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Executive Summary

The case study presented in this report, related to the toxic spill damaging the Guadiamar River and part of the Doñana National Park in 1998, is part of the EU funded project Resource Equivalency Methods for Assessing Environmental Damage in the EU (REMEDE). The design and set-up of the case study is too limited for the results to play a role of any significance in actual environmental liability jurisdiction. The case study primarily aims to illustrate the application of a value based equivalency method in the context of the Environmental Liability Directive (ELD) (2004/35/EC) with regard to the prevention and remediation of environmental damage based on the polluter pays principle.

The ELD prioritises other equivalency methods, like resource-to-resource, but keeps the door open for economic valuation methods for environmental damage assessment and subsequent remediation and compensatory measures. Economic valuation is expected to play an important role in environmental liability cases where socio-economic welfare considerations are an integral part of the compensation mechanism and a discrepancy is observed between the winners and losers affected by the environmental resource damage on the one hand and environmental resource compensation on the other hand.

An important starting point for any economic valuation exercise is the availability of sufficient information about the environmental damage in question, its remediation and compensation. Economic valuation hence follows the resource-to-resource evaluation and is in this sense complementary to the latter in practical ELD cases. An important outcome of this study is that unless considerable budgetary resources will be available, the usefulness of the economic valuation results may be limited in actual practice. Consequently, the case study focuses on the evaluation of just one compensatory measure, i.e. the Green Corridor of Guadiamar, and does not include a full assessment of a range of possible remediation options given that the compensatory measures were already in place for many years.

A series of willingness to pay (WTP) questions is used to measure the equivalency values involved, referred to as 'debits' and 'credits'. The first WTP question is related to the prevention of environmental damage in the Doñana - like the damage due to the 1998 toxic spill - from happening again (debit), while the second WTP question relates to securing the Green Corridor as compensation for the environmental damage due to the toxic spill (credit). The average economic value for the debit is €9 per household per year (0.05% of disposable household income) and is higher than the average economic value for the credit (€5 per household per year). The results are based on a small sample of local Andalusian residents. In view of the national and international importance of the Doñana National Park, a national or even international study would have been more appropriate to assess the total aggregated economic value of the spill. The case study nevertheless points out the important role of aggregation and discounting as this changes the results significantly. Although the debits outweigh the credits on average for both 'users' and 'non-users', when accounting for the differential time horizon of the debits and credits the latter outweigh the former in the longer term at lower discount rates, suggesting that the environmental damage is compensated in the long term.

The results presented in this report also have to be interpreted with the necessary care from a methodological point of view. Although the valuation design follows basic good-practice recommendations for non-market valuation after the Exxon Valdez compensatory damage assessment, the small sample size impedes the use of split sample procedures, which would

have allowed us to explicitly test for information, sensitivity to scope, temporal stability, instrument bias, and distance-decay effects. Moreover, the polluter pays principle, the main driving force behind the ELD, is the most important reason for protest response in the contingent valuation survey, in view of the fact that there is a clearly identifiable polluter. In this case study this is the company who owned the mine responsible for the toxic spill. A high level of protest against the WTP question invalidates the survey results. In this case study, we find around 15-20% of the total sample population protesting against the WTP question, especially for the compensation measure, i.e. the Green Corridor. Although in line with the ELD, this type of protest is of limited use to elicit the 'true' socio-economic values people hold in cases where environmental damage has to be remediated and compensated.

1 Introduction

The nature reserve of Doñana is situated in the delta of the Guadalquivir River Basin in southern Spain. This area encompasses 106,000 ha of protected land of natural systems including Aeolian sheets, marshes, coastline and river estuary. There are two main parts; the National Park (50,720 ha) and the Natural Park (55,323 ha). The former is governed by the Spanish national government, and the latter by Andalusia, its southernmost 'state' (autonomous community). The international importance of Doñana was recognised by the International Biosphere Reserve in 1980, by the Ramsar Convention in 1982, and it was declared a World Heritage Site by UNESCO in 1995. Currently it is included in the Nature 2000 network as a special protection area under the Birds Directive and zone of communitarian interest.

