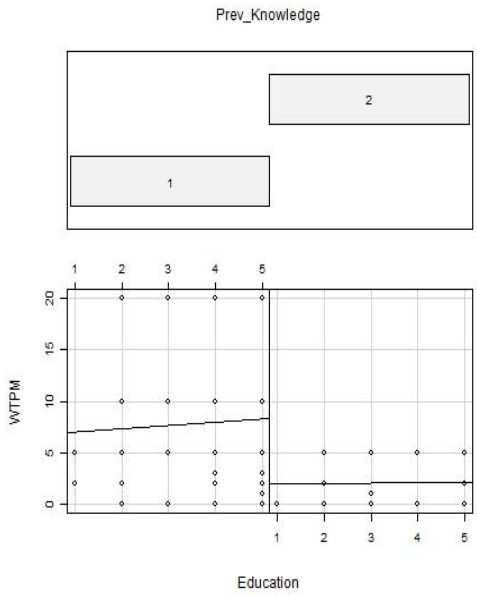

Figure 3.16 Relationship between the participants' level of education and their WTP maintenance values for PHS MR site, with previous knowledge as the conditioning factor (WTPM= £ values; Previous knowledge 1= yes, 2= no).

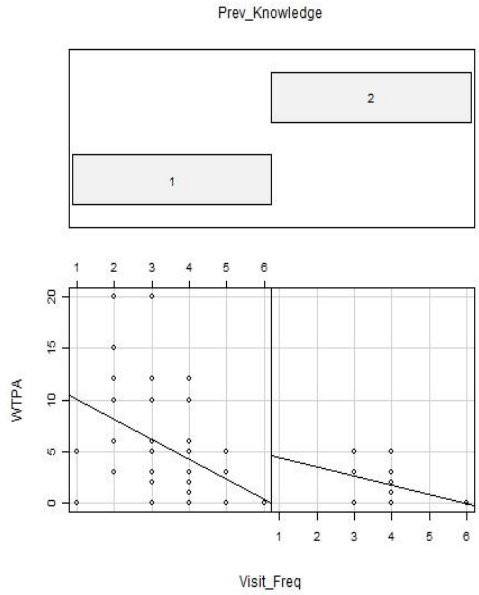

Figure 3.17 Relationship between WTP access values and frequency of visit to PHS MR site, with the participants' previous site knowledge as the conditioning factor. (WTPM= £ values; Previous knowledge 1= yes, 2= no).

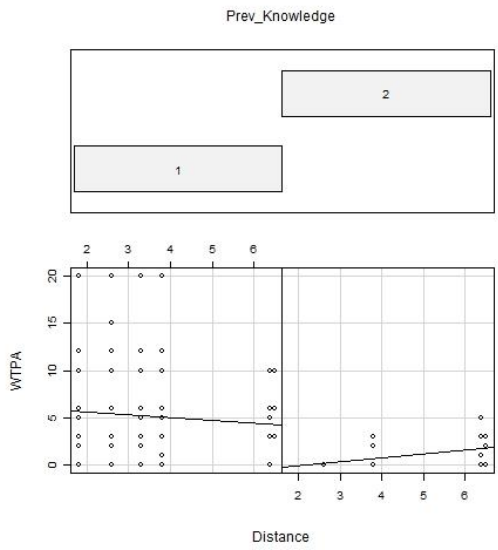

Figure 3.18 Relationship between distance from PHS MR site and WTP maintenance, with conditioning variable of previous knowledge. (WTPM= £ values; Previous knowledge 1= yes, 2= no; Distance= miles from the site)

Results from the coplot analyses confirm what was initially discovered in the exploratory analysis, that previous knowledge of the site, distance and income are important factors to consider. The coplots have also showed that participant education level should be considered as an influencing variable.

3.12 Principal component analysis.

The scree plot showing eigenvalues from all the included variables, showed an inflection after the first two components. Following Kaiser's recommended criterion of retaining all components with an eigenvalue greater than one, it was decided that a two component PCA was suitable.

The PCA was initially conducted with all variables included. The Pearson correlation coefficients were analysed, and none were more than 0.9, limiting problems that may arise due to singularity in the data. The determinant of the correlation matrix was also greater than the necessary value of 0.1×10^{-4}, and therefore multicollinearity was unlikely to be an issue (Zuur et al., 2009). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was assessed, as this number represents the ratio of the squared correlation between variables to the squared partial correlation between variables. Kaiser (1974) stated that a result of 0-0.5 means the sum of partial correlations is too large relative to the sum of correlations, and therefore there would be diffusion in the pattern of correlations and PCA would be inappropriate. A result between 0.5-1 would indicate that the patterns of correlations are relatively compact, and PCA should yield reliable factors. The analysis had a KMO value of 0.560 and a Bartlett's test of sphericity significance of 0.00 ($p< 0.01$). The KMO value is not a high as perhaps one would hope, but as the Bartlett's test is significant, continuing with the PCA is justified.

The anti image correlations between each variable were analysed for significance, those for distance and gender were less than 0.5 ($p> 0.5$). Because of the lack of significant correlation between these variables and all the others, it was decided the PCA should be analysed again without these two variables. After removing them, all anti image correlations were significant ($p>0.5$), and the KMO value increased to 0.607. Bartlett's test of sphericity remained 0.00 and therefore still significant ($p<0.01$). The re-analysed scree plot still suggested a two component PCA and therefore this was carried out with an oblimin with Kaiser normalization rotation

method to optimize the factor structure and equalize the relative importance of the two factors.

The extracted sums of squared loadings revealed that component 1 accounts for 32.3% of the total variance, and component 2, 25.6% of the total variance (58% total). The factor loadings in the pattern matrix reveal that component 1 seems to represent participant socio-demographic details whilst component 2 represents participant relationship with the MR site (Table 3.5)

Table 3.5 Pattern matrix containing factor loadings for PCA for PHS data.

Pattern Matrix[a]

	Component	
	1	2
Children	.864	
Age	.807	
Income	-.628	
Education	-.576	
Visit_Frequency		.818
Time_Spent		-.803
Prev_Knowledge		.722

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 4 iterations.

Although the pattern matrix shows a clear distinction between components 1 and 2, the correlation coefficient between the two components is quite low (0.109). This would suggest that the correlation between participant socio-demographic details and their relationship with the MR site is relatively weak. However, these results cannot be trusted, as within the variables in the PCA there is a high percentage of non-redundant residuals with absolute values greater then 0.05 (61%, p< 50%). Therefore, further analysis is needed to analyse the relationships between the variables.

3.13 Generalised linear modelling for maintenance values.

All nominal and ordinal variables were factored, and then analysed using Poisson GLM due to the response variable being a continuous variable. However the initial Poisson model was overdispersed (Phi>1.5 (AIC value=1.95)) and therefore it was not suitable to continue with the Poisson model. Quasi-Poisson GLM was selected instead, as it can deal with a certain amount of overdispersion, and the analysis was run again.

A backwards stepwise selection was conducted manually in the statistical package R to select the best model. All variables were included in the model initially, and the least important variable amongst those that were not significant (ie the variable with the highest *p* value >0.05) was identified. A new model was refitted without this variable and tested again, and so on until all the remaining variables in the model are statistically significant.

The results from this process resulted in the GLM model:

Glm(WTPM ~ fVisit.Freq + fPrev.Knowledge)

With both variables significant at the 0.001 level (Table 3.6)

Model validation is based on analysis of the residuals of the model. The standardised residuals and fitted values were extracted and plotted against one another, as this is useful for checking homogeneity (Figure 3.19). We can see from the figure that there is no pattern in the residuals, such as the ‘cone effect’ which could be a sign of heterogeneity, and therefore is a positive in terms of model validation. The standard deviance residuals were plotted against the theoretical quantiles in a Q-Q plot. This shows that although there is some variation in the residuals, the pattern follows the line of best fit closely (Figure 3.20). A histogram plotted of the residuals was also analysed, alongside a normal distribution curve to compare the difference (Figure 3.21). Although the distribution of the residuals is not precisely normal, it is similar enough that the model does not have to be rejected.

Table 3.6 Descriptive values for variables in PHS GLM WTP maintenance model.

Variable	Df	Deviance	F value	P value
Visit frequency	5	818.33	20.665	<2.2e-16
Previous knowledge	1	692.81	40.694	6.596e-10

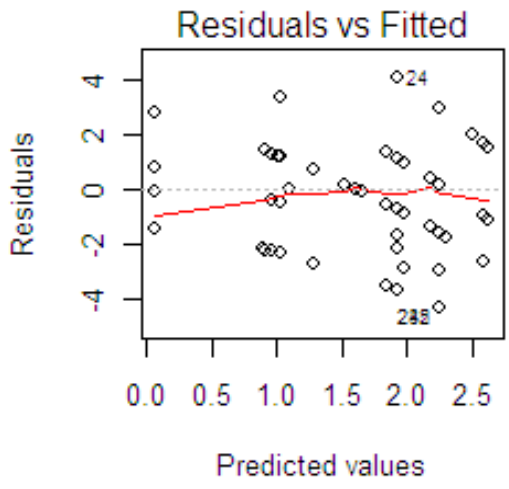

Figure 3.19 PHS WTP maintenance GLM model residuals plotted against fitted values, with line of best fit

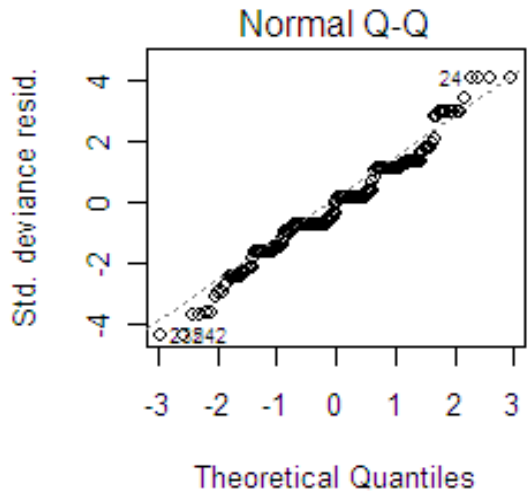

Figure 3.20 PHS WTP maintenance GLM model residuals plotted against theoretical quantiles with line of best fit.

The percentage of variance in the data explained by the model was also calculated (using the null deviance (1024.15) and residual deviance (611.25) of the model). 40.32% can be accounted for by the model. Although there is no formal threshold for what is classed as a significant percentage, the higher the percentage of variance explained by the model, the better. Given the variables being tested, this is the best model, but as the percentage of variance accounted for by the model is quite low, there may be other variables or factors which have an effect on WTP maintenance which have not been accounted for. The analysis of the residuals and the percentage of variance accounted for shows that the model cannot be fully accepted, however perhaps should not be fully rejected either. This model requires further analysis, which will be carried out with a Decision Tree analysis.

3.14 Generalised linear modelling for access values.

After the nominal and ordinal variables were factored, Poisson GLM was used to analyse the variables against WTP access. The dispersion and overdispersion were checked, and the data did appear slightly overdispersed, but was within the guideline limits for Poisson distribution GLM, less than 1.5 (overdispersion value= 1.48) and therefore the analysis was continued with Poisson GLM.

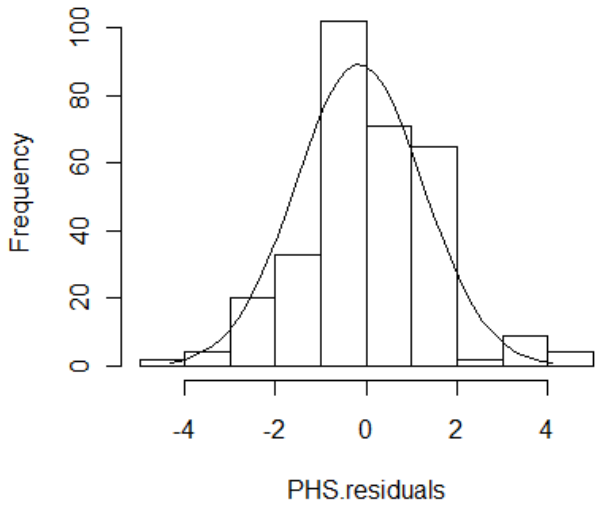

Figure 3.21 Histogram of PHS GLM WTP maintenance model residuals, with the line showing normal distribution.

A manual backward selection was implemented to select the correct model:

Glm(formula = WTPA ~ fVisit.Freq + fTime.Spent + fPrev.Knowledge)

Showing that the frequency of visit to the site, the time the participant spends at the site, and whether they have knowledge of the site prior to completing the survey are the most influencing factors on the maximum amount they are willing to pay for access to the site. Details from the variables in the model are shown in table 3.7.

Table 3.7 Descriptive values for variables in PHS GLM WTP access model.

Variable	Deviance	AIC	P value (Chi)
Visit frequency	571.36	1486.73	< 2.2e-16
Time spent	482.85	1402.23	0.003326
Previous knowledge	508.85	1432.23	2.943e-10

To test how the data meets the assumptions of the model, homogeneity was tested by plotting the residuals against the fitted values (Figure 3.22). The plotted values are fairly homoscedastic, as they are equally spread from zero and there is no visible pattern. The residuals were also plotted against the theoretical quantiles, which showed that although the residuals are following a similar pattern to the line of best fit, it is not close enough to be able to justify the model (Figure 3.23).

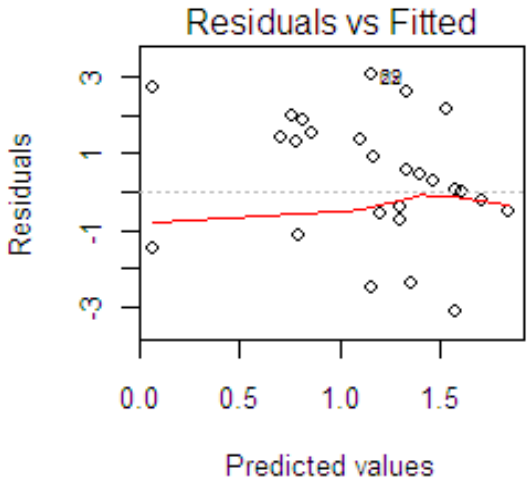

Figure 3.22 PHS WTP access GLM model residuals plotted against fitted values, with line of best fit

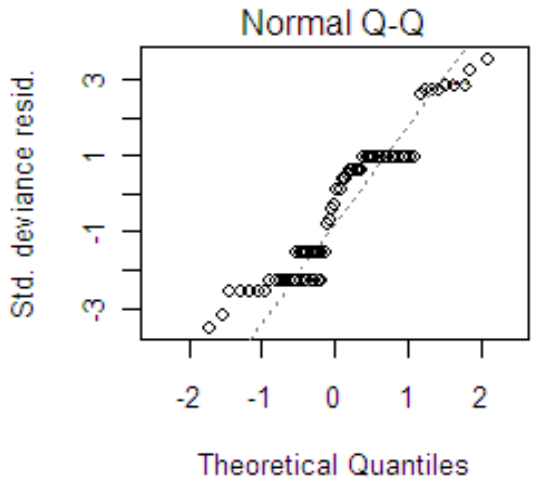

Figure 3.23 PHS WTP access GLM model residuals plotted against theoretical quantiles with line of best fit.

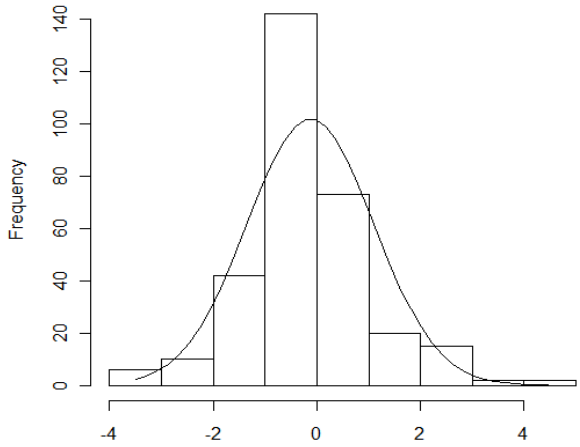

Figure 3.24 Histogram of PHS GLM WTP access model residuals, with the line showing normal distribution.

The residuals were plotted in a histogram, will a normal curve superimposed over the top. Although the residuals frequency in the middle is quite high compared to the normal curve, the overall shape is correct, and not too dissimilar to reject the model (Figure 3.24) The percentage of variance in the data explained by the model was calculated using the null deviance (918.39) and residual deviance (469.14). 48.92% can be accounted for by the model. Considering the residuals plots and the percentage of variance, this model cannot be accepted on these factors alone. Therefore further statistical analysis through Decision Tree analysis will be conducted in order to further examine the statistically significant influential explanatory variables.

3.15 Decision tree analysis for WTP maintenance values.

A decision tree analysis was carried out to analyse the willingness to pay for maintenance data, in order to see patterns between the WTP maintenance values and the explanatory variables. Through the use of other techniques we know that statistically significant relationships are present between certain explanatory variables and the response variable, but it may be useful to see diagrammatically how the variables interact (Figure 3.25).

The decision tree analysis shows that previous knowledge of the site has the most influence on willingness to pay for maintenance, as those who answered ‘yes’ to having previous knowledge were willing to pay an annual amount of just over £8 for maintenance of the site, which is £6 more than those who did not have previous

knowledge. The difference between these two nodes (1 & 2) was tested for significance using a Mann- Whitney U test, and was found highly significant (p< .001) (Table 3.8). Of those who did have previous knowledge, they were then divided by the frequency that they visit the site, whether it is more or less than fortnightly. Those who visited fortnightly or more often, were willing to pay an average of £2.94 more than those who visited less than fortnightly. The difference between nodes 3 and node 4 was also statistically significant (p< .001).

The participants that visited the site fortnightly or more frequently were then split by their age category. Those in the 55- 64 years old category or younger, were willing to pay an average of £10.08 annually, compared to those who were older than 64 who were willing to pay £3.22 less per year, with an average of £6.86. When this difference was analysed with a Mann- Whitney U test, it was found significant at the 95% level (p= .021). Participants who visited the site less than fortnightly were further segregated into the amount of time they spent at the site per visit. If a participant spent 30 minutes or less at the site per visit, the data suggests their average annual willingness to pay for maintenance value as £4.60. However those who spend more than 30 minutes at the site per visit were willing to pay an average of £7.11. The statistical difference between nodes 7 and 8 was found significant at the 95% level with a Mann- Whitney U test (p=< .001).

The participants who were older than the 55- 64 years old age category, were then split with regards to their income level. Those whose earnings fell into the 0- 20,000 or 20,001- 40,000 income category were willing to pay on average £7.68 for maintenance of the site. Those who earned more than 40,000 a year, and therefore were in the higher income categories were willing to pay an average of £11.04 annually (£3.36 more). The difference between nodes 9 and 10 was statistically significant when analysed with a Mann- Whitney U test (p< .001), as was the difference between Nodes 11 and 12 (p= .004), which showed the segregation of those who spent an average of half an hour or more at the site per visit, into the distance they live from the site. Those who live less than 2.2 miles away were willing to pay on average £3.80 for maintenance, whilst those who lived further away than that were willing to pay £7.40.

Table 3.8 Mann- Whitney U values and statistical significance for PHS WTP maintenance decision tree analysis.

Variable	Difference between nodes:	Z value	P Value	Level of significance.
Previous knowledge	1 & 2	-7.997	.000	95%
Visit frequency	3 & 4	-8.340	.000	95%
Age	5 & 6	-2.305	.021	95%
Time Spent	7 & 8	-5.346	.000	95%
Income	9 & 10	-3.565	.000	95%
Distance	11 & 12	-2.886	.004	95%

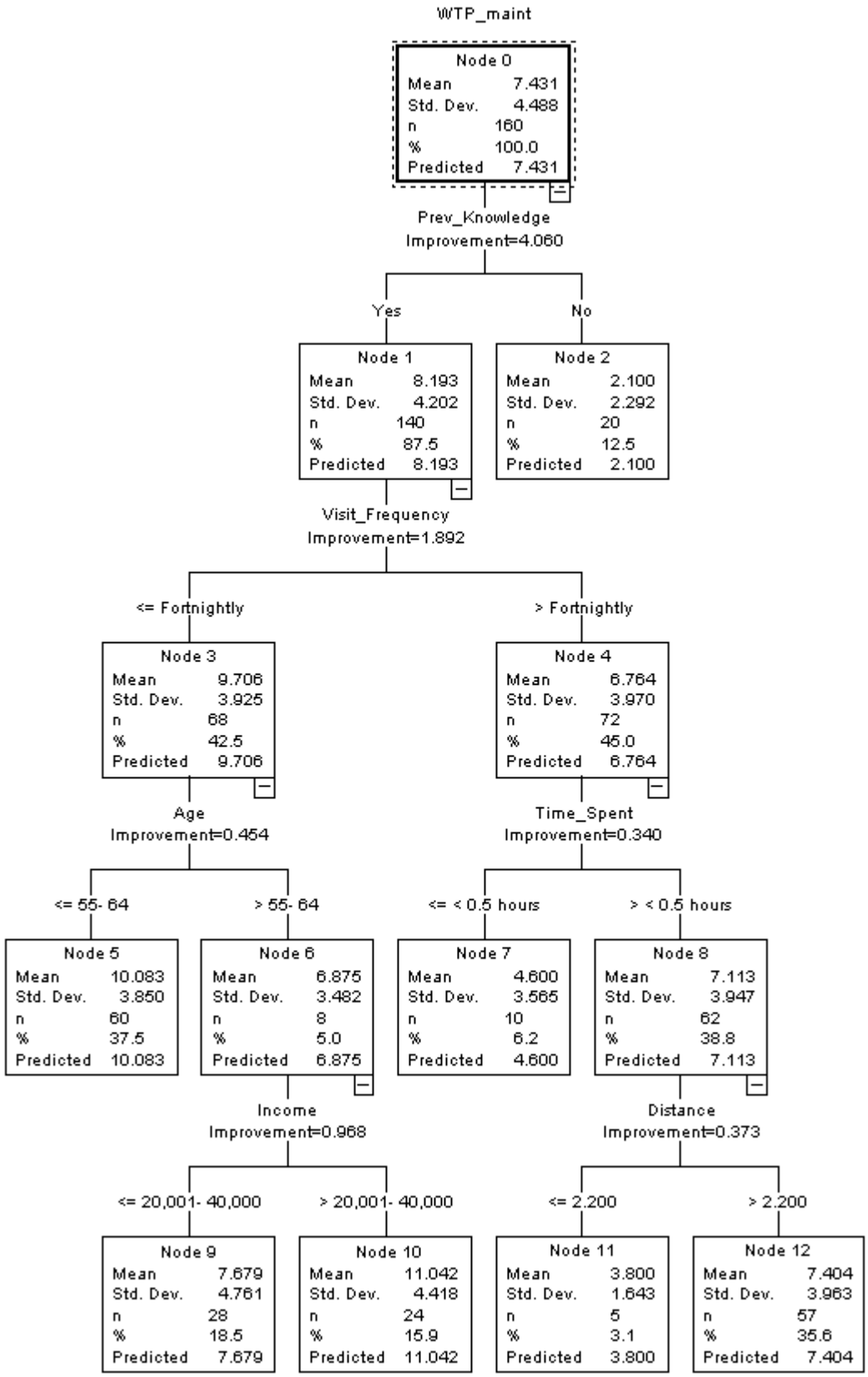

Figure 3.25 Decision tree analysis for PHS WTP maintenance values.

3.16 Decision tree analysis for WTP access values.

The same methods for decision tree analysis that were applied to analyse WTP maintenance values were also applied to analyse the influence of the explanatory variables on WTP access values (Figure 3.26). Visit frequency to the site was shown to be the most influential factor for WTP access values, and was split into those who visited the site on a daily or weekly basis who were willing to pay an average of £9.44 for access per year, and those who visited less often than this (fortnightly, monthly, yearly or never) who had an average WTP access value of £4.23. The difference between nodes 1 and 2 was tested for statistical significance using a Mann- Whitney U test and was found significant at the 95% level ($p < .001$).

Both nodes 1 and 2 were then both further segregated according to the amount of time that the participant spent at the site per visit. Those that visited the site on a daily or weekly basis were divided into those who spent 30 minutes or less time at the site and were willing to pay an average of £15.67 for access to the site; and those who spent more than 30 minutes at the site per visit who were willing to pay £8. Those that visited the site on a less than weekly basis were divided into those who spent no time at the site, and were not willing to pay anything for access, and those who spent at least some time at the site, and were willing to pay £4.59 for access annually. The difference between nodes 3 and 4, and nodes 5 and 6 were analysed using a Mann- Whitney U test, and were both found significant at the 95% level (both p values < .001).

Participants who spent 30 minutes or less at the site per visit were further segregated by their income level. Those who earned £40,001- 60,000 a year or less were willing to pay an average of £13.50 for access to the site, compared to those who earned more than £60,000 a year who were willing to pay £20 annually, although the difference between these two nodes was not statistically significant ($p = .433$). Those who spent more than 30 minutes at the site were divided by whether they had previous knowledge of the site or not. If they did, their average WTP access value was £4.83. If they did not have previous knowledge, their average annual WTP access value was £1.67. The difference between these two nodes (9 and 10) was found statistically significant to the 95% level with a Mann- Whitney U test ($p < .001$).

Participants who had previous knowledge of the site were separated according to their age category. If the participant was less than 74 years old, they were willing to pay on average £4.72 for access to the site, compared those who were over 74 who were willing to pay £8.67 on average, although the difference between these nodes was not found statistically significant with a Mann- Whitney U test (*p*= .877). Those over the 65- 74 age category (Node 12) were then divided by their income, with those earning £20,000 or less per year willing to pay an average of £13 of access to the site, whilst those who earned more than £20,000 were not willing to pay anything, however as this was in relation to the higher age categories, they were likely to be retired and therefore their income refers solely to their annual pension estimate. The difference between these two nodes was found significant at the 95% level (*p*= .002) (Table 3.9).

Table 3.9 Mann- Whitney U values and statistical significance for PHS WTP access decision tree analysis.

Variable	Difference between nodes:	Z value	P value	Level of significance
Visit frequency	1 & 2	-5.199	.000	95%
Time spent	3 & 4	-6.205	.000	95%
Time spent	5 & 6	-8.502	.000	95%
Income	7 & 8	-.784	.433	_
Previous knowledge	9 & 10	-7.372	.000	95%
Age	11 & 12	-.155	.877	_
Income	13 & 14	-3.039	.002	95%

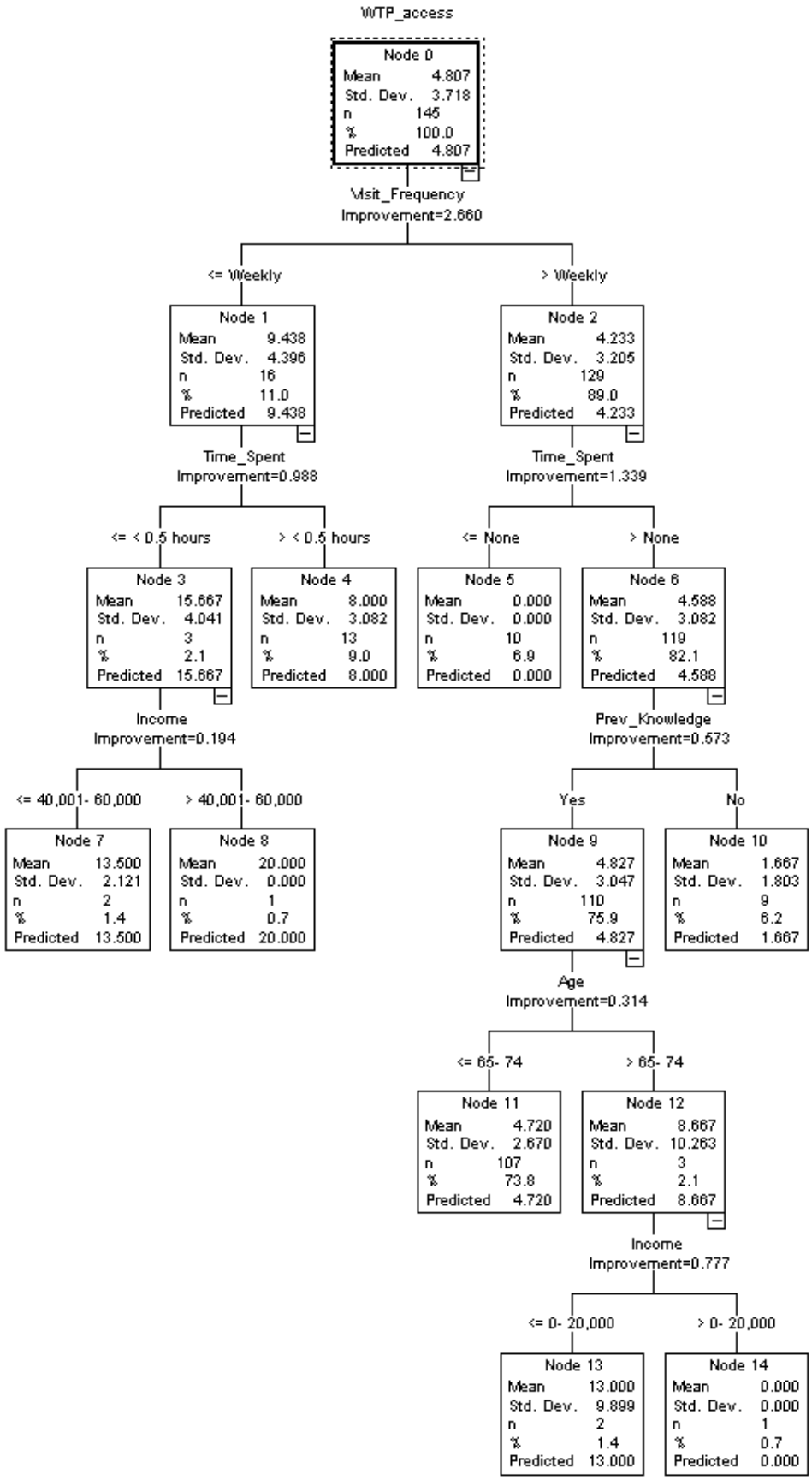

Figure 3.26 Decision tree analysis for PHS WTP access values.

3.17 Contingent ranking.

The participant was asked to rank the societal benefits in order of importance to them, 1 being the most important and 5 being the least important. Their first choices, and first and second choices combined were plotted in an attempt to discern whether there were any preferences toward a certain benefit, or whether all benefits were as important as each other.

It was clear from the results that the sites use for disturbance prevention, such as flood protection, is the most important societal benefit, as 86% of participants chose it as their most important benefit, and 98% chose it as either their first or second most important benefit (Figure 3.27). Out of the other benefits, more people chose leisure and recreation as their first choice than cognitive values, feel good/warm glow or future unknown/ speculative benefits, however when first and second choices are combined, cognitive values were revealed as the most important with 47% choosing it as either their first or second most important benefit, 28% chose leisure and recreation as their first or second preference, just over 4% chose feel good/ warm glow benefits, and approximately 22% chose future unknown/ speculative benefits. This suggests that non-use values are valued as more important than use values by the local population.

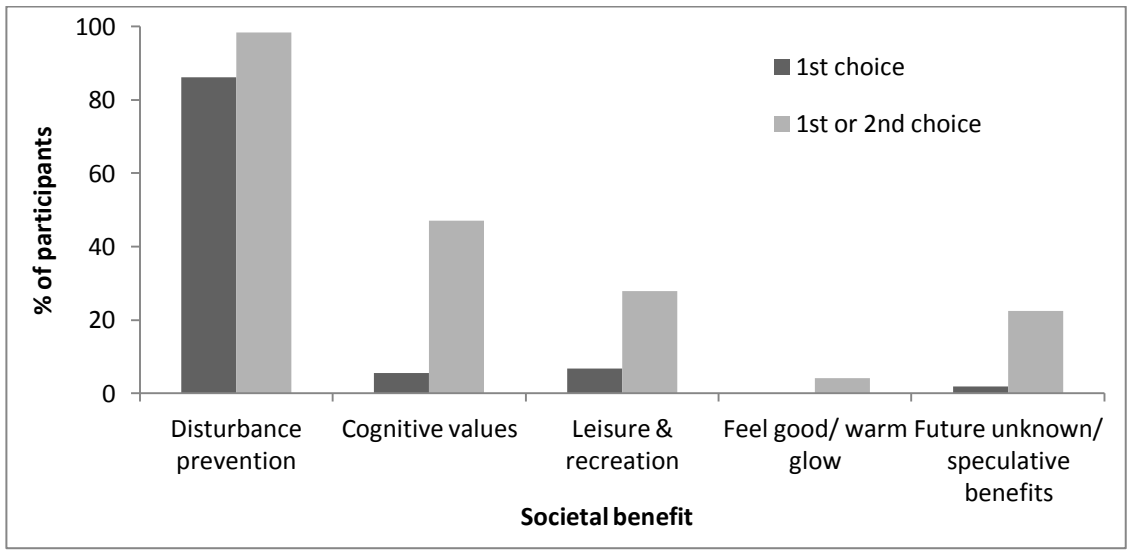

Figure 3.27 Percentage of participants' first and second choices when ranking societal benefits provided by PHS MR site in order of importance.

3.18 Summary and conclusions.

In summary, the survey completion rate for the population around the PHS MR site was 4.76% counting all households in the sample population, or 20.85% only considering those who answered the door. The mean WTP maintenance value was £7.32 per year, with an annual WTP access amount of £4.64. For the respondents who chose not to pay anything for maintenance of the site or access to it, the most popular reason was because they do not visit or use the site. The majority of site users participate in walking to enjoy the scenery or relaxing and enjoying the surroundings whilst at the site, with just under 50% visiting the site for general nature watching. The characteristics that were found to most influence WTP values for maintenance were their frequency of visit to the site and whether they had previous knowledge of the site. In relation to influencing the participants' WTP values for access to the site, the most statistically significant characteristics were their frequency of visit to the site, whether they had knowledge of the site prior to survey, and the amount of time they spend at the site per visit. Results from the ranking benefits question reveal that disturbance prevention is the most important societal benefit provided by the MR site, with the majority of respondents ranking it first or second. This is supported by the difference between the WTP maintenance and WTP access values. The mean values for WTP maintenance were higher, suggesting that non-use values may be identified as more valuable than use-values.

Whether the participant had knowledge of the site prior to completing the survey has been shown as an influencing factor for both WTP maintenance and WTP access values. This is supported by the EA, who in 2007 conducted a postal survey to 250 households in the area in order to examine public perceptions in relation to the MR site. The results from this survey revealed that 61% of the respondents use the site, and these people were more likely to be aware that PHS was developing into an MR site, prior to work starting. This shows that those with previous knowledge are more likely to be users of the site, and may be more willing to pay a higher amount for maintenance of the site, or access to it.The majority of the respondents who use the site, do so for walking or running, or to enjoy the scenery and fresh air, which is also what was found in this study. Although 80% were not involved in any consultation events prior to work on the PHS MR site starting, 70% correctly identified that the primary goal for creating the site was flood defence. This suggests that the site and its reasons for creation have become well known within the local population.

Perhaps facilitating the public's knowledge of the site are events such as the "explore wetland wildlife" events that are coordinated by the Yorkshire wildlife trust (*ywt.org.uk),* and publicised on the 'visit Hull and east Yorkshire' website, encouraging the public to visit PHS and participate in nature walks and nature identification gatherings (visithullandeastyorkshire.com/wildlife-trust/nature-reserves). Events such as these highlight the importance of integrating the ecological characteristics of a site such as PHS, with the benefits to society they can mean. The development of habitat complexity at PHS has increased opportunity for visit frequency to the site, which was also identified as a statistically significant influencing variable on WTP values. Encouraging the public to visit the site creates awareness of the site's use benefits, such as leisure and recreational activities like nature walks, and non-use benefits such as the benefits of the site for flood protection. Therefore, increasing the public's value of the societal benefits associated with the site, and the ecological and economic value of the site.

As well as visit frequency, the amount of time the participant spends at the site per visit was also identified as an influencing variable on WTP values. A suggestion for the reason behind this may be the lack of substitute sites nearby. Unlike some of the MR site, such as Welwick which some of the sample population are nearer to the area of natural habitat at Spurn point, there are very few areas of natural habitat close enough to PHS to deter people from visiting the site. This lack of substitute sites means a higher frequency of visit to the site, and a longer amount of time spent at the site per visit, which has shown to positively influence WTP values.

The Yorkshire Wildlife trust have recently revealed plans for the 'Hull Green Arc Project', which aims to '*create a sweeping, wildlife-rich swathe of green areas within this built-up environment: a Living Landscape where wildlife can flourish and which people of all ages can enjoy*' (ywt.org.uk, 2012). Essentially the project aims to connect areas of habitat together, creating larger conservation areas, however this project is still in the planning and development phase with restoration works continuing over October and November 2012 at two of the six key sites identified in the 'Green Arc Project'. In the future, this could be beneficial or detrimental to the ecological and economical value of PHS. It may mean that visit frequency specifically to PHS decreases, as more areas of natural habitat become available to visitors, especially those who live closer to one of the other areas identified in the project. However, it could also encourage people from further away to visit the site,

as it is a large conservation area. This would ultimately increase the value of the societal benefits provided by the site.

Participant characteristics that have shown to have a statistically significant influence on their WTP values are all characteristics associated with their interaction with the site. This would suggest that the ecological structure of the site has an influence on participant valuations, and therefore the value of the societal benefits provided by the site are intrinsically linked to the site's ecological status.

CHAPTER 4

4. VALUATION OF SOCIETAL BENEFITS: WELWICK.

4.1 Introduction.

This chapter will attempt to ecologically and economically value the societal benefits associated with the MR site at Welwick, as well as looking at the main socio-demographic influences on participant willingness to pay responses.

The MR site will be described, including its position within the Humber estuary and the main reasons it was created, followed by a brief discussion of the sites ecology through monitoring reports conducted by ABPmer. Saltmarsh development and vegetation assemblages are summarised, and the abundance and diversity of bird, fish and invertebrate species is assessed in order to give a comprehensive overview of the sites ecological status. This will aim to better inform the reasons behind participant WTP values for both maintenance and access.

Statistical analysis of the data obtained from the interview survey questionnaires will attempt to illicit which socio- demographic factors may influence participant WTP values, as well as how much they are willing to pay for both maintenance and access to the site. The relative importance of the societal benefits in question will also be explored through the analysis of the contingent ranking data. This will offer insight into why the participants are willing to pay their stated amount.

The results will be discussed and summarised in an attempt to show possible ecological or physical influences the site may have on WTP values, and which societal benefits are considered most important to residents.

4.2 Site description.

The primary objective for the managed realignment site at Welwick was to contribute to a compensation package for the impacts (mainly habitat loss) of constructing the new harbour at Immingham, commissioned by ABP. The outer estuary site of Welwick was constructed over a two year period, as work was restricted to between April and August to avoid disturbing any overwintering or breeding bird colonies. Flood defences were created to the rear of the site to protect

housing from potential flood damage, and so saltmarsh would hopefully develop in front of the barriers (ABPmer, 2011).

The old defences were removed in a series of stages, to allow the site to flood and drain sufficiently, however as Welwick is considered a small site in comparison to the estuary as a whole (it encompasses 0.4% of the estuaries intertidal area, and 0.2% of its spring tidal prism), the effects on estuarine tidal velocities, sedimentation and accretion, and water levels, were expected to be extremely localised and small in comparison to the impact on other sites (ABPmer, 2003). The site was created in this way to improve connectivity with the wider estuary; produce a more accurate re-creation of the type of environments which existed prior to the reclamation; to allow the whole cross sectional area of the estuary, including the realignment site, to respond to estuary wide changes; to increase the energy levels within the site, and so improving the probability that mudflat habitat will be maintained (ABPmer, 2011). The primary objectives at Welwick were to create between 15-38ha of intertidal mudflat, together with 12-28ha of saltmarsh and 4-10ha of grassland (Hemingway *et al*., 2008) (Figure 4.1).

The realignment scheme at Welwick was breached in June 2006, costing a total of £1.5 million. A 10 year monitoring programme is currently being undertaken in order to ascertain the development of the site's bathymetry, saltmarsh evolution, topography and changes to intertidal invertebrates and water bird usage (Hemingway *et al*., 2008).

There are limited additional facilities for visitors to the site; there is no specified car park, although lane side parking is available. Visitors are required to stay on the floodbank, as deep creeks make walking anywhere else possibly hazardous, and disabled access is difficult.