The Doñana, embedded in a Mediterranean area with a strong Atlantic influence and irregular precipitation, harbours 803 floral and 458 animal species, including 361 bird species. Seventy percent of all European bird species are represented in the Park, many of them following a seasonal migration (200,000 individuals/year stop at Doñana). It has one of the few mobile dune systems in the world and it is home to the endangered Iberian lynx as well as many other endemic species. In addition to its natural value, Doñana also provides resources for important agricultural activities (forestry, livestock, fisheries) and recreational use (376,521 visitors to the park in 2005 and about 1 million pilgrims visiting the El Rocio Church via the park during the annual pilgrimage).

On 25 April 1998 a breach of the tailings dam of a pyrite mine – owned by the company Boliden Apirsa - in Aznalcóllar, 50 km north of the park, resulted in the release of 6 million m^3 of acidic water and toxic sludge high in heavy metals. Contaminated material washed 40 km down the Guadiamar River, the toxic mud covering a zone of approximately 400 m on both river banks. The major part of the spill was diverted away from the National Park by a series of hastily constructed barriers outside the National Park, in the Entremuros area. Locked in by these dams, some contaminated waters remained in this part of the Natural Park, threatening and indirectly affecting the National Park. In fact, spawned by the incident, an analysis of the risks of similar mining incidents in Europe is available (Sol et al., 1999).

The purpose of the Doñana case study in REMEDE is to test - in a unique, particularly large and ecologically highly valuable site - value based equivalency methods of the socioeconomic impacts of a very toxic spill from the perspective of nearly 10 years of recovery using a non-market (stated preference) valuation method called contingent valuation (CV). The Doñana case is intended to illustrate the Toolkit with regard to aspects of socio-economic impact assessment and valuation with a focus on illustrating what is referred to as non-use aspects in the environmental economics literature (e.g. Pearce and Turner, 1990) such as nature conservation. An important research question in this case study is to what extent robust equivalency values can be elicited by means of social survey methods.

The fact that the spill took place 10 years ago allows us to examine to what extent the environmental damage has been compensated (or not) based on public perception of the environmental damage involved and the subsequent compensation. On the other hand, the Environmental Liability Directive (ELD) was not in existence 10 years ago. The case study will therefore be treated as a 'what if' case, that is, if the historical incident in 1998 were to happen today, with the ELD in force, what would be the equivalency values involved? The

primary focus of analysis here is hence the use of Value Equivalency Analysis from the REMEDE Toolkit (value-to-value to be precise).

This report is structured as follows. Section 2 describes the case study in more detail, including, the toxic spill near the Doñana National Park, the affected areas, the short and long term effects of the spill, the ecological goods and services affected, and the remediation actions put in place directly after the spill incident. Section 3 provides a brief overview of the relevant economic theory underlying the value-to-value approach. Using the value-to-value approach from the REMEDE Toolkit, Section 4 then attempts to quantify in monetary terms the debits, and Section 5 the credits. Finally, Section 6 compares the debits and credits and Section 7 contains the discussion and conclusions.

2 Case study description

2.1 The incident

On 25 April 1998, at about 3.30 in the morning, the dam of the Aznalcóllar mine tailings lagoon burst across a width of approximately 50 m. Approximately 4 million m^3 of acidic water (pH ≈ 3) and 2 million m^3 of toxic mud containing high concentrations of heavy metals (including arsenic, cadmium, zinc, lead, copper, antimony, cobalt, thallium, bismuth, silver, mercury and selenium) were released into the Agrio River and then passed into the Guadiamar River, a tributary of the Guadalquivir River. About 25 million m^3 of mud and water remained in the lagoon.

About 400 meters on either side, both banks of the Agrio River and the Guadiamar River were flooded with water and covered with sludge and mud along a stretch of 40 km. The layer left behind was about 1.7 m thick in the vicinity of the mine and decreased to a few centimetres near the end of the stretch. The quantity of sludge deposited is estimated at about 2 million m^3. The 4 million m^3 of polluted water continued its path for another 20 km, where most of it was diverted away from the National Park by a series of hastily-constructed barriers in the Entremuros area, and discharged directly into the Guadalquivir River, to be flushed into the Atlantic Ocean. As a result of this speedy intervention, of the 4,286 ha affected by the toxic spill, just 98 ha were in the National Park itself. Some of the pollution was retained between the series of dams in the Entremuros area, which is a part of the Natural Park, and a feeding area for some of the birds from the National Park.