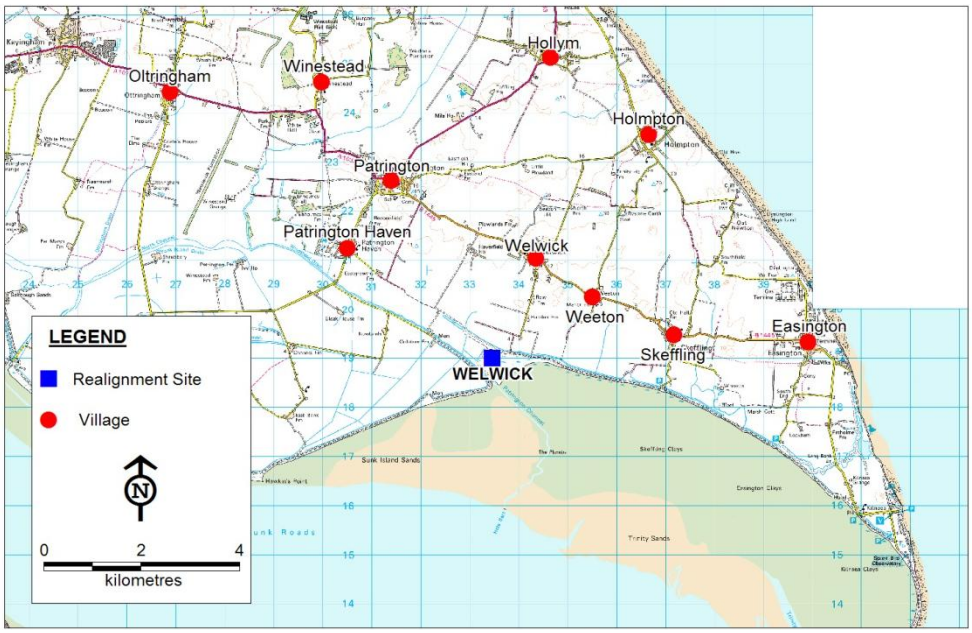

Figure 4.1 Map showing Welwick MR site and surrounding villages within 7 mile travel distance

4.3 Ecological overview.

The ecological monitoring reports for Welwick are predominantly produced by ABPmer, with information regarding the saltmarsh development and vegetation coverage, birds, invertebrates and fish. Basic observational monitoring of the site has shown an overall accretionary trend, with an average increase of 15cm across the site being estimated, there is also evidence of small scale erosion along the seaward boundary sites.

4.3.1 VEGETATION COVERAGE.

After the initial breach, pioneer species such as *Salicornia* sp were recorded, as well as occasional patches of annual sea-blite (*Suaeda maritima*), common saltmarsh grass (*Puccinella maritima*) and common cord-grass (*Spartina anglica*) (ABPmer, 2010). A year after the breach, the distribution of these vegetation species was similar to that found previously, but strands were more consolidated and the general cover of the vegetation was more established and extensive. In addition, strands of pioneer species initially did not colonise areas of the MR site lying below 2.5 metres ODN, however now localised strands were occurring in this area, representing a further establishment of the key vegetation species on the saltmarsh.

Over the next two years of vegetation monitoring up to August 2010, there was more extensive colonisation of the initial species recorded there, as well as the development and establishment of other low- marsh species amongst the *Salicornia*. In 2007, the south west area of the MR site was almost entirely *Salicornia*, in 2009 had extensive cover of common saltmarsh grass and associated species, such as annual sea blite , common cord grass, sea purslane (*Atriplex portulacoides*) and sea aster (*Aster tripolium*). This occurrence was also documented at the northern margin of the site, with small patches of common cord grass extending towards the centre of the site, and linear strips of predominantly sea couch (*Elytrigia atherica*) occurring at the edges of the site (ABPmer, 2010).

By August 2010, the vegetation cover around the northern border of the site had further established itself, although there are still extensive areas of open mud on lower ground, generally below 2m ODN. The overall trend of vegetation development shows a shift from dominating pioneer species towards transitional low-marsh vegetation, which is an important component of the pre-existing Humber foreshore habitat (ABPmer, 2010).

4.3.2 INVERTEBRATES.

Colonisation of the sediment by invertebrates is essential in order to attract foraging birds to the site. Early monitoring reports regarding invertebrate colonisation were promising, and by 2009, between 667 and 7,286 organisms were found per m^2 of sediment, belonging to between 5 and 13 different species including *Hediste diversicolour* and *Hydrobia ulvae*, both typical of estuarine intertidal areas such as this realignment site (ABPmer, 2011).

The abundance, diversity and biomass of invertebrate species present in the Welwick MR site mudflat have been steadily increasing since the breach in 2006, however they are still typically lower in comparison to pre-existing mudflat site outside of the realignment site (ABPmer, 2011). If invertebrate communities do not develop to match those of pre-existing mudflats, this will likely have a negative impact on foraging for birds, and so reduce the abundance of bird species at the site.

4.3.3 BIRDS.

The first winter after breach (2006/07) a total of 29 waterbird species were recorded at the site, with a number of these using the site for roosting at high water, and subsequently moving onto the fronting or adjacent intertidal areas as the tide receded. Following the sites further development, increasing number of Grey Plover, Redshank, Dunlin and Curlew were recorded foraging, as well as wildfowl species such as Shelduck also foraging from high to low water at the site (Hemingway *et al*., 2008). As part of the MR scheme, terrestrial habitats that might support a range of farmland birds was also required. Surveying of saltmarsh, hedgerows and floodbanks in 2007 found to support a range of breeding bird communities, with a total of 27 different bird species observed.

Further details of the bird monitoring were revealed in 2009, when a total of 31 different waterbird species were recorded as using the realignment site over the winter months. Species such as Red Knot, Dunlin, Curlew and Bar-Tailed Godwit are established as frequent users of the site for roosting capabilities, with overall numbers observed exceeding original predictions of bird use at Welwick (ABPmer, 2011).

Other species which have not been formerly recoded in a monitoring report, but which may be of public interest to look for include Greylag Goose, Brent Goose, Hen Harrier, Sparrowhawk, Kestrel, Merlin, Peregrine Falcon, Snipe, Greenshank, Barn Owl, Short-eared Owl and Meadow Pipit.

4.3.4 FISH.

There is little data on fish assemblages at Welwick in the years directly following the breach, however data was collected on fish species inside the MR site and compared to data collected from outside the MR site, as an indication of how the site was developing as an area that can be used by fish as nursery and breeding grounds. Data was also collected with regards to different gear types, so a more comprehensive view of the fish population inside the MR site is shown. Data was provided by Dr. Rafa Perez- Dominguez, and PhD student Meii Mohammad Norizam (2011) both from IECS, University of Hull.

With regards to a comparison between abundance of fish species inside and outside the MR site, results from a fyke net analysis revealed a much higher abundance inside the site than outside it. European flounder (*Platichthys flesus*) was the most abundant, with other species such as Plaice (*Pleuronectes platessa*), Golden Grey Mullet (*Liza aurata*), Eel (*Anguilla anguilla*) and Saithe (*Pollachius virens*) also present at the site. In terms of other gear types used to collect fish abundance data, Common Goby (*Pomatoschistus microps*) and Herring (*Clupea harengus*) were the most abundant with a seine net, with smaller numbers of Sprat (*Sprattus sprattus*), Greater Pipefish (*Syngnathus acus*) and Three-Spined Stickle back (*Gasterosteus aculeatus*). A large abundance of Common Goby were also caught with an epibenthic trawl, with only single samples of Greater Pipefish and Three-Spined Stickle back also present in the catch.

4.4 Survey population and response rates.

All households within a seven mile radius of the Welwick MR site were sampled (Figure 4.1). These households were grouped into nine individual villages, mostly surrounded by agricultural fields. All households in these nine villages were included in the sample population, in order to maximise the potential number of surveys in the data set, and provide a solid basis for statistical analysis (Table 4.1).

Table 4.1 Summary of survey population statistics (Welwick).

Village	Number of households	Number of complete surveys	% complete surveys
Welwick	96	4	4.17
Weeton	21	1	4.76
Patrington & Patrington Haven	119	30	25.21
Skeffling	36	3	8.33
Easington	93	18	19.35
Holmpton	43	4	9.30
Winestead	24	1	4.17
Ottringham	82	10	12.20
Hollym	60	8	13.33
Total	574	79	13.76

The total number of completed survey (13.76%) is a percentage of all the households in the Welwick survey catchment area, as an attempt was made to survey every single household in the area. Many of the households not represented here, were not surveyed because no resident answered the door. On 155 occasions (Welwick: 24, Weeton: 5, Patrington: 41, Easington: 27, Holmpton: 10, Winestead: 3, Ottringham:14, Hollym: 31) residents answered the door, but then declined to answer the survey questions. There was also 1 instance (Easington) when the survey had commenced but the participant declined before eliciting any WTP values. This survey was disregarded immediately. If the percentage of completed surveys were to be based on those people who answered their door, the response rate would be 50.97%, however as all households were attempted to be included, all should be included. Time constraints on the study limited the researcher from revisiting the households that did not answer the door on the first attempt. It is noted that this may cause sample selection bias in the data set, as if the households are only surveyed once, this could cause selection bias against those who are out or at work during the sample time.

4.5 Data preparation.

Through analysis of all separate variables with boxplots and dotplots, 2 outliers were identified and removed from the data set. In this case, the data points were identified as outliers in the set either because they were a value that is extremely far removed from the rest of the data set, or because one of the socio-demographic categories is extremely underrepresented (i.e. only has one participant in it) and therefore cannot be treated as indicative of that particular socio- demographic category in general. Both the boxplots and the dotplots were performed with and without the outliers in the data set for thorough analysis, and the identified outlier were removed from the data set before any further statistical analysis was performed. 4 respondents were also removed as protest bidders (definition in Chapter 2).

A full summary of all variable aggregations transformed from the original binary format in the questionnaire survey is given in Table 3.2 (Chapter 3). The scale values WTP maintenance, WTP access and distance were aggregated into ordinal values for the purpose of performing X^2 on them. For all other statistical analysis, they remain as scale variables.

4.6 General characteristics of the respondents.

Socio- demographic details were collected from the survey respondents, this provides an idea as to how complex a cross section of the population was taken, can reveal patterns into what variables effect WTP values, and is vital in successful identification of protest bids (Chapter 2). A summary of the general characteristics of the respondents is given below (Table 4.2).

Obvious trends that can be seen from looking at the table include the fact that 50% of participants earn between 20,001- 40,000 a year (after tax), and very few live less than 2 miles from the site, however this is perhaps due to there being fewer dwellings this close to the MR site, in comparison to the amount found further than 2 miles from the site. There were slightly more male representatives than female. There were also marginally more participants who have children than those who do not, which perhaps correlates to the age of the majority of participants, as the average age for a first child in UK is 29.5 years (ons.gov.uk).

4.7 Knowledge and use of the site.

The largest group of participants did not have knowledge of the site prior to being interviewed (88.9%) and just over 90% of the respondents never visit the site or spend any time there. For the participants who do visit the site, they were asked what activities they participate in. None had an occupation which would cause them to visit the site for reasons other than personal, therefore it was concluded that all visits to the site were for recreational reasons. Of the five survey participants who had visited the site at least once in the last 12 months, all five used the site for dog walking, four used the site for bird watching, and five enjoyed the site for relaxing or enjoying the scenery (participants could choose more than one activity). None used the site for walking either for fitness or to enjoy the scenery, picnicking, or general nature watching (Figure 4.2).

Table 4.2 General summary of respondents' characteristics (Welwick).

Question	Answer	N	No of responses	% Response
Age	18- 24	72	0	0
	25- 34		7	9.7
	35- 44		20	27.8
	45- 54		18	25
	55- 64		3	4.2
	65- 74		17	23.6
	75- 84		7	9.7
Income	< 20,000	72	14	19.4
	20,001- 40,000		36	50
	40,001- 60,000		19	26.4
	60,001- 80,000		3	4.2
	80,001- 100,000		0	0
	100,001- 120,000		0	0
	> 120,001		0	0
Gender	Male	72	40	55.6
	Female		32	44.4
Education	Primary	72	0	0
	Secondary		9	12.5
	Vocational		8	11.1
	Training		24	33.3
	Further		30	41.7
	Higher		1	1.4
	Postgraduate			
Children	Yes	72	42	58.3
	No		30	41.7
Distance	< 2 miles	72	4	5.6
	2- 5 miles		35	48.6
	> 5 miles		33	45.8
Visit Frequency	1= Daily	72	0	0
	2= Weekly		0	0
	3= Fortnightly		0	0
	4= Monthly		4	5.6
	5= Yearly (once)		1	1.4
	6= Never		67	93.1
Time spent at the site	0= None	72	67	93.1
	1= < 0.5		0	0
	2= 0.5- 1		5	6.9
	3= 1- 1.5		0	0
Previous knowledge of the site	1= Yes	72	8	11.1
	2= No		64	88.9

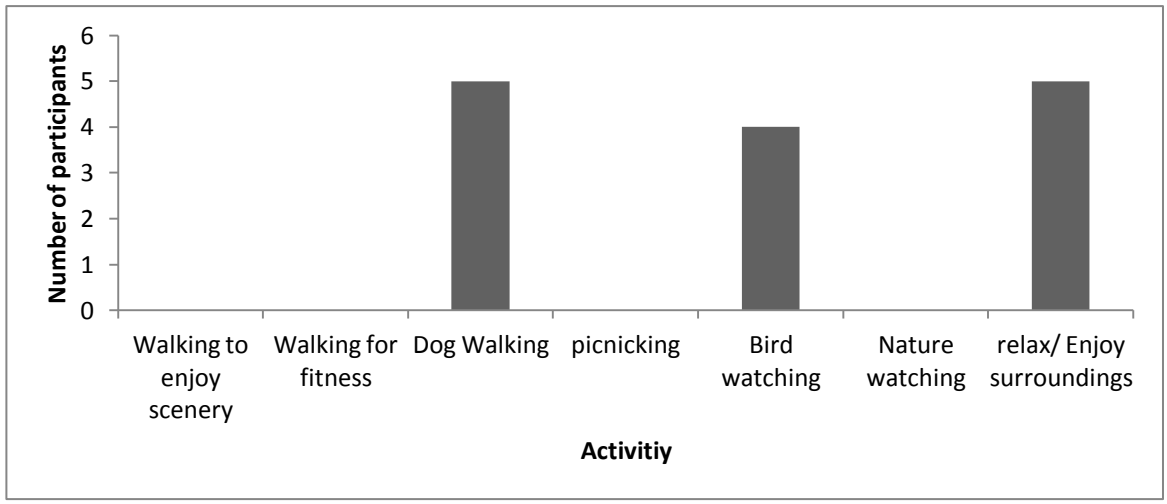

Figure 4.2 Uses of Welwick MR site. Count does not equal the total number of respondents, as respondents were allowed to choose all activities they participate in.

4.8 Willingness to pay responses.

The results from the initial choice experiment question are summarised below (Table 4.3). The difference between those willing to pay something for maintenance and those willing to pay something for access is noticeably large. Just over 93% of participants chose to not pay for access, compared to just over 44% who chose not to pay for maintenance.

Table 4.3 Summary of choice experiment results for Welwick.

Willing to pay for MAINTENANCE?	Number of participants	% Response
Yes	40	55.56
No	32	44.44
Willing to pay for ACCESS?	Number of participants	% Response
Yes	5	6.94
No	67	93.06

4.9 Distribution of bids.

Participant attitudes towards WTP scenario's was derived in two ways, firstly with the bimodal distribution choice experiment question which gave them the option between paying something and gaining something, or not paying anything and remaining with the same situation; secondly by asking for the specific amount they would be willing to pay, in a contingent valuation question. Approximately 55.56% of were willing to pay at least £1 per year in order to maintain the MR site to its current

standard. Of those who chose not to pay anything, 8.33% stated they would be willing to pay something, but could not afford to at this time. 2.78% were not willing to pay anything as the site's maintenance was not a priority for them, and 23.61% stated they did not use or visit the site, so would not pay for it. 4.16% did not value any of the benefits provided by the site, 2 participants each objected to paying higher taxes, and did not trust the government to use the money as intended (Figure 4.3).

Only 5.6% of participants were willing to pay £1 or more, specifically for access to the site. Of the 67 people who chose not to pay an annual amount for access, 23.61% stated that they could not afford to, but they would be willing to if they could and 4.17% claimed it was not a priority for them. 56.9% chose not to pay because they do not use or visit the site, whilst 4.16% did not value any of the benefits provided by the site. 2 people objected to paying higher taxes, and 2 people did not trust the government to use the funds as intended (Figure 4.3). The participants who chose options F, G or H were removed as protest bidders.

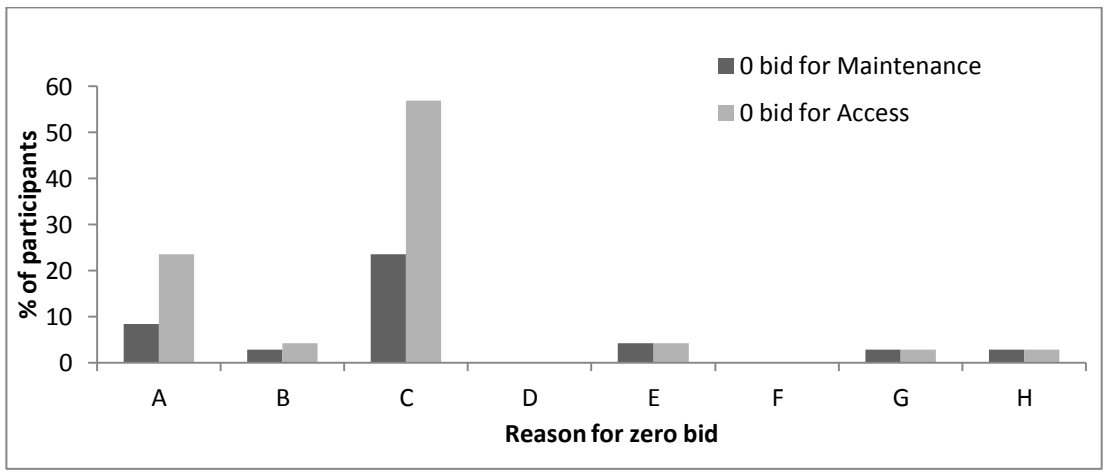

Figure 4.3 Participants' reasons for choosing NOT to pay for maintenance of or access to Welwick MR site. (A= 'I cannot afford to pay, but I would do; B= 'It is not a priority for me'; C= 'I do not use or visit the site; D= 'I am not interested in the wetland environment; E= 'I do not value any of the site's benefits; F= 'The organisation that created the site should pay; G= 'I object to paying higher taxes'; H= 'I do not trust the government to use the taxes as intended'.

Those who chose to pay something for maintenance of the MR site were asked a series of follow up questions in order to find out their exact WTP values. The WTP maintenance values stated by the participants wishing to pay something ranged between £1 and £10 a year. All bids combined (including zero bids) had mean of

£3.13 (SD= 3.16), with median and mode of £5 and £0 respectively (Figure 4.4). It is noted that this is a bimodal distribution for WTP.

For those who chose to pay for access to the site, the range of WTP access values is between £1 and £6, averaging (for all bids) at £0.28 (SD= .23) with median and mode both at £2 (Figure 4.4)

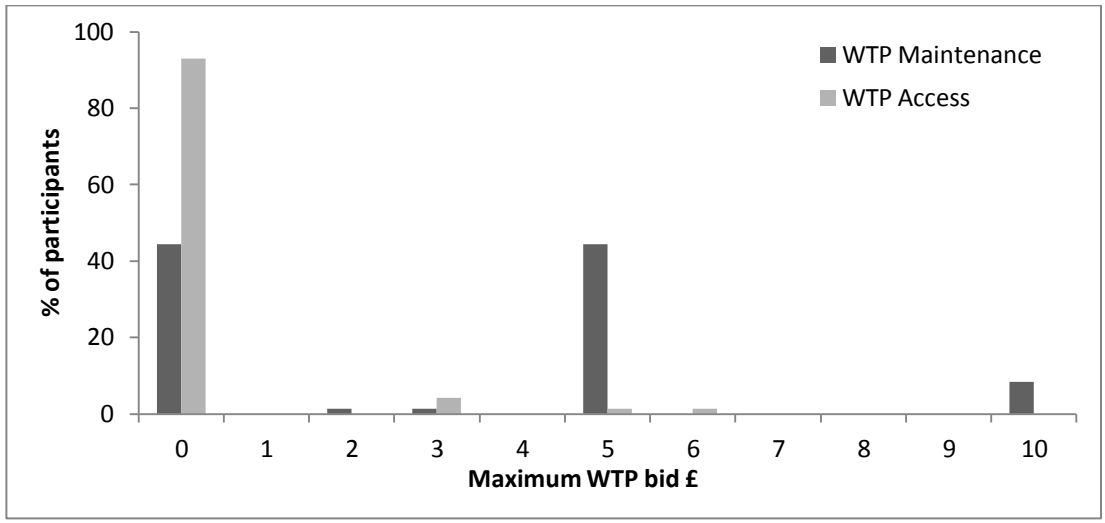

Figure 4.4 Distribution of WTP bids for Welwick MR site.

4.10 Exploratory and chi-square analysis.

To determine which explanatory variables may or may not be influencing the participant willingness to pay values for maintenance or access, exploratory techniques (described in Chapter 2) were used to look any patterns that may occur in the data.

Firstly, the relationship between the distance the participant lives from the site and their WTP maintenance value was considered. The scatterplot shows a weak negative correlation, suggesting that the closer the participant lives to the site, the more they are willing to pay for maintenance of the site (Figure 4.5). The relationship was tested statistically using a X^2 test and was found non- significant at the 95% level (X^2 = 10.28) however, 55.6% of the cells had an expected count of less than 5, and therefore we must assume a loss of statistical power. To check the validity of this test, a Spearman's rank order test was applied to the same data. The results were statistically significant at the 95% level (r_s= -.331, p=< .005) and therefore distance will not automatically be include in any aggregation of the results,

but will be still be treated as a variable of interest, and analysed further to discern its true importance to WTP maintenance values. In terms of the effect distance may have on participant WTP values for access; the relationship was statistically significant with Pearson's chi square (X^2= 22.483, p< 0.001) showing that the further away the participant lives from the site, the less they are willing to pay for access to it (Figure 4.6).

Similarly, where loss of statistical power occurs in the X^2 output due to a high percentage of cells having an expected count of less than 5, a Spearman's rank order will always be performed as well as the X^2, in order to increase the statistical validity of the results. This occurs in most cases in the Welwick data set, due to the smaller number of completed surveys from the Welwick catchment compared to the other sites.

Participant annual income was also assessed in relation to how much they were willing to pay for maintenance and for access, with a supposition that someone with a higher income may be prepared to pay more for the MR site, than someone who has a lower income. In terms of WTP maintenance values (Figure 4.7), the relationship was found non-significant with a X^2 (X^2= 16.35), however 60% of the cells had an expected count of less than 5, and the Spearman's rank order was found statistically significant (r_s = .410, p=< 0.001). In terms of WTP access values in relation to income, both X^2 (X^2= 5.57) and r_s (r_s = .180) were found non-significant.

The frequency of participant visits to the site has a statistically significant effect on their WTP access values, suggesting that the more frequent their visit, the more likely they are to pay for access to the site (Figure 4.8). This relationship had a X^2 value of 63.94 (p<.001), but 88.9% of the cells had an expected count of less than 5, and therefore r_s was implemented, which also yielded a significant result (r_s = -.903, p<.001).

The same was also true for the variable showing the amount of time the participant spends at the site per visit, as this also had a statistically significant relationship with WTP access, the longer the participant chooses to spend at the site, the more they are willing to pay for access (X^2= 74.38, p<.001; r_s =.999, p<.001) (Figure 4.9). Whether the participant had previous knowledge of the site or not prior to the survey

also appears to have a statistically significant effect on their WTP access values (Figure 4.10). The relationship was tested with X^2 (X^2= 34.91, p< .001), and also with r_s as there were too many cells with an expected count lower than five to rely on chi square alone (r_s = -.695, p< .001).

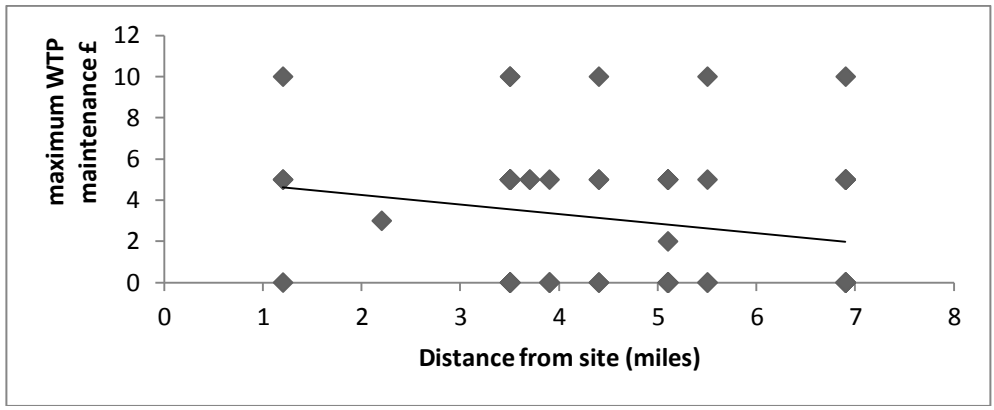

Figure 4.5 Relationship between the distance that the participant lives from Welwick MR site, and their maximum WTP maintenance value. Points may represent more than one case. The trendline reflects this.

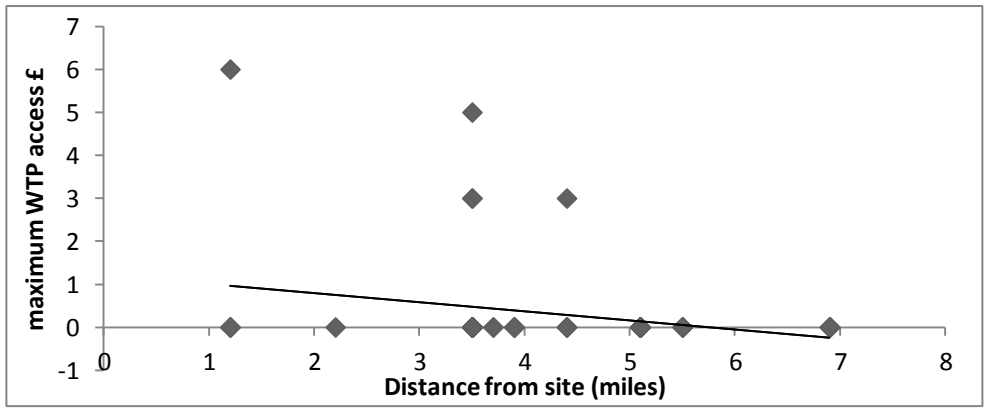

Figure 4.6 Relationship between the distance that the participant lives from Welwick MR site site, and their maximum WTP access value. Points may represent more than one case. The trendline reflects this.

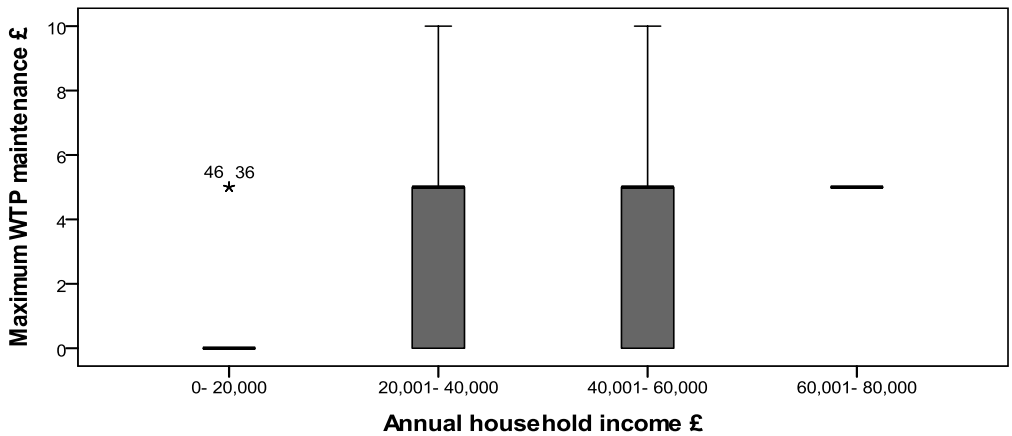

Figure 4.7 Relationship between participants' maximum WTP maintenance values for Welwick MR site and their annual income (**o** = outliers, ***** = extraneous variables).

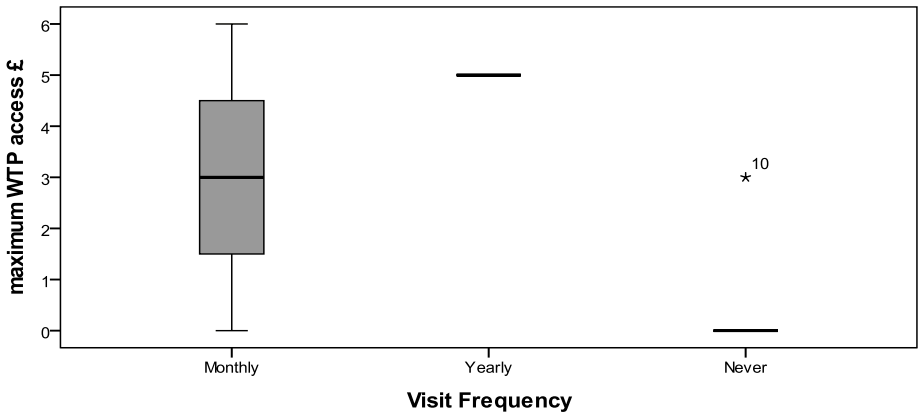

Figure 4.8 Relationship between the participants' visit frequency to Welwick MR site in the last 12 months, and their WTP access value (**o** = outliers, ***** = extraneous variables).

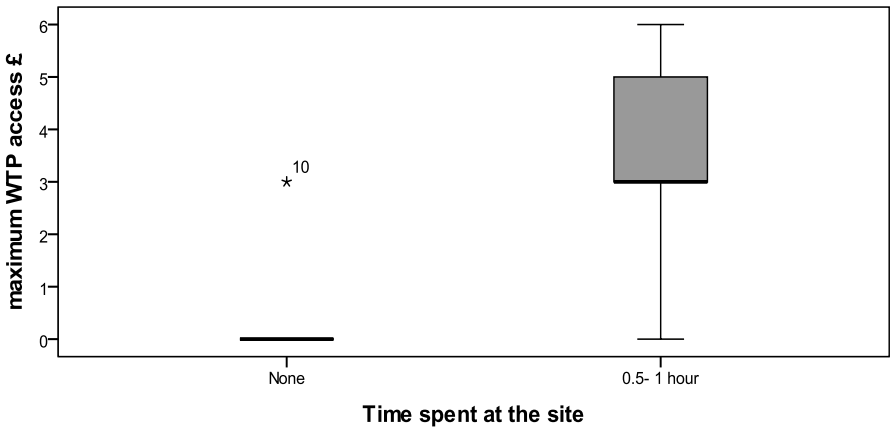

Figure 4.9 Relationship between average time spent at Welwick MR site per visit and maximum WTP access values (**o** = outliers, ***** = extraneous variables).

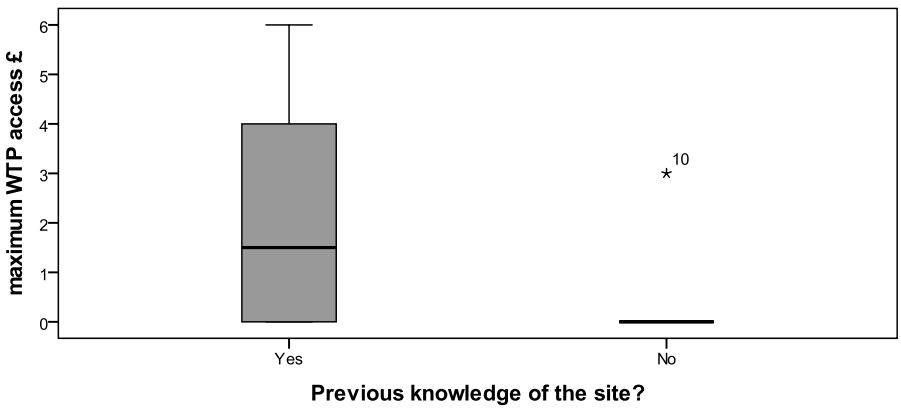

Figure 4.10 Relationship between whether the participant had knowledge of Welwick MR site prior to survey or not, and their maximum WTP access value (**o** = outliers, ***** = extraneous variables).

Although the three explanatory variables of visit frequency to the site, time spent at the site, and previous knowledge of the site all have a statistically significant correlation with willingness to pay for access, they are all non- significant in relation to willingness to pay for maintenance values (Visit frequency X^2 = 2.80, r_s = -.168; Time spent X^2 = 1.70, r_s = .150; Previous knowledge X^2 = 4.35, r_s = .114). There were also other explanatory variables which did not have a statistically significant influence on either WTP maintenance or WTP access values. These were the participant age (WTP maintenance X^2 = 13.44, r_s = -.123; WTP access X^2 = 16.38, r_s = .054), their level of education (WTP maintenance X^2 = 8.64, r_s = .210; WTP access X^2 = 8.24, r_s = -.075), their gender (WTP maintenance X^2 = .25, r_s = -.031, WTP access X^2 = 1.25, r_s = .029) and whether they have children or not (WTP maintenance X^2 = .37, r_s = -.070; WTP access X^2 = 1.5, r_s = .064).

Results from the initial exploratory and X^2 analysis revealed that in relation to WTP maintenance values, influencing factors are identified as the distance that the participant lives from the site and their annual household income. In relation to WTP access values, influencing factors may be the distance that they live from the site, the frequency that they visit the site, the amount of time they spend at the site per visit, and whether they have knowledge of the site prior to completing the survey.

4.11 Coplot analysis.

Following the initial exploratory analysis looking at the influence of one explanatory variable on the response, it is then useful to use coplot analysis to look at the influence of more than one explanatory variable on the response variable. The effects of distance the participant lives from the site coupled with their previous knowledge of the site have an effect on willingness to pay for both maintenance (Figure 4.11) and access (Figure 4.12). If the participant does have previous knowledge of the site, the distance they live from the site has a large influence on the amount that they are willing to pay for maintenance or access, they are willing to pay more the closer they live to the site. However, if the participant does not have knowledge of the site prior to completing the survey, distance has a lesser effect on WTP maintenance values, but still shows that those who live closer are willing to pay more than those who live further away. There is no relationship between WTP access values and the distance that the participant lives from the site, if they do not have previous knowledge of the site.

The relationship between WTP, previous knowledge and visit frequency was also analysed for both maintenance and access values. In terms of maintenance values, if the participant had knowledge of the site prior to the survey, their frequency of visit had a positive relationship with their WTP value meaning the more often they visited the site, the more they were willing to pay for maintenance of it. If the participant did not have previous knowledge of the site, there is a negative relationship between WTP and visit frequency meaning the fewer times they visit the site the higher their WTP value (Figure 4.13). In relation to willingness to pay for access values, as with the maintenance values if the participant had previous knowledge of the site, the higher their frequency of visit the higher their WTP access value was. If the participant did not have knowledge of the site prior to the survey, their visit frequency to the site had no effect on their willingness to pay for access values (Figure 4.14).

The relationship between WTP maintenance values and income in relation to the previous knowledge of the site was also analysed (Figure 4.15). If the participant had previous knowledge of the site, those with a higher level of income were willing to pay less for maintenance than those with a lower level of income. However if the participant had no knowledge of the site prior to the survey, the relationship between income and WTP maintenance may be closer to what is expected, with those with a higher level of income willing to pay more for maintenance of the site than those with a lower level of income.

Overall, results from the coplot analysis reveal that whether the participant has previous knowledge of the site prior to the interview survey or not has an influence on their WTP values for both maintenance and access, when in conjunction with various other explanatory variables such as visit frequency, distance from the site and income. However, it should be noted that due to the low number of cases in the data set, other techniques will be used in the analysis to validate the results found here.

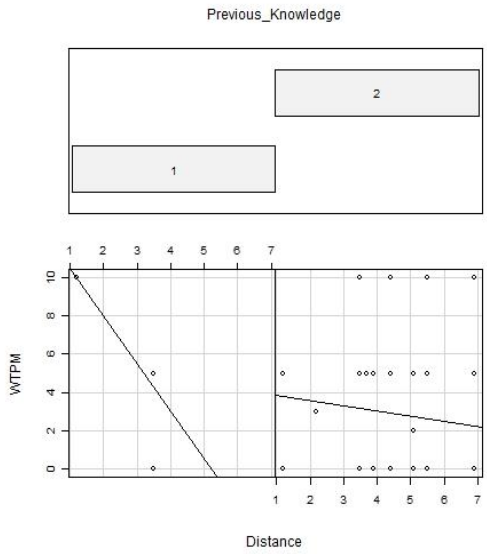

Figure 4.11 Relationship between WTP maintenance and distance from Welwick MR site, with conditioning variable previous knowledge (WTPM= £ values; distance= miles from the site; previous knowledge 1= yes, 2= no)

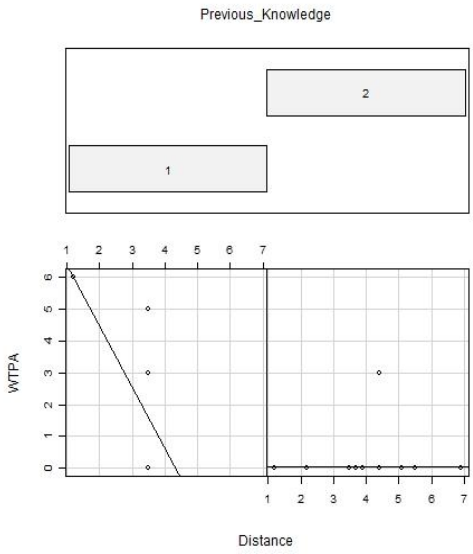

Figure 4.12 Relationship between WTP access and distance from Welwick MR site, with conditioning variable previous knowledge (WTPM= £ values; distance= miles from the site; previous knowledge 1= yes, 2= no)

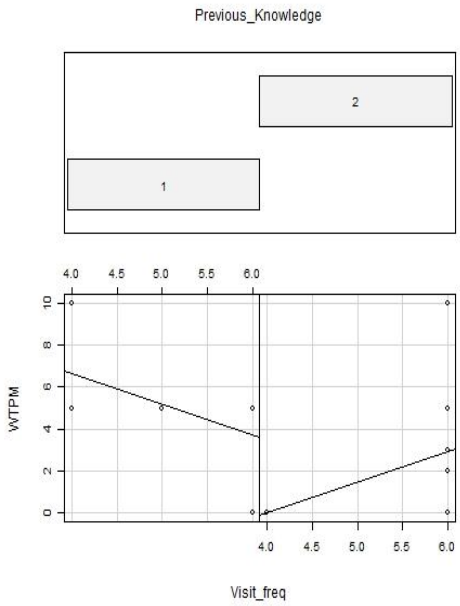

Figure 4.13 Relationship between WTP maintenance and visit frequency to Welwick MR site, with conditioning variable previous knowledge (WTPM= £ values; previous knowledge 1= yes, 2= no)

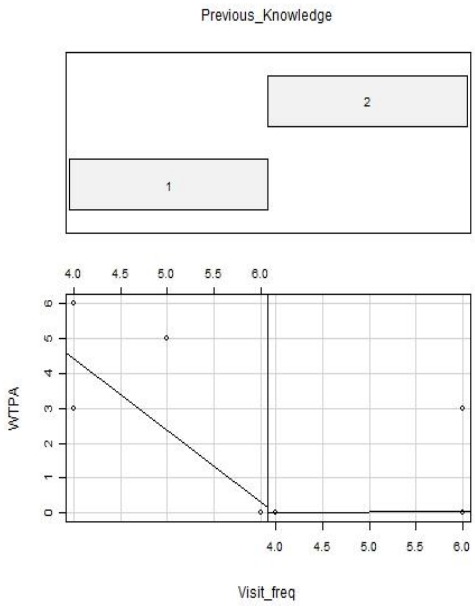

Figure 4.14 Relationship between WTP access and visit frequency to Welwick MR site, with conditioning variable previous knowledge (WTPM= £ values; previous knowledge 1= yes, 2= no)

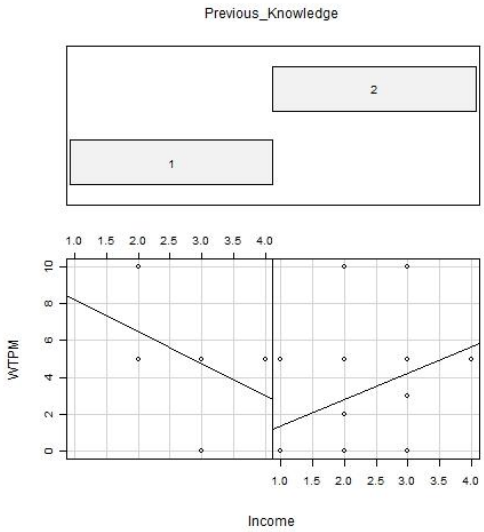

Figure 4.15 Relationship between maximum WTP maintenance values for Welwick MR site and annual income, with conditioning variable previous knowledge (WTPM= £ values; previous knowledge 1= yes, 2= no)

Results from the coplot analysis confirm what was found in the initial exploratory analysis, that previous knowledge is an important influencing factor, on its own and when in combination with other factors, such as visit frequency, income and distance.