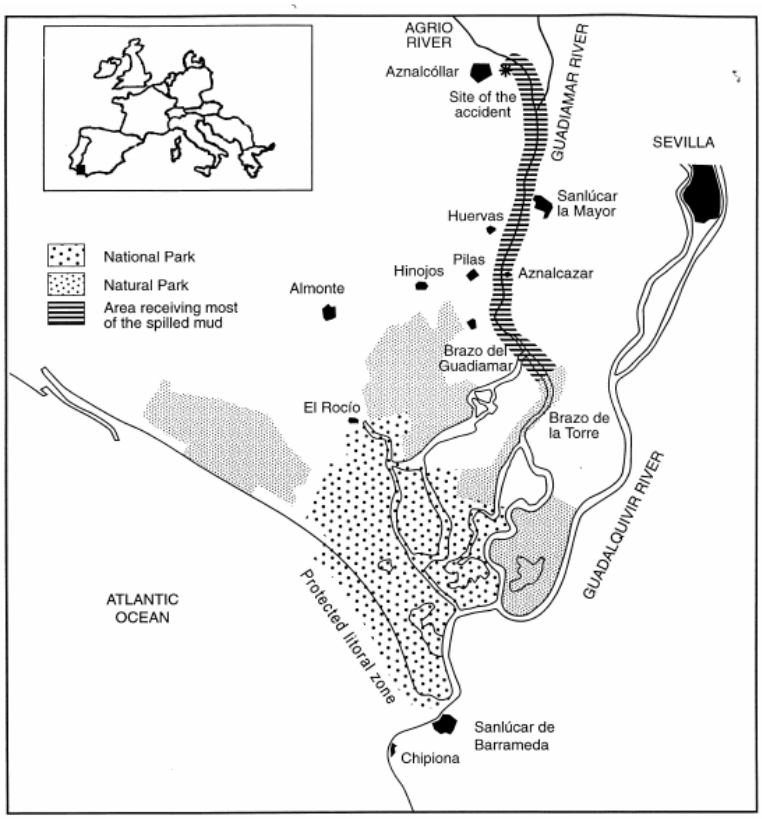


Figure 1: Map of the Doñana Parks and their surroundings. Source: Grimalt et al. (1999).

In short, four areas with decreasing exposure to the pollution can be distinguished (see Figure 1):

A. The 40 km stretch of river that received most of the mud, which was deposited on both banks (the dashed area in Figure 1). The agricultural land along the Agrio and Guadiamar Rivers is not covered by the ELD, but in the rivers themselves protected fish species may be killed and, in addition, the Water Framework Directive (WFD) may apply.
B. The Entremuros area, a canalised stretch of the Guadiamar River, which received some of the spill (the shaded area near Brazo de la Torre in Figure 1). Although at the time it was a part of the Natural Park, not the National Park, the Habitat Directive (HD) may still apply, and some protected fish species may have been killed.
C. The National Park itself, which received a minor amount of pollution. Nevertheless, its birds were affected, if only by the dams in the Entremuros area, which cut off an important water supply route to the National Park. Furthermore, sections of the park (primarily in the Natural Park) were closed to visitors for removal of the pollution. In fact, the number of visitors to the Doñana National Park itself decreased significantly in the year of the spill, after years of annual increases. In addition, in the year of the spill the traditional path - mentioned in many traditional folk songs - followed by the pilgrims to the El Rocio Church was modified because the authorities prevented the 300,000 pilgrims coming from the direction of Sevilla to cross the Guadiamar River at Vado del Quema. In summary, the ELD and Wild Birds Directive (WBD) clearly seem to apply.

D. The Guadalquivir River mouth and Atlantic Ocean, including the littoral zone. The WFD may apply there.

For the remainder of the analysis, we will focus primarily on the Agrio and Guadiamar Rivers, the Natural Park (governed by the Autonomous Community of Andalusia) and the National Park (governed by the Spanish national government), assuming that these areas would be covered by the ELD.

It should be clear, however, that at the time of the incident the National Park was the only Natura 2000 site and, therefore, the protection status of the Natural Park might have been ambiguous.

2.2 The damage

The surface area affected by the spill has been estimated at 4,286 ha, of which 1,054 ha are forest, grasslands and saltmarshes. A breakdown is given in Table 1.

Table 1: Surface area affected by the 1998 Aznalcóllar spill

Land use	Area (ha)
Cultivated herbaceous crops	999
Cultivated herbaceous crops under plastic	172
Cultivated fruit trees and olive groves	261
Rice paddies	491
Brackish marsh grazing	315
Pastures	176
Uncultivated arable land	154
Other (water flows, vegetated marshland, barren soil)	1,729
Total	**4,286**

Source: Grimalt et al. (1999).