4.12 Principal component analysis of explanatory variables.

Initially, a scree plot with eigenvalues from all the included variables was analysed, and was found to have an inflection after the first 3 components. The first three components also had eigenvalues greater then 1, and following Kaiser's recommended criterion, it was decided that a three component PCA was the most suitable for this data set. However once the analysis had run, inspection of the anti-image correlations showed that the variables Gender and Education had values lower than 0.5 (.398 and .457 respectively) and therefore it was decided to remove these variables from the data set.

A second scree plot was analysed with Gender and Education removed, and this time the inflection occurred after the first two components, and only the first two components had eigenvalues of more than 1. Therefore based on the new data set,

a two component PCA was the most suitable, and the analysis continued based on this. With Gender and Education removed, none of the anti- image correlation values were lower than 0.5. as well as this, when the correlation matrix was re-analysed, none of the pearson correlation coefficients had a value higher than 0.9, which reduces problems that may arise due to singularity in the data (with Gender and Education included in the PCA, several of the values had been higher then 0.9). The determinant of the correlation matrix was also greater than the necessary value of $0.1x10^{-4}$ (determinant= .004) and therefore it can be assumed that multicollinearity is not an issue.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was assessed, which represents the ratio of the squared correlation between variables to the squared partial correlation between variables. A value between 0 and 0.5 indicates the sum of partial correlations is too large relative to the sum of correlations, leading to a diffusion in the pattern in correlations and PCA would be inappropriate. A value between 0.5 and 1 means the correlation patterns are compact, and PCA can be trusted to give reliable components (Kaiser, 1974). For this two component model, the value is higher than 0.5 (KMO= .649), coupled with the highly significant Bartlett's test of spericity ($p< .001$), the use of PCA is justified, using an oblimin with Kaiser normalization rotation method as we may expect some correlation between the two factors here.

The extracted sums of squared loadings showed that components 1 and 2 account for 44.2% and 27% of the total variance found in the PCA model respectively (71.2% total variance). Because an oblique rotated component solution (or factor solution) was used in the analysis, the pattern matrix was the primarily point of interpretation with regards to the nature of the PCA. 0.3 is regarded as a threshold to determine whether a variable is contributing to the component in a meaningful way. Time Spent at the site, Visit Frequency to the site and Previous Knowledge of the site were all highly meaningful to component 1, whilst Age, whether the participant has children or not, and Income were all meaningful values in component 2. Distance could be classed as meaningful in either component 1 or 2, as it's vale in both was above the 0.3 threshold, however both Distance values were much lower than the other variables (Table 4.4). This seems to be indicating that component 1 shows the variation for the participant relationship with the site, whilst component 2 shows the variation for participant socio-demographic details. The

distance the participant lives from the site could perhaps be considered as being a part of either category, and therefore is considered in both components.

Although a distinction between components 1 and 2 is clearly shown in the pattern matrix, the component correlation matrix reveals that the correlation between the two components is quite low (.253) and therefore it is reasonable to assume that there is independence between the factors. However, these findings need to be further analysed, as 71% of the nonredundant residuals in the PCA have absolute values greater than 0.05, when ideally there would be less than 50% of the nonredundant residuals with values higher than 0.05.

Although the results of this PCA have shown that socio-demographic details and characteristics that include participant interaction with the site can be separated, the results from this analysis are non-significant. Therefore the results of this PCA will only be trusted on an exploratory basis.

Table 4.4 Pattern matrix containing factor loadings for PCA for Welwick data. Values considered meaningful to the component are in bold.

Pattern Matrix[a]

	Component	
	1	2
Time_Spent	**-.953**	.031
Visit_Freq	**.943**	-.035
Prev_Knowledge	**.789**	-.002
Age	-.079	**.934**
Children	-.161	**.926**
Income	-.159	**-.726**
Distance	**.338**	**.395**

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

4.13 Generalised linear modelling for maintenance values.

All nominal and ordinal variables were factored, and then analysed using Poisson GLM as the response variable is continuous and used for count data. The initial Poisson model was overdispersed (Phi> 1.5, AIC value= 3.82) and therefore it was inappropriate to continue with Poisson model. Quasi- Poisson model was selected instead, as it can deal with a certain amount of dispersion, and the model was run again. Dispersion in this case was less than 20, and therefore Quasi- Poisson is suitable for model selection.

All variables were included in the model initially, and the least important variable amongst those that were not significant identified. A new model was refitted without this variable and tested again, and so on until all the remaining variables in the model are statistically significant.

The results from this process resulted in the GLM model:

Glm(WTPM ~ fIncome)

With only the explanatory variable of income significant in the model at the 0.05 level (Table 4.5). Therefore this suggests that participant income has the most influence on their willingness to pay for maintenance values, and is the only explanatory variable to have a statistical significance on WTP maintenance in the GLM model.

Table 4.5 Descriptive values for variables in Welwick GLM WTP maintenance model.

Variable	Df	Deviance	F value	P value
Income	3	287.95	3.0071	0.0362

Model validation is based on analysis of the residuals of the model. Homogeneity is checked by plotting the extracted standardised residuals and fitted values (Figures 4.16 & 4.17). The plot of the residual and fitted values shows there is no specific pattern to the residuals, and therefore in terms of heterogeneity, the assumptions of the model are not violated. Although the residuals plotted in the Q-Q plot do not follow the best-fit line exactly, the general pattern is the same.

A histogram of the residuals was also plotted, and analysed alongside a normal distribution curve to compare the difference between them (Figure 4.18). The plot shows that the residuals do not follow a similar pattern to the normal distribution line, and therefore the model cannot be fully justified.

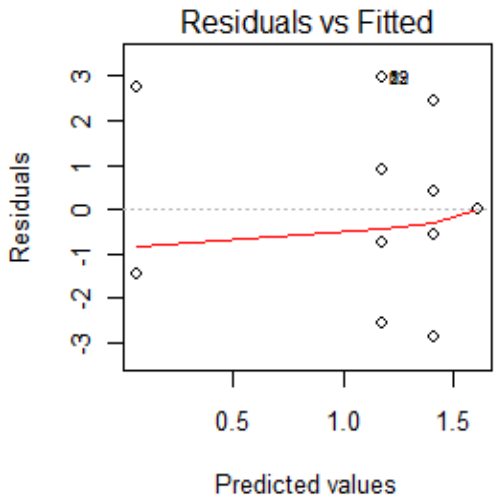

Figure 4.16 Welwick WTP maintenance GLM model residuals plotted against fitted values, with line of best fit

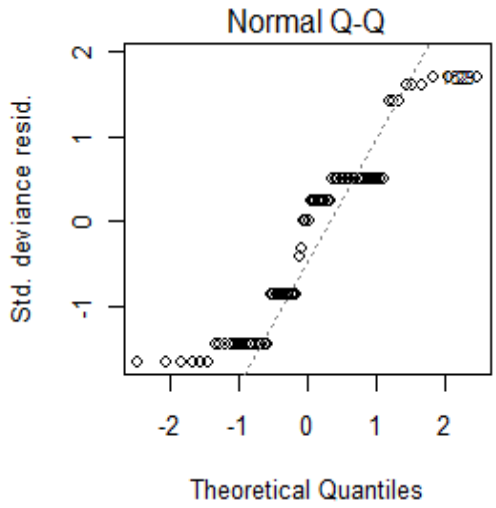

Figure 4.17 Welwick WTP maintenance GLM model residuals plotted against theoretical quantiles with line of best fit

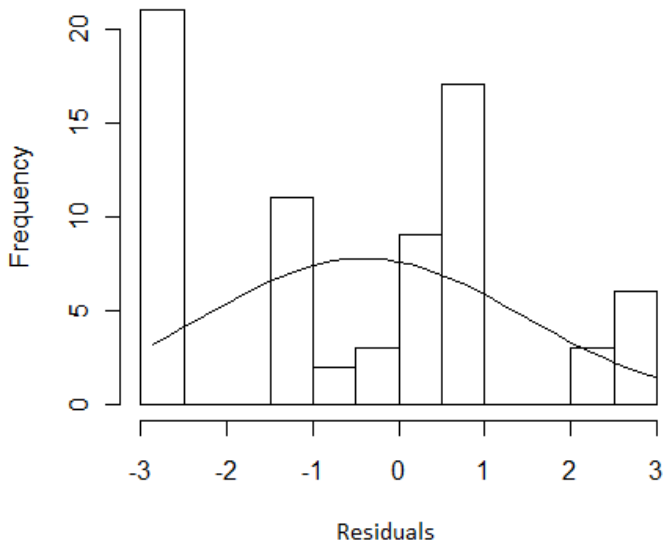

Figure 4.18 Histogram of Welwick GLM WTP maintenance model residuals, with the line showing normal distribution.

The percentage of variance in the data explained by the model was calculated using the null deviance (287.95) and the residual deviance (254.22). 11.71% can be accounted for by the model which although there is no formal variable, the higher the value the better. Given the variables tested against this response variable, this is the best model, but there may be other factors not considered here that have an effect on WTP maintenance. Considering the percentage of variance accounted for and the analysis of residuals, this model is rejected. The influence of the variables will be tested using decision tree analysis in order to further analyse the relationship between these explanatory variables and the response WTP maintenance variable.

4.14 Generalised linear modelling for WTP access values.

The glm modelling for the WTP access data was slightly different from the model selection for WTP maintenance data, as the access data was zero-inflated. More than 87% of the data were zero's the response variable, and as a result it was decided that Poisson modelling was not the most suitable technique to use on the WTP access data. Instead, the response variable was converted into a binary variable instead of scale and Binomial model selection was used. By using Binomial instead of Poisson model selection, fewer errors occur during model selection due to overdispersion of the data, and a more concise result from the model will be gained. The negative of using this model selection is mainly that the information gained in the analysis will perhaps not be as instructive as if Poisson model selection had been used, however we will still learn which explanatory variables have the most influence on whether someone is willing to pay for access or not, and therefore will still contribute to answering the main research questions.

As with the WTP maintenance Poisson model, all variable were included initially in the model, and were removed via backwards step selection, in order of least statistical significance. The model resulting from this process was:

Glm(WTPA ~ fPrev.knowledge)

Showing that previous knowledge of the site is the only explanatory variable that has a statistically significant influence on whether they are willing to pay for access or not. It was significant at the 95% level (Table 4.6).

Table 4.6 Descriptive values for variables in Welwick GLM WTP access model.

Variable	Df	Deviance	AIC	P value (Chi)
Previous knowledge	1	80.976	82.976	4.421e-07

The model was validated by analysing the plotted residuals (Figures 4.19 & 4.20). In the residuals against the fitted values plot, the difference between the red line of best fit and the line at 0 is quite large, and in the histogram we can see that the line of normal distribution is very different from the distribution of the residuals. The percentage of variance explained by the model calculated with the null and residual deviance is 51.45%, which not too low as to discount the model, but in terms of heterogeneity, the assumptions of the model have been violated and therefore the model must be rejected. Further analysis through decision tree analysis is required, to reinforce the results from this model.

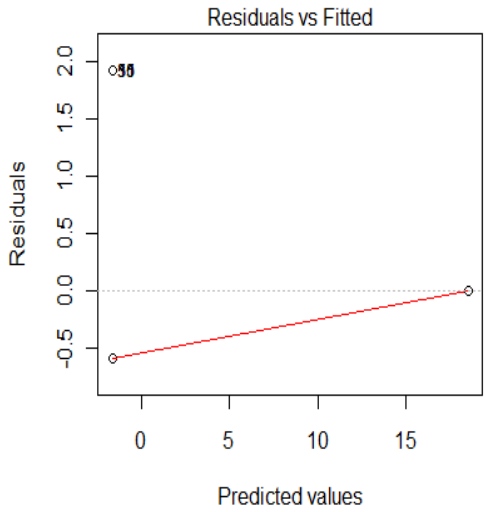

Figure 4.19 Welwick WTP access GLM model residuals plotted against fitted values, with line of best fit

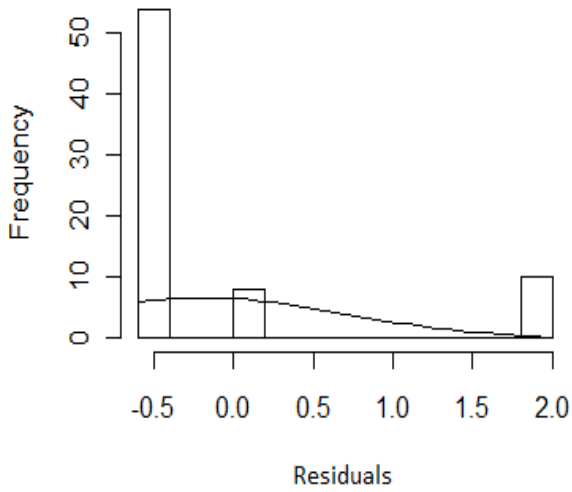

Figure 4.20 Histogram of Welwick GLM WTP accessmodel residuals, with the line showing normal distribution.

4.15 Decision tree analysis for WTP maintenance values.

The decision tree analysis shows that income has the most influence on willingness to pay for maintenance, as those whose households earn over £20,000 a year were willing to pay an average of £3.61 a year for maintenance, as opposed to those who earn £20,000 or less a year, who were willing to pay £2 a year for maintenance (Figure 4.21). The difference between these two nodes (1 & 2) was tested for significance using a Mann- Whitney U test, and was found significant at the 95% level (p= 0.005) (Table 4.7). Of those that earned more than £20,000 a year, these participants were divided by the distance that they live from the site. Those who lived less than 3.8 miles from the site were willing to pay an average of £2.35 a year, and those living closer than 3.8 miles to the site were willing to pay £4.74 for maintenance. The statistical significance between node 3 and node 4 was found non- significant with a Mann- Whitney U test.

Participants that lived 3.8 miles or less from the site were then further segregated by age. Those that were in the 35- 44 age bracket or younger were willing to pay an annual amount of £3.33 for maintenance of the site. Those older than 44 were willing to pay £6 per year, a difference which is found statistically significant level (p= .006) using a Mann-Whitney U test. Those that were younger than 44 were then divided by gender as the next most influential explanatory variable. Males in this situation were willing to pay £3 more than females, at £5 and £2 respectively, although this was not found to be statistically significant.

The participants who lived further than 3.8 miles away were segregated according to distance again, but this time a further distance from the site. Participants that live equal to, or less than 6.2 miles from the site were willing to pay £1.67, whilst those who live more than 6.2 miles away were willing to pay £4 annually for maintenance of the site. However, the difference between nodes 7 and 8 was not found statistically significant. Those that lived equal to or less than 6.2 miles from the site were then further divided with regards to their age category. Participants who were 54 or younger were willing to pay an annual average of £0.63 for maintenance, whilst those who were older than 54 were willing to pay £3.75 per year for maintenance, although this difference was not found to be statistically significant with a Mann- Whitney U test.

Table 4.7 Mann- Whitney U values and statistical significance for Welwick WTP maintenance decision tree analysis.

Variable	Difference between nodes	Z value	P value	Level of significance
Income	1 & 2	-2.790	.005	95%
Distance	3 & 4	-1.771	.77	-
Age	5 & 6	-2.737	.006	95%
Distance	7 & 8	-.866	.483	-
Gender	9 & 10	-.978	.328	-
Age	11 & 12	-1.377	.169	-

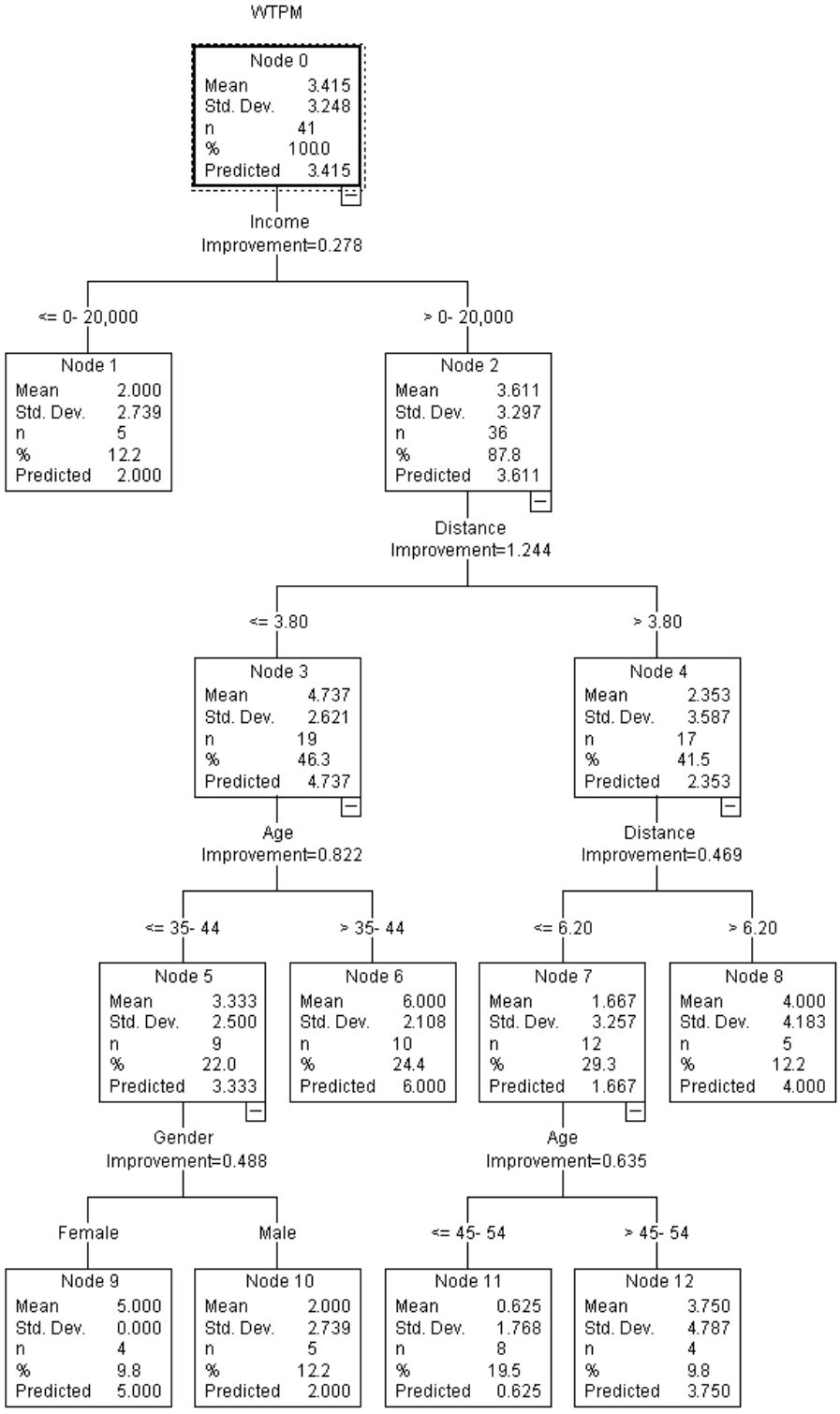

Figure 4.21 Decision tree analysis for Welwick WTP maintenance values.

4.16 Decision tree analysis for WTP access values.

The decision tree analysis was also applied to the willingness to pay for access data (Figure 4.22). The response variable (WTP access) was initially split by whether the participant had previous knowledge of the site or not, further enforcing what the GLM analysis showed, which is that previous knowledge has the most influence on willingness to pay for access. Those participants who did have previous knowledge of the site were willing to pay an average of £3 annually for access to the site. The participants who did not have previous knowledge of the site, were willing to pay an average of £0.08 for access. The difference between nodes 1 & 2 was tested for its statistical significance using a Mann- Whitney U test, and was significant at the 95% level ($p < .001$) (Table 4.8).

Those who did have previous knowledge of the site were further split according to how far they live from the site. Those who lived 2.35 miles or less from the site were willing to pay on average £6 annually for access. Those who lived more than 2.35 miles away were willing to pay £4.50 less than that annually, at £1.50. The significance between these two values (nodes 3 & 4) was tested with a Mann-Whitney U test, and was found non- significant. The participants who lived more than 2.35 miles from the site, were then split by their visit frequency to the site. Those who had visited the site on a monthly basis or more frequently than this over the last 12 months, were willing to pay £3 on average for access to the site. Those who visited the site less than monthly were not willing to pay anything on average, and the difference between these values (nodes 5 & 6) was found to be significant at the 95% level with a Mann- Whitney U test ($p < .001$).

The participants that did not have previous knowledge of the site were also segregated by their visit frequency to the site. The same values occurred here, with those who visited monthly or more frequently willing to pay £3 for access, and those visiting less frequently than that, not willing to pay anything. However the difference between these two nodes (7 & 8), although still significant with a Mann- Whitney u test, was not as significant as the previous split regarding visit frequency ($p = .029$).

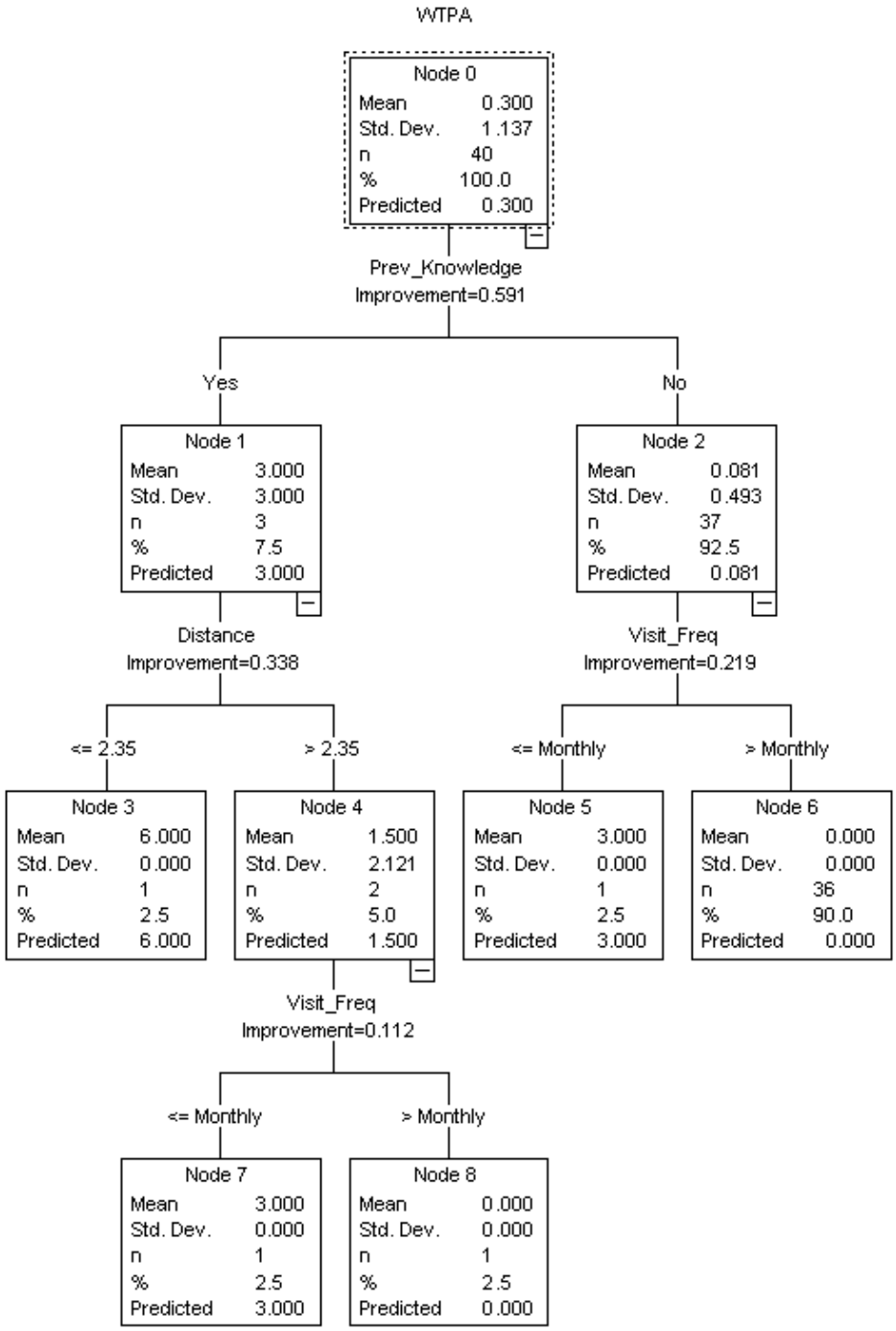

Figure 4.22 Decision Tree analysis for Welwick WTP access values.

Table 4.8 Mann- Whitney U values and statistical significance for Welwick WTP access decision tree analysis.

Variable	Difference between nodes	Z value	P value	Level of significance
Previous knowledge	1 & 2	-5.678	.000	95%
Distance	3 & 4	-1.556	.120	-
Visit frequency	5 & 6	-4.545	.000	95%
Visit frequency	7 & 8	-2.181	.029	95%

Results from the decision tree analyses for both maintenance and access show similar results to those gained from GLM, in that the most influential explanatory variable in terms of WTP maintenance is income level, and the most influential variable for WTP access is whether the participant has previous knowledge of the site or not. The distance that the participant lives from the site is also influential to both WTP maintenance and WTP access, with distance being the variable that is split between nodes 3 & 4 in both decision tree analyses.

4.17 Contingent ranking.

After answering the choice experiment and contingent valuation questions, participants were then asked to rank each of the societal benefits in order of importance to them, 1 being the most important, 5 being the least important. This question was included so that the main reasons a participant may be willing to pay their specific amount for either maintenance of the site or access to it could be further analysed. After the participants had rated the societal benefits, the results were aggregated into first choices, and combined first and second choices (Figure 4.23).

In terms of first choices, figure 4.23 shows clearly that disturbance prevention was the first choice for the majority of participants (81.94%), and also was the highest ranked benefit when first and second choices were aggregated, with just over 97% of the participants ranking it first or second in importance. The cognitive values associated with the site, such as research and educational opportunities were ranked the second most important benefit overall, with 12.5% ranking it as their first choice, and a little less than 60% ranking it either first or second. None of the

participants ranked either leisure and recreation, or feel good/ warm glow, as their most important benefit, however they were ranked in second place of importance by 13.89% and 2.78% of the survey population respectively. Future unknown or speculative benefits were ranked in third place of importance overall, with 5.56% of the survey population choosing at as their most important benefit, and just under 28% of the population ranking it either first or second. This suggests that non-use values are valued as more important than use values by the local population.

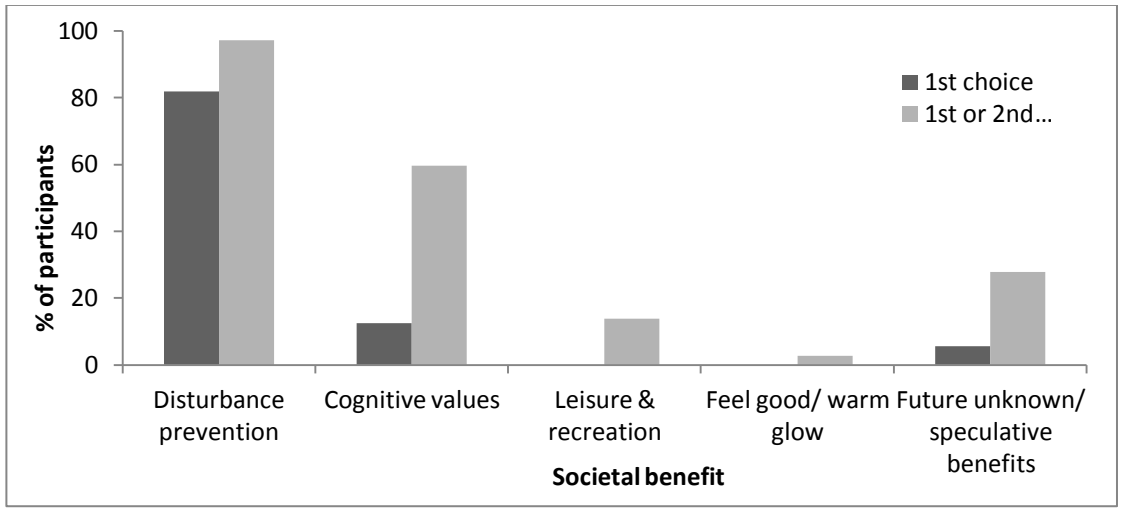

Figure 4.23 Percentage of participants' first and second choices when ranking societal benefits provided by Welwick MR site in order of importance.

4.18 Summary and conclusions.

In summary, the survey completion rate from the population around the Welwick managed realignment site was 13%. The mean WTP maintenance value was £3.13 per year, whilst the WTP access was only £0.28, for the participants who chose not pay anything for either, the most popular reason was that they do not use or visit the site. The main activities by those who did visit the site were dog walking, bird watching, and relaxing or enjoying the surroundings. The characteristics of a participant that most influenced their WTP maintenance values were their annual household income, and the distance that they live from the site. The characteristics that influence whether a participant is willing to pay for access to the site or not are their previous knowledge of the site, the distance they live from the site, and how often they visit the site. It is suggested through both the WTP values and results from the ranking benefits question, that disturbance prevention is the most important societal benefit provided by the site at Welwick. This can be attributed to the

ecological development of the site, because the development of saltmarsh at the site will lead to a greater dissipation of wave energy, without which flood protection would not be as efficient as it is presently.

Perhaps indicative of the relatively low WTP access value is the fact that very few of the participants that completed the survey had previous knowledge of the site, and those that did have knowledge, sometimes did not visit the site at all, and those that do, visit infrequently. This can perhaps be attributed to the lack of consultation between ABP and the local parish during the sites' breach process, as portrayed by a survey of the local parish members by the Coastal Futures Humber Community Project (2006). The survey gathered feedback such as:

> "We're...cross because consultation was promised... on the Welwick (site) and we've never been approached. Committees happen and we've never been invited..." (opinion former)

A lack of communication during the process may have meant the local population are uninformed as to the sites' existence, or are uninterested in using a site they were not consulted on. Although this report also explains that ABP were surprised by this feedback, as they felt the local community had been engaged in the process.

The distance that participants lived from the site was also identified as an influencing explanatory variable on the response variable, with those living closer to the site willing to pay more for both access and maintenance compared to those living further away from the site. As the main reason people were willing to pay has been identified as for the sites' flood protection, it is reasonable that those who live closer, and therefore would benefit from flood protection the most, would be willing to pay more. But this could also be attributed to the positioning of the outer villages, as the villages that are towards the edge of the seven mile radius set for the survey population may be in closer proximity to a more desirable destination.

For example, the village of Easington is six miles from Spurn head, which is a narrow sand spit on the tip of the coast owned by the Yorkshire Wildlife Trust. It is a designated National Nature Reserve, Heritage Coast, and is part of the Humber Flats, Marshes and Coast Special Protection Area. The area is well equipped for bird watchers, with a bird observatory, and due to Spurn's position it has many

migratory bird species, as well as similar species of birds that may be visible at Welwick, due to the developed mudflat there. It is also home to one of the only full-time staffed RNLI lifeboat stations in the country, and a disused lighthouse for photograph opportunities (spurnpoint.com). The villages of Hollym and Holmpton are 2.3 and 3.5 miles respectively from the seaside town of Withernsea, which has many tourist attractions such as a pier with various attractions and a blue flag beach (withernseatowncouncil.co.uk). Although this was not investigated in this survey, it may be worth considering in the future investigating the number of participants who visit areas such as Spurn and Withernsea, and if they weren't there, would they visit Welwick instead.

As well as competition from other attractions possibly causing people to go elsewhere, the lack of facilities at the Welwick MR site could also be responsible for low WTP values. Most of the dwellings in the area are over a mile away, but there is no specified carpark for the site, visitors are required to park on the road. Also, there are few designated footpaths on the site, and disabled access is limited, which may deter possible visitors. Despite 4 of the 11 participants that visited the site saying they did so for bird watching, there are no bird watching hides or other facilities that may aid this activity, and may attract more bird watchers to the site.

For those people who do visit, the ecological development of the site has proven to be important. As well as the development of saltmarsh meaning greater flood protection, the variety of saltmarsh vegetation makes a pleasant environment to walk, with or without a dog, and enjoy the scenery, which was one of the activities chosen by those that visit the site. It also provides roosting habitat for bird species which may attract bird watchers to the site, another of the reasons participants may visit. Therefore, it can be suggested that the ecological value of the site is intrinsically linked to the socio- economic value of the site.

CHAPTER 5

5. VALUATION OF SOCIETAL BENEFITS: ALKBOROUGH.

5.1 Introduction.

The overall aim of this chapter is to ecologically and economically value the societal benefits provided by the MR site at Alkborough, north Lincolnshire. In addition, several statistical analysis techniques will be used in order to ascertain the main socio- demographic influences on participant WTP responses.

The MR site at Alkborough will be described, including its position within the wider estuary and its reasons for creation. The sites ecological characteristics will be outlined, including the status of the saltmarsh by analysing the vegetation assemblages, and the abundance and diversity of bird, fish and invertebrate species that use the site. It is suggested that site ecology is an important detail with regards to participant WTP values, and therefore it is essential that the ecology is known.

The data provided by the interview survey questionnaires are then statistically explored and analysed using various techniques in an attempt to discover which socio- demographic factors are likely to influence participant WTP responses for both maintenance and access to the site. How important each societal benefit is to the local residents will also be explored when the contingent ranking data is assessed, which will offer insight into the reason behind particular WTP amounts.

Finally, the results from the ecological and economic analysis will be summarised and discussed in an attempt to show the main social demographic influences on WTP values, possible influences the sites' ecological or physical characteristics may have on WTP values, and which societal benefits are considered most important to the local population.

5.2 Site description.

The Alkborough flats site is situated at the confluence of the Trent and Ouse rivers at the upper end of the estuary. The 440 ha site was breached in 2006 to replace arable farmland with new wildlife habitat at the foot of the Jurassic escarpment at the base of the village of Alkborough (Edwards & Winn, 2006). The site at Alkborough is the biggest coastal realignment site to be completed as part of the Humber Shoreline Management Plan, and is jointly owned by the Environmental Agency, Natural England and Associated British Ports.

The scheme cost a total of £10.2 million, and a detailed monitoring plan is currently established to assess the general development of the site and ensure the intertidal habitat is developing and functioning as expected. An individual goal set by the EA for Alkborough was to allow wildlife to acclimatise to sea level rise on the estuary; however this site is an example of where stakeholder involvement from the outset has facilitated the development of a much wider range of objectives than those identified by the initial project team, such as using monitoring reports to inform future EA MR ventures at a regional and national level (EA technical report, 2010).

Access to the MR site at Alkborough is via three separate footpath entrances, with roadside parking available near the entrances. There is a network of footpaths covering approximately 8.2km, with 2.8km of these surfaced, in order to provide easier disabled access. There are three specially constructed bird hides placed throughout the site, also with disabled access, and a tearoom serving refreshments near the site. There are also information boards explaining how the site was created, and what wildlife can be seen there. Unlike the other sites in this research, Alkborough has a full time on-site manager, and work is gradually being undertaken to specifically make the site more desirable to visitors.

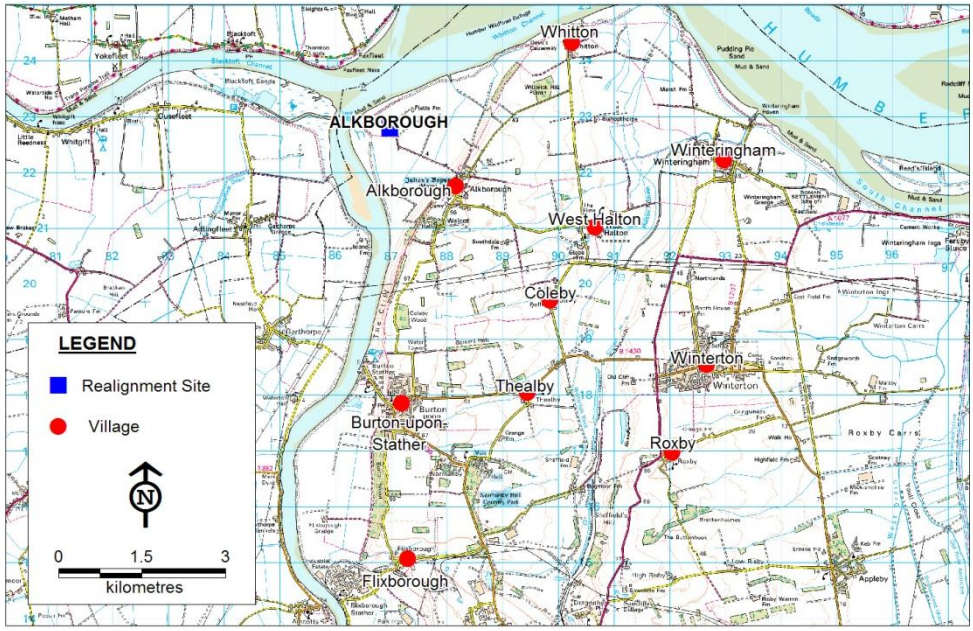

Figure 5.1 Map showing Alkborough MR site and surrounding villages within 7 mile travel distance.

5.3 Ecological overview.

5.3.1 VEGETATION COVERAGE.

A general overview of the vegetation community showed a higher number of species identified compared to previous years, the majority of these were species colonising saltmarshes at different elevation levels, but some terrestrial species were also detected. A total of 19 different species, 15 of them saltmarsh specific were recorded inside the realignment site. Compared to vegetation surveys conducted in 2009 where the terrestrial perennial ryegrass *Lolium perenne* was abundant, the 2010/11 surveys showed the remains of the ryegrass were scarce, whilst saltmarsh species such as *Aster tripolium*, *Atriplex prostrate*, *Sciprus maritimus* and *Alopecurus geniculatus* were more frequently recorded (Franco *et al*., 2012).

Dense patches of *Phragmites australis* (Common Reed) were found on areas of the mudflat, and particularly along the edges of drainage ditches, with typical saltmarsh plants such as *Elytrigia repens* (Common Couch) and *Agrostis stolonifera* (Creeping Bent) colonising areas in front of the Reed. The highest diversity of vegetation species was recorded in the transition zone from a terrestrial to a wetland site, where evidence of both types of vegetation were present (Franco *et al*., 2012).

5.3.2 INVERTEBRATES.

The types of invertebrate species found differed whether the samples were inside or outside of the realignment site. The community inside the site included terrestrial, freshwater and estuarine species, dominated by collembolan which accounted for 90% of the invertebrate abundance. However, outside the site was dominated by typical estuarine species such as the oligochaetes *Heterocheata costata* and *Paranais litoralis.*

Generally, monitoring over the last three years has shown there is a greater abundance and diversity of species outside the realignment site compared to inside the site. Whilst changes in the species composition inside and outside the site have been minimal, there are notable differences in the relative proportions of them. After the breach, inside the site saw a steady increase in both species richness and diversity up until 2009, since which richness and diversity have both decreased. However outside the site, there were significant increases in species richness between 2007 and 2008, and between 2009 and 2010, suggesting that the invertebrate assemblages inside the realignment site are not behaving in a similar fashion to those outside the realignment site. Decreasing numbers of invertebrates inside the realignment site could ultimately have a detrimental impact on the numbers of birds using the site to forage.

5.3.3 BIRDS.

During monitoring over the winter months in 2007/8 the site was shown to regularly support several species of wildfowl, including several hundred Shelduck, approximately 100 Widgeon and over 1000 Teal. Many species of wader were also present at the site during the autumn passage, primarily consisting of over 100 Avocet and Black-tailed Godwit using the site for feeding, and over 2000 Golden Plover, Lapwing, Dunlin and Redshank roosting at the site (Hemingway *et al*., 2008).

During the monitoring surveys that took place during 2010/11, a total of 10 wader and 19 wildfowl species were recorded. The most frequently occurring wildfowl species were Widgeon and Greylag Goose, however other wildfowl species such as Shelduck, Teal and Mallard were recorded using the site for both feeding and roosting. Grey Heron, Canada Goose, Pink-Footed Goose, Shoveler and Gadwall

were noted as primarily using the site for feeding. The most frequently occurring species of wader at the site was Curlew, using the site for both feeding and roosting. Lapwing were also recorded both feeding and roosting, whilst Redshank and Dunlin were recorded as mainly using the site for feeding, and Golden Plover mostly using the site for roosting. Although both types of bird were seen using the site for both purposes, overall it seemed greater numbers of wildfowl use the realignment site for feeding, whilst more waders tend to use the site for roosting (Franco *et al*., 2012).

4.3.4 FISH.

Approximately 18 months after the site at Alkborough was breached, a typical sampling of the fish species in the area was undertaken. The species richness and diversity was found to be similar both inside and outside the realignment site, which could mean an initial colonisation by locally occurring species, such as European flounder (*Platichthys flesus*), Three-spine Stickleback (*Gasterosteus aculeatus*), European eel (*Anguilla anguilla*) and Silver Bream (*Blicca bjoerkna*) (Hemingway *et al*., 2008).

The 2010 data from the Alkborough site revealed that European flounder, European eel and Common goby (*Pomatoschistus microps*) were the dominant components of the fish assemblage. The abundance of these species appears to have steadily increased since the sites' breach, especially European eel, which proves important as numbers of eel have been dramatically falling throughout Europe in recent years (Franco *et al*., 2012). Flounder and gobies in particular, but also Dace, Common Bream and Perch have shown strong seasonal variations, and have been recorded at various lengths, suggesting they use the site throughout their life cycle, from juvenile to adult, highlighting the importance of the site as a nursery ground for these species.

5.4 Survey population and response rates.

All households within a seven mile radius of the Alkborough MR site were included in the sample, in an attempt to maximise the potential number of completed surveys, and provide a substantial sample for statistical analysis (Figure 5.1). The households were naturally grouped into ten villages of varying size, mainly surrounded by agricultural fields.

Table 5.1 Summary of survey population statistics (Alkborough).

Village	Number of households	Number of complete surveys	% complete surveys
Alkborough	203	15	7.39
Walcot	14	0	0
West Halton	124	9	7.26
Whitton	97	12	12.37
Coleby	28	3	10.71
Burton-Upon-Stather	1165	61	5.24
Thealby	75	1	1.33
Winterton	2106	181	8.59
Winteringham	436	16	3.67
Flixborough	737	83	11.26
Roxby	202	10	4.95
Total	5187	391	7.54

The total number of completed surveys (7.54%) is a percentage of all the households in the survey population, as the author attempted to survey every household in an attempt to maximise the number of completed surveys. It is noted that this may have lead to sample selection bias in the data set, as if the households are only surveyed once, this could cause selection bias against those who are out or at work during the sample time. The majority of the households not represented in the data set, were those in which none of the residents answered the door. Due to time restrictions on this research and the volume of households in the survey population, the researcher was not able to return to any households that did not answer the door for a second attempt. There were 1081 instances of participants answering the door, but then declining to participate in the survey (Alkborough: 54, Walcot: 2, West Halton: 21, Whitton: 24, Coleby: 5, Burton-Upon-Stather: 274, Thealby: 31, Winterton: 442, Winteringham: 102, Flixborough: 114, Roxby: 12). In

relation to the number of people who answered the door, the survey response rate was 36.17%.

5.5 Data preparation.

A total of 7 cases were identified as outliers in this data set, via objective analysis of the variables using boxplots and dotplots. These identified outliers were either values that were extremely far removed from the rest of the data set, or because one of the socio demographic categories was extremely underrepresented, and could cause an erroneous interpretation of how influential that category is on participant WTP values. Both the boxplots and dotplots were analysed with and without the outliers present for thorough analysis, and the identified outliers were removed from the data set before any further statistical analysis was performed. It should be noted, that although objective techniques were used to identify the outliers, the author had to use some subjective reasoning to identify the true outliers. For example, the nature of the WTP bids meant that the participant could choose any amount they wished, and as such tended to opt for rounded numbers such as £5, £10 and in some cases £20, rather than £14 or £17. Therefore, the boxplots could initially show that all £20 bids were outliers, when they had already been identified in the initial discounting of zero bids process (Chapter 2) as genuine bids that should be included in the data set. Therefore, a combination of statistical analysis and the researchers' judgement was used to identify these outliers. 8 participant valuations were identified as protest bids in the data set. These values were removed before any further analysis was conducted, and are identified in section 5.9.

A full summary of the key variable aggregations transformed from the original binary format in the questionnaire survey is given in Table 3.2 (Chapter 3). The scale values of WTP maintenance, WTP access and Distance, are aggregated into ordinal variables for the purpose of performing Chi Square analysis on them. For all other statistical analysis, they remain as continuous variables.

5.6 General characteristics of the respondents.

In order to explore possible influences on participant WTP values, their socio-demographic details were recorded in the survey. This also ensures that as wide a cross section of the population as possible is taken. A summary of the respondents general social characteristics is given in Table 5.2.

Obvious trends in participant social characteristics include that 35.3% of participants are 45- 54, and just fewer than 90% are between 35 and 64. 40% of the respondents earn £60- 80,000 annually after tax, which is higher than expected for this region, however this parish is considered relatively affluent. Slightly more females answered the questionnaire than males. Around 40% of the participants have education to a further or higher level, such as A-levels or a University degree respectively, which is considered more than is expected from the north Lincolnshire area in general, although the affluent nature of this parish could account for the higher education level. A large majority of the participants have both at least one young person living with them, and live between 2 and 5 miles from the site.

5.7 Knowledge and use of the site.

Over 90% of the participants had knowledge of the site prior to being interviewed, suggesting that press articles and word-of-mouth information on the site have reached the majority of the local population. Most people visit the site on a fortnightly or monthly basis, spending between 30 minutes and an hour and a half there each time they visit. The 336 participants that stated they had visited the site at least once in the last 12 months, were asked which activities they participated in whilst at the site. The most common activities are walking to enjoy the scenery, relaxing/ enjoying surroundings with 311 and 326 people choosing these options respectively. A lot of respondents also visit the site for its wildlife, with 162 people going there specifically for bird watching, and 260 visiting for more general nature watching. 74 of the participants used the site primarily for exercise, 86 for walking their dogs, and 29 had used the site in the past for picnicking (Figure 5.2).

Table 5.2 General summary of respondents' characteristics (Alkborough).

Question	Answer	N	No of responses	% Response
Age	18- 24	377	0	0
	25- 34		8	2.1
	35- 44		107	28.4
	45- 54		133	35.3
	55- 64		92	24.4
	65- 74		31	8.2
	75- 84		6	1.6
Income	< 20,000	377	14	3.7
	20,001- 40,000		65	17.2
	40,001- 60,000		118	31.3
	60,001- 80,000		151	40.1
	80,001- 100,000		24	6.4
	100,001- 120,000		5	1.3
	> 120,001		0	0
Gender	Male	377	157	41.6
	Female		220	58.4
Education	Primary	377	0	0
	Secondary		25	6.6
	Vocational		81	21.5
	Training		127	33.7
	Further		141	37.4
	Higher		3	.8
	Postgraduate			
Children	Yes	377	231	61.3
	No		146	38.7
Distance	< 2 miles	377	23	6.1
	2- 5 miles		346	91.8
	> 5 miles		8	2.1
Visit Frequency	Daily	377	4	1.1
	Weekly		33	8.8
	Fortnightly		103	27.3
	Monthly		156	41.4
	Yearly (once)		40	10.6
	Never		41	10.9
Time spent at the site	None	377	40	10.6
	< 0.5		2	.5
	0.5- 1		193	51.2
	1- 1.5		142	37.7
Previous knowledge of the site	Yes	377	342	90.7
	No		35	9.3

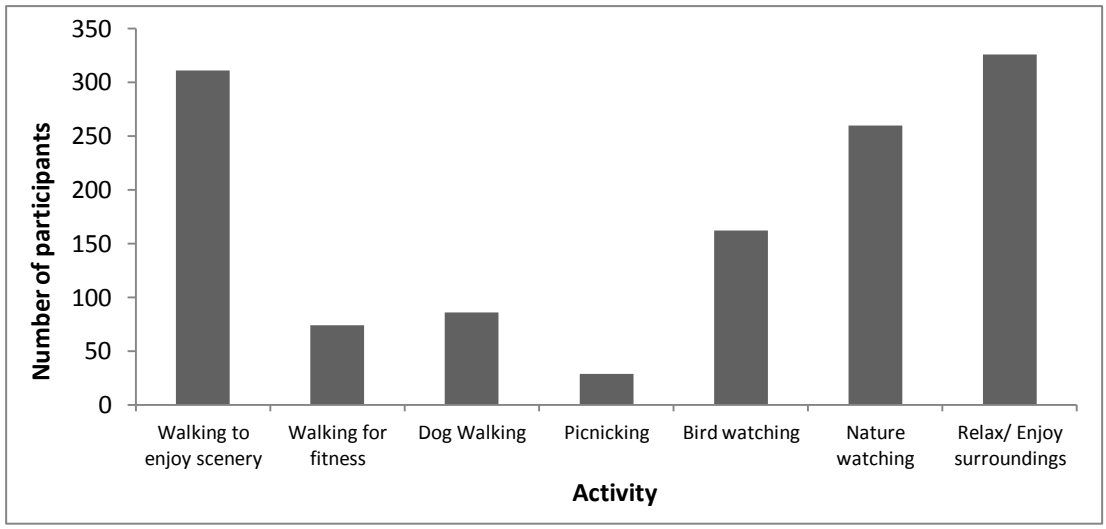

Figure 5.2 Uses of the MR site at Alkborough. Count does not equal the total number of respondents, as they were permitted to choose more than one activity.

5.8 Willingness to pay responses.

The results from the initial choice experiment section of the questionnaire are presented in Table 5.3. It is clear from the table that a large majority of respondents were willing to pay at least £1 annually towards the cost of maintenance, or access to the site. There is only a 1.6% difference between those willing to pay something for maintenance, and those willing to pay something for access to the site, suggesting that the participant's value being able to use the site, as well as its non-use values.

Table 5.3 Summary of choice experiment results for Alkborough.

Willing to pay for MAINTENANCE?	Number of participants	% Response
Yes	334	88.6
No	43	11.4
Willing to pay for ACCESS?	Number of participants	% Response
Yes	328	87.0
No	49	13.0

5.9 Distribution of bids.

The contingent valuation section was included in the questionnaire, so that once a participant had stated they would pay something towards either maintenance or access, the exact amount that they would be willing to pay was derived. This means a distinction can be made regarding the extent to which the participant values the site for its various attributes. 11.4% of the respondents chose not to pay anything for maintenance. Of these, the majority of stated that they chose not to pay anything because they do not use or visit the site (46.51%). Just over 25% stated that they could not afford to pay, and approximately 14% thought that the organisation that created the site should pay for maintenance of it. Approximately 7% of the respondents chose not to pay because they do not trust the government to spend the money on its intended purpose. One respondent (2.32%) claimed it was not a priority for them, 4.65% did not value any of the benefits provided by the site, and just over 2% objected to paying higher taxes in general. None of the respondents chose not to pay because they had no interest in the wetland environment (Figure 5.3).

Of the 49 participants who chose not to pay anything for access to the site, none of them chose not to because they do not have any interest in the wetland environment, nor because they do not value any of the benefits provided by the site. However the majority of people chose not to pay because they do not use or visit the site (57.14%), and just over 18% stated that they could not afford to pay anything at this time. Approximately 4% each claimed that it was not a priority for them, and that they objected to paying higher taxes, whilst 2% chose not to pay anything because they do not trust the government to use the funds for their intended purpose (Figure 5.3).

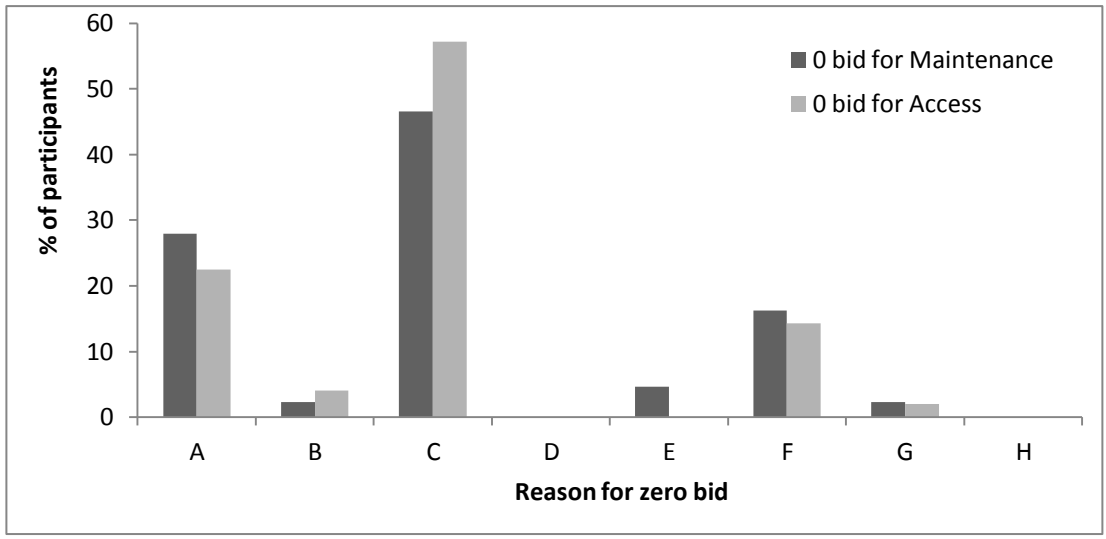

Figure 5.3 Participants' reasons for choosing NOT to pay for maintenance of or access to Welwick MR site (A= 'I cannot afford to pay, but I would do; B= 'It is not a priority for me'; C= 'I do not use or visit the site; D= 'I am not interested in the wetland environment; E= 'I do not value any of the site's benefits; F= 'The organisation that created the site should pay; G= 'I object to paying higher taxes'; H= 'I do not trust the government to use the taxes as intended').

For those who chose to pay something for maintenance or access, their exact bids are shown in Figure 5.4. The bids for maintenance ranged from £2 to £20, with a mean (including zero bids) of £9.29 (SD= 5.52), and the median and mode for the maintenance data are both £10. For the respondents who chose to pay for access to the site, their bids also range from £2 to £20, but with a mean of £6.20 (SD= 3.72). The median and mode for the access data are both £6 (Figure 5.4).

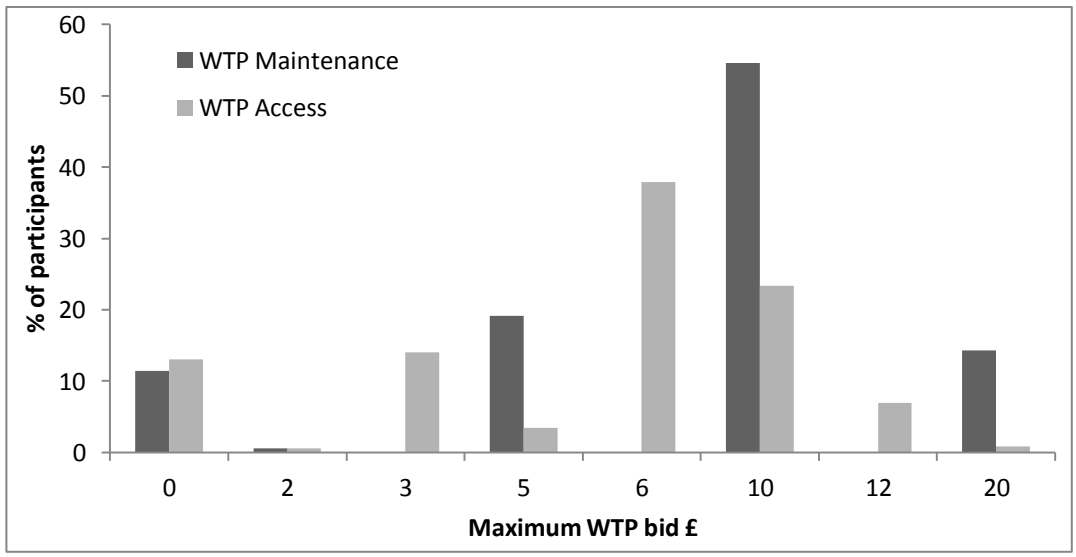

Figure 5.4 Distribution of WTP bids for Alkborough MR site.

5.10 Exploratory and chi square analysis.

One of the key research aims of this study involves investigating which socio demographic variables influence WTP values. In order to do this, various statistical analysis techniques have been employed (described in Chapter 2), in order to look for any significant relationships in the data, starting with exploratory techniques.

The relationship between the distance that the participant lives from the site and their WTP values was analysed primarily. For both WTP maintenance values and WTP access values, the scatterplots depicting the relationship between distance and WTP values showed that the closer the respondent lives to the site, the more they are willing to pay for maintenance of the site or access to it (Figures 5.5 & 5.6 respectively). This correlation was tested statistically using a X^2 test and was found significant for both maintenance values (X^2= 21.45, p<.001) and access values (X^2= 25.32, p<.001). Primary analysis suggests that distance has an influence on WTP values, and therefore should be included in any further analysis that is conducted.

Whether the participant had any knowledge of the site prior to being interviewed for the questionnaire was also analysed. The overall trend of the data was similar for both WTP maintenance values (Figure 5.7) and WTP access values (Figure 5.8), in that those who did have knowledge of the site before completing the survey were willing to pay more annually for both maintenance of the site and access to it. The relationship between previous knowledge and WTP maintenance values had a X^2 value of 193.17, and therefore is significant at the 95% level. The relationship between previous knowledge and WTP access values was also significant at the 95% level (X^2= 246.17), so previous knowledge should be included in any further analysis of influences on both WTP values.

The frequency in which the participant visits the site was assessed to discern if this had any influence on WTP values. In terms of maintenance values, the boxplot shows clearly that those who visit the site more frequently, are willing to pay more towards the maintenance of the site compared to those who visit the site less frequently (Figure 5.9). This pattern in the data is also shown in the WTP access data, the more frequently the participant visits, the more they are willing to pay for access to the site (Figure 5.10). The influence of visit frequency on WTP values was tested statistically with a X^2 test to check its statistical significance. The results showed that the relationship between both WTP maintenance values and WTP

access values and their visit frequency were both significant at the 95% level (WTP maintenance X^2= 300.60, WTP access X^2= 335.69), and therefore should be considered when analysing the data further.

The amount of time that a participant spends at the site during their visit was considered, to determine whether this influences their WTP values. With regards to willingness to pay for maintenance, there is a positive relationship between the amount of time that a participant spends at the site, and the amount they are willing to pay for maintenance (Figure 5.11). This relationship was tested for its significance using a X^2 test, and was found significant at the 95% level (X^2= 260.03). However, more than 20% of the cells in the analysis had an expected count of less than 5, meaning a loss of statistical power. Therefore a r_2 test was performed in order to increase the statistical validity of the results, the results from this test also proved statistically significant at the 95% level (r_2= .232). In terms of WTP access values, a positive relationship between WTP values and the amount of time spent at the site was also present (Figure 5.12). This relationship was found to be statistically significant using a Pearson's chi- square test (X^2= 298.08, p<.001), and therefore it can be suggested that the amount of time a participant spends at the site influences both their WTP maintenance and WTP access values, and should be included in further analysis of the data.

Level of education was analysed in order to see if this influenced their WTP values. The Pearson's chi-square values for both WTP maintenance and WTP access were statistically non-significant (X^2= 12.88 and 20.12 respectively), however in both chi-square analyses more than 20% of the cells had a count less than 5, and therefore a r_2 was conducted in order to increase the statistical validity of the analysis. Results from the analysis showed r_2= .11 (p< .05) for the relationship between education and WTP maintenance, and r_2= .12 (p< .05) for the relationship between education and WTP access. Neither is highly significant, although education does show some influence for both WTP values, and therefore will be considered in further analysis.

The participants were asked to give their age, and this was analysed as a possible influencing variable on WTP values, however it was found non-significant for both WTP maintenance values and WTP access values (WTP maintenance X^2= 63.92, r_2= -.084; WTP access X^2= 70.98, r_2= -.092). There were also other explanatory variables which were found to have no statistically significant influence on either

WTP maintenance or WTP access values. These were income (WTP maintenance X^2= 68.62, r_2= 0.040, WTP access X^2= 50.32, r_2= .027), their gender (WTP maintenance X^2= 23.02, r_2= .002; WTP access X^2= 16.34, r_2= -.103), and whether they had children or not (WTP maintenance X^2= 18.19, r_2= -.030; WTP access X^2= 23.11, r_2= -.035).

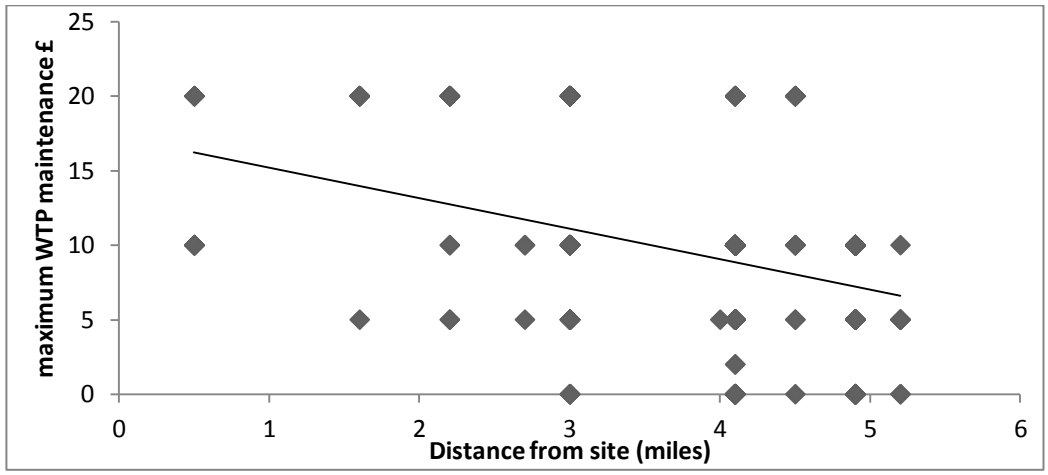

Figure 5.5 Relationship between the distance that the participant lives from Alkborough MR site, and their maximum WTP maintenance value. Points may represent more than one case. The trendline reflects this.

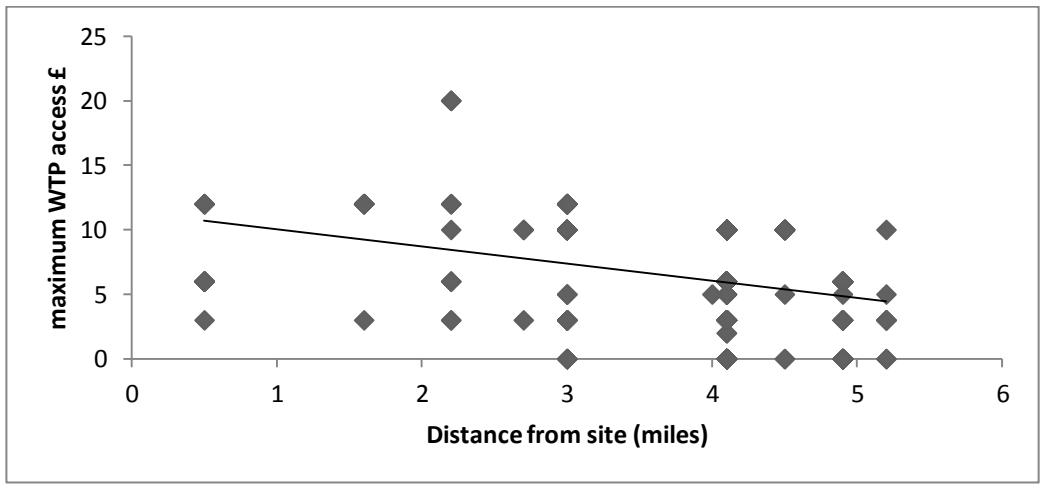

Figure 5.6 Relationship between the distance that the participant lives from Alkborough MR site, and their maximum WTP access value. Points may represent more than one case. The trendline reflects this.

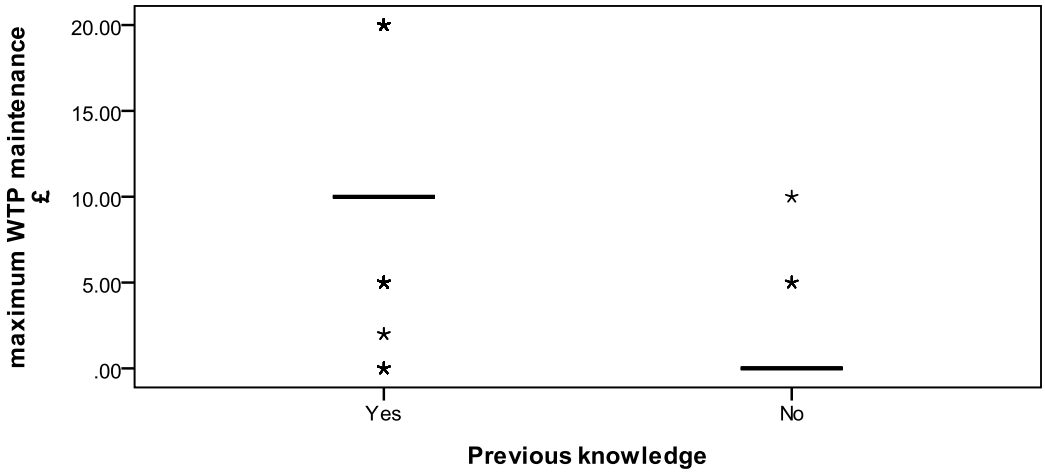

Figure 5.7 Relationship between whether the participant had knowledge of Alkborough MR site prior to survey, and their WTP maintenance value (**o** = outliers, ***** = extraneous variables).

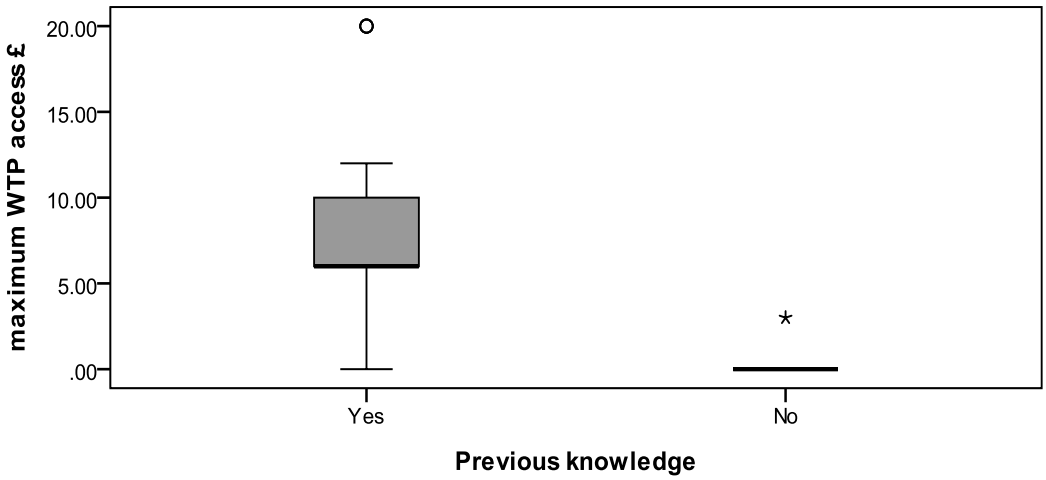

Figure 5.8 Relationship between whether the participant had knowledge of Alkborough MR site prior to survey, and their WTP access value (**o** = outliers, ***** = extraneous variables).

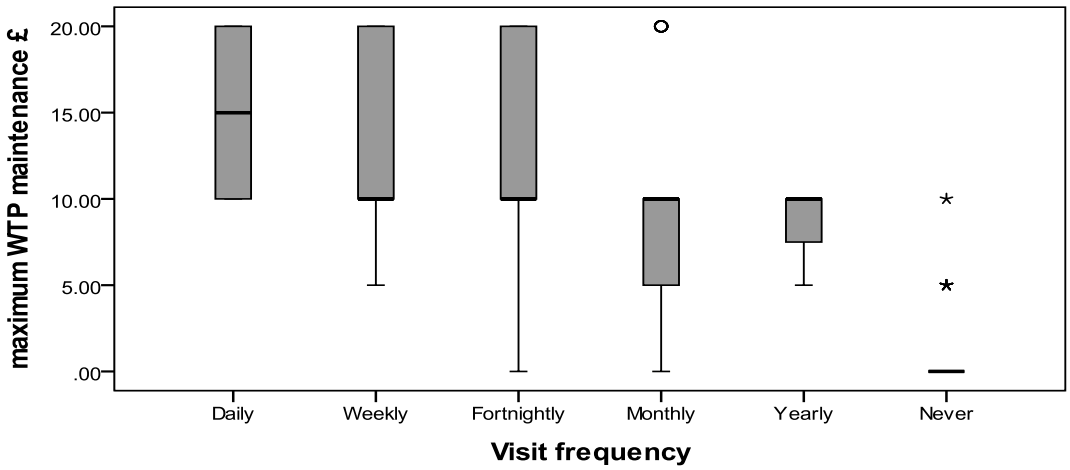

Figure 5.9 Relationship between how frequently the participant visits Alkborough MR site, and their WTP maintenance value (**o** = outliers, ***** = extraneous variables).

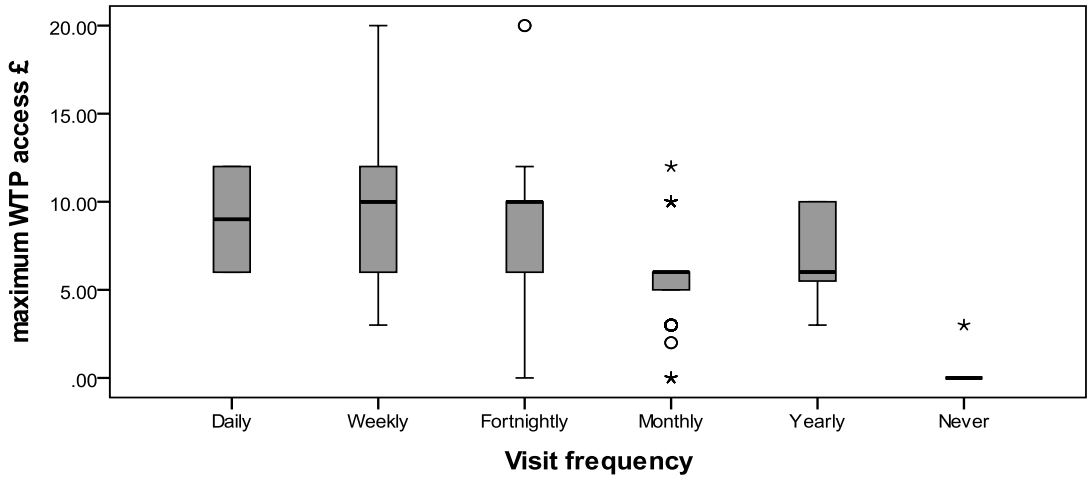

Figure 5.10 Relationship between how frequently the participant visits Alkborough MR site, and their WTP access value (**o** = outliers, ***** = extraneous variables).

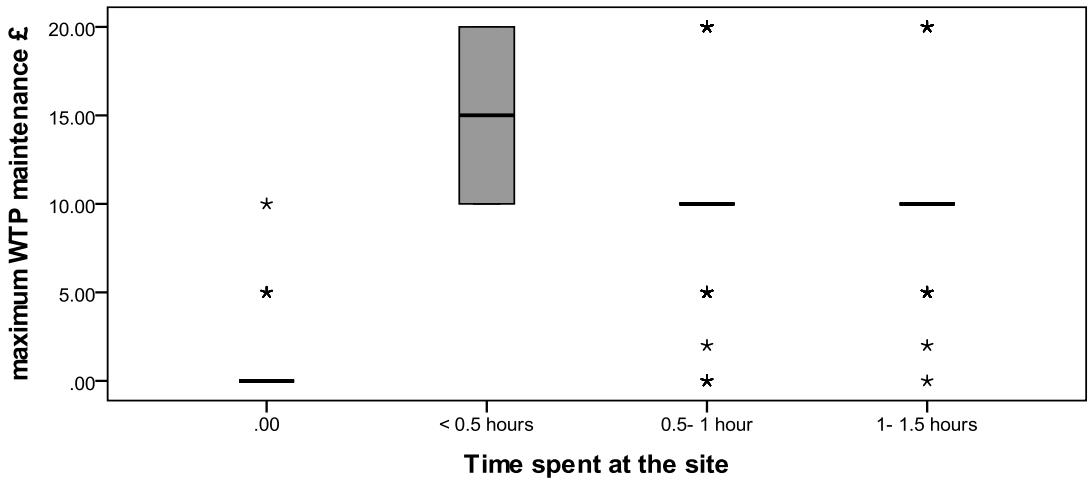

Figure 5.11 Relationship between the amount of time the participant spends at Alkborough MR site, and their WTP maintenance value (**o** = outliers, ***** = extraneous variables).

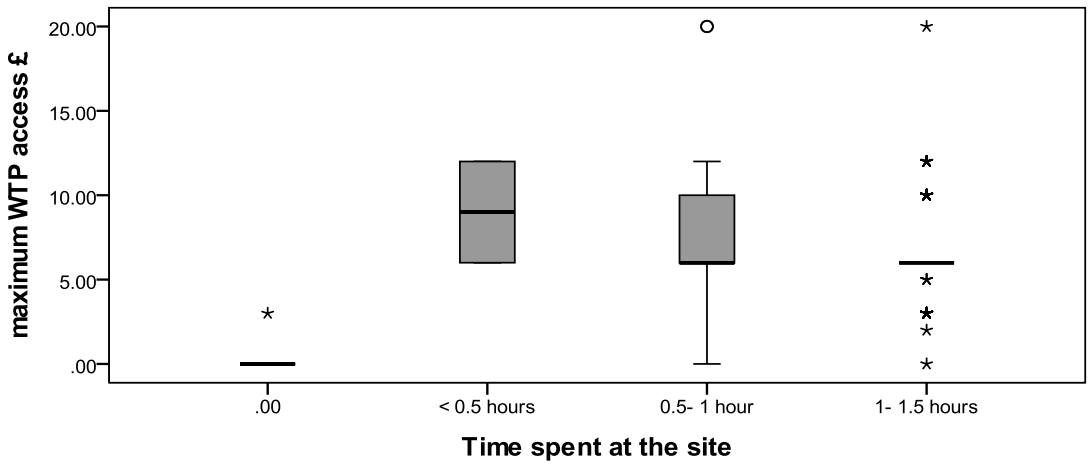

Figure 5.12 Relationship between the amount of the time the participant spends at Alkborough MR site site and their WTP access value (**o** = outliers, ***** = extraneous variables).

The results from the initial exploratory and X^2 analysis for the results from the Alkborough surveys show that the same variables have a statistically significant effect on both WTP maintenance and WTP access values. they are the distance that the participant lives from the site, whether they have previous knowledge of the site or not, their frequency of visit to the site and the amount of time they spend at the site per visit. These variables will be further analysed with a coplot analysis.

5.11 Coplot analysis.

Following the initial use of Pearson's chi-square to analyse the influence of one explanatory variable on a response variable, it is also useful to use coplot analysis to consider the influence of more than one explanatory variable on a response variable.

For the response variable of willingness to pay for maintenance of the site, the effects of visit frequency was coupled with the distance that they live from it. Analysis of the coplot suggested that distance has the greatest effect on WTP maintenance values for those who visit the site daily and weekly, the closer they live to the site, the more they are likely to pay for maintenance. For those who visit the site less frequently than this- on a fortnightly, monthly or yearly basis, the distance they live from the site does not have as big an influence on their WTP maintenance values (Figure 5.13).

The relationship between the distance the participant lives from the site and their visit frequency was also considered in terms of its influence on WTP access values (Figure 5.14). Analysis of the coplot differed from the results of the WTP maintenance coplot, and showed that the distance that the participant lived from the site had an influence on their WTP access values regardless of their visit frequency. There was a negative correlation between distance and WTP access, suggesting the closer the participant lives to the site, the higher their WTP access value. This correlation occurred in all the visit frequency plots, although in differing strengths.

The explanatory variable, level of education had shown some significance in the initial exploratory data analysis, and is considered here in the coplot showing the relationship between education level and participant visit frequency in relation to their WTP maintenance values (Figure 5.14). The coplot indicates that if the

participant visited the site daily, their level of education had a larger influence on their WTP maintenance values compared with those who visited the site less frequently than that. For those who visited the site daily, there is a positive relationship between level of education and WTP maintenance values, the higher the level of education, the more they are willing to pay. However for the participants who visit the site weekly, fortnightly, monthly or yearly, their level of education does not seem to influence their WTP maintenance value.

A similar pattern is seen in the coplot showing the relationship between level of education and visit frequency, and their influence of WTP access values. For those who visit the site daily, the coplot suggests a positive correlation between level of education and WTP access values. Whereas if the participant visits the site less frequently than this, their education level had little influence on their WTP access values (Figure 5.15).

Results from the coplot analysis further illustrate that distance and visit frequency are influential explanatory variables in terms of both WTP maintenance and WTP access values. The further analysis of the effect of participant education level on WTP values reveal that although it may be influential in some cases, they are in the minority and education may not be influential in a wider analysis model.

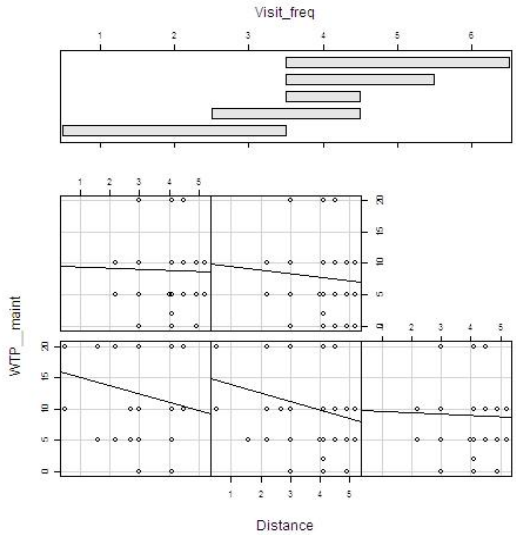

Figure 5.13 Relationship between WTP maintenance and distance, with conditioning variable visit frequency to Alkborough MR site.

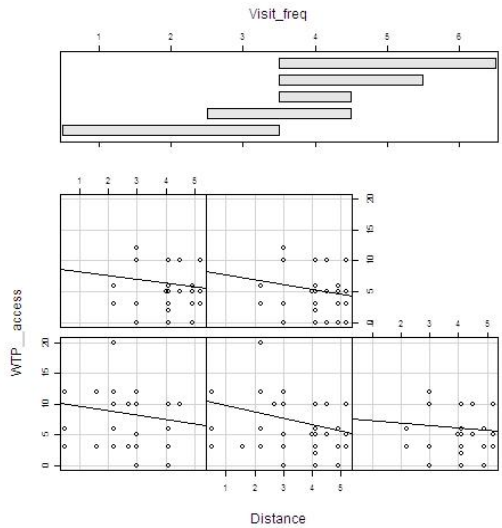

Figure 5.14 Relationship between WTP access and distance, with conditioning variable visit frequency to Alkborough MR site.

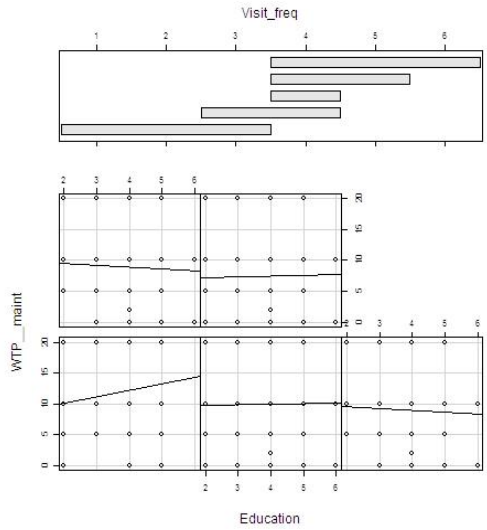

Figure 5.15 Relationship between WTP maintenance and education, with conditioning variable visit frequency to Alkborough MR site.