Of the 4,286 ha affected, 98 ha are situated in the actual Doñana National Park and 2,656 ha in the Doñana Natural Park.

The fauna of the Rivers Agrio and Guadiamar was significantly affected by the spill, particularly by the toxic sludge, which killed all aquatic life it came directly into contact with, owing to both toxic and mechanical, i.e. being smothered or crushed, causes. For the purpose of a preliminary damage assessment, an overview of 25 habitats from Annex I of the EU Habitats Directive (HD) present in the Park was provided by Ozdemiroglu et al. (2001: 57). A review of the reported damage from the spill suggests that only five of these habitats were actually affected (Ozdemiroglu et al., 2001: 59):

- Mediterranean saltmeadows (*Juncetalia maritimi*) (code 1410);
- *Salix alba* and *Populus alba* galleries (code 92A0);
- Thermo-Mediterranean riparian galleries (*Nerio-Tamariceteae*) and south-west Iberian Peninsula riparian galleries (*Securinegion tinctoriae*) (code 92D0);
- Sclerophilous grazed forests (Dehesas) with *Quercus suber* and/or *Quercus ilex* (code 6310), and
- Mediterranean tall herb and rush meadows (code 6420).

Habitat types 92A0, 92D0 and 6310 seemed to be most affected, primarily in the Guadiamar area.

In addition, a total of 44 *bird* species listed in Annex I of the EU Wild Birds Directive also occur in significant numbers. Again, an overview of all bird species is provided by Ozdemiroglu et al. (2001: 58). In addition to the large number of WBD Annex I bird species recorded from the Natura 2000 site, many migrant birds also use the area. Only for 14 types of birds a prediction of the impact could be made, primarily based on their feeding and habitat preferences. These birds are listed in Table 2.

Table 2: Preliminary damage assessment of Aznalcóllar Mine Spill on WBD Annex I Birds in the Doñana National Park and the Corredor Ecologico de Rio Guadiamar Natura 2000 Sites
Species (Annex I of Wild Birds Directive)
Black-winged stilt *Himantopus himantopus*
Avocet *Recurvirostra avocetta*
Crested coot *Fulica cristata*
Purple galinule *Porphyrio porphyrio*
Ruff *Philomachus pugnax*
Kingfisher *Alcedo atthis*
White stork *Ciconia ciconia*
Spoonbill *Platalea leucorodia*
Purple heron *Ardea purpurea*
Little egret *Egretta garzetta*
Squacco heron *Ardeolla ralloides*
Night heron *Nycticorax nycticorax*
Little bittern *Ixobrychus minutes*
Bittern *Botaurus stellaris*

Source: Ozdemiroglu et al. (2001: 61).

Finally, a number of species of mammals, reptiles, amphibians and invertebrates have also been recorded from the Natura 2000 site. Information about the effects on reptiles and amphibians is not available. The likely impact on 10 species for which some ecological impact information could be derived or reasonably predicted is listed in Table 3. The impact was largest on fish since most of the fish in the Guadiamar River was killed downstream of the spill (see below). Of the five fish species listed in Table 3, we identified just one HD Annex II protected species as living in the Guadiamar River, i.e. *Chondrostoma willkommi* (OTC, 2005: 42), also known as *Chondrostoma polylepis willkommi, i.e.* a subgenus of *Chondrostoma polylepis* (Herrera and Fernandez-Delgado, 1994).

Table 3: Preliminary damage assessment of Aznalcóllar Mine Spill on HD Annex II Species in the Doñana National Park and the Corredor Ecologico de Rio Guadiamar Natura 2000 Sites
Species (Annex II of Habitats Directive)
Otter *Lutra lutra*
Mauremys leprosa
Emys orbicularis
Testudo graeca
Cobitis taenia *
Barbus comiza *
Chondrostoma polylepis *
Acipenser sturio *
Aphanius iberus *
Coenagrion mercuriale

Source: Ozdemiroglu et al. (2001: 60). * Major impacts on fish seem likely.