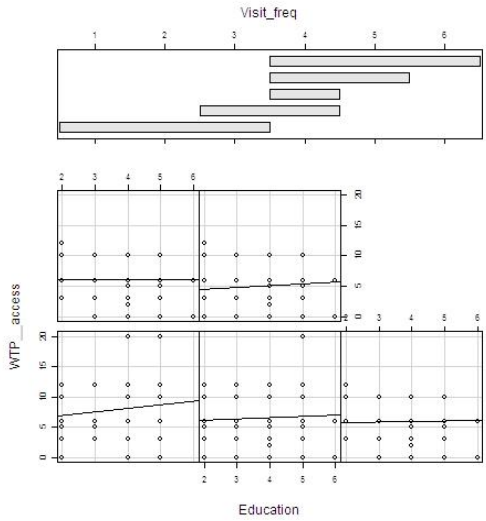

Figure 5.16 Relationship between WTP access and education, with conditioning variable visit frequency to Alkborough MR site

Results from the coplot analysis show that visit frequency and distance are still significant when interacting with each other, but also the participants' level of education has shown to have an influence on visit frequency and WTP values.

5.12 Principal component analysis for explanatory variables.

To discern how many components should be extracted for the analysis, a scree plot including all the variables was created. The scree plot showed an inflection after the first three components, and therefore suggested that three components should be extracted. To reinforce this, Kaiser's recommended criterion was also followed, which states that all components with eigenvalues greater than 1 should be extracted (Kaiser, 1974). This also suggests that three components should be extracted, and therefore a three component PCA was deemed the most suitable for this data set.

The PCA was initially run including all the explanatory variables, however inspection of the anti-image correlations showed that the variables of participant gender, their education level and whether they have children or not had values lower than 0.5 (.388, .488 and .497 respectively), and therefore were identified as non-significant and were removed from the PCA. A second scree plot was analysed without the

non-significant variables, and this time the inflection occurred after the first two components, and only the first two components had eigenvalues of more than 1. Therefore based on the new data set, a two component PCA was the most suitable, and the analysis continued based on this. With the variables of gender, education and children removed from the analysis, none of the anti-image correlation values were lower than 0.5. The values in the correlation matrix were considered, and none of the pearson correlation coefficients had a value higher than 0.9, which suggests that problems due to singularity in the data are minimised. The determinant of the correlation matrix was also greater than the necessary value of $0.1x10^{-4}$ (determinant= .109) and therefore it can be assumed that multicollinearity is not an issue.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was assessed, which represents the ratio of the squared correlation between variables to the squared partial correlation between variables. A value between 0 and 0.5 indicates that the sum of partial correlations is too large relative to the sum of correlations, leading to diffusion in the pattern in correlations, and therefore PCA would be inappropriate. However, a value between 0.5 and 1 means the correlation patterns are compact, and PCA can be trusted to give reliable components (Kaiser, 1974). The KMO value for this two component model is higher than 0.5 (KMO= .642), this value is improved from the initial three component model (KMO= .582), which further justifies the removal of the three non-significant variables. The Bartlett's test of sphericity is also highly significant (p<.001), which means there is at least one statistically significant correlation in the matrix, this also means that the use of PCA analysis on this data set is justified, using an oblimin with Kaiser normalization rotation method as we may expect some correlation between the 2 components in the model.

The extracted sums of squared loadings revealed that component 1 accounts for 41.39% of the total variance, and component 2 accounts for 25.19% of the total variance found in the PCA model (66.58% total variance). An oblique rotated component solution (or factor solution) was used in the analysis, and therefore the pattern matrix produced in the analysis was the primary point of interpretation for the overall composition of the PCA. 0.3 is regarded as a threshold to determine whether a variable is contributing to the component in a significant way.

Previous knowledge of the site and time spent at the site are both highly meaningful to component 1, whilst the distance the participant lives from the site and their income are meaningful to component 2. Age is not meaningful to either component; however visit frequency is meaningful to both components (Table 5.4). The pattern matrix suggests that the variables that show participant interaction with the site are in component 1, with their other socio-demographic characteristics in the second component. However, the component correlation matrix shows that the correlation between the two components is very low (.012), and therefore it can be assumed that the two components are independent of one another. Analysis of the non redundant residuals in the data show that 86% of them have absolute values greater than 0.05, when there should be no more than 50%. This means that this PCA should only be trusted on an exploratory basis, and further more complex statistical analysis will be undertaken.

Table 5.4 Pattern matrix containing factor loadings for PCA for Alkborough data. Values considered meaningful to the component are in bold.

Pattern Matrix[a]

	Component	
	1	2
Prev_knowledge	**.907**	.089
Time_spent	**-.892**	.019
Visit_freq	**.681**	**.615**
Age	.288	-.193
Distance	.180	**.827**
Income	-.244	**.788**

5.13 Generalised linear modelling for maintenance values.

As the response variable (WTP maintenance) is continuous, Poisson GLM was used as this model selection type specialises in count data. All the ordinal and nominal explanatory variables were factored before the analysis began. The initial Poisson model was found to be overdispersed (Phi<1.5, AIC value= 2212.7), therefore it was inappropriate to continue with Poisson GLM, and Quasi-Poisson was selected instead for its ability to be able to deal with certain amounts of dispersion. The dispersion of the model analysed using Quasi-Poisson was less than 20, and therefore Quasi-Poisson is suitable for model selection.

All explanatory variables were included in the model initially, with backwards step process used to remove the least statistically significant variable from the model each time, and tested again without the non-significant variable. This process continued until all the variables in the model were significant.

The results from this process resulted in the WTP maintenance GLM model:

GLM (WTP_maintenance ~ fVisit_freq + fPrev_knowledge + Distance)

Suggesting that frequency of visit to the site, their previous knowledge of the site, and the distance they live from the site are the most influential, and statistically significant, variables on their WTP maintenance values (Table 4.5).

Table 5.5 Descriptive values for variables in Alkborough GLM WTP maintenance model.

Variable	Df	Deviance	F value	P value
Visit frequency	5	972.12	12.9343	1.319e-11
Previous knowledge	1	840.05	5.7527	0.01696
Distance	1	836.71	4.2629	0.03965

To validate this model, the residuals were analysed. Homogeneity was checked by plotting the extracted standardised residuals against the fitted values (Figure 5.17), and standard deviance residuals plotted against the theoretical quantiles in a Q-Q plot (Figure 5.18). Figure 5.17 shows that all the residual points are relatively evenly distributed around 0, and the line of best fit is quite close to the 0 line. The Q-Q plot shows that the standard deviance residuals follow the direction of the best-fit line, and do not deviate greatly from it. Therefore in terms of heterogeneity, the assumptions of the model are not violated. A histogram plotted of the residuals and analysed alongside a normal distribution line, shows that although the pattern of the histogram does not precisely follow the normal distribution line, they are in the same general shape.

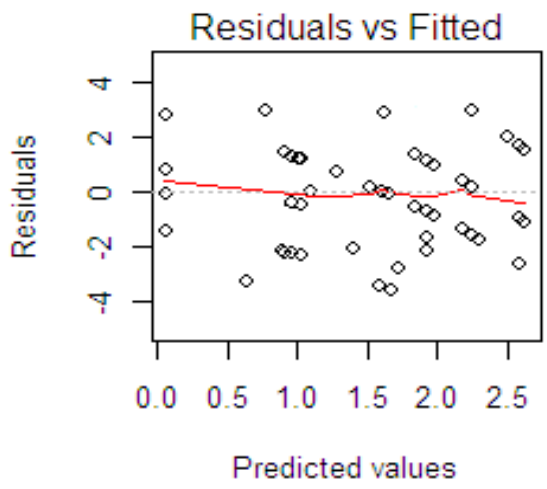

Figure 5.17 Alkborough WTP maintenance GLM model residuals plotted against fitted values, with line of best fit

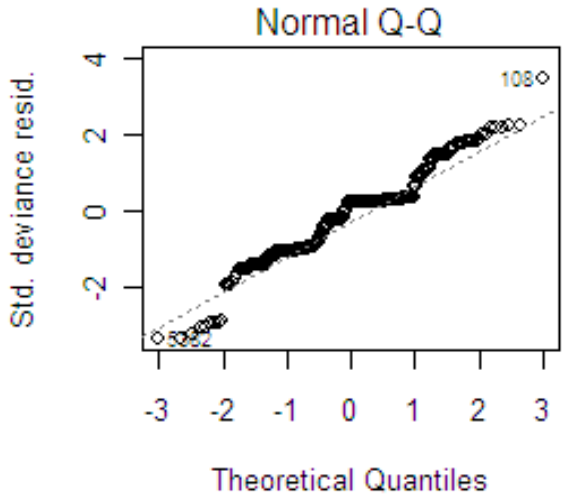

Figure 5.18 Alkborough WTP maintenance GLM model residuals plotted against theoretical quantiles with line of best fit

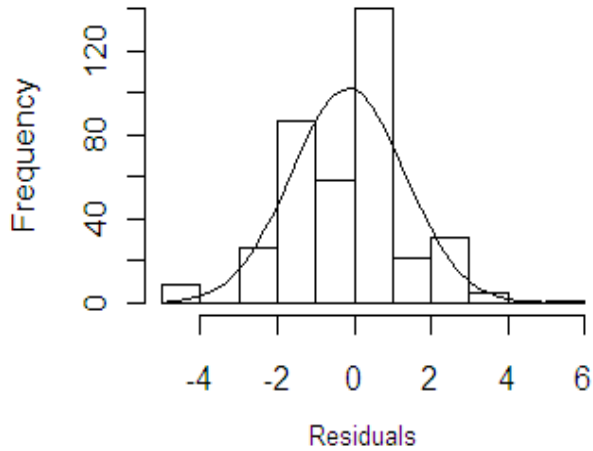

Figure 5.19 Histogram of Alkborough GLM WTP maintenance model residuals, with the line showing normal distribution.

The percentage of variance in the data explained by the model was calculated using the null deviance (1498.03) and the residual deviance (254.22). Just over 83% of the variance can be accounted for by the model. Although there is no recommended threshold, as high a percentage as possible is required to be able to justify the model. With this value, along with the residuals plots, this model can be considered justified, and is accepted.

5.14 Generalised linear modelling for access values.

After the ordinal and nominal variables were factored, analysis of the data was conducted with Poisson GLM. Overdispersion of the initial model (including all explanatory variables) was examined, and was found within the limits acceptable for Poisson selection (Phi= 1.36). Therefore, analysis continued with Poisson selection, once again using a backwards step process and removing the least statistically significant variable from the model at each step. The result from this process yielded the following model for WTP access values:

GLM (WTP_access ~ Distance + fIncome + fVisit_freq)

This shows that the distance the participant lives from the site, their income, and the frequency in which they visit the site are statistically the variables most likely to influence the amount they are willing to pay for access to the site (Table 5.6). Participant income has previously not shown to be significant, which highlights the importance of using several analysis techniques with this type of data. As the GLM shows that income is influential on WTP access, but not WTP maintenance values, this suggests that access may be seen as not as important as maintenance, and is something the participant will pay more for if they have surplus income.

Table 5.6 Descriptive values for variables in Alkborough GLM WTP access model.

Variable	Df	Deviance	AIC	P value
Visit frequency	5	924.68	1718.88	<2.2e-16
Income	5	495.77	1734.92	8.739e-05
Distance	1	482.69	1729.84	.000317

As with the WTP maintenance data, the residuals from the model were plotted in several graphs in order to discern the validity of the model. The graph showing the residuals plotted against the predicted values (Figure 5.20) shows that the residuals are not arranged in any obvious pattern, and are evenly distributed around 0. The Q-Q plot (Figure 5.21) shows the standardised deviance residuals to be following the line of best-fit very closely, and the histogram plotted of the residuals shows them to be a similar pattern to the line of best- fit (Figure 5.22). The percentage of variance in the data explained by the model was also calculated in addition to the validation plots, using the null deviance (1068.62) and the residual deviance

(469.72). Just over 56% of the variance can be accounted for by the model. Although there is no recommended threshold, as high a percentage as possible is required to be able to justify the model. This value does not validate the model alone, however the analysis of the residuals is enough to justify the model.

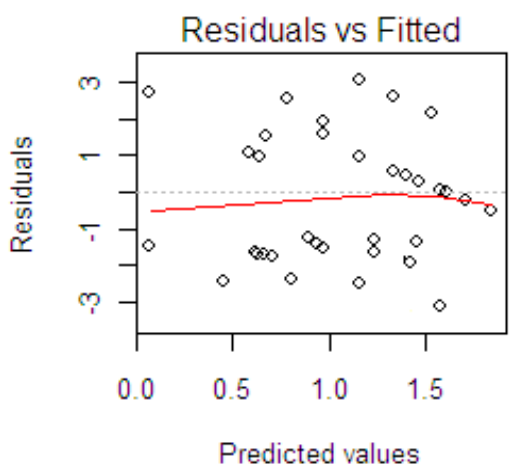

Figure 5.20 Alkborough WTP access GLM model residuals plotted against fitted values, with line of best fit

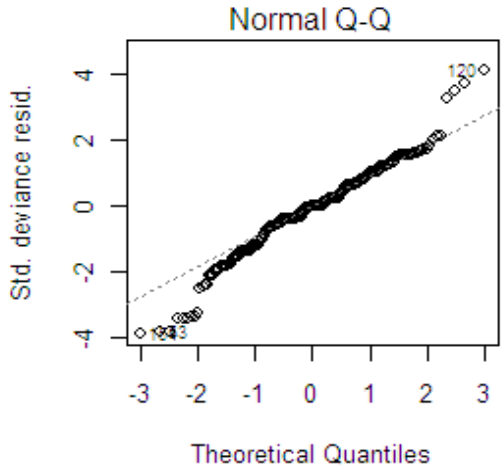

Figure 5.21 Alkborough WTP access GLM model residuals plotted against theoretical quantiles with line of best fit

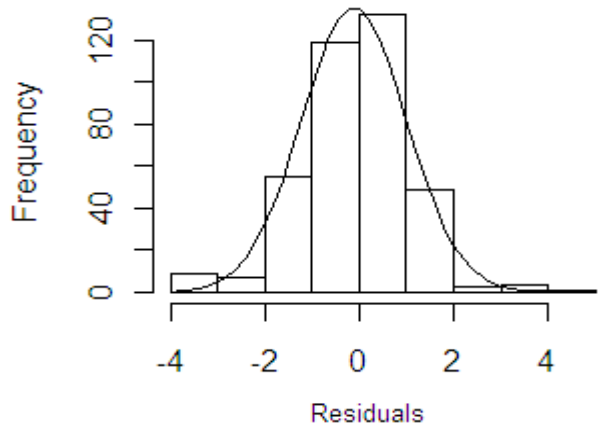

Figure 5.22 Histogram of Welwick GLM WTP access model residuals, with the line showing normal distribution.

5.15 Decision tree analysis for WTP maintenance values.

Results from the decision tree analysis revealed that the frequency in which the participants visit the site was the most influential explanatory variable on the response variable WTP maintenance (Figure 5.23). Those who visited the site, regardless of frequency, were willing to pay an average of £10.65 annually for maintenance, whereas those who did not visit the site were willing to pay £1 on average for maintenance. The difference between these values (nodes 1 & 2) was tested using a Mann Whitney U test, and was found statistically significant at the 95% level ($p < .001$). A summary of the Mann Whitney U statistics is given in Table 5.7.

Participants who did visit the site, were divided according to the distance that they live from it. Those who lived less than or equal to 2.45 miles from the site, were willing to pay an average of £15.83 annually for maintenance (node 3). Whereas those who lived more than 2.45 miles from the site, were willing to pay £9.77 (node 4). The difference between nodes 3 and 4 was tested for significance using a Mann Whitney U, and was found to have a 95% level of significance ($p < .001$). Those who lived 2.45 miles or less from the site, were further segregated by how often they visit the site. Those who visited the site fortnightly or more often, were willing to pay £16.30 on average; whilst those who visited the site less than fortnightly were willing to pay £5 annually for maintenance. The significance between these (nodes 5 & 6) was found statistically significant at the 95% level with a Mann Whitney U test ($p < .05$). The participants who lived more than 2.45 miles from the site were further divided by whether they had previous knowledge of the site or not. Those that did, were willing to pay an average of £10.25 for maintenance (node 7), whilst those that did not have previous knowledge were willing to pay £0.94 annually for maintenance (node 8). The difference between nodes 7 and 8 was tested for statistical significance with a Mann Whitney U test, and was found significant at the 95% level ($p < .001$).

The participants who visited the site fortnightly or more frequently were also further divided by the distance that they live from the site again. Those who lived 1.05 miles or closer to the site were willing to pay an annual amount of £14.17 on average for maintenance of the site, whilst those who lived further from the site than this were willing to pay an average of £18.64 annually. The difference between these values

(nodes 9 & 10) was found statistically significant with a Mann Whitney U test at the 95% level ($p < .01$).

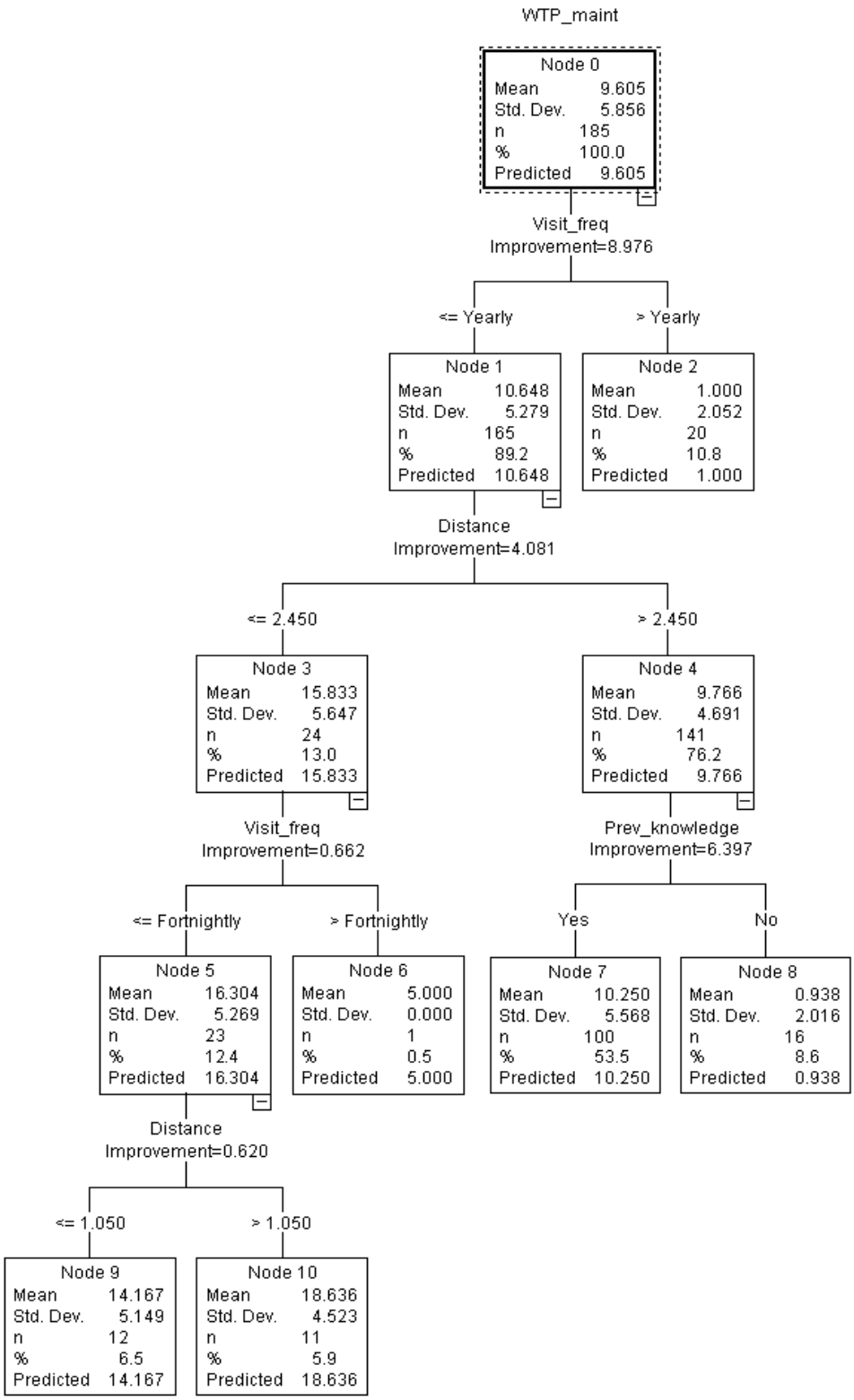

Figure 5.23. Decision Tree analysis for Alkborough WTP maintenance values

Table 5.7 Mann- Whitney U values and statistical significance for Welwick WTP maintenance decision tree analysis.

Variable	Difference between nodes	Z value	P value	Level of significance
Visit frequency	1 & 2	-10.512	.000	95%
Distance	3 & 4	-5.449	.000	95%
Visit frequency	5 & 6	-2.212	.027	95%
Previous knowledge	7 & 8	-4.545	.000	95%
Distance	9 & 10	-2.660	.008	95%

Results from the decision tree analysis show that visit frequency, distance from the site, and previous knowledge of the site are the variables which have a statistically significant influence on WTP maintenance values.

5.16 Decision tree analysis for WTP access values.

Results from the decision tree analysis for willingness to pay for access to the site showed that the frequency in which the participant visits the site is the most influential explanatory variable (Figure 5.24). Those who have visited the site at least once in the past year were willing to pay an annual amount of £7.04 for access to the site. Those who had not visited the site in the previous 12 months were willing to pay £0.13 for access. The difference between these values (nodes 1 & 2) was tested for statistical significance using a Mann Whitney U test, and was found significant at the 95% level ($p < .001$) (Table 5.8).

The participants who had visited the site at least once in the previous 12 months, were further segregated according to their annual household income. Those who earned £60,000 or less were willing to pay £5.17 annually for access to the site, whilst those who earned more than £60,000 were willing to pay £6.49 annually for access to the site. This difference was found significant at the 90% level using a Mann Whitney U test ($p = .067$).

Those that earned less than £60,000 annually, were further divided by the distance that they live from the site. Those who live 3.5 miles or less from the site were willing to pay an average of £9.08 annually for access to it, whilst those who live

further than 3.5 miles from the site were willing to pay £7.11 on average for access to it. The difference between these two nodes (5 and 6) was tested using a Mann Whitney U, and was found statistically significant at the 95% level ($p < .001$).

Participants who live 3.5 miles or less from the site were then divided by their level of education. Those respondents who had a further or higher level of education (A-levels or a university degree), or an equivalent qualification were willing to pay an average of £9.90 annually for access, whilst those who have an educational the equivalent of secondary school (GCSE/O Level) or vocational training were willing to pay £7 for access to the site. The difference between these values (nodes 7 and 8) was tested for statistical significance using a Mann Whitney U test, and was found non-significant. Those who lived more than 3.5 miles from the site were divided again by the distance that they live from the site. Participants who live 4.3 miles or less from the site were willing to pay £6.80 for access (node 9), whilst those who lived further than 4.3 miles from the site were willing to pay more, an annual amount of £10 on average (node 10). The statistical significance between nodes 9 and 10 was tested with a Mann Whitney U, and was found significant at the 95% level.

Results from the decision tree analysis show that visit frequency, annual household income, the distance the participant lives from the site are all statistically significant variables in terms of influencing WTP access.

Table 5.8 Mann- Whitney U values and statistical significance for Welwick WTP access decision tree analysis.

Variable	Difference between nodes	Z value	P value	Level of significance
Visit frequency	1 & 2	-10.516	.000	95%
Income	3 & 4	-1.830	.067	90%
Distance	5 & 6	-5.057	.000	95%
Education	7 & 8	-1.159	.247	-
Distance	9 & 10	-2.832	.005	95%

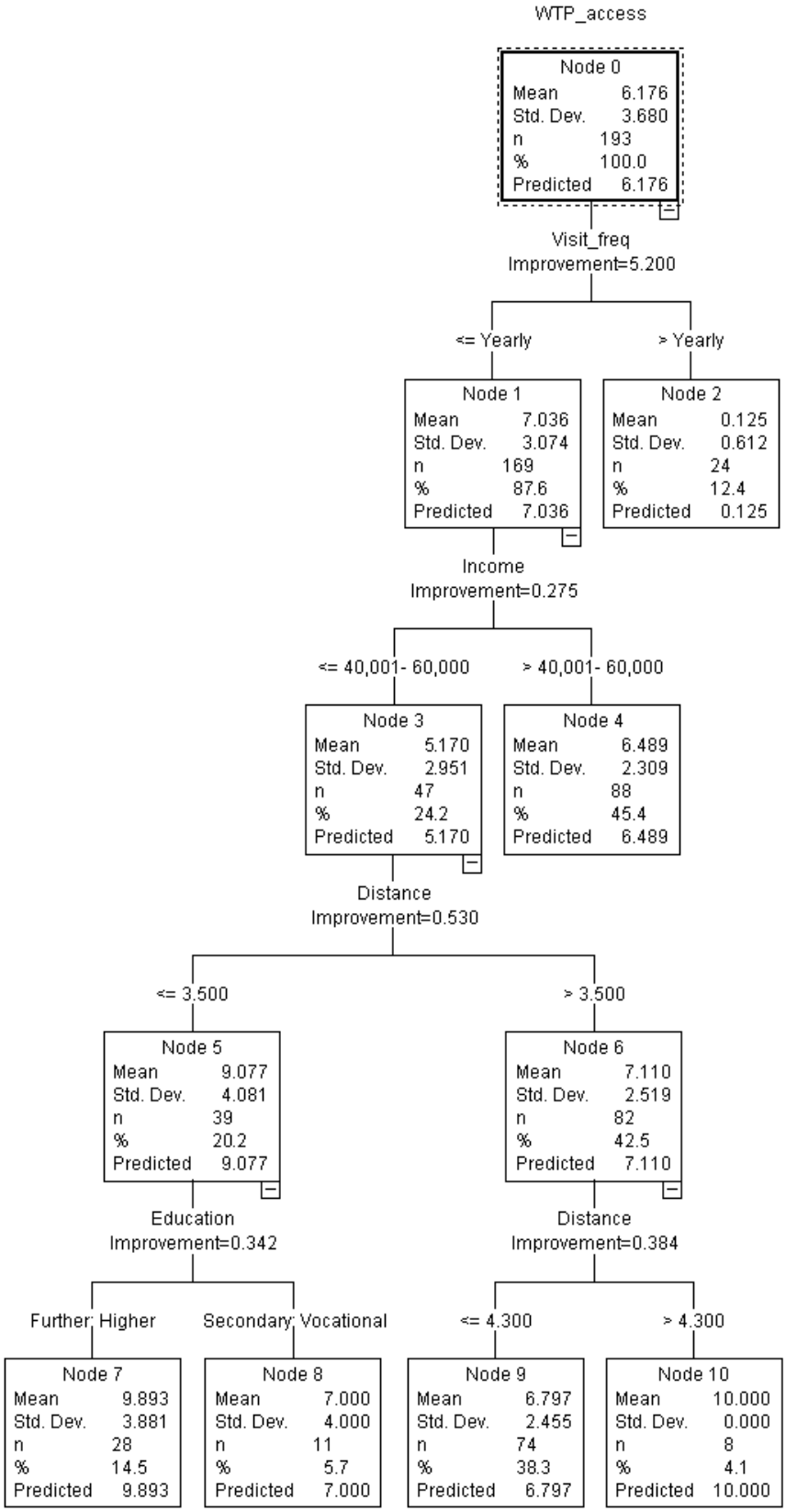

Figure 5.24 Decision Tree analysis for Alkborough WTP access values

5.17 Contingent ranking.

After answering the choice experiment and contingent valuation questions, the respondents were asked to rank each of the societal benefits identified, in order of importance to them (1= most important, 5= least important). This question was included so that the main reasons behind a participants' specific WTP value could be further understood. After the participants had ranked the societal benefits, the results were aggregated into first choices, and combined first and second choices (Figure 5.25).

The results from respondents' first choices revealed that the majority (72.41%) ranked disturbance prevention as the most important societal benefit. 16.18% ranked leisure and recreation first, and future unknown or speculative benefits were identified by 9.81% of the respondents. 1.33% ranked cognitive values as the most important societal benefit, and none of the participants ranked feel good or warm glow effects as first. When respondents' first and second choices were aggregated, disturbance prevention was again identified as the highest ranked societal benefit, with 88.06% of the respondents ranking the benefit either first or second. The benefit of cognitive values was chosen first or second by 39.79% of the respondents, and leisure and recreation by 30.77%. 22.81% ranked feel good or warm glow effects as either first or second, and 18.3% chose future unknown or speculative benefits as either their first or second choice. These results suggest that non-use values are more important than use values to the local population.

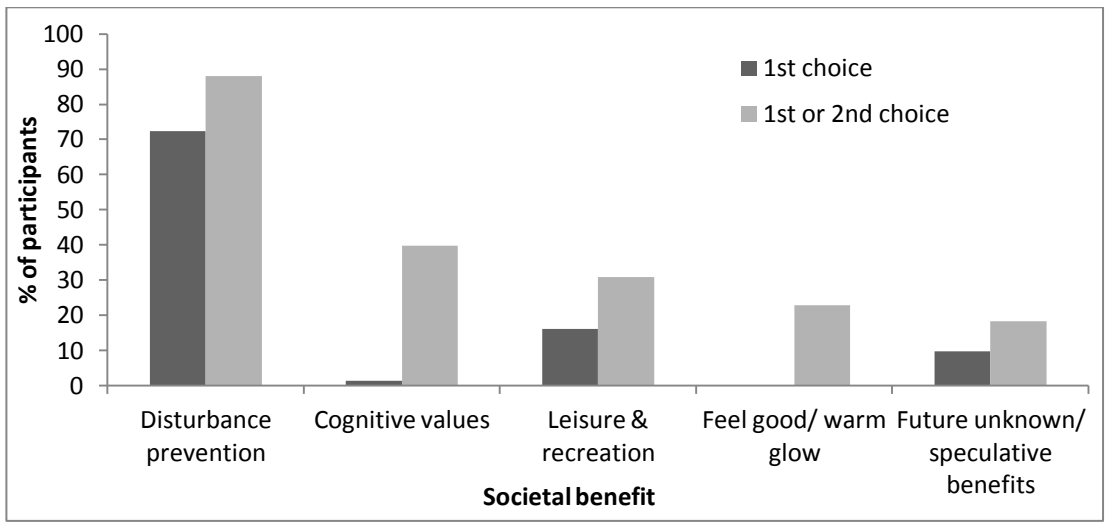

Figure 5.25 Percentage of participants' first and second choices when ranking societal benefits provided by Alkborough MR site in order of importance.

5.18 Summary and conclusions.

In summary, the survey completion rate from the population surrounding the Alkborough managed realignment site was 7.54%. The mean WTP maintenance value was £9.29 annually, and the annual mean for WTP access values was £6.20. For the respondents' who chose not to pay anything for either maintenance or access, the most common reason for this was that they did not use or visit the site. For those who did visit the site, main activities whilst there included walking to enjoy the scenery, nature and bird watching, and relaxing and enjoying the surroundings.

The suite of techniques used to analyse participant socio-demographic details suggest that the most influential explanatory variables on WTP maintenance values are their frequency of visit to the site, the distance that they live from the site, and whether they have knowledge of the site prior to answering the survey questions. For WTP access values, the most influential variables are their visit frequency, the distance they live from the site, their annual household income, and to a lesser extent their level of education. The results from the contingent ranking question show that that disturbance prevention is the most important societal benefit to the participants in relation to the other benefits; this is also suggested through the fact that the mean WTP value for maintenance of the site is more than the mean WTP value for access, therefore a functional site that protects the area from flooding may be regarded as more important than one that can be visited for recreational purposes.

During the conception of the Alkborough flats MR site, the Environment Agency consulted and actively engaged the local community in the development of the site, from its inception to implementation (Everard, 2009). This was achieved through detailed community-based feasibility and planning studies, meaning the process could act as a rural and local regeneration project, and therefore maximising opportunities to improve the regional tourist product and promoting rural business enterprises in the Alkborough area. A series of open meetings took place, with the support of community liaison officers, in order to inform the population on the status of the site as it develops, and offer a platform for the community to voice their opinions (Everard, 2009). This may account for the high percentage of participants that have previous knowledge of the site (90.7%) and also why the explanatory variable of previous knowledge had a significant influence on participant WTP maintenance values.

The frequency in which participants visit the site was an important variable for both WTP access and maintenance values and can perhaps be attributed to the sites' ecological characteristics, and the several facilities available at the site which make it an inviting environment for visitors, such as extensive footpaths, information boards, specifically designated bird hides, and areas of disabled access. The higher quality facilities at a site like this (in relation to other MR sites on the Humber) would perhaps mean the participants want to visit the site more often, and also pay more for maintenance of it and access to it. The large areas of saltmarsh and terrestrial vegetation have meant a higher occurrence of waders and wildfowl, as well as terrestrial species such as roe deer, which are likely to attract visitors on a more frequent basis.

North Lincolnshire council have also publicised the Alkborough MR site as one of their 'places to visit' whilst in the area, and have marketed it as part of a few attractions in the area (such as Julien's Bower) that can be part of a day out in the countryside. Although non-local visitors to the site were not included in this study, the materials that advertise the site are available to all residents in north Lincolnshire, and therefore may have increased local knowledge of the site as well as from further away, leading to a higher percentage of survey participants with previous knowledge of the site, and possibly increasing visit frequency.

Participant annual household income was identified as having a statistically significant influence on their WTP access values, but not their WTP maintenance values. This, along with the ranking benefits data, perhaps suggests that maintenance is seen as more of an essential cost, as it could potentially protect their house and belongings from flood damage, and therefore should be paid regardless of income. Whereas access to the site might be seen as a leisure activity, and is therefore not as essential to those in a lower income bracket, but is a worthwhile expense to those in a higher income bracket.

The WTP values expressed, although in an economic setting, are all associated with the ecological development of the site, further demonstrating the relationship between the two principles in a situation such as this. Perhaps what the site at Alkborough shows, is that developing the sites' facilities and making it more visitor friendly in general, could lead to higher WTP maintenance and access values, but

without the cost of increased foot traffic having a detrimental effect on the ecological status of the site.

CHAPTER 6

6. VALUATION OF SOCIETAL BENEFITS: CHOWDER NESS.

6.1 Introduction.

The primary aim of this chapter is to ecologically and economically value the societal benefits associated with the MR site at Chowder Ness, north Lincolnshire. The key socio-demographic influences that may influence the survey populations' value amount will also be investigated, in an attempt not only to find out the survey populations' value of the societal benefits of the site, but also the differences between why one participant may have a different value to another.

The MR site located at Chowder Ness will be described, including its position within the Humber and the main reasons it was created. An overview of the sites ecological status will be provided, forming a basis of the reasoning behind why a participant WTP value is what it is. This overview is given via ecological monitoring reports conducted primarily by ABPmer. The development of saltmarsh at the site is recorded through the monitoring of vegetation assemblages; and the abundance and diversity of bird, fish and invertebrate species is assessed in order to give a comprehensive account of the sites' ecological status.

The data collected from the interview survey questionnaires from the survey population, will then be statistically analysed using a suite of techniques, with the aim to find out which socio- demographic characteristics may influence participant WTP values for both maintenance of the site, and access to it. Results from the contingent ranking question will be analysed, and along with the WTP data will offer insight into why participants are willing to pay their stated amount.

6.2 Site description.

Chowder Ness was created from acquired farmland by ABP. This MR site, together with Barton upon Humber and the MR site at Welwick have created around 60 ha of new habitat, specifically created to replace just 22 ha of lost habitat from the expansion and developments of the ports in Hull and Immingham (ABPmer, 2011). The inner estuary site of Chowder Ness accounts for 14 ha of this realignment area. These managed inter-tidal habitats were created in line with the EA's plans for

habitat improvement and flood defence along the banks of the Humber. In order to create the site, new flood defences were constructed to the rear, removing 570m of existing sea wall over time. The removal of existing sea wall rather than the creation of solitary breaches was chosen as the preferred methodology for this site as it improved connectivity with the wider estuary, this is a more accurate re-creation of the type of environments which existed prior to land claim, it allows the whole cross sectional area of the estuary including the realignment site to respond to estuary wide changes; it increases energy levels within the site, and so improving the probability that mudflat habitat will be maintained, as mudflat creation is the primary objective for the site. The site at Chowder Ness is considered relatively small scale in relation to the estuary as a whole, mainly because it has a total area of 14ha, which only accounts for around 0.02% of the estuary's total intertidal area.

As the sea wall is removed, ABPmer (2004) are anticipating the effects on estuarine tidal velocities, sedimentation and accretion to be highly localised and small in magnitude in comparison to other sites of managed realignment on the Humber. An initial 10 year monitoring programme is currently being undertaken to describe both changes to the sites in front of the realignment, and to the site itself. Observers are monitoring topography, saltmarsh composition and changes to the intertidal invertebrates and wildfowl usage (Hemingway *et al*., 2008).

The MR site itself can be described as an extension of the Far Ings nature reserve, which is adjoined to the MR area. This nature reserve is well established, with a carpark and a visitor's centre with information on what species you are likely to see at the site. Bird hides are also provided for those who wish to bird watch. Although these facilities are not directly for the Chowder Ness MR site, it provides incentive to visit this specific area of the Humber bank. The North Lincolnshire wildlife trust also provide suggestions for walks along the south bank of the Humber which include the Far Ings nature reserve, and the Chowder Ness MR site in association (lincstrust.org.uk).

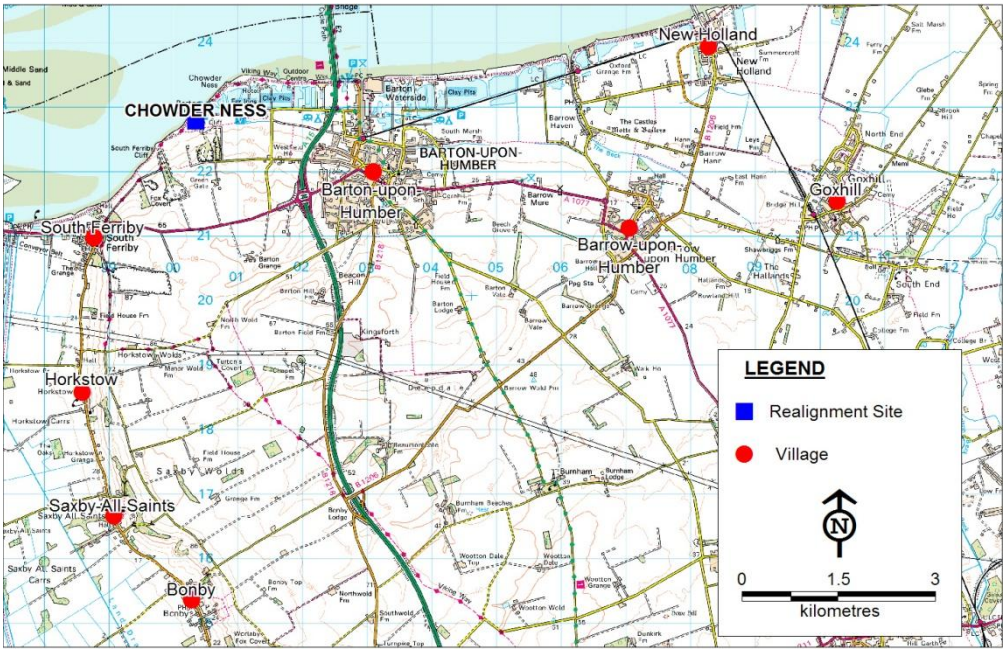

Figure 6.1 Map showing Chowder Ness MR site and surrounding villages within 7 mile travel distance.

6.3 Ecological overview.

The ecological monitoring reports for the MR site at Chowder Ness are conducted and written by ABPmer, recording information on saltmarsh development, and bird, invertebrate and fish abundance and diversity.

6.3.1 VEGETATION COVERAGE.

Results from the vegetation survey in 2007 (a year after breach) showed that vascular plants only colonized small areas at the margins of the newly created site. However, by 2009 colonisation of various plant species such as sea aster (*Aster tripolium*) and sea club-rush (*Bolboschoenus maritimus*) had significantly increased (Hammond, 2010).

When the sites' vegetation was monitored in 2010, results showed areas up to 20 metres wide of sea club-rush, a marked increase from the 2009 monitoring report. These areas also included some patches of common reed (*Phragmites australis*) and small patches of prostrate orache (*Atriplex protrata*). Rayed sea aster also forms several more consolidated patches on the open mudflat, and in places forms dominant strips up to 24 metres out from the embankment. This, along with sea

club-rush, has shown significant expansion and consolidation since 2009, extending in some places up to 54 metres from the embankment (Hammond, 2010). As expected for a site such as this, by 2009 (2 years after breach), a small proportion of the site has developed into saltmarsh, and includes species such as spear-leaved orache and sea milkwort, but is dominated by Rayed sea aster, which was shown to have expanded by 2010, and has become the dominant plant community at the site (ABPmer, 2011).

There are some potentially important saltmarsh species identified at Chowder Ness, in terms of their presence in the wider estuary. These include common saltmarsh grass, several forms of red fescue (*Festuca rubra*) and saltmarsh rush (*Juncus gerardii*), however, as of the 2010 monitoring reports, there is no clear indication of whether these particular species are important in terms of vegetation development at this site (Hammond, 2010). The terrestrial habitats at the site were created specifically with the aim of supporting a range of farmland bird species at the top and landward side of the new flood embankment (ABPmer, 2011).

6.3.2 INVERTEBRATES.

There is limited information available on the invertebrate status at the Chowder Ness site, however the information that had been reported has shown a general increase in diversity and abundance of key species from 2008 to 2009, leading to colonisations of between 571 and 15,429 individuals per m^2, belonging to between 2 and 6 species (ABPmer, 2011). The abundance, diversity and biomass of invertebrate species in the mudflat have increased, and are now similar to the numbers that are expected outside the MR site. This suggests that the mudflat has developed at a fast rate post breach, and is a suitable foraging habitat for birds.

6.3.3 BIRDS.

During the 06/07 count season, 13 different species of waterfowl were observed to be using the newly created area, which is all but one of the target species set for the site (Black-tailed Godwit was not present). The species in most abundance were Golden Plover, Lapwing, Dunlin, Black-headed Gull and Curlew, with Lapwing, Dunlin and Redshank present for all seven months of monitoring (Hemingway *et al*., 2008). The additional requirement of providing terrestrial vegetation sites for

farmland bird species (previously mentioned in section 6.3.1), was seen to be accomplished already by 2007, through the recording of six different bird species using the grassland, four of which held breeding territories, despite the habitat being relatively new at the time (Hemingway *et al*., 2008). Monitoring in 2009 confirmed this, with 8 bird species shown to be using the terrestrial habitat, of which six held breeding territories, including Moorhen, Skylark, Meadow Pipit, Pied Wagtail, Reed Bunting and Grasshopper Warbler (ABPmer, 2011).

Results from monitoring the bird assemblages in 2009 revealed that the number of waterbird species using the site had increased to 16. The highest abundances of species included Golden Plover, Shelduck, Dunlin, Lapwing, Curlew, Common Gull and Black-headed Gull (ABPmer, 2011). The increase in species diversity at the site suggests a further development of invertebrates and vegetation assemblages, attracting the birds to the site for feeding and roosting.

6.3.4 FISH.

Of the fish species monitored in 2007, the same two dominant species of flounder and eel were identified in both inside the MR site, and outside of it. However the composition of the less abundant species was slightly different. Inside the MR site were shown to be either freshwater or anadromous species such as European smelt (*Osmerus eperlanus*), however species composition outside the site was primarily brackish species of marine origin (Hemingway *et al*., 2008). This may be attributed to the slow colonisation of invertebrate species inside the MR site, analysis of stomach contents showed that the fish species were not feeding inside the site at this time. However this is likely because the first monitoring sessions occurred a year after initial breach, and may not have been long enough for extensive colonisation of the mudflats inside the site (Heminqway *et al*., 2008).

Results from fish surveys conducted in 2012 showed that the fish assemblages inside the MR site had now become more similar to those outside the MR site, with a high abundance of Flounder (*Platichthys flesus*) as well as species such as Common Bream (*Abramis brama*), European Eel (*Anguilla anguilla*), Brown Shrimp (*Crangon crangon*) and Three-spine Stickleback (*Gasterosteus aculeatus*) also present at the site (EA report, *in progress*).

6.4 Survey population and response rates.

The total number of completed surveys (5.19%) (Table 6.1) is a percentage of all the households within 7 miles of the MR site (Figure 6.1). Although an attempt was made to survey every household in the area, the majority of the surveys that were not answered, were because there was no response at the house. Time constraints limited the researcher from revisiting each of the houses where there was no answer at the door. This also may cause sample selection bias in the data set, as if the households are only surveyed once, this could cause selection bias against those who are out or at work during the sample time. A total of 1104 residents answered the door, but declined to answer the survey (Barton upon Humber: 744, Horkstow: 13, Barrow upon Humber: 113, Saxby-All-Saints: 23, Goxhill: 42, New Holland: 45, Bonby: 17, South Ferriby:77). If the percentage of completed surveys were calculated according to every household who answered the door, the survey completion rate is 32.25%.

Table 6.1 Summary of survey population statistics (Chowder Ness).

Village	Number of households	Number complete surveys	% complete surveys
Barton upon Humber	4019	222	5.52
Horkstow	63	2	3.17
Barrow upon Humber	793	26	3.28
Saxby-All-Saints	103	1	0.97
Goxhill	964	67	6.95
New Holland	458	17	3.71
Bonby	228	6	2.63
South Ferriby	233	15	6.44
Total	6861	356	5.19

6.5 Data preparation.

Boxplots and dotplots were used initially on the raw data, with the aim of identifying any outliers that should be removed from the data set. Thorough consideration of all extraneous variables resulted in the extraction of 6 cases from the set. They were removed on the basis that they were either extremely far removed from the rest of the data, or because they were the only representative in their socio-demographic category, and perhaps therefore assumptions could not be made based on a single representative. 15 participants were identified as protest bidders, through their reasons for declining to pay for either maintenance of or access to the MR site (explanation in Chapter 2). These cases were removed from the data set before any further analysis occurred.

Primarily for speed during the interview process, all the respondents' answers were recorded in binary format; however this was not suitable for the statistical analysis being used. The answers were all aggregated into ordinal values, and can be seen in Table 3.2 (Chapter 3). The scale values WTP maintenance, WTP access and distance are changed into ordinal values for the purpose of conducting the X^2, but remain as continuous values for all other analysis techniques.

6.6 General characteristics of the respondents.

Socio- demographic details were gathered from the surveys and put into a table (Table 5.2). This was so any early patterns can be seen, and also to see the cross section of the population taken. It is also essential to know certain socio-demographic details when identifying possible protest bids in the surveys (Chapter 2).

34.5% of participants are in the 45- 54 age bracket, with just over 50% earning an annual household income of £40,001- 60,000 after tax. The majority of the participants live less than 2 miles from the site, this is due to the largest village in the survey (Barton-upon-Humber) also having the closest proximity to the site. There are distinctly more respondents with children living with them than without, and also slightly more female participants than male participants.

Table 6.2 General summary of respondents' characteristics (Chowder Ness).

Question	Answer	N	No of responses	% Response
Age	18- 24	330	0	0
	25- 34		20	6.1
	35- 44		71	21.5
	45- 54		114	34.5
	55- 64		76	23.0
	65- 74		49	14.8
	75- 84		0	0
Income	< 20,000	330	5	1.5
	20,001- 40,000		50	15.2
	40,001- 60,000		168	50.9
	60,001- 80,000		70	21.2
	80,001- 100,000		23	7.0
	100,001- 120,000		14	4.2
	> 120,001		0	0
Gender	Male	330	152	46.1
	Female		178	53.9
Education	Primary	330	0	0
	Secondary		28	8.5
	Vocational		81	24.5
	Training		112	33.9
	Further		109	33.0
	Higher		0	0
	Postgraduate			
Children	Yes	330	189	57.3
	No		141	42.7
Distance	< 2 miles	330	221	67
	2- 5 miles		29	8.8
	> 5 miles		80	24.2
Visit Frequency	1= Daily	330	7	2.1
	2= Weekly		86	26.1
	3= Fortnightly		79	23.9
	4= Monthly		71	21.5
	5= Yearly (once)		40	12.1
	6= Never		47	14.2
Time spent at the site	1= None	330	49	14.8
	2= < 0.5		59	17.9
	3= 0.5- 1		200	60.6
	4= 1- 1.5		22	6.7
Previous knowledge of the site	1= Yes	330	284	86.1
	2= No		46	13.9

6.7 Knowledge and use of the site.

Just over 86% of the respondents had heard of the site before being interviewed, and most visit on a weekly, fortnightly or monthly basis, spending between 30 minutes and an hour at the site per visit. As part of the survey, participants were asked which activities they participate in whilst at the site. As none of the respondents had an occupation associated with the site, it can be suggested that all reasons for visiting the site are recreational or educational. 283 of the 330 respondents revealed they had visited the site at least once in the last 12 months. The most common reasons for visiting the site were walking (to enjoy the scenery rather than for fitness), and relaxing and enjoying the surroundings. 88 participants walked specifically for fitness, and 77 walked their dogs at the site. 74 respondents stated they bird watched whilst at the site, whilst 162 stated they participated in nature watching, showing a more general interest in all nature at the site. 20 participants had taken a picnic with them to the site in the last 12 months, however in most cases this activity is in conjunction with another (e.g. bird watching), as the participants were permitted to state all the activities they use the site for, not only 1 per respondent (Figure 6.2).

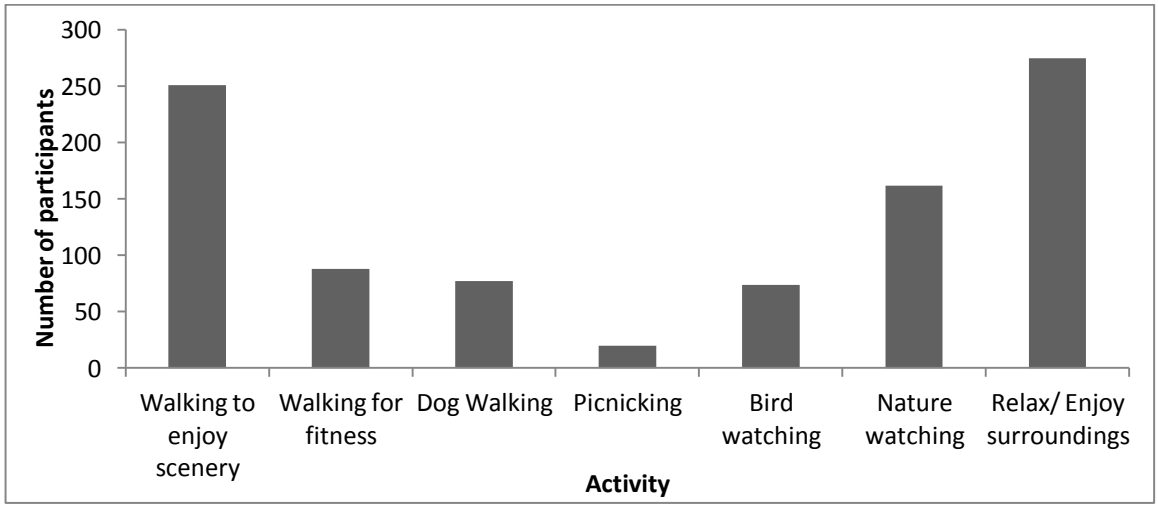

Figure 6.2 Uses of the MR site at Chowder Ness.

6.8 Willingness to pay responses.

A summary of the results from the first valuation question in the survey, the choice experiment, revealed that 84.5% of the participants were willing to pay at least £1 towards the maintenance of the MR site. Slightly less were willing to pay at least £1 annually for access to the site (77.6%) (Table 6.3).

Table 6.3 Summary of participants' choice experiment answers for Chowder Ness MR site.

Willing to pay for MAINTENANCE?	Number of participants	% Response
Yes	279	84.5
No	51	15.5
Willing to pay for ACCESS?	Number of participants	% Response
Yes	256	77.6
No	74	22.4

6.8 Distribution of bids.

For those participants who did not wish to pay anything, they were asked to explain the main reason why this was, for both WTP maintenance and WTP access values. This only occurred for genuine zero bids, those who valued maintenance of the site or access to the site as £0 (Figure 6.3). Protest bids of £0 are excluded before this stage of the analysis (Chapter 2).

In relation to willingness to pay for maintenance of the site, the most common reason for choosing not to pay anything was because the participant did not use or visit the site (33.33%). Just over 31% of the respondents stated that they could not afford to pay at this time, but that they would if they could afford it, and 21.57% thought that the organisations that created the site should pay for any maintenance to it. 3.92% do not value any of the benefits the site has to offer, whilst 5.88% and 1.96% respectively either objected to paying higher taxes generally, or did not trust the government to use the funds for their intended purpose. None of the participants chose not to pay anything because they are not interested in the wetland environment, and 1 participant did not see it as a priority.

In relation to paying an annual amount for access to the site, over half of the respondents stated the reason for not paying was because they do not use or visit the site (55.41%). 13.51% could not afford to pay for access to the site, but would

do; and 4 participants (5.41%) did not value any of the benefits created by the site. 3 participants objected to paying for higher taxes, and 1 did not trust the government to use the funds as intended. 2.7% stated paying for access was not a priority for them, and 14.86% thought the organisation that created the site should not charge for access. 2.7% stated they were not interested in the wetland environment.

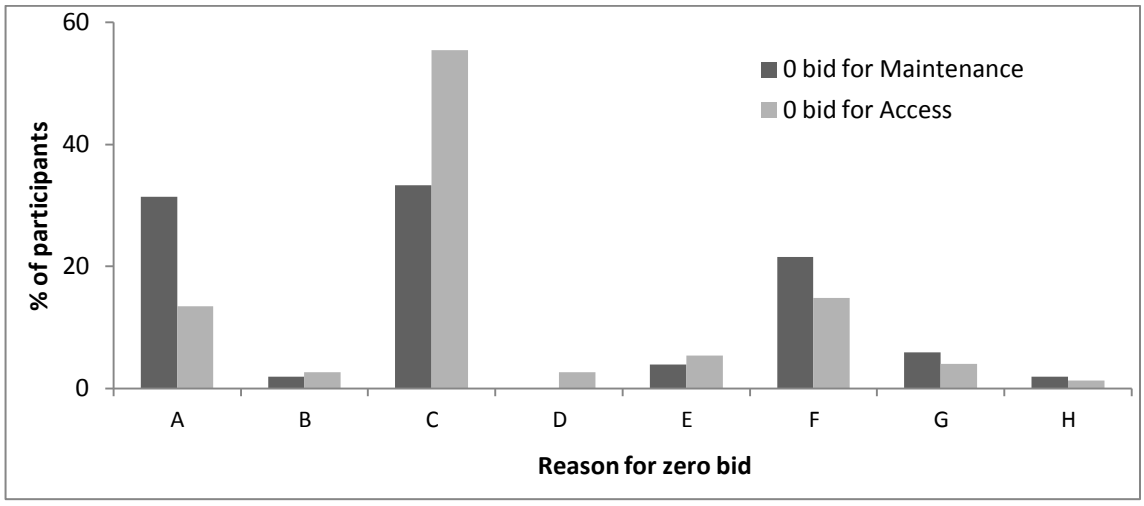

Figure 6.3 Participants' reasons for choosing NOT to pay for maintenance of, or access to the MR site at Chowder Ness. . (A= 'I cannot afford to pay, but I would do; B= 'It is not a priority for me'; C= 'I do not use or visit the site; D= 'I am not interested in the wetland environment; E= 'I do not value any of the site's benefits; F= 'The organisation that created the site should pay; G= 'I object to paying higher taxes'; H= 'I do not trust the government to use the taxes as intended').

A summary of the results from the contingent valuation question for all values is shown in Figure 6.4. For those who wished to pay for maintenance of the site, their values ranged from £1 to £20. All WTP maintenance bids combined (including zero bids) had a mean value of £6.96 (SD= 5.17), with median and mode both £5. In relation to WTP access bids, the participants who chose to pay something had values ranging from £1 to £20. All the WTP access bids combine, including zero bids, had a mean value of £4.43 (SD= 3.35) with median and mode values both at £3.

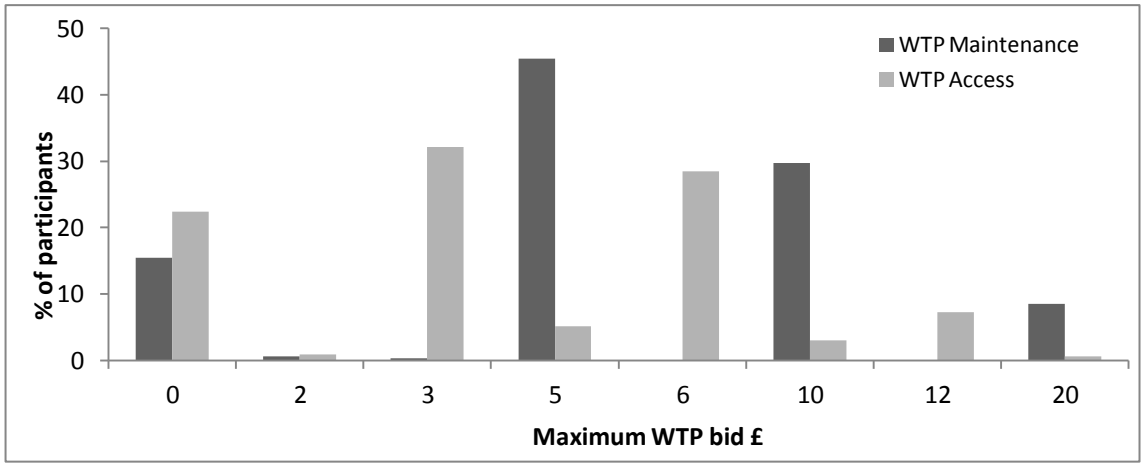

Figure 6.4 Distribution of bids for WTP values for Chowder Ness MR site.

6.10 Exploratory and chi square analysis.

Boxplots and X^2 analyses were used initially on all the variables, to determine if any had a statistically significant relationship with either WTP maintenance or WTP access values.

The results from the Chi-square analysis revealed that all 9 explanatory variables had a statistically significant relationship with both the response variable of WTP maintenance, and WTP access at the 95% level; except for whether the participants had children or not with WTP access, which was found non-significant. The validity of the analysis was checked by analysing the number of cells with expected counts of less than 5 for each X^2. In all of the tests, less than 20% of the cells had expected counts of less than 5, which suggests there is no need to also conduct a r_2 test on the data to validate the X^2.

The relationship between the distance that the participant lives from the site, and their WTP values for both maintenance and access were shown to be statistically significant at the 95% level (X^2= 150.42 and 179.69 respectively) . Therefore, the further away the participant lives from the site, the less their WTP maintenance or WTP access value is likely to be (Figures 6.5 & 6.6). Participant WTP values for maintenance and access were shown to increase with their frequency of visit to the site (X^2= 323.06 & 249.98 respectively) shown in figures 6.7 & 6.8, and the amount of time they spent at the site per visit (X^2= 250.42 & 214.56 respectively), as well as

whether they had knowledge of the site prior to completing the survey (X^2= 171.89 & 139.14 respectively).

Age should be considered in any further analysis of the influence of WTP maintenance (X^2= 158.37) and WTP access (X^2= 169.02), as should their level of education (X^2= 90.36 & 7.32 respectively). The influence that the respondents' annual household income has on their WTP maintenance and access values should be further analysed (X^2= 65.29 & 234.29 respectively) (Figures 6.9 & 6.10), as well as what gender they are (X^2= 40.03 & 37.27 respectively). As already mentioned, whether the participant had children or not was found statistically significant in relation to their WTP maintenance values (X^2= 40.20), but not in relation to their WTP access values (X^2= 4.27).

It is clear that further analysis of the influence the explanatory variables have on the response variables in required in order to ascertain those with the most influence on WTP values for both maintenance of the site and access to it.

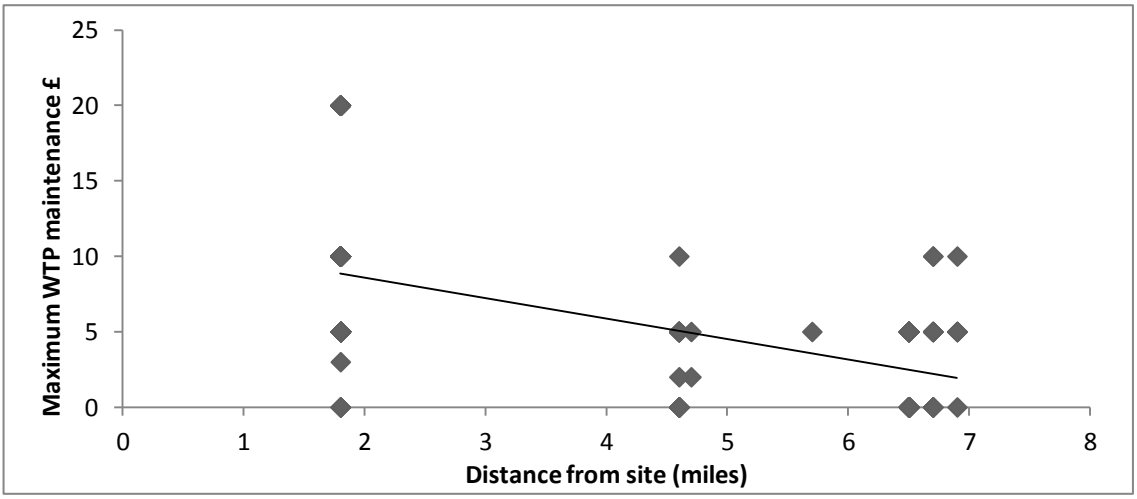

Figure 6.5 Relationship between the distance that the participant lives from Chowder Ness MR site, and their maximum WTP maintenance value. Points may represent more than one case. The trendline reflects this.

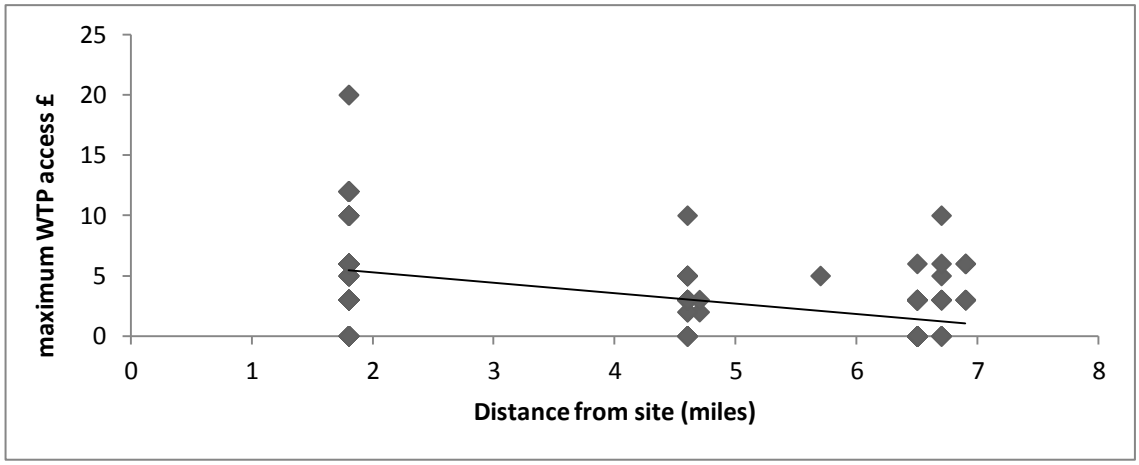

Figure 6.6 Relationship between the distance that the participant lives from the Chowder Ness MR site, and their maximum WTP access value. Points may represent more than one case. The trendline reflects this.

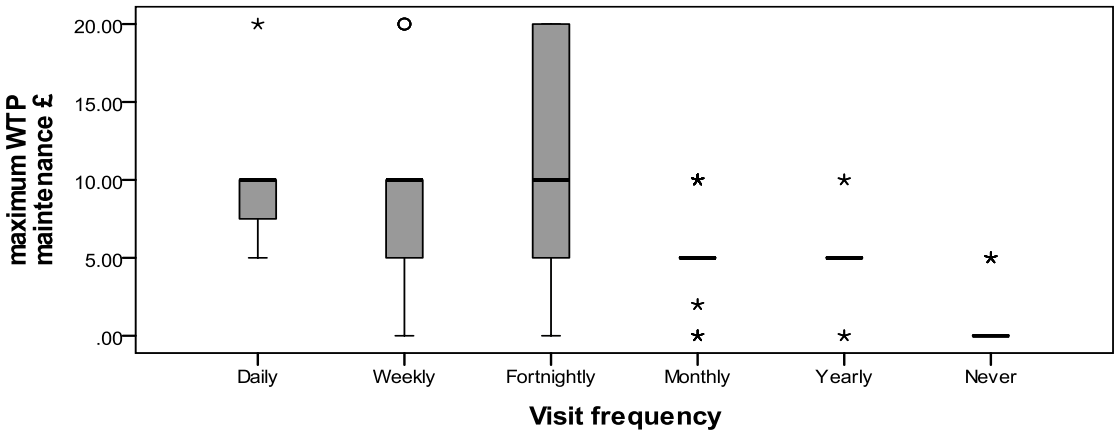

Figure 6.7 Relationship between participants' visit frequency in the last 12 months to the Chowder Ness MR site, and their maximum WTP maintenance value (**o** = outliers, ***** = extraneous variables).

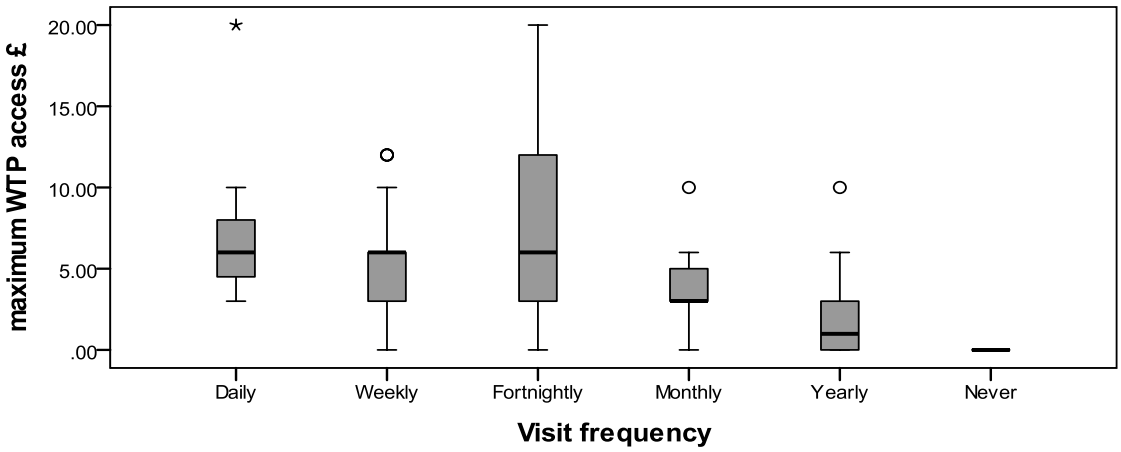

Figure 6.8 Relationship between participants' visit frequency in the last 12 months to the Chowder Ness MR site, and their maximum WTP access value (**o** = outliers, ***** = extraneous variables).

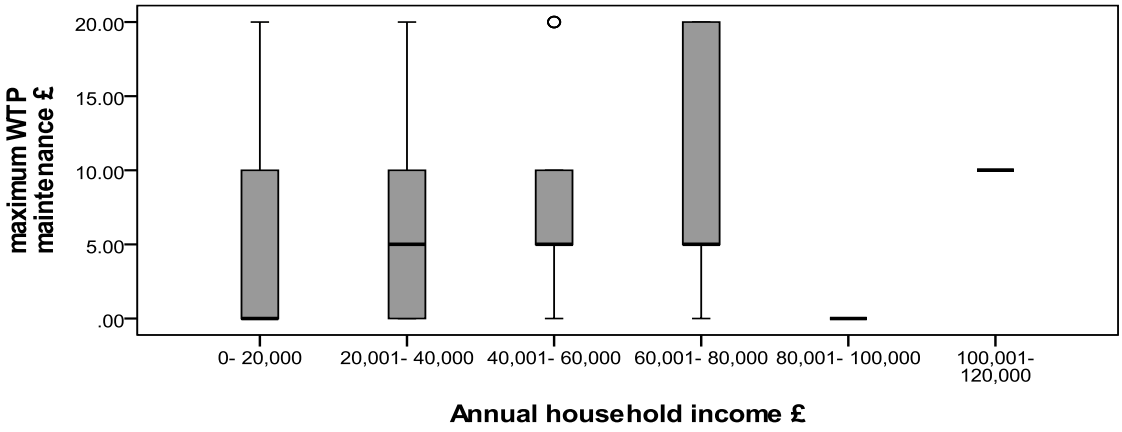

Figure 6.9 Relationship between participants' annual household income and their maximum WTP maintenance values for the Chowder Ness MR site (**o** = outliers, ***** = extraneous variables).

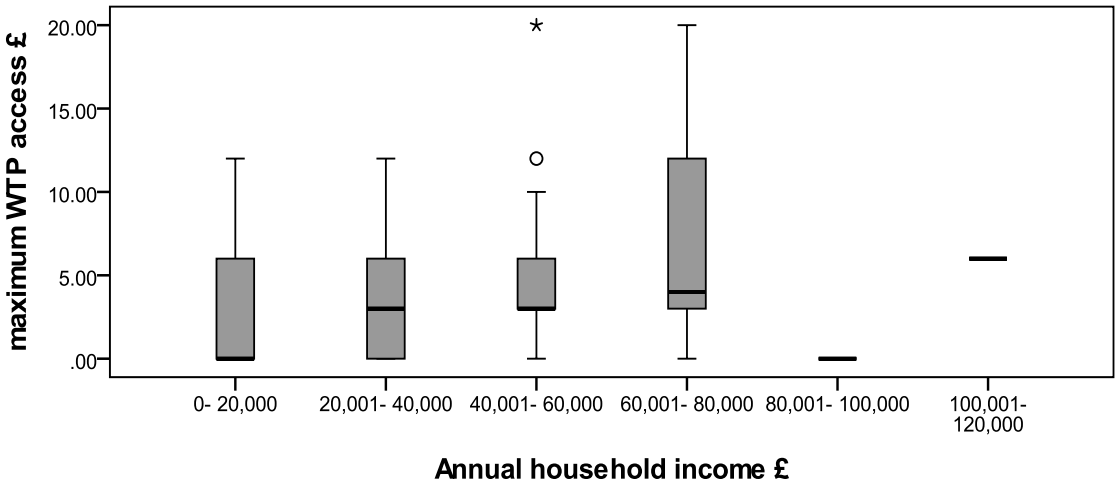

Figure 6.10 Relationship between participants' annual household income and their maximum WTP access values for the Chowder Ness MR site (**o** = outliers, ***** = extraneous variables).

The results from the initial exploratory and Pearson Chi-square analysis revealed that nearly all of the explanatory variables had a statistically significant relationship with the response variables. Therefore the coplot analysis can be used to see the effects of more than one explanatory variable on the response variable, in an attempt to see if their relationships change when they interact.

6.11 Coplot analysis.

Participant annual household income coupled with their age had a similar effect on both WTP for maintenance (Figure 6.11) and WTP access (Figure 6.12). If the participant is less than 54 years old (e.g. they are in the first 4 age brackets), then the amount they are willing to pay for either maintenance of the site or access to it, increases as their household income increases. If the participants are in the 55- 64 age category, their income does not appear to have any effect on their WTP values. However, if the participant is aged between 65 and 74, their income appears to have a detrimental effect on their WTP values.

The relationship between the participant knowledge of the site prior to the survey and the distance they live from the site was analysed for its effect on WTP maintenance values. If the participant does have previous knowledge of the site, the distance that they live from the site affects their WTP maintenance value in that the closer they live

to the site, the higher their value. Proximity to the site has a much larger influence on their WTP maintenance values if they do have previous knowledge, compared to if they do not have previous knowledge of the site. There is still a slight correlation, but it is much weaker (Figure 6.13).

In terms of participant WTP access values, the distance that the participant lives from the site and the frequency in which they visit the site on an annual basis were analysed (Figure 6.14). For those who visit the site either daily or weekly, the distance that they live from the site has a relationship with their WTP access values; a close proximity to the site suggests a higher WTP value. If the participant visits fortnightly, the same relationship is seen but it is not as extreme. There seems to be no relationship between the distance the participant lives from the site and their WTP access values if they visit less frequently, either monthly or yearly, suggesting that those who visit the site relatively frequently, may do so due to their proximity to it.

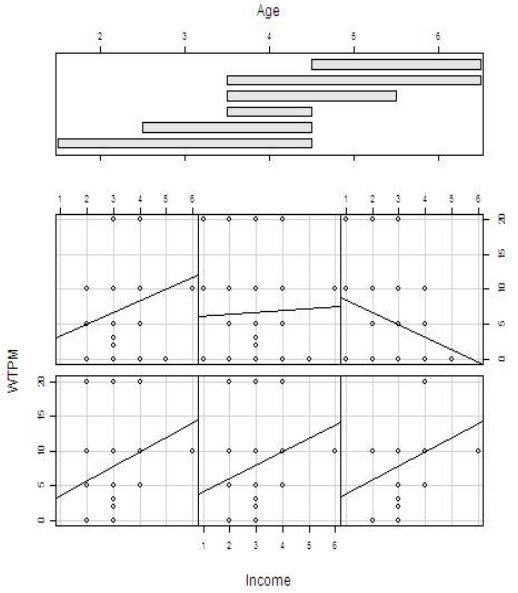

Figure 6.11 Relationship between WTP maintenance and income, with conditioning variable age (Chowder Ness) (WTPM= £ values)

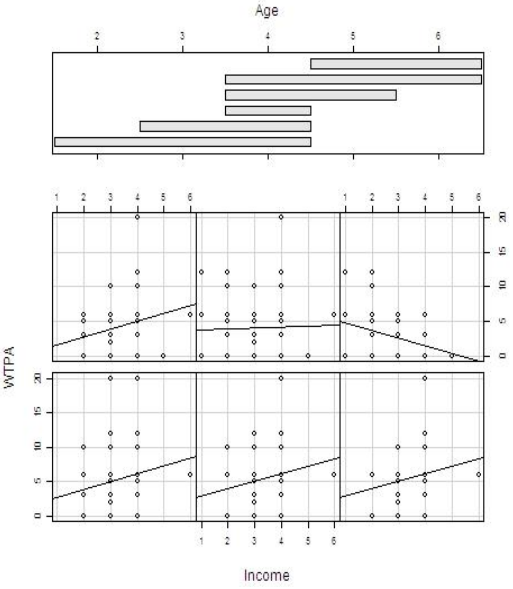

Figure 6.12 Relationship between WTP access and income, with conditioning variable age (Chowder Ness) (WTPA= £ values)

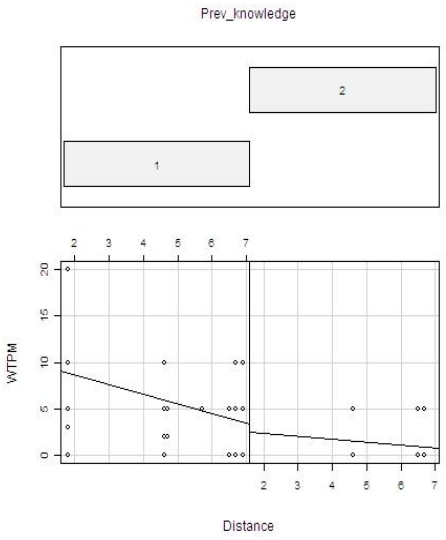

Figure 6.13 Relationship between WTP maintenance and distance from the Chowder Ness MR site, with conditioning variable previous knowledge (WTPM= £, Distance= miles, previous knowledge 1= yes, 2= no.

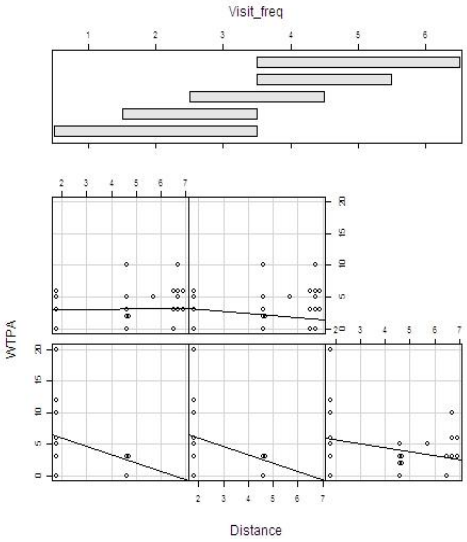

Figure 6.14 Relationship between WTP access and distance from the Chowder Ness MR site, with conditioning variable visit frequency (WTPA= £, distance = miles)

Overall results from the coplot analysis reveal that income is effected by age in relation to both WTP maintenance and WTP access values; and the distance that the participant lives from the site has shown to interact with both previous knowledge of the site in terms of WTP maintenance values, and frequency of visit to the site in relation to WTP access values. These variables will be considered further in any additional statistical analysis.

6.12 Principal component analysis of explanatory variables.

All explanatory variables were included initially in the analysis, however inspection of the anti- image correlations revealed that the variables Children and Gender had values below the accepted 0.5 threshold for significance (.473 and. 442 respectively), and therefore these variables were removed and the analysis was completed without them.

Analysis of the scree plot of the eigenvalues from the new set of variables revealed an inflection after the first two components, suggesting a 2 component PCA. In addition, both these components had eigenvalues greater than 1, which follows the recommended criteria for component selection suggested by Kaiser (1974). With variables Children and Gender removed from the analysis, none of the anti-image correlation values were lower than 0.5. In addition, none of the Pearson correlation coefficients in the analysis were above the accepted criteria of 0.9, which means the analysis should not encounter any problems due to singularity in the data. The determinant of the correlation matrix is also above the necessary value of $0.1x10^{-4}$ (determinant= .061), which suggests that multicollinearity should not be problematic.

As stated in earlier chapters (e.g. Chapter 3), the Kaiser-Meyer-Olkin (KMO) value should be analysed as this represents whether the correlation patterns are compact, and therefore whether PCA is appropriate or not. For this 2 component model, the KMO value is .788, which increased from .737 when all variables were included in the PCA. This is above the threshold of 0.5 suggested by Kaiser, in addition, the Bartlett's test of sphericity is highly significant (p<.001) which means there is at least 1 statistically significant correlation in the matrix, and therefore the PCA can be trusted to give reliable components, and it is appropriate to continue. Once again, an oblimin with Kaiser normalization rotation method is used, as some level of correlation between the two components is expected.

The extracted sums of squared loadings revealed that component 1 accounts for 47.18% of the total variance found in the PCA model, and component 2 accounts for 16.96% (64.14% total variance). The rotation method for this analysis is oblimin with Kaiser normalization, as such the pattern matrix is seen as the primary point of interpretation for the PCA model. As 0.3 is regarded as the determining value in terms of whether a variable is contributing to the component in a meaningful way, we can see a clear distinction between the 2 components (Table 6.4). Previous knowledge of the site, the participant visit frequency, their proximity to the site, the amount of time they spend at the site per visit, and their age are all meaningful to component 1. Level of education and annual household income are meaningful to component 2. With the exception of age, the components seem to be divided according to participant contact with the site, and their socio-demographic details.

The pattern matrix suggests that there is a distinction in the variables between components 1 and 2, however the component correlation matrix suggests that the 2 components are not significantly correlated (correlation= .017), and therefore it should be assumed that there is independence between the factors. However, investigation of the nonredundant residuals in the PCA revealed that 76% have absolute values higher than .05, and therefore this PCA cannot be validated, and should only be used as part of the exploratory analysis. Further analysis will be undertaken to consider the variables with the most influence on the response variables.

Table 6.4 Pattern matrix containing factor loadings for PCA for Chowder Ness data. Values considered meaningful to the component are in bold.

Pattern Matrix[a]

	Component	
	1	2
Prev_Knowledge	**.869**	.197
Visit_Freq	**.865**	-.089
Distance	**.837**	-.006
Time_Spent	**-.819**	-.139
Age	**.517**	-.163
Education	-.260	**.787**
Income	.284	**.695**

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

6.13 Generalised linear modelling for maintenance values.

Once all ordinal and nominal variables were factored Poisson GLM was attempted for the WTP maintenance model, however the model was found to be overdispersed (Phi> 1.5), and therefore it was inappropriate to continue with a Poisson GLM, and instead Quasi-Poisson was selected for its ability to manage a certain amount of dispersion. Overdispersion was analysed again, and was found within the limits suitable for Quasi-Poisson GLM, and therefore the analysis continued using Quasi-Poisson.

Backwards step selection was conducted manually, by removing the least statistically significant variable from the model before retesting the new model each time, until only significant variables remained.

The resulting model was revealed as:

GLM(WTPM ~ Distance + fIncome + fVisit_freq + fGender)

Suggesting that the primary influencing factors on participant WTP maintenance values are the distance they live from the site, their annual household income, the frequency which they visit the site and their gender. All these variables were found to be statistically significant (Table 6.5).