Until 27 May 1998, when intensive retrieval of carcasses was halted, some 37.4 tonnes of dead fish were collected (of which 75-80% carp *Cyprinus carpio*, 10-16% thin-lipped grey mullet *Liza ramada*, 6-8% *Barbus sclateri*, 4% European eel *Anguilla anguilla*, and other species 5%). Also collected were 96 terrestrial vertebrates; one white stork, 40 marsh frogs (*Rana perezi*), 11 mallards, 8 coot and 8 rabbits. Also 890 birds' eggs were collected, plus 14 chicks and 9 live birds, which were all sent to the recuperation centre of El Acebuche (Grimalt et al., 1999). It should be noted, however, that the efficiency of carcass searches is typically low (e.g. 1-20% for fish, and can be slightly higher for certain birds), and is clearly biased to larger organisms and adult life stages.

No human lives were lost. The rivers suffered a great reduction in pH and an increase in dissolved metals. Apart from a few wells, it looks like groundwater was not seriously affected based on the limited monitoring of fluvial groundwater contamination, although it seems unlikely that alluvial groundwater near the tailings pond was wholly unaffected (Grimalt et al., 1999; Manzano et al., 1999; Ozdemiroglu et al., 2001).

Direct losses to the local economy in the region of 40,000 million pesetas (€240 million) were estimated after one year. Exports of Doñana strawberries were banned; cotton, cereals and peaches were prohibited from being collected in the area; 2,557 ha of arable land, rice paddies and pastures were affected; there was a prohibition on harvesting of seven species of molluscs from the Guadalquivir estuary; and hunting was banned in the three provinces with territory in Doñana - Cádiz, Sevilla and Huelva (Ozdemiroglu et al., 2001).

Following the Millennium Ecosystem Assessment categorization, the following ecological goods and services can be found in the area, which are more or less affected by the toxic spill:

Geo-hydrological:
- floodwater storage and conveyance
- groundwater recharge and discharge
- pollution assimilation
- sediment trapping and control
- nutrient cycling
- shoreline stabilisation

Production/Habitat:
- fish and shellfish habitats
- habitat for furbearers, waterfowl and other wildlife
- food production
- oxygen production
- organic material
- pollination
- maintenance of gene pools
- maintenance of plant populations

Ecosystem Integrity:
- natural open space
- climate regulation
- biodiversity storehouse
- carbon cycling
- resistance and resilience

Human related services include recreational opportunities (e.g. wildlife viewing), and the provision of cultural and religious heritage. For example, the Doñana has been a favourite hunting reserve of Spanish kings, and since the late 17th century a Catholic religious pilgrimage (*romería*) takes place in the week before Whitsunday when people gather (traditionally on horseback and in wagons) on the doorstep of the National Park to visit El Rocio's Ermita de Nuestra Señora (The Church of Our Lady) and the shrine of La Virgen del Rocio (the Virgin of the Dew), also known as La Reina de las Marismas (the Queen of the Wetlands) and La Paloma Blanca (the White Dove). The communities living in the Doñana area have always been involved in a variety of productive activities like aquaculture, rice farming, strawberry production etc. (see Maestu et al., 2005). The Park also plays an important role in international research. Ornithological research has taken place since the 1950s and studies have since been carried out on vertebrate zoology, botany, ecology, plant ecology, entomology, limnology, geography, ethology, pesticides and diseases. The scientific research is coordinated by the Doñana Biological Station (EBD), which belongs to the Spanish Council of Scientific Research (*Consejo Superior de Investigaciones Científicas*, CSIC) in Sevilla.

2.3 The remediation

Most of the toxic spill was kept outside the National Park because of the construction of a series of walls in the Entremuros area (which achieved Special Protected Area (SPA) status after the incident) and discharged directly into the Guadalquivir River, and then into the Atlantic Ocean. The authorities acted with unsurpassed swiftness immediately after the incident. As a result of this quick reaction, the main impacts were restricted to areas outside the park proper, primarily upstream. When the toxic spill reached the Entremuros area, a dam was in place, and when that overflowed, additional dams were constructed immediately, diverting the spill around the Park.

The actual remediation of the environmental damage carried out included the creation of the Corredor Ecologico de Rio Guadiamar, also known as the Green Corridor. This area largely coincides with the Guadiamar River. Although in 1998 only the National Park was a Natura 2000 site, the current exercise is followed as if the National Park, the Guadiamar River and the Natural Park constituted a single Natura 2000 site. The Green Corridor currently holds the status of 'protected landscape' under the regional law. The Guadiamar River would qualify under the WFD at any rate.

The establishment of the Green Corridor may be viewed as complementary or compensatory remediation, or indeed both. According to Ozdemiroglu et al. (2001: 65) the costs of the Green Corridor were estimated at €22.5 million, and the damage to agricultural property at €140 million. In the CEA White Paper (CEA, 2007: 29), preventive measures (building the 3 walls) were estimated at about €4 million, primary restoration at about €97 million, complementary measures at about €68 million, and compensatory measures were indicated as zero. The €68 million is claimed to be for the creation of the Green Corridor, which CEA obviously considered to be complementary, exclusively. Here, we consider the Green Corridor as a combination of complementary and compensatory remediation in view of the fact that the corridor provides an important green passageway between the protected area of the Doñana National Park and the protected area of Sierra Morena, which was lacking there. Before detailing the value-to-value approach applied in this practical case study, the next section briefly addresses the concept of economic valuation of environmental damage.

3 Economic valuation of environmental damage

Environmental damage can be 'valued' in economic terms with the help of economic valuation methods. This requires for the environmental damage to be qualified and quantified in biophysical terms first, followed by the identification and quantification of the human welfare implications involved. This is usually addressed by examining the impact of the environmental damage on the ecosystem goods and services provided by the natural asset, which are considered beneficial to society. Different groups of people may attach different values to the goods and services supplied by the environment. Environmental damage impairs the flow of provision of these goods and services. Depending on the nature of the environmental damage and the goods and services involved, an appropriate economic valuation method is selected (for an overview of economic valuation methods see, for example, Freeman, 2003 and Annex 6 of the Toolkit).

In economics, values are measured through individuals' preferences for the conservation or improvement in resource quality as well as individuals' loss of welfare owing to resource depletion or quality decline. The value people attach to un-priced natural resources and the services these resources provide is measured in money terms through the concept of individuals' willingness to pay (WTP) or willingness to accept (WTA) compensation. Of these two, the WTP approach has become the most frequently applied and has been given peer review endorsement through a variety of studies (e.g. Cummings et al., 1986; Arrow et al., 1993). One important reason for this endorsement is that WTP is theoretically constrained by income levels whereas WTA is not. The WTP measure is therefore believed to produce more reliable valuation outcomes.

The monetary WTP and WTA measures indicate how changes in the provision level of public environmental goods, including quality changes, impact upon individual welfare. The notion of individual welfare is at the core of neo-classical economic theory, from which the values above are derived. In this theory, values are determined by what individuals want (individual preferences) and measured by the extent to which they are willing to trade off scarce means such as time or money income to obtain something (secure a gain), preserve something (prevent a loss) or accept in compensation when losing something (either forego a gain or tolerate a loss). A change in welfare is evaluated as the money income adjustment (WTP or WTA) necessary to maintain a constant level of welfare before and after these changes.

Aggregated across those who benefit from natural resources and their services and who will hence be affected by any change in their provision, including quality, the aggregated WTP or WTA amount provides an indicator of their Total Economic Value (TEV). Environmental economists have introduced a taxonomy of this TEV, distinguishing between use values and non-use values, in order to account for the various reasons and motives people may have to value environmental change (e.g. Pearce and Turner, 1990). Use values are associated with the current or potential future use of a natural resource (e.g. drinking water, fish consumption, irrigation water). Non-use values are not related to any actual current or potential future use, but refer to values attached to the environment and natural resource conservation based on considerations that, for example, the environment should be preserved for future generations or because plants and animals also have rights.

A distinction can be made between two types of welfare measures based on two different points of reference (Hicks, 1943): the 'compensating surplus' (CS) and the 'equivalent

surplus' (ES). The former equals the money income adjustment necessary to keep an individual at his initial welfare level before the change in the provision level of a public environmental good, while the latter equals the money income adjustment necessary to maintain an individual at his new welfare level after the change in the provision level of the environmental good. Four relevant welfare measures associated with welfare gains and welfare losses can be distinguished (Bateman and Turner, 1993):

- WTP to secure a welfare gain (CS_{WTP});
- WTA to forego a welfare gain (ES_{WTA});
- WTP to prevent a welfare loss (ES_{WTP});
- WTA to tolerate a welfare loss (CS_{WTA}).