Table 6.5 Descriptive values for variables in Chowder Ness GLM WTP maintenance model.

Variable	Df	Deviance	F value	P value
Distance	1	574.51	23.165	2.308e-06
Income	5	703.34	19.84	< 2.2e-16
Visit frequency	5	634.62	11.730	2.047e-10
Gender	1	554.64	11.431	0.0008128

This model is validated via the analysis of its residual values. The extracted standardised residuals were plotted against the fitted values to assess homogeneity (Figure 6.15). The plotted values show no specific pattern, which shows no sign of heterogeneity, and are relatively evenly spread about 0, suggesting the assumptions of the model are not violated. In addition, the plotted Q-Q plot (Figure 6.16) reveals the values to follow a very similar pattern to the best-fit line. A histogram of the residuals was also plotted, with a normal distribution curve plotted on top in order to

compare the difference (Figure 6.17). The figure shows the histogram follows a very similar shape to the normal distribution curve, further justifying the validity of the model. The percentage of variance in the data explained by the model was calculated using the null deviance (1381) and the residual deviance (535.27). This results in 61.24% of the variation in the data being explained by this model. This is a relatively high percentage, therefore suggesting that this model is fairly justified, and can be accepted.

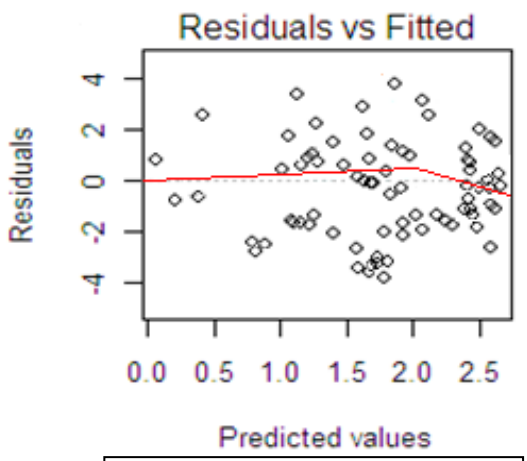

Figure 6.15 Chowder Ness WTP maintenance GLM model residuals plotted against fitted values, with line of best fit

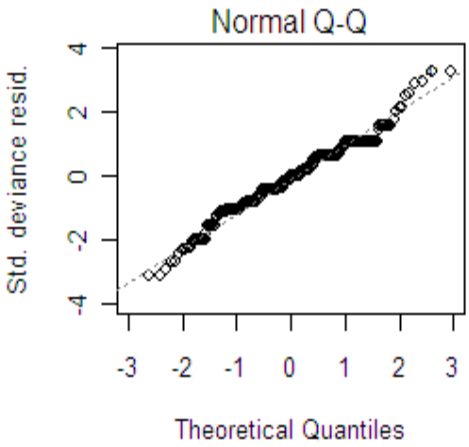

Figure 6.16 Chowder Ness WTP maintenance GLM model residuals plotted against theoretical quantiles with line of best fit

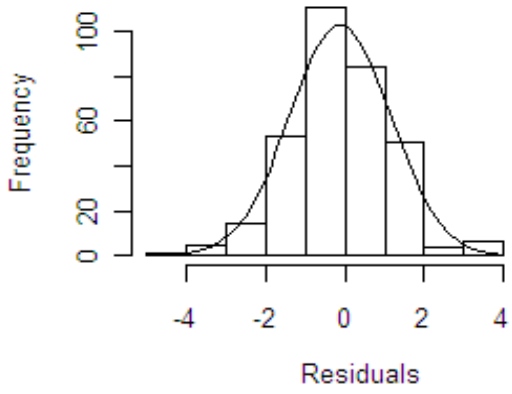

Figure 6.17 Histogram of Chowder Ness GLM WTP maintenance model residuals, with the line showing normal distribution.

6.14 Generalised linear modelling for access values.

Modelling for the WTP access values was conducted using Poisson GLM, overdispersion was found to be within the limits for Poisson (Phi< 1.5) and therefore once again backwards step selection was used to eliminate the non-significant variables from the model until all variables were statistically significant (Table 6.6). The model that resulted from this process was:

GLM(WTPA ~ fAge + fIncome + fVisit_freq)

This reveals that age, annual household income, and visit frequency are the primary influencing factors on what they are willing to pay for access to the site.

Table 6.6 Descriptive values for variables in Chowder Ness GLM WTP access model.

Variable	Df	Deviance	AIC	LRT	P value (Chi)
Age	4	422.33	1327.60	25.87	3.359e-05
Income	5	445.52	1348.79	49.06	2.160e-09
Visit frequency	5	662.15	1565.43	265.70	< 2.2e-16

Model validation is based on analysis of the residuals. The extracted standardised residuals and fitted values are plotted, and show no particular pattern, and somewhat equally spread about 0, therefore in terms of heterogeneity we can deduce that the assumptions of the model are not violated (Figure 6.18). The Q-Q plot reveals that the plotted standard deviance residuals mostly follow the best-fit line (Figure 6.19) and the residuals plotted as a histogram follow the normal distribution curve, therefore the behaviour of the residuals in the model go some way to validating it.

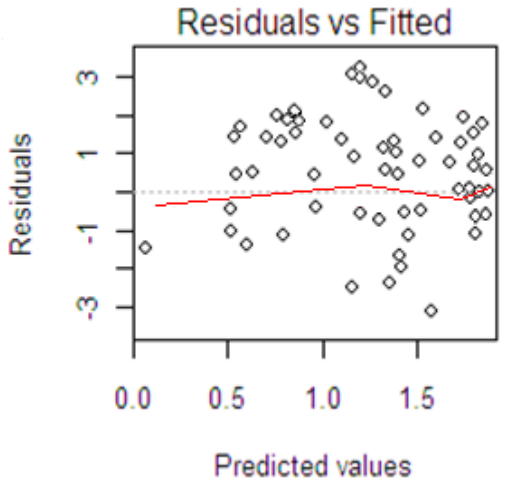

Figure 6.18 Chowder Ness WTP access GLM model residuals plotted against fitted values, with line of best fit

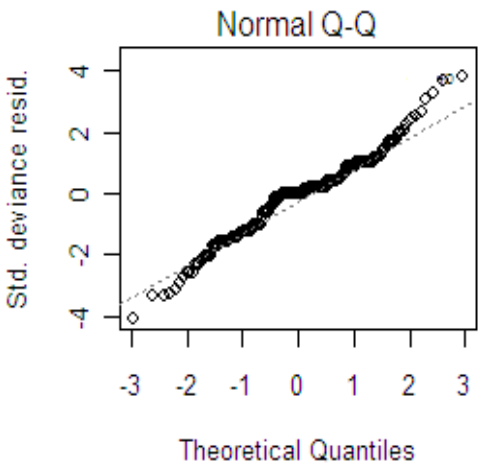

Figure 6.19 Chowder Ness WTP access GLM model residuals plotted against theoretical quantiles with line of best fit

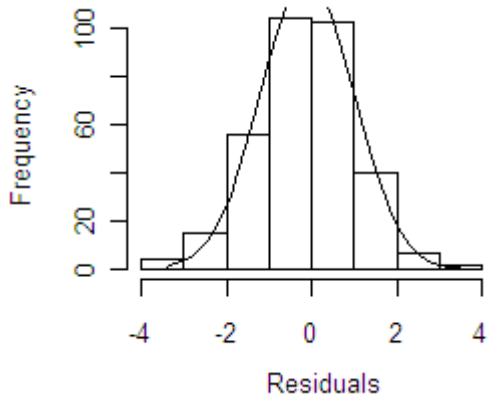

Figure 6.20 Histogram of Chowder Ness GLM WTP access model residuals, with the line showing normal distribution.

From the null deviance (1081.96) and residual deviance (396.46) in this model, the percentage of variance in the data explained by the model is calculated as 63.36%. This value is a relatively high percentage, and coupled with the residual plots, we can assume this model to be validated.

6.15 Decision tree analysis for WTP maintenance values.

The decision tree analysis shows that the distance that the participant lives from the site is the most influential explanatory variable on the response variable WTP maintenance (Figure 6.21). Those who live 3.2 miles or less from the site, were willing to pay an average of £9.60 annually for maintenance of the site, whilst those who live more than 3.2 miles from the site were willing to pay an average of £3.21. The difference between these two values (nodes 1 & 2) was tested for statistical significance with a Mann-Whitney U test, and was found significant at the 95% level (MWU= 3598).

The respondents' who fell into Node 1, were then divided according to their annual household income (after tax). Those with an income of £60,000 or less (node 3) were willing to pay £7.83 on average for maintenance of the site, whilst those who earned more than £60,000 (node 4) were willing to pay £14.82. The statistical difference between node 3 and node 4 was found significant at the 95% level with a Mann-Whitney U test (MWU= 952). Participants that live further than 3,2 miles from the site were segregated into those who have visited the site at least once in the past 12 months (node 5) and those who have not (node 6). The difference between nodes 5 and 6 was statistically analysed using a Mann-Whitney U test, and was found significant at the 95% level (MWU= 374.5).

Those who have an annual household income of less than £60,000 were then divided according to their gender. Results from this division show that the male respondents were willing to pay an average of £6.29 for maintenance of the site, and female respondents were willing to pay £2.46 more per year, at £8.75. The differences in the amounts male and female respondents were willing to pay was found statistically significant at the 95% level. For those who have an annual household income of more than £60,000, the next split involved their frequency of visit to the site again, this time dividing between those who visited daily or weekly (node 9) and those who visited less often than weekly (node 10). The participants in node 9 were willing to pay an average of £9.50 annually for maintenance of the site, and those in node 10 were willing to pay £17.78. However, the difference between node 9 and node 10 was not found to be statistically significant ($p > .5$).

Lastly, those who visited the site less frequently than weekly were separated by their age. Those in node 11 (less than 65 years old) were willing to pay an average of

£8.07, whereas those in node 12 (65 or over) were willing to pay £12 annually. However, the relationship between nodes 11 and 12 was found non-significant with a Mann-Whitney U test (Table 6.7).

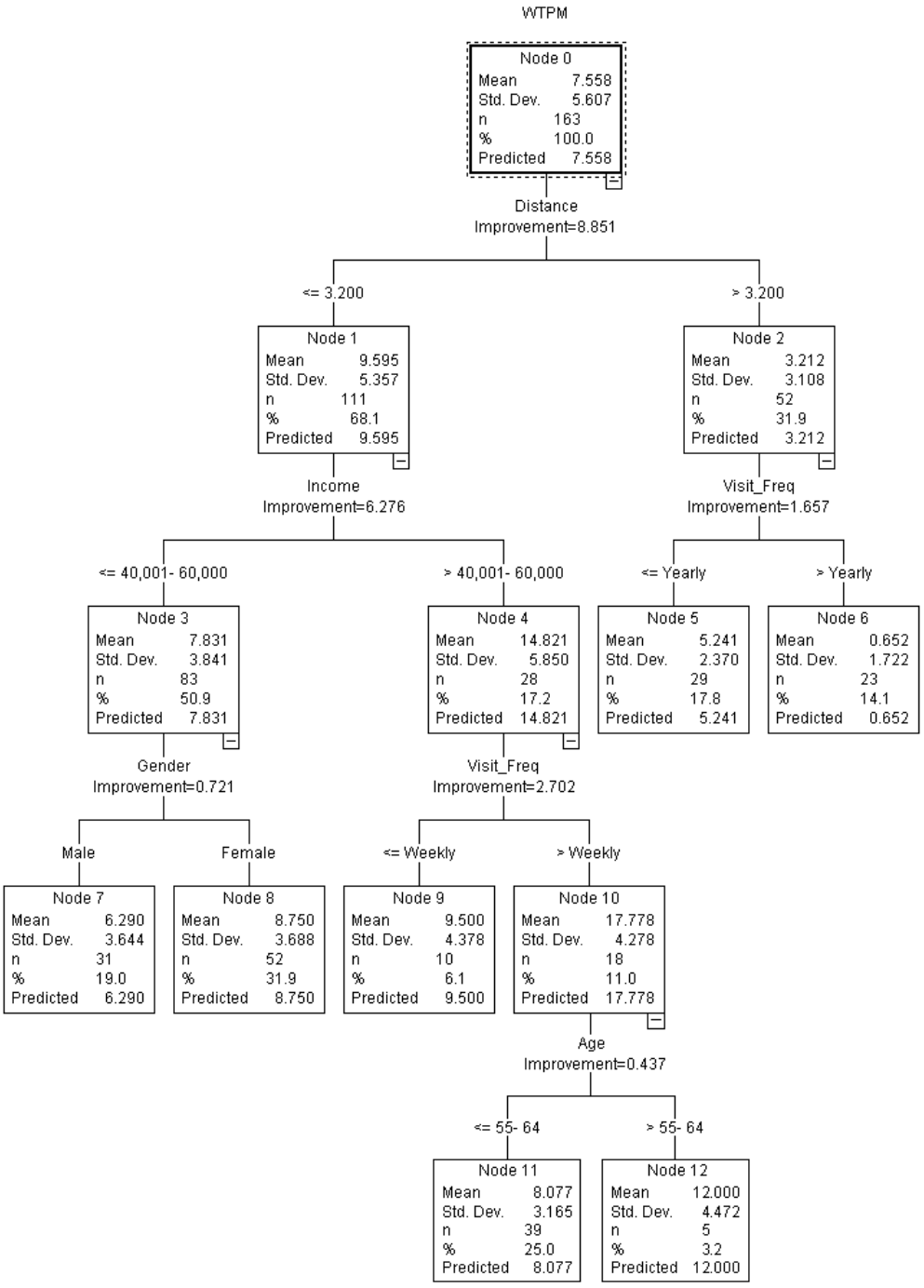

Figure 6.21 Decision Tree analysis for Chowder Ness WTP maintenance values

Table 6.7 Mann-Whitney U values and statistical significance for WTP maintenance decision tree analysis.

Variable	Difference between nodes	Z value	P value	Level of significance
Distance	1 & 2	-11.074	.000	95%
Income	3 & 4	-2.336	.019	95%
Visit frequency	5 & 6	-7.479	.000	95%
Gender	7 & 8	-2.327	.020	95%
Visit Frequency	9 & 10	.000	0.10	-
Age	11 & 12	-.004	.996	-

6.16 Decision tree analysis for WTP access values.

In terms of WTP access values, the most influential explanatory variable was shown to be the frequency in which the participant visits the site. Those who visit the site once a fortnight or more frequently, were willing to pay an average of £6.22 for access to the site, whilst those who visit less often than this were willing to pay £2.11. The difference between these values (nodes 1 & 2) was found statistically significant at the 95% level with a Mann- Whitney U test.

The respondents' who visited the site fortnightly or more often, were then categorised by their annual household income. Those who had an income of up to £60,000 were found to have a WTP access value of £4.61 (node 3). Those who earned more than £60,000 a year had an average WTP access value of £8.66 (node 4). The difference between nodes 3 and 4 was analysed with a Mann-Whitney U test and was found statistically significant at the 95% level.

Those who visited the site less frequently than fortnightly, were further segregated according to their age. The participants who were 44 years old or less, were willing to pay an average of £4.93 annually for access to the site. Those who were older than 44 years old were willing to pay less, at £1.37 annually. The difference between these values (nodes 5 and 6) was found statistically significant with a Mann-Whitney U test at the 95% level.

Participants who had an annual household income of more than £60,000 (node 4) were then divided by their level of education. Those with 'further' qualifications, such as A-levels were willing to pay an average of £6.86; whilst those with 'higher' qualifications, such as a university degree, were willing to pay an average of £12 annually for access to the site. The difference between these values was found significant at the 95% level with a Mann-Whitney U test.

Those who were 44 years of age or older (node 6) were further segregated according to their visit frequency again. Those who visited the site monthly or more frequently, were willing to pay £2.78 annually for access to the site; whilst those who visited less than monthly were willing to pay £.70 for access. The difference between these two values (nodes 9 and 10) was found statistically significant at the 95% level with a Mann-Whitney U test (Table 6.8).

Table 6.8 Mann-Whitney U values and statistical significance for WTP access decision tree analysis.

Variable	Difference between nodes	Z value	P value	Level of significance
Visit frequency	1 & 2	-11.228	.000	95%
Income	3 & 4	-5.547	.000	95%
Age	5 & 6	-5.043	.000	95%
Education	7 & 8	-2.721	.007	95%
Visit frequency	9 & 10	-7.519	.000	95%

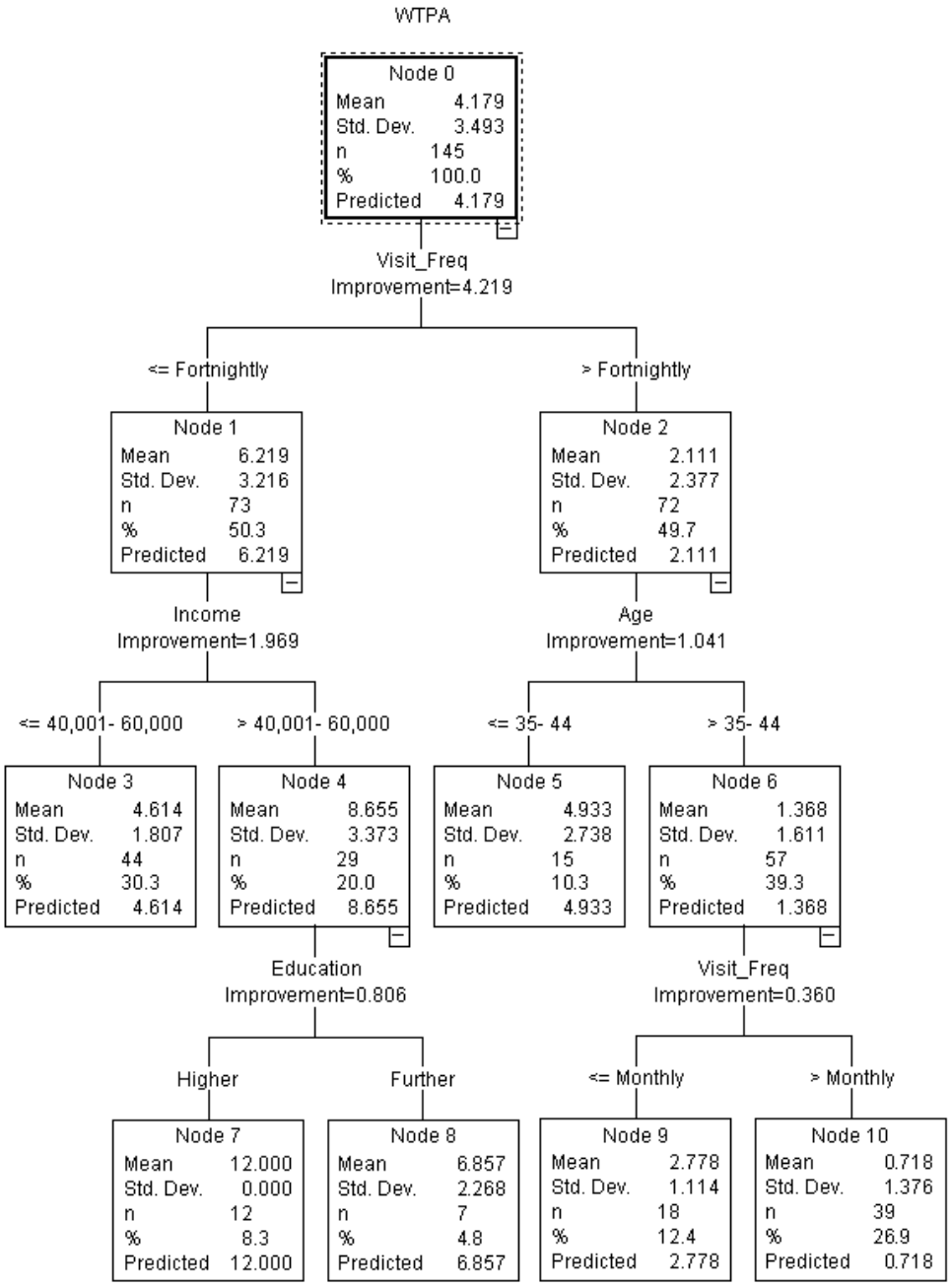

Figure 6.22 Decision Tree analysis for Chowder Ness WTP access values

6.17 Contingent ranking.

Results from the contingent ranking question, in which the participants were asked to place each societal benefit in order of preference, are given in Figure 6.23. The participants were asked to order the societal benefits from 1 to 5, 1 being the most important to them, 5 being the least. The results show that a large majority of participants (82.42%) ranked disturbance prevention (e.g. flood protection) as the most important societal benefit to them. Further to this, 88.79% of participants ranked it either first or second, revealing disturbance prevention to be the most important societal benefit to the respondents in a 7 mile radius of Chowder Ness MR site. Leisure and recreation was shown as the second most important societal benefit, with 12.42% of respondents ranking it first and 58.48% of respondents ranking it as either their first or second choice. Cognitive values, such as educational and research purposes were 5.15% first choice, and 11.21% of participants' first or second choice. Feel good or warm glow values, and future unknown or speculative benefits were not chosen as any of the participants' first choice, but were ranked as second by 25.76% and 15.76% respectively. This suggests that non-use values are valued as more important than use values by the local population.

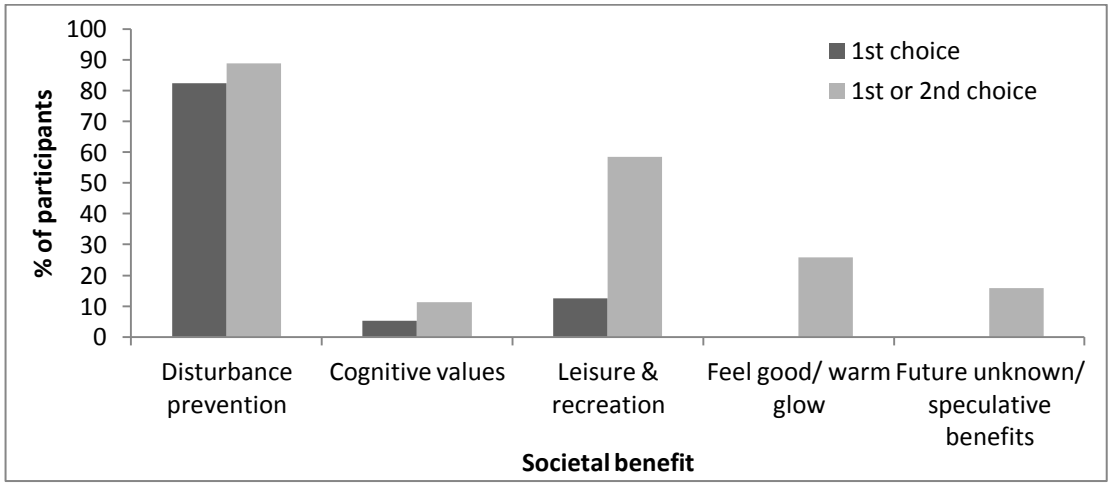

Figure 6.23 Percentage of participants' first and second choices when ranking societal benefits provided by Chowder Ness MR site in order of importance

6.18 Summary and conclusions.

The completion rate for the Chowder Ness MR site surveys was 5.19%. The mean willingness to pay for maintenance value derived from the surveys' contingent valuation question was £6.96, and the mean willingness to pay for access value was £4.43. For those participants who did not wish to pay anything for the maintenance of or access to the MR site, the main reason for their genuine zero bid was because they do not use or visit the site, and therefore do not want to pay for something they do not use. For those who did visit or use the site, the majority partook in such activities as walking to enjoy the scenery, general nature watching, and relaxing and enjoying the surroundings.

By analysing the data using a suite of techniques, the key influencing variables have been extracted. In terms of the response variable WTP maintenance, the main influencing explanatory variables are the distance that they live from the site, their annual household income, their frequency of visit to the site, and their gender. In relation to WTP access values, the primary influencing explanatory variables are age, annual household income, and the frequency in which the participant visits the site.

It is shown from the ranking benefits data, and in because the WTP maintenance values are higher than the WTP access values; it can be assumed that disturbance prevention is considered the most important societal benefit provided by the MR site. However, the disturbance prevention aspect of the site, or indeed any of the societal benefits, can only be realised through the ecological development of the site. For example, a large majority of the respondents stated they enjoyed the scenery at the site, as well as walking and nature watching. If these activities were not available, perhaps due to poor ecological conditions at the site causing a lower aesthetic value and fewer species present, this could affect the frequency in which participants visit the site. As visit frequency has shown to be an influential variable for both WTP maintenance and WTP access values, this could in turn lower the average WTP values for the site.

Visit frequency to the site may also have been positively influenced by the north Lincolnshire wildlife trust, which promote the site on their website and include it in any wildlife information they provide on the north Lincolnshire area. They also create set routes for walkers and ramblers, which cross through the Far Ings nature

reserve and into Chowder Ness MR site, widening the knowledge base surrounding the site. Although participant previous knowledge of the site was not found to be a significant variable in terms of influencing WTP values, participant knowledge of the site is intrinsically linked to whether they will visit the site or not, which is an influencing factor for both WTP maintenance and WTP access values.

The sites' ecological status also relates to its performance in terms of disturbance prevention, which most identified as the most important societal benefit provided by the site. As explained in Chapter 2, wave attenuation is a key aspect of the dissipation of wave energy required to halt a possible flood threat. The more developed the saltmarsh, grassland and reed bed species are, the more efficiently the site functions to prevent natural disturbances, such as flooding.

Therefore, the ecological status of the site is intrinsically linked to the economic valuation of the societal benefits provided by it; one cannot be measured without considering the other.

CHAPTER 7

7. GENERAL DISCUSSION AND CONCLUSIONS.

7.1 Introduction.

The main research question addressed in this study was identified as 'how valuable are the MR sites on the Humber in terms of their societal benefits?' In order to be able to answer this question, several research aims were also outlined and investigated. These included eliciting the local residents' valuation of both use and non-use values, by using choice experiment and contingent valuation questions on an interview survey to ask how much they were willing to pay (WTP) for maintenance of, and access to, their local MR site. The participants' socio-demographic details and information on how they interact with the site were also obtained, in order to see which variables may influence their WTP values. It was also important to study how the ecological status of the site influenced its economic value, as all the use and non-use values were linked either directly or indirectly to the ecological development of the site.

It has been suggested that an individual WTP value may mean little if the aggregation of the participants' other characteristics are not fully understood (Smith, 1993; Loomis, 2000; Bateman *et al*., 2006a). Therefore, the aim of this chapter is to discuss the relationship between ecological status and economic value, and how this relationship can be affected by participants' various socio-demographic characteristics.

7.2 Summary of WTP values.

The results from the choice experiment and contingent valuation study for each site show a notable difference in the values between each site (Table 7.1). The highest values for both maintenance and access are both for the MR site at Alkborough, and the lowest are both for the Welwick MR site. The WTP values for maintenance are approximately 3 times higher for Alkborough than they are for Welwick, and participants were willing to pay approximately £6 more annually for access to Alkborough compared to the average WTP value for access to the Welwick site. The WTP values for Paull Holme Strays (PHS) and Chowder Ness are similar for both maintenance and access, which may suggest they have similar characteristics in

other aspects of their composition. The differences in these sites' values could be indicative of several differences in their associated survey population socio-demographic details, ecological or physical characteristics, or a number of additional features that must be fully considered when analysing the reasons behind certain WTP values.

The final row shows the average of all the combined WTP Maintenance and Access values for all MR sites. It is noted that this is an unweighted average of the four individual sites, and for a more accurate calculation, the average should be weighted. However, the purpose of the following calculation is to present an estimated example of what could perhaps be done with the data in the future. At present, more detailed analyses are beyond the scope of this study, and as such, some assumptions have been made. However, these calculations may still be of some use in terms of estimating a 'payback period' for the MR sites. By scaling up the values to show a mean for all residents included in the surveys, this may show a preliminary insight into the differences between how much the sites cost to make, and how much they are worth in terms of their societal benefits.

PHS, Welwick, Alkborough and Chowder Ness cost £7.4, £1.5, £10.2 and £1.5 million to create respectively; therefore £20.6 million has been spent creating MR sites on the Humber estuary. Here, we make the assumption that the WTP values for maintenance and access are applicable to all council tax payers of the relevant authorities. PHS and Welwick are a part of East Riding of Yorkshire Council, Alkborough and Chowder Ness belong to North Lincolnshire Council. The 2011 census data shows there are 143,000 households paying council tax in the East Riding authority, and 70,700 in North Lincolnshire, 213,700 in total. All households within the relevant authorities were used in this estimation, as this is consistent with the payment mechanism (council tax) used in the surveys. It also removes the need to define the perimeters for inclusion of households, as the relevant councils have previously defined these.

Table 7.1 Survey results from the contingent valuation question, for all sites.

Site	Average annual WTP maintenance values	Average annual WTP access values
PHS	£7.32	£4.64
Welwick	£3.13	£0.28
Alkborough	£9.29	£6.20
Chowder Ness	£6.96	£4.43
Combined average value for MR sites on the Humber	£6.68	£3.89

In relation to what residents are willing to pay for maintenance of a site, or non-use values, the WTP maintenance average for all sites was identified as £6.68 per year. If the local government were collecting this from all households in the East Riding and North Lincolnshire councils, they would be collecting £1,427,516 per year, paying for the creation all the MR sites in approximately 14.5 years. As the average for use values (access) was £3.89 per year, £831,293 would be collected annually, and would pay for the creation of the MR sites on the Humber in just under 25 years. When we look at the situation holistically, including the creation of habitat, diminishing the effects of flooding on housing, opportunities to local schools and the opportunities for future generations the sites will give, the time frame suggested by these estimations present the sites as a justifiable asset to the estuary. Therefore, based on the valuation of the four sites in terms of their societal benefits alone, and these preliminary calculations, it seems plausible that creating these sites is justified.

7.3 Influencing factors on WTP values.

7.3.1 DISTANCE DECAY EFFECTS.

Various spatial factors, such as the distance the individual lives from the site and the availability of alternative areas, can influence the economic value that an individual may place on ecological benefits (Pellegrini & Fotheringham, 2002). The effects of increased distance in relation to substitute sites (or alternative areas) available was shown primarily in the results from the surveys conducted in the residents local to the MR site at Welwick (Chapter 4). This site in particular had a very low survey completion rate in relation to the other sites, perhaps due to the lower sample population in relation to the other sites, as it is reasonable to suggest that the larger the population, the larger the opportunity to collect surveys and therefore the larger the response rate; however there was a strong correlation between the distance that the participant lived from the site and their WTP values, which may have been due to other areas of recreational interest in proximity to the MR site. Notably, villages east of the Welwick MR site such as Easington are a similar distance from environmental interest area, Spurn Point. In addition, those living further north such as the residents of Hollym, were closer to the seaside town of Withernsea than Welwick. Therefore unless they were nature enthusiasts, they may have preferred to visit elsewhere, implying lower WTP values for their local MR site. This is supported by Birol *et al*. (2011), who found distance decay effects significantly influenced respondents' WTP values for wetland conservation.

At the PHS MR site, although the distance that the participant lived from the site was analysed for significance of influence on WTP values, it was found to be statistically non-significant in terms of their WTP values for either maintenance or access. Unlike the situation at Welwick, PHS has no equivalent area in terms of areas to visit recreationally which provide similar benefits nearby to it, indicating that the participants who live further away are willing to pay as much as those who live closer to the site, as they have no alternative site of ecological habitat to visit. This may also be true for WTP access values for Chowder Ness. Distance was revealed as a significantly influential explanatory variable in relation to WTP maintenance values, perhaps because the key benefit derived from the WTP maintenance values through the ranking benefits question was disturbance prevention. Continued maintenance of the site means that the vegetation assemblages are managed, and are available to dissipate wave energy and prevent flooding, the people who live

closer to the site may be willing to pay more for this benefit, as if flood protection fails, they will be the first to submit to flood damage. This is in comparison to those who live several miles away, and are unlikely to have property directly damaged to the extent of those living closer if the flood defence fails. In addition, the Chowder Ness MR site adjoins another area of natural habitat, the Far Ings Nature Reserve. Therefore, if the participants were to be charged for access to the Chowder Ness site, as in the payment scenario presented to them for WTP access values, the participant could visit Far Ings instead, foregoing any charges but still benefitting from the use of an area of natural habitat.

The 'distance decay effect' (Loomis, 2000) refers to the decline in WTP values the further away the respondent lives from the site. Distance decay effects were also revealed for both WTP maintenance values and access values at Alkborough MR site. The situation at this site could be considered different to that at the other sites, in that the residents who live locally to the Alkborough MR site have limited substitutes in the immediate surroundings which would cause a lower WTP value. In this instance, the distance decay effects are likely to be related to the users and non-users of the site, rather than the distance they live from it.

The effects of distance on WTP values has been widely studied within stated preference and CV literature (Bateman et al., 2006a; Johnston & Duke, 2009; Brouwer et al., 2010; Schaafsma et al., 2012), the latter of which also suggested that a key reason for including distance as an explanatory variable is to infer the distance from the site that the participant is no longer willing to pay for the site. This distance could determine the geographical boundary, and so economic jurisdiction of the MR site (Schaafsma et al., 2012). Stronger distance decay effects can be expected in areas (or in directions) which have substitute sites, and lower decay effects can be expected in areas where the population have fewer alternatives, however if the heterogeneity in space or across respondents is disregarded, biased or non-significant results may erroneously occur (Cameron, 2006).

'Users' of the site, are likely to value it according to its use values such as leisure and recreational activities, and option use values i.e. the potential that the site has to be used for these activities; they may also value the non-use values such as disturbance prevention (flood defence). It is likely that 'non-users' will value the site according to its option use, and non-use values. Therefore, the users have more aspects of the site to value, such as the activities in which they participate whilst

there, the added protection of flood defences, and the knowledge that the site will be available for use in the future, possibly by future generations. The benefit of creating a 'triple win' scenario, which involves management plans that incorporate ecology, economy (to save building flood defences) and public safety (from flooding) should be the ultimate management goal for any policy makers regarding area's such as these (Edwards & Winn, 2006). In addition, this research also highlights the importance of including other uses, such as recreation.

The differences between the activities participated in at each of the four MR sites is highlighted in Figure 7.1. The data for Alkborough shows a higher number of users participating in 1 activity, and a higher number of users participating in more than one activity whilst at the site, suggesting a wider variety of possible activities in which to participate (for example, areas for picnicking are readily available at Alkborough, however they are not so available at Welwick). This implication that users of the site will have higher WTP values than those who do not use the site is supported by Bateman (2006a), who suggested that user will have higher WTP values than non-users, as they value use values, non-use values and option use values; whilst non-users value non-use values and option use values.

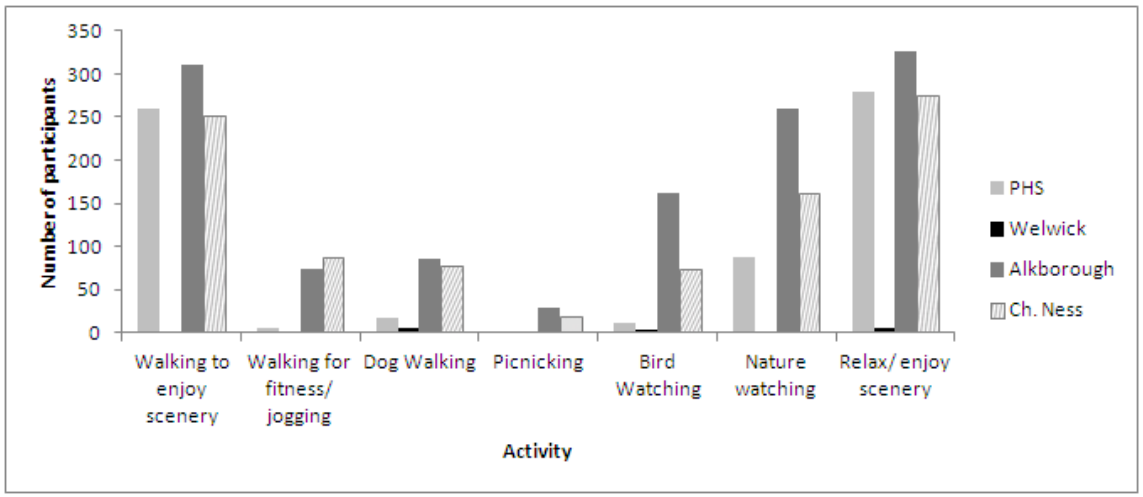

Figure 7.1 Uses of all MR sites. Count does not equal the total number of respondents, as respondents were allowed to indicate all activities they participate in.

7.3.2 PREVIOUS KNOWLEDGE OF THE SITE AND FREQUENCY OF VISIT TO IT.

The concept of 'users' and 'non-users' was reflected in the participants' frequency of visit to the site. Their visit frequency, including whether they had not visited in the last 12 months (a non- user) was found to have a significant influence on both WTP maintenance values and WTP access values at PHS, Alkborough and Chowder Ness, and on WTP access at Welwick. Although the overall value for WTP access at Welwick is considerably lower than the WTP maintenance value, visit frequency remains a significant influence on access amounts, suggesting that users of the site are influenced by use values, but not as much by non-use values which confirms Bateman's theory of users of the site having a higher WTP value than non-users (2006). This was also shown by Birol *et al*. (2011) who found respondents' WTP values for the conservation of a wetland site increased with the number of times they visited the wetland. However, there are other characteristics of the respondents that will be responsible in part for the differences in WTP values for both maintenance and access (Figure 7.2).

Whether the participant had knowledge of the site prior to completing the survey significantly influenced the WTP maintenance values for the local residents of PHS and Alkborough, as well as the WTP access values for those in proximity to PHS and Welwick. If Alkborough and Welwick are considered first, there is a considerable difference between them with regards to the public's involvement in planning stages before the site was created, and as development at the site was ongoing.

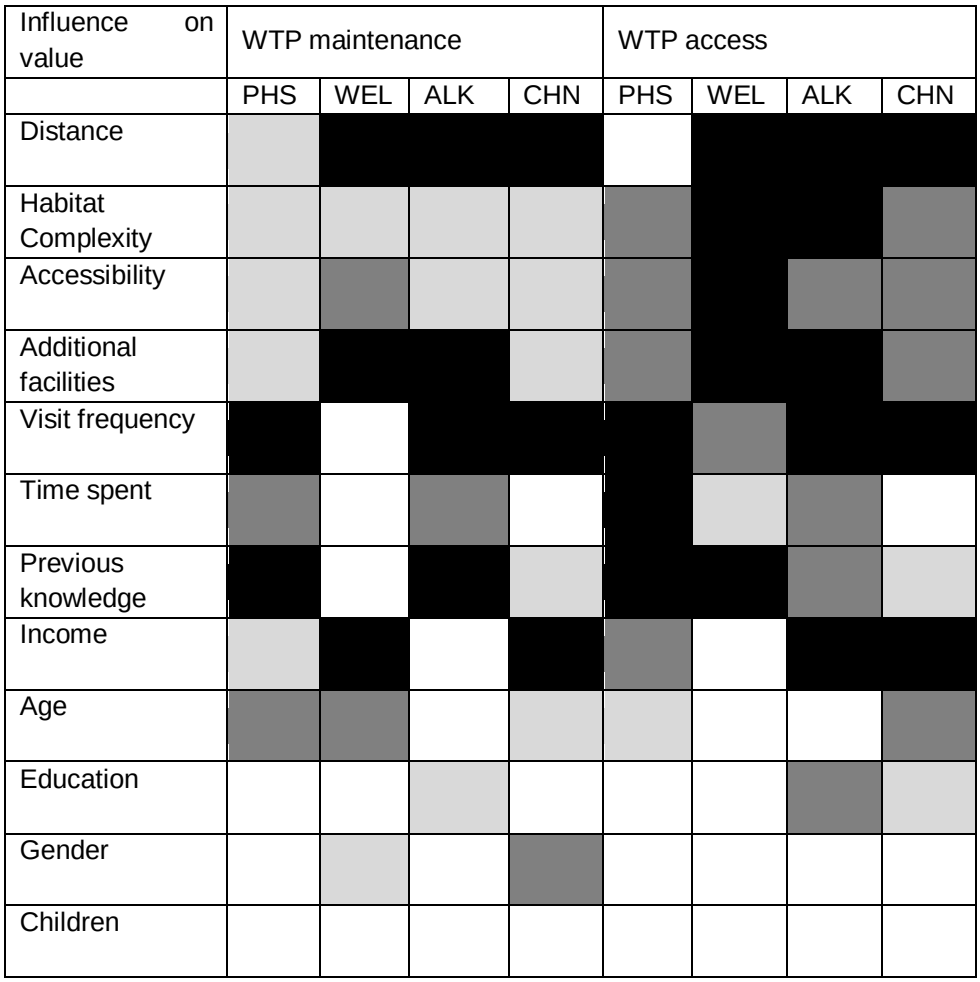

Figure 7.2 Information matrix showing the level of influence (positive or negative) on WTP maintenance and access values (■ Very influential; ▩ Influential; ▨ somewhat influential; □ not influential); PHS= Paull Holme Srays, WEL= Welwick, ALK= Alkborough, CHN= Chowder Ness.