The choice for one of these measures depends inter alia on the perceived distribution of property rights to the environmental good or service involved (e.g. Freeman, 1979; Knetsch and Sinden, 1984; Hanemann, 1991). In this case study, a series of WTP questions are used to measure the equivalency values involved. The first WTP question is related to the prevention of similar future damages in the Doñana from happening again and is measured through the ES WTP, while the second WTP question related to securing the Green Corridor as a compensation for the environmental damage due to the toxic spill is measured through the CS WTP (see Annex 4 of the Toolkit for comparison of concepts from welfare economics and resource equivalency).

4 Determining the Debits

4.1 Introduction

In the Doñana case study we apply two different WTP welfare measures to assess the economic value of the environmental damage (debit) and the compensatory remediation (credit), based on a Contingent Valuation (CV) survey. The most important reason for the use of the CV method is the expectation that in this specific case study non-use values make up a large share of the Total Economic Value (TEV) under consideration by the ELD. Stated preference methods like CV are the only available methods capable of capturing this part of TEV (see Annex 6 of the Toolkit).

The economic value of the publicly perceived environmental damage in 1998 (welfare loss) is measured by individuals' willingness to pay to prevent any future environmental damage comparable to what happened in 1998, i.e. potential welfare loss if it would happen again. The equivalent economic resource value for the compensatory remediation (compensation of the perceived welfare loss) is measured through individuals' willingness to pay to conserve and manage the Green Corridor in its current state 10 years after the incident. The 'value-to-value' approach to the ELD requires that the welfare compensation through WTP for remediation of the Green Corridor is equal to (or higher than) the welfare loss measured through WTP to avoid similar damage in the future.

To this end, a total of 350 people were interviewed in a CV survey between 22 October and 9 November 2007 in 25 different municipalities in the provinces of Huelva, Cádiz, Sevilla and Córdoba in the South of Spain. Figure 2 shows the 25 sampling points around the National Park

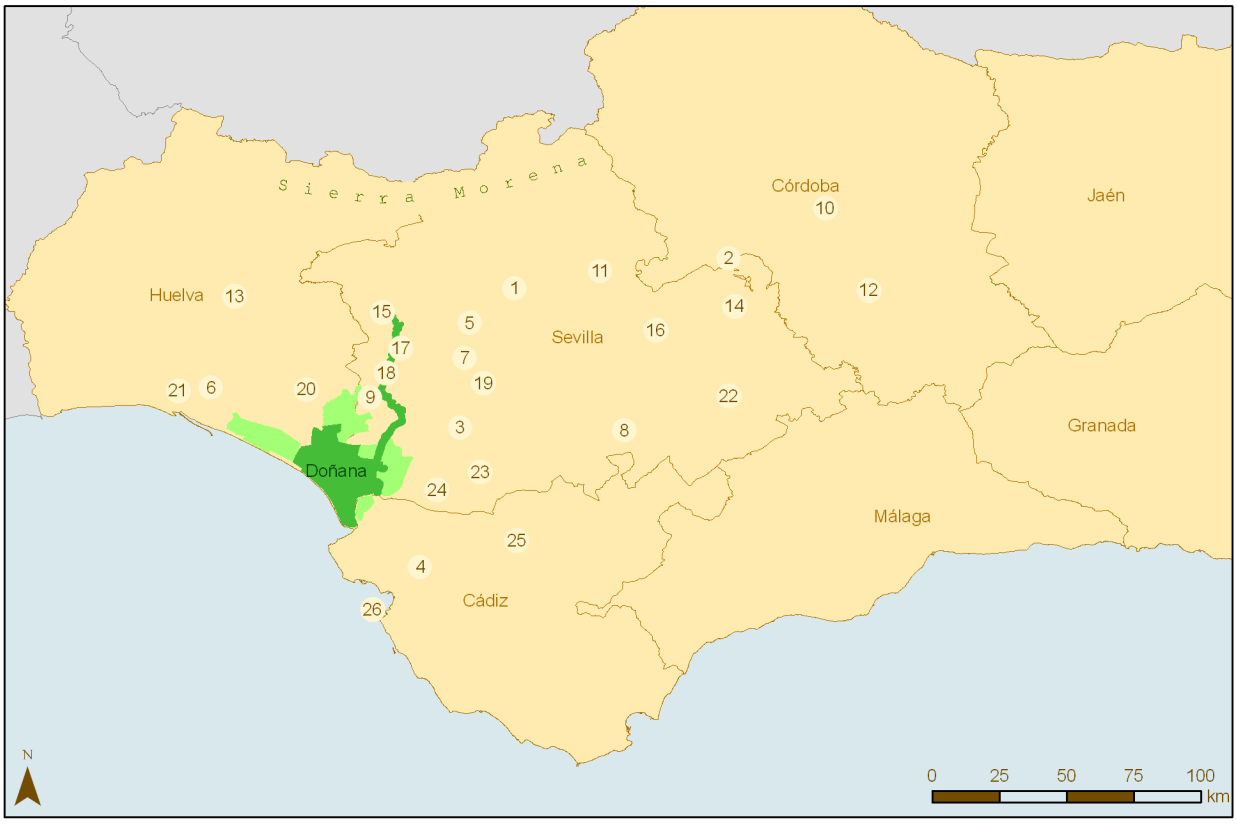
and the Green Corridor of Guadiamar[1]. A relatively large number of interviews were conducted in the cities Sevilla (50), Córdoba (35), Cádiz (15), Jerez de la Frontera (20) and Huelva (20). The interview locations were chosen at different distances from the National Park to test whether the stated WTP values differ depending on the distance from the park (so-called distance-decay effects)[2].