There is also a difference between the reasons for both site creation, and the loss of land. Alkborough was created in order to accommodate the land loss due to sea level rise, allow the local fauna to adapt to sea level rise, and for flood defence. The local residents were fully aware of site creation and development, and the site is advertised as one of North Lincolnshire's 'places to visit' by North Lincolnshire council (www.visitnorthlincolnshire.com). As a result, Alkborough has a relatively widespread exposure, and therefore most of the surveys completed from the Alkborough residents showed a previous knowledge of the site and consequently a largely positive attitude towards it. Welwick, however, was created to compensate habitat loss from the port expansion at Immingham, and local residents have stated prior to this particular survey, that they were disappointed with the amount of consultation during site conception (Coastal Futures Humber Community Project,

2006). This coupled with the relatively small size, contributed to most of the participants being unaware of the sites' existence, or unaware of its purpose and uses, possibly resulting in a lower WTP value. Previous knowledge was found influential to both WTP maintenance and WTP access values at PHS, where the majority of those who had knowledge of the site gave a positive WTP response. PHS was the first site to be breached on the Humber and therefore has had the longest ecological development. This also means that if the participants' were not aware of the site when it was breached, it is likely that they would be aware of it now via local knowledge sources, such as 'word of mouth' from other local residents.

7.3.3 SOCIO-DEMOGRAPHIC INFLUENCES ON WTP VALUES.

The effect that the participants' annual household income may have on their WTP values is also found to be important (Figure 7.2). In general, when an individual considers paying for an environmental benefit, we may expect their answers regarding the valuation question to be constrained by their (disposable) income (Jacobsen & Hanley, 2009). Therefore, it is expected that their income should correlate with their WTP value (Liebe *et al*., 2011). With regards to the influence the participants' annual household income may have on their WTP values, income was found to have a statistically significant influence on WTP maintenance values for Welwick, WTP access values for Alkborough, and both WTP maintenance and access values for Chowder Ness. The argument for the influence that the participants' income may have on their WTP values is also supported by the reasons they gave for any genuine zero bids. When the participant has a WTP value of £0, it must be identified as a protest answer or a genuine valuation (Chapter 2). Protest answers are removed from the data set whilst genuine bids are included. One of the most cited reasons for not paying for maintenance or access was that they could not afford it at this time, therefore income is usually included in stated preference and CV surveys, is expected to have a positive correlation with WTP (Carson *et al*., 2001), and often is found to be influential (Jacobsen & Hanley, 2009; Meyer & Liebe, 2010; Yu *et al*., 2011; Ressurreição, 2012).

The less significant variables in relation to having an influence on WTP values of the areas as a whole included participant level of education, which is also supported by Han *et al*. (2011), who found that level of education was not statistically influential in relation to WTP values. However education was found to be a statistically

significantly influential characteristic by Birol *et al*. (2011), where respondents with a university degree had higher WTP values than those who didn't. Age was found statistically non-significant in this study in relation to its influence on WTP values, as in Ge *et al*. (2009), and the participants' Gender was also found to be statistically non-significant, which is supported by Surendran & Sekar's findings (2010). However, whether the participant has children or not is widely found in other studies to have a statistically significant influence on valuation, but was found to be statistically non-significant for all aspects in this report (Dupont, 2004; Hoyos *et al*., 2009; Birol *et al*., 2011).

The time that the participant spends at the site was identified as significant for WTP access for PHS, but was not found to be statistically significant for any other site. The reason that their visit duration is significant at PHS may be because this site was created first, and therefore the ecological status of the site is further developed and is therefore more aesthetically pleasing and had a higher diversity of flora and fauna. Also, as mentioned before there a no substitute site close to the PHS MR site which offer the same benefits, which may cause a longer visit time.

7.3.4 SUBSTITUTE EFFECTS.

How much a participant is willing to pay for one site, may be influenced by whether they have a similar site they would be able to use instead. If there are other 'substitute sites' a similar distance from their local MR site, it would be expected that the value of the societal benefits provided by the MR being valued would be lower if there were substitute areas present, compared to if there were no substitutes available in the local area (Brander et al., 2013). This was shown by Ghermandi *et al*. (2009) who found that the value of the wetland in question decreased when the proximity to a substitute wetland was shorter. However, substitute sites do not always lead to a decrease in respondent valuation. This was shown in a recreational context by Loomis & Keske (2009) who studied the substitution effect of hikers in Colorado. CV surveys were administered in an area where there are several peaks of around 14,000 feet, and which frequently reach ecological and social carrying capacity. The survey showed that 60% of the hikers would rather pay an admission fee than hike at a substitute site, of which there were many.

Although the MR site at PHS currently has no substitute sites in close proximity in terms of areas of habitat, the Yorkshire Wildlife Trust's plans to create and link six areas of recreated habitat together to form a network, including PHS, will likely act as substitute sites. The result of linking these areas of habitat could mean an increase in value for PHS, as increased habitat area coverage will attract more wildlife, including birds and small mammals. It is likely that this will increase the number of visitors, and visit frequency of those who already visit. However, having five other habitat areas linked to PHS could also mean that visitors will frequent these, decreasing visit frequency at the MR site. As the process of creating and linking the sites together is still in development, either outcome will be uncertain for the foreseeable future, until the sites have fully developed. It is likely that the situation did not influence the value of PHS at this time, however as the site is surrounded by agricultural fields, specific recreational activities could be influenced by these substitute sites, such as dog walking, as there are several public footpaths in the area. Also, the aesthetic value of the site could be influenced by the surrounding agricultural fields.

The main substitute sites available for those residents within the population catchment for Welwick MR site are the seaside town of Withernsea, and the National Nature Reserve at Spurn Point. It can be suggested that both Withernsea and Spurn Point both have characteristics that would cause residents local to Welwick to visit these attractions instead. Withernsea is a small seaside town with an attractive pier, and Spurn Point is very popular with bird watchers and families wishing to have a pleasant area for an afternoon trip, with many available areas for walks and picnicking. Although these substitute sites are not solely responsible for the comparatively low WTP values for Welwick in relation to the other MR sites, it is likely that they are accountable for at least some of the motives behind the respondents' values.

Whilst it is true that the north Lincolnshire area where Alkborough is has several areas of interest, it is unlikely that any would act as a substitute site. Julian's Bower, a unicursal maze measuring 43 feet in diameter, is situated outside the village of Alkborough and is a popular attraction to people visiting the area, and for those who live locally. However it is unlikely that this would act as a substitute for the wetland habitat MR site. The lack of substitute sites may somewhat account for the comparatively high WTP values for Alkborough MR site in comparison to the other sites valued.

The substitute site in local proximity to Chowder Ness is identified as Far Ings Nature Reserve, as both habitat areas are part of the Waters' Edge Country Park and Visitors Centre near Barton upon Humber. Although not an MR site, and therefore not included in the valuation research, many of the same bird species that are found at Chowder Ness are also found at Far Ings, and the Nature Reserve is more equipped to interact with the public, as they hold many educational events for schools, have a gift shop and cafe, and have devised set routes for walkers and ramblers, which pass through both the Nature Reserve and Chowder Ness MR site. Rather than act as a substitute site for Chowder Ness, decreasing the number of visitors, it is likely that because Far Ings is so close to Chowder Ness it encourages people to visit the MR site, and increases visitors.

Although it is true that the presence or absence of substitute sites may have influenced participants' WTP responses, it should be noted that it was not the only contributing factor, and all influencing reasons should be taken into consideration when analysing WTP values.

7.4 How ecological status influences economic value of MR sites.

The previous section explains why the particular explanatory variables may have had a statistically significant influence on the response variable (WTP), but this does not explain why the WTP values are higher for some sites in relation to others. When considering the sites, either together or separately, the participants' interaction with the site such as their visit frequency or previous knowledge appears to have a larger influence on their WTP values rather than socio- demographic details such as their age or income. This suggests that the reasons behind the differences in the average WTP maintenance and WTP access values for the four sites all originate from ecological structure and associated additions, such as its accessibility and additional features.

7.4.1 HABITAT COMPLEXITY.

In relation to disturbance prevention, the largest site with the most complete coverage of vegetation is likely to be the most efficient in relation to dissipation of wave energy and preventing the local area from flooding (Figure 7.2). Therefore the site which has the largest assemblages of developed flora will be the site most suited to disturbance prevention. Sites with a larger surface area coverage of flora such as reed beds, grassland and pioneer saltmarsh such as Salicornia sp. will be able to attenuate more wave energy, as saltmarsh and other types of vegetation has shown to absorb wave energy, preventing water travelling too far inland and alleviating the effect of eroding wave action (Doody, 2012; Morris, 2012). Wave attenuation over saltmarsh has also shown to be 50% higher than over sandflat (Moller *et al*., 1999), with the width of the saltmarsh significantly influencing this as well (King & Lester, 1995). Therefore, Alkborough is likely to be more effective for flood prevention than Chowder Ness or Welwick as it has a larger areas of vegetation assemblage. To consider the leisure and recreation activity opportunities, we can refer to the activities that the respondents participate in at the site (Figure 7.1). This shows that the several people who visit the site at Welwick only do so to walk their dogs, enjoy the scenery, or bird watch; whereas at Chowder Ness, PHS and Alkborough, the respondents' activities, although notably more varied, are also largely connected to the establishment of the functioning ecosystem, such as enjoying the scenery or nature watching.

As the ecological status of the site develops towards a mature functioning ecosystem, more leisure and recreational activities become available to the users, and therefore it would suggest their WTP values would increase. Cognitive values, which involve research and educational opportunities (such as school visits) would possibly increase as the ecology of the site becomes more established, in particular as more flora and fauna to identify are apparent. One would perhaps expect feel good or warm glow benefits to be directly related to the aesthetic disposition of the site, with 'feel good' benefits increasing as the complexity of the habitat at the site matures. Finally, future unknown or speculative benefits refer to possible uses of the site in the future, possibly by future generations. This refers to a value placed on the site in the knowledge that the same benefits available to the participant will also be available to any future generations. The only way of comprehending a societal benefit such as this is to value the site as it is now, with the intention that it may (or may not) improve with time. In this respect, this is similar to valuing the site for feel good or warm glow effects, in that it is perhaps solely based on how the participant values one or more of the facets of the ecological status of the site, for its aesthetically pleasing view and for its disturbance prevention abilities.

7.4.2 ADDITIONAL FEATURES AND ACCESSIBILITY.

Additional features are identified in this study as any mechanism at the site that has a purpose surplus to the basic requirement of the MR site, ie they are not required in any disturbance prevention capacity or do not physically add any extra land to the site. The MR site at Alkborough is an example of an area which has acquired additional features in order to make the site "visitor friendly". For example, several bird hides have been strategically placed at the site, to provide visitors with a sheltered place from where to watch birds and other wildlife, without the danger of wildlife suffering from 'disturbance response', where the presence of people may affect the natural behaviour of birds or other wildlife. This is an important element in the management of a site where visitor frequency is relatively high as unrestricted movement of recreationists has shown to significantly disturb certain wildlife species (Bennett *et al*., 2009; Wasson & Woolfolk, 2011). The additional feature of nature hides enables a greater visitor frequency, without the detrimental effect of their presence. Therefore ensuring wildlife abundance remains at the site, encouraging further visitors.

Information boards or similar interpretive features, add to the visitors understanding of why the site was created, and also what they may expect to encounter at the site. These are inexpensive tools which could possibly aid understanding of the importance of site creation, perhaps to visitors who may be cautious of a site created in their area. Information boards could also promote awareness to visitors of the effects of human disturbance of the wildlife, and encourage them to be respectful of that. This subject was addressed by the Humber advisory group, who in 2009 produced the Codes of Conduct of the Humber Management Strategy. This set of voluntary codes for users of the estuary highlighted the topics discussed in this study, such as the effects of human disturbance on bird roosting behaviour, aiming to increase awareness on this issue. The purpose of the codes is to '*promote the responsible use of the estuary and its environs, whilst providing a safer environment for both local people and visitors to enjoy*' (humberems.co.uk). Diminishing disturbance response effects and possibly encouraging wildlife abundance to increase, ultimately increasing the ecological (and therefore economic) value of the site.

Specially created footpaths which facilitate accessibility around that site have several advantages. Firstly, they encourage visitors to not get too close to bird or other wildlife assemblages, reducing a possible disturbance response. Secondly, they may afford access to disabled users of the site, increasing the availability of the site to more people, and therefore increasing visitor frequency, and ecological and economic value. Thirdly, footpaths suggest an aspect of safety to these sites. In the information regarding Welwick, visitors are advised to keep to strict areas of the site to avoid contact with any of the softer muddier parts. This may discourage families with children as it may be deemed unsafe. If footpaths are available, it is a recognised safe place to walk and may encourage use by families, again increasing the availability of the site to a wider section of the public. Although the presence or absence of children in a household was found insignificant in this study, it has been shown in the literature that whether the household has children or not does have a significant effect on their valuation of an environmental area (Dupont, 2004; Hoyos *et al*., 2009).

7.4.3 SIZE.

The size of a wetland site can significantly improve the abundance of wildlife there. Studies have shown that larger sites encourage a higher abundance and increase the number of successful fledglings in a nest of several species of wetland bird (Tozer *et al*., 2010). A larger spatial scale can mean a larger area for vegetation to develop, which in turn provides a more pleasing aesthetic view, more surface area for dissipation of wave energy causing more efficient disturbance prevention, more choice for roosting or feeding areas for various types of wildlife. A larger site also means more mudflat habitat will be available for wetland bird feeding grounds, encouraging wetland bird abundance and therefore ecological (and economic) value. It is suggested by Brander *et al*. (2006) that there is no definite expectation of a positive or negative relationship between value and the size of the area, as although there can be diminishing marginal returns to environmental services as area increases, alternatively some ecological functions require minimum thresholds of habitat area, which would suggest an increase in environmental value as size increases. With regards to this research, it is concluded that the size of the site would have had a positive rather than a negative influence on participants' WTP values.

The relationship between the size of the site and its ecological and economic value should be related to site carrying capacity. The carrying capacity of an ecosystem must consider a number of different aspects including ecological, social and economic infrastructures in order to define a set if indicators and create and follow a management plan (Yozzo *et al*., 2000; MacLeod & Cooper, 2005; Jurado, 2009).

Furthermore, it can also be defined as exceeded when the mortality rate of a population is higher than the recruitment rate (the rate at which new/ young organisms are added to the population), caused by environmental limitations (a stressor that particular ecosystem can withstand before the ecological value is unacceptably affected)- a definition more widely adopted in fisheries science. However, fisheries scientists also acknowledge the difficulty of defining ecological value and unacceptable change. Again implying a value judgement regarding what is acceptable change against a reference condition (MacLeod & Cooper, 2005).

In terms of natural systems and societal aspects, carrying capacity can be defined as the maximum population and/or community that can be supported by an area's

resources, such as food, space, and suitable reproductive partners (Stillman *et al*., 2005). With regards to the marine and estuarine environment, an example of a high carrying capacity could be the ecosystems ability to support high numbers of juvenile fish, over-wintering avifauna or benthic invertebrates, or vegetative matter. However, the societal aspect of carrying capacity, such as the ability of an area to support human activity is of great relevance in this study (Elliott *et al*., 2007). If an area is well mixed and high-energy, it may have a high carrying capacity to absorb organic waste without adverse effects being detected (assimilative capacity). Elliott *et al*., (2007) recommend a composite definition that *'carrying capacity is the maximum number of users (population and community) that can be supported by the ecosystems goods and services provided by an area'* (pp. 354). This definition highlights the importance of incorporating all the users into a management policy or framework, the ecological users such as water birds and the societal users, the human population. Where a resource such as space is limiting, it can be assumed that carrying capacity is reached when one organism has to leave a site after the arrival of another, suggesting carrying capacity would benefit from a larger area (Stillman *et al*., 2005).

7.5 Suggested framework for site valuation.

Although the main fieldwork in this research was to elicit local residents' economic values for the maintenance of and access to their closest WTP site, the overall aim of this discussion was to indicate and explain why the economic values associated with maintenance and access, all originate from how the site develops ecologically. Therefore, for valuation of the societal benefits of a managed realignment site, it is crucial to consider ecological status, before the economic value can be derived. This is shown in a possible model for the explanation of these results (Figure 7.3). Firstly, the model shows that MR site ecological processes are influenced by its size and its position within the estuary. Estuaries are dynamic and complex ecosystems, and whether an area of habitat is closer to freshwater or marine systems, affects its physical, chemical and biological processes (Telesh & Khlebovic, 2010). These ecological processes are interlinked with ecological structure, such as the development of mudflat and saltmarsh, and subsequent fauna species, ultimately affecting site assimilative capacity (Borja *et al*., 2010).

The factors associated with ecological structure with relevance to this study include habitat complexity, accessibility to the site and any additional facilities it may have. These are all linked to the ecological structure of the site as subsequent management decisions regarding these factors are a response to visitor frequency, which is a response to the habitat complexity of the site via its ecological structure. For example, better accessibility encourages people to visit it, an increase in numbers of people visiting the site means the site needs to remain easily accessible, and so on. The ecological structure of the site directly influences the ecosystem services provided by it, such as biological remediation and resistance and nutrient cycling. Both ecological structure and ecosystem services, impact upon the availability and effectiveness of the societal benefits provided by the site.

The links between ecological structure, ecosystem services and societal benefits is a well documented area in the field of ecological economics. This research has attempted to further this field by addressing the influence of the local populations' socio-demographic characteristics and interactive activities with the site, on the ecological and economic value of the site. The framework shows that the research here suggests that certain societal characteristics have a statistically significant influence on the value of the societal benefits of the site, and therefore its ecological and economic value. An increase in public interaction with the site also influences

and is influenced by ecological structure and its associated qualities. An increase in habitat complexity will influence the public's visit frequency as a more complex habitat will provide a more interesting and aesthetically pleasing view, as well as encourage a higher abundance and diversity of fauna to observe. An increase in the public's visit frequency will influence management decisions on accessibility to the site, and increase the requirement for additional facilities at the site to accommodate the higher numbers of visitors; which will further influence the public's valuation of the societal benefits provided by the site.

The level of management required at the MR site is also identified as an influencing factor in this framework. Management decisions will influence the separate qualities of ecological structure, for example the implementation of any additional facilities at the site, in response to a higher visitor frequency. Therefore, the level of ecological management at the site also influences the ecological and economic value of the site.

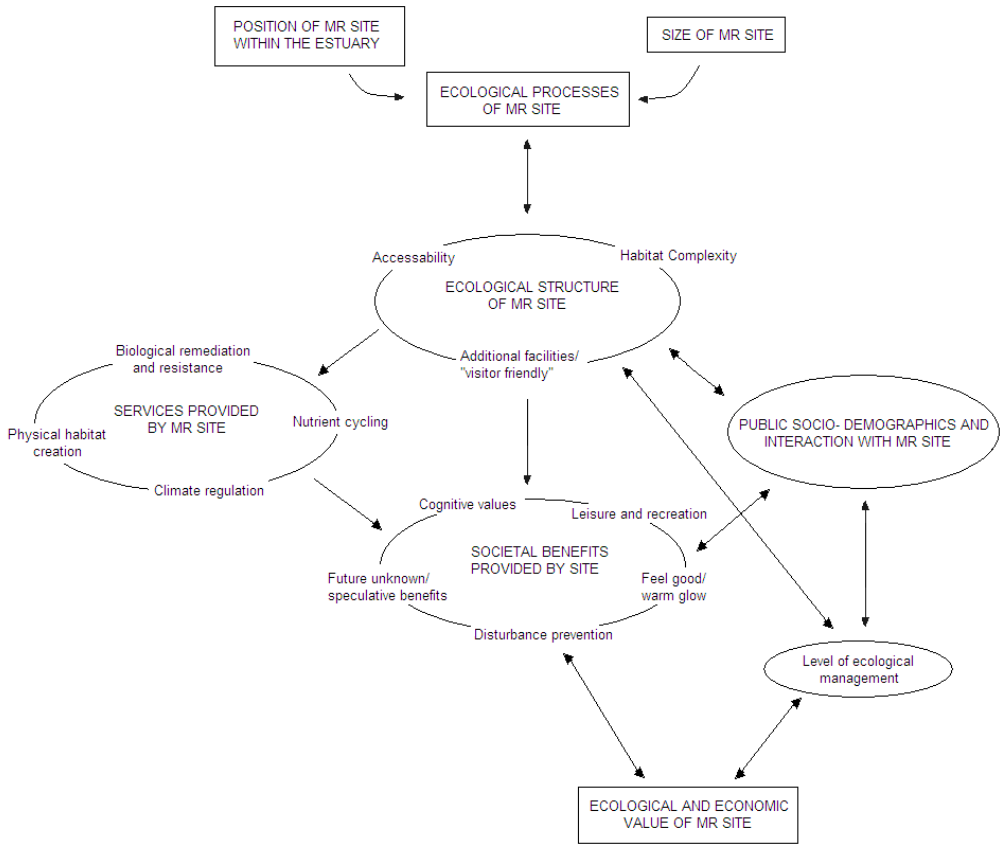

Figure 7.3 Conceptual model for the ecological and economic valuation of managed realignment sites.

7.6 Critique of the study.

There are several components to this study which worked well, and some areas which could be improved upon. In terms of methodology (Chapter 2), the use of informal focus groups in deciding the payment mechanism and other key factors of the survey implementation proved a valuable use of time, as their suggestions reflected the thoughts of the survey population, facilitating the creation of a quick and concise interview questionnaire which encouraged a lot of responses from the survey population.

Also, the use of Decision Tree analysis was invaluable in analysing the data, as this technique allowed several variables measured on different scales to be analysed together in the same model. Also, as cross validation was used to validate the model, it could be used on smaller sets of data, such the data set for the Welwick MR site.

If this research were to be repeated, the data collection process would start considerably earlier in the process. The development of the questionnaire survey via pilot studies in a small village revealed the need to change certain aspects of the survey. This meant a redesign was required, and reduced the overall amount of time for data collection. In addition, one of the key flaws in this study was the volume of households that were not surveyed, due to them being unavailable or not answering the door on the first attempt. Had the data collection started earlier and more time been available, a second attempt could have been made to all these households, possibly considerably increasing the number of completed surveys, and ultimately strengthening the statistical models. Although the Decision Tree analysis was unaffected by the smaller sample size provided by the Welwick MR site catchment, the GLM process yielded an unvalidated model for this data set, which was likely due to the small sample size. The small sample sizes could also be addressed by increasing the survey's 7 mile travel distance from the site. This was initially chosen as it represents a half way point between the South Bank sites Chowder Ness and Alkborough. However the chosen travel distance for survey could be extended further southwards from these sites, and extended northwards from the North Bank sites, potentially increasing sample sizes and further validating statistical modelling.

Due to the discussed differences between the MR sites, it was decided that they would be treated individually, rather than as a single Humber cell. This differs from

many studies in relevant literature, that state whole areas (e.g. an estuary) should be treated as a single project with the valuation in terms of the MR sites within it (Luisetti, 2010). However, the differences between the sites on the Humber are very different in terms of the societal benefits they provide, area size, aestheticism and local demographic, and therefore this was seen as justification for the methodology used. In addition to this point, by combining all the responses and addressing this research as a study on the MR sites of the Humber, rather than as individual sites, the overall data set would have expanded drastically, and may have improved the validity of some of the statistical analyses, especially for Welwick MR site which had a small sample. This would not be changed completely if the study were to be conducted again, but the author would perhaps analyse the data in both ways to see if any comparisons could be drawn. However, the initial reason for not doing this still remains, in that the four MR sites are so different, comparisons between them are few.

Use of the MR sites as fish nurseries and feeding grounds was discussed briefly in chapter 2, however although a summary of the fish diversity and likely abundance is given for each site in each chapter, this could not be substantiated into how the ecological status of the fish directly affects the societal benefits of the site related to its economic value through WTP values. This does not mean that it is less important to the ecological state of the estuary as a whole, but it is less important in terms of the influences on economic value identified in this study. If more time were available, it would be spent developing the framework in a way which includes the value of fish assemblages within the scope of this study, perhaps through a thorough analysis of recreational fishing in the area and their angling members.

Although data were collected regarding membership to environmental groups, a large majority were former members who, due to the current economic climate, had not continued their membership. The specifics of how to treat this variable were not fully organised during data collection, and therefore to reduce the risk of producing erroneous results regarding this variable, it was discounted from the explanatory variable list. However, this particular variable remains of interest with regards to this study, and if the research were to be undertaken again, the effect it may have on WTP would be considered further.

During the contingent valuation question in survey interview, the participant was encouraged to give whichever value they thought appropriate, although a suggested

price of £10 annually for maintenance and £6 annually for access was given. This was done to distinguish between the two separate questions, encourage the participant to think of the questions separately, and to build a rapport between interviewer and respondent. It is plausible to consider that the suggestion of this amount may have prompted an anchor bias, and yielded an answer similar to the suggestion. Therefore, further work may consider not suggesting a price, to see if there is any significant difference in values between the two studies.

It is likely in this research that the presence of substitute sites influenced WTP values for the MR sites. The main substitute sites for each MR area were identified in the results sections, however their possible influence was not incorporated into the WTP value itself. For the statistical analysis in this study, the qualitative assumption was made that the substitute sites are not influential. However if the decision was made to include their influence, possibly as a further explanatory variable, this would make the WTP values more policy relevant and this study would contribute more to the wider field.

It is understood here that the use of a choice experiment to value disturbance prevention, as opposed to e.g. disturbance avoidance, is not often seen in the literature, however this is justified as necessary considering the different stages of MR development on the Humber in comparison to other studies based elsewhere. The MR sites have already been developing for 6-9 years (depending on the site) and the cost to create each site is already known. In this sense, we already know the value of disturbance prevention. However, this value is not indicative of the societal benefit that the sites hold in terms of flood protection, or rather how important the sites are to society. The survey is used to see whether local residents value the MR sites in terms of their benefits, which is why this method was used.

7.7 Suggestions for further work.

- The majority of houses that were not surveyed were because the first attempt resulted in none of the residents answering the door. However due to time constraints during fieldwork, second attempts to elicit a response were not possible. Therefore, a suggestion for further work would be to attempt to collect more completed surveys, to justify and further validate the statistical models and gain a more complex cross section of the population. This would also improve any sample selection bias that occurred during data collection, as further visits to households could be conducted at different times during the day.

- Further development of the methodology and analysis techniques would be beneficial to include the possible inclusion of the effects recreational fisheries have on visit frequency to the site and WTP values, to discern its influence on the economic values of the site.

- Further data collection focussed on whether the participant is or was a member of an environmental group and whether this influences their WTP values.

- A similar study may be conducted with minor alterations to the initial CE value suggestions, in an attempt to eradicate any anchor bias.

- A more thorough examination of the effects of travel costs to the site. This particular piece of research concentrated on distance and visit frequency, without considering mode of transportation. However, results from this may add a further dimension to the WTP values for access to the site.

- The distances that the participants lived from the site were aggregated according to the village in which they were from, in order to discern which villages were within the parameters set for the fieldwork or not. A more detailed analysis of where the participant lives could be implemented using GIS techniques, therefore further justifying the results suggesting distance decay effects occurred, and highlighting the possible areas of economic jurisdiction.

- The scope of this research saw the survey questionnaires extend to a 7 mile travel distance radius. It would be interesting to extend this radius further, to solidify the economic jurisdiction, and research participants' knowledge of the sites further away from them.

- By pooling the data for all for sites and re-analysing it, greater validity could be gained for the statistical analyses. The total resident population could also be calculated, meaning a clearer outcome for policy makers.

- Conducting bi-nomial modelling on the data may be of interest, in order to see if any of the statistically influential variables change between continuous WTP values and the nominal Yes/No answers to the choice experiment question.

- The influence of substitute sites would be further researched and would be tested to infer whether their influence on WTP values is statistically significant or not.

7.8 Wider implications.

The implications of this work on a wider scale mainly extend to the use of the ecological and economic valuation of MR sites framework described in this study (Figure 7.2) in a future analysis of the societal benefits of an area of environmental habitat, and in the management suggestions for future MR site creation.

As the need for soft coastal flood defence solutions, and compensation or mitigation for habitat loss remains, the creation of managed realignment sites will continue. It seems prudent that as these sites must be created, one of their aims should be to design sites that can be used by the public and maximise their potential economic value. However, the issue of the type of land lost when the MR site is allowed to flood, should also be noted. In many cases, including the sites presented in the study, the loss of land is agricultural and whilst MR may be economically viable if the farmland is inexpensive; if the land was previously used for food or biofuel production, the economic value of the site would be reduced. In their sequential approach to realignment policy, Turner *et al*. (2007) identified the sites which have the lowest opportunity cost as part of the framework (ie lower quality agricultural land displacement), which would reduce the amount of higher grade agricultural land lost to MR. However, it should also be noted that approximately 57% of high grade agricultural land is currently less than 5 metres above sea level, and therefore is at increasing risk from flooding, erosion and salt water intrusion as sea levels rise (Harrison *et al*., 2008). The adaptation to sea level rise and increased flood risks may involve the abandonment of high grade agricultural land, but if it were subsequently realigned, it would have the potential to alter both carbon stocks and net greenhouse gas emissions on a local scale (Andrews *et al*., 2006).

As the results from this research suggests, site managers should aim to involve the local residents as much as possible during the sites conception through to implementation, ensuring a positive attitude towards the site, and increasing knowledge of the site, as this was shown to be an influencing variable on WTP values. An aim should be made to create a site which will develop (after initial breach/ creation) a complex and naturally functioning habitat with abundant and diverse species present. This will improve the sites disturbance prevention efficiency, which was found the most important societal benefit, and therefore the sites position within the estuary or along the coastline and the size of the site is essential to facilitate this.

An effort should be made to ensure it is accessible to a wide variety of people through the addition of footpaths, and additional features such as nature hides should be added to the site where possible. This will ensure a high visit frequency and subsequently a higher valuation, but also diminish disturbance response, resulting in high 'use' values through those who visit the site for leisure and recreation reasons, and a high 'non-use' value for societal benefits such as future unknown uses and feel good/ warm glow uses, ultimately increasing the economic value of the site's societal benefits.

Placement of the site in relation to the local population can also have beneficial or detrimental effects on the ecological value, and economic value of its societal benefits. An example of these differences is shown with the MR site at Welwick, which some of its catchment area is close to a substitute site, and therefore distance decay effects are more prominent here than at the PHS MR site, which does not have a substitute area of environmental habitat nearby, and its value is not effected to the same extent as the MR site at Welwick.

These influences have proven to be important to how the local population value the sites, and therefore should be taken into consideration during the conception of new MR sites. These factors could also prove useful to those wishing to perform benefits transfer techniques to value similar sites to any described here. Benefits transfer is a valuation tool used when the collection of primary data is unsuitable due to budget constraints (Rossenberger & Loomis, 2001). It involves taking the economic values of the ecological and societal benefits already known at one site, and using them to estimate what these values may be at another site (Plummer, 2009). Therefore, this framework is transferable in order to value sites at other locations.

7.9 Conclusions.

The primary aim of this thesis was to ascertain the ecological and socio-economic value of the four MR sites on the Humber in relation to their societal benefits. The set of objectives to answer this included the development of a questionnaire survey to elicit local residents WTP values for maintenance of the site, and access to it, essentially the non-use and use values respectively. They were also asked to rank the importance of the societal benefits provided by the site, in which a more complex view of what they valued as important was gained. The ecological status of the site was identified, as well as any additional facilities available.

The ecological status coupled with the sites facilities, were analysed along with the participants' socio-demographic details in order to examine which aspects had influence on the participants WTP value amount. Finally, a possible conceptual framework was produced that summarised these findings diagrammatically (Figure 7.2).

The principal conclusion drawn on valuing the societal benefits of an MR site are that an understanding of the ecological status of the site is essential to analysing the public's WTP values, as societal benefits cannot exist without first the site developing ecologically. This is reflected on varying degrees in all societal benefits, and therefore all economic values are essentially a reflection on ecological status.

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APPENDIX I. MAP OF THE HUMBER MANAGED REALIGNMENT SITES

APPENDIX II. INTERVIEW SURVEY.

INTERVIEW SURVEY.

Location of
Questionnaire.....
In relation to which MR
site.....
Date ..... / ..... / ..... Day.....

Weather Conditions:

- Sunny / broken cloud / overcast
- Hot (>20°C) / Temperate (12-20°C) / Cold (<12°C)
- Dry / drizzle or showers / persistent rain

Said to participant:

- Hello, my name is Natasha Bhatia and I'm a Ph.D. student from the University of Hull.
- I'm doing some research into what you think of your local natural environment.
- I'm not selling anything, asking for any money, or asking for you to sign up to any charities, clubs or organisations.
- Would you be willing to answer a few questions about this? It should just take 5 minutes and all information provided will be kept strictly confidential. *If yes, continue. If no, thank them for their time and move on.*

Q1. Are you the home owner/ bill payer? Yes / No

If yes, move to Q2. If no, ask if the home owner is in. If yes, continue with the home owner. If no, ask for a convenient time when the homeowner will be in. Note the time and revisit the house.

SECTION 1: KNOWLEDGE ABOUT USE OF THE NATURE SITES

Q2. Are you aware of any of the nature sites in the Humber area? Yes (tick which ones) / No

Paull Holme Strays □ **Alkborough** □ **Chowder Ness** □ **Welwick**

Introduction.

- (If needed, show picture to the respondent of the 4 nature sites, indicate which one is closest to them).
- When other areas of habitat have been built on, these sites are created to compensate for the loss of habitat.
- As sites develop over time, they are used for:
  - Flood protection (grass absorbs wave energy, excess water storage).
  - Conservation of various animal and plant species.
  - Recreational and sporting activities.
  - Indirectly benefitting house prices.

Please answer the following questions as if answering on behalf of your household.

Q2b How many people are permanently resident in your household?

.....

Q2c. How many of these are under 18? .....

Q2d. Do you or any members of your household visit these site(s)?

Yes / No

Q2e. If no, why not?

.....

If no to Q2e, go to 'Site Information'

Q2f. If yes to Q2e, approximately how often did you or a household member visit your closest site in the last 12 months?

Daily Weekly Fortnightly Monthly Once a Year

Q2g. On average, how long did you (or they) spend at the site, per visit?

<0.5hr 0.5-1hr 1-1.51hrs 1.5-2hrs >2hrs

Q3. How do you (or they) travel to the site?

(Walk / Car / Motorcycle / Bicycle / Public Transport)

Q3b. Approximately how much time does it take to travel to the site?

.....

Q4. How do members of your household use the site? Please state how often you, or someone in your household, participated in the following activities <u>at the site,</u> over the last 12 months.

	Once	Daily	Weekly	Fortnightly	Monthly	Year	Never
Walking- scenery							
Walking- fitness							
Dog walking							
Angling							
Sailing							
Canoeing							
Rowing							
Picnicking							
Camping/ Caravanning							
Bird watching							
Nature watching							
Relaxing/ Enjoying scenery							
Other							

SECTION 2: THE VALUE OF THE SITE.

Site information

- Currently, the organisation that paid to create the site closest to you (ABP or EA), also pays for its maintenance.
- Maintenance includes bank inspections and repairs; maintenance of structures; clearance of large debris and cutting grass.
- They also record and monitor the birds and fish that use the site.
- This will remain the company's responsibility, unless other management arrangements are set up.

- Now consider that the company has hypothetically arranged other management for the maintenance of the site.
- One option might be for maintenance of the site to become the responsibility of the local council, and could be funded by an increase in local taxes, for example council taxes.
- Remember that this is a purely hypothetical option and is not being discussed by the Local Authority.

I will now read two different scenarios regarding the maintenance of the nature site. Please consider both options and indicate which one you would prefer.

Q6.

	Maintenance	**No Maintenance**
Site characteristics	• Natural beauty of the site will stay the same. • Animal and plant species remain at the site. • The areas around the site are still protected from flooding. • There are education opportunities (for school children) to learn about nature and wetlands • All leisure and recreation activities currently available to the public will remain available. • The site will be available for future generations to enjoy.	• Decrease in the sites natural beauty. • Less effective flood protection. • Less education opportunities. • May lead to a decrease in available leisure and recreation activities. • Site may not be maintained to a level that can be enjoyed by future generations.
Annual increase in tax	£10 (As council tax is paid over 10 months, this is £1/month)	£0

If you chose 'Maintenance':

Q6a. Would you pay double the tax amount (i.e. £20 which equates to £2/month)? Yes / No

Q6b. If yes, what would be the maximum amount you would be willing to pay for this option? .....

Please go to Q7.

If you chose 'No Maintenance':

Q6c. Would you pay half the tax amount for this option (i.e. £5 or 50p/month)? Yes / No

Q6d. If no, would you pay anything? Yes £...../ No

Go to Q7.

Q6d. If no, why not? Please indicate the reason (A to L) most important to you.

Show the participant the 'NO' options card A1.

If DID NOT answer 'K', skip Q7 and Q8.

Q7. Now consider that access to the nature site is restricted to the public through hedges and locked gates. The site would remain maintained to its current standard. I would like you to think of this question as a separate issue to the maintenance question I have just asked you. You would not be paying for both issues at the same time

	Access	**No Access**
Site characteristics	• Site will be maintained to its current standard and all associated benefits will remain intact, such as flood protection, pleasant view, educational opportunities, and availability for future generations. • Access will be available to the site for any reason, at any time, including all leisure and recreation activities.	• Site will be maintained to its current standard and all associated benefits will remain intact, such as flood protection, pleasant view, educational opportunities, and availability for future generations. • Access is restricted via hedges and locked gates, and public rights of way are diverted around the site. Site cannot be used for leisure and recreational activities.
Annual increase in tax	£6 (As council tax is paid over 10 months, this is 60p/month)	£0

If chose 'Access'

Q7a. Would you pay double the tax amount (i.e. £12 which equates to £1.20/month)?

Yes / No

Q7b. If yes, what would be the maximum amount you would be willing to pay for this option? .....

Please go to Q8.

If chose 'No Access'

Q7c. Would you pay half the tax amount (£3 or 30p/month)? Yes / No

Q7d. If no, would you pay anything? Yes £...../ No

If 'no' Show the participant the 'NO' options card A2.

If DID NOT answer 'H', skip Q8.

Q8. In addition to what you're already paying in either of the previous situations (not both), would you be willing to pay an extra £1 per year, per suggestion, for any of the following improvements to the site?

Footpaths	□	Information boards	□
Picnic areas	□	Toilets	□
Car parks	□	Specific nature watching sites	□
Other? Please specify.....			□

Q8b. If no, why not? Please indicate the reason (A to K) most important to you .....

Show the participant the 'NO' options card B.

Q9. How important is the site <u>to you</u> in terms of its uses? Please indicate the importance of these options, ranking them 1- 6 (1= most important, 6= least important)

Show the participant the Ranking Benefits card.

A	
B	
C	
D	
E	

<u>SECTION 3: SOCIO-DEMOGRAPHIC DETAILS.</u>

Finally, I'd just like to ask you some details about you and your household. Please remember that the information you give me will only be used for analysis in my study, I will not record your name, exact address, or any contact details. It is also very important to my research that your answers are accurate.

Q10. Could you please tell me which of these groups A to H your age falls?

.....

Show the participant the Age card.

Q11. Could you please tell me which group, A to G your income falls? This is the total income for all earners in your household, after tax).....

Show the participant the Income card

Q12. Gender Male □ Female □

Q13. What is the highest form of education you have received?

Primary education □
Secondary education (GCSEs/ O levels) □
Further (A levels) □
Higher (Degree) □
Postgraduate (Masters/ Ph.D.) □
Vocational training □

Q14. What is your occupation?

.....

Q14b. If you are retired, what was your former occupation?

.....

Q15. Are you a member of any nature based interest groups?

Royal Society for the Protection of Birds (RSPB) □
(East Yorkshire members group)
National Trust □
Greenpeace / Friends of the Earth □
World Wide Fund for Nature □
Yorkshire Naturalists Union (YNU) □
Yorkshire Wildlife Trust □
Yorkshire and Humberside Biodiversity Forum □
South Holderness Countryside Society (SHCS) □
British Trust for Conservation Volunteers (BTCV) □
South Yorkshire Badger Group (SYBG) □
Hornsea and North Holderness Countryside Society □
Other? Please specify.....

Thank the respondent and offer contact details.