Interviewers were instructed to approach men and women of different age groups. Table 4 summarises the sample's main socio-demographic characteristics. A comparison of these characteristics with the ones for the population of the Andalusian Region (including the provinces of Huelva, Cádiz, Sevilla and Córdoba) shows that the sample is fairly representative compared to the whole population from which it was drawn (although obviously not geographically representative). The English translation of the questionnaire is reproduced in the Appendix to this report.

In view of the national and international importance of the Doñana National Park, a national or even international study would have been more appropriate, but was not feasible given the limited time and financial resources for this case study. In addition, the study does not aim to produce a complete damage assessment but to illustrate the potential role, use and usefulness of stated preference valuation methods for environmental damage assessment in the ELD.

1 The Green Corridor is geographically speaking a 'line object', meaning that people can access it at different points.

2 The Doñana National Park is accessible through five entrances (La Rocina, El Acebuche, Fabrica de Hielo, Centro de Visitantes Jose Antonio Valverde, Palacio del Acebron). The shortest road distance from the sampling point to the nearest Park entrance was calculated. The range of distances varies from less than 1 km to 173 km.



1 Cantillana
2 Fuente Palmera
3 Isla Mayor
4 Jerez de la Frontera
5 La Rinconada
6 Moguer
7 Sevilla
8 Moron de la Frontera
9 Villamanrique de la Condesa
10 Cordoba
11 Lora del Rio
12 Montilla
13 Valverde del Camino
14 Ecija
15 Aznalcollar
16 Fuentes de Andalucia
17 Sanlucar la Mayor
18 Aznalcazar
19 Dos Hermanas
20 Almonte
21 Huelva
22 Osuna
23 Las Cubezas de San Juan
24 Lebrija
25 Arcos de la Frontera
26 Cadiz

Figure 2: Map of the sampling locations showing the Doñana, Green Corridor and Sierra Morena.

Table 4: Socio-demographic characteristics of the sample and the Andalusian population		
Characteristic	**Sample**	**Population***
Age group (% of total)		
18-34 years old	31.4	32.5
35-59 years old	48.3	48.8
60 or older	20.3	18.7
Sex ratio (% women > 18 years, of total population > 18 years)	49.7	51.4
Household size (% of households by number of family members)		
1 member	6.9	3.2
2 members	26.6	14.7
3 members	24.3	19.0
4 or more members	42.2	63.1
Households without children (% of total households)	60.3	63.8
Level of education (% of total population)		
No education	18.0	17.1
Intermediate education (primary and secondary)	57.1	69.9
High education (academic)	24.9	13.0
Average income (net per household per month in euros)	1,639	1,619

*Source for the population characteristics: Official Regional Statistics Institute of Andalusia.

4.2 Estimating the debits

The environmental damage is valued with the help of the estimate of WTP to prevent any future environmental damage comparable to what happened in 1998. Given the time lapse since the spill and the fact that mitigation and remediation measures were put in place right away, resulting in limited environmental damage compared to what could have happened without such a swift response, one of the main challenges in the CV study was to come up with a relevant, credible and realistic economic valuation design. In the CV survey we therefore addressed both the actual and potential environmental damage by asking residents (visitors (users) and non-visitors (non-users) of the National Park) the perceived damage costs in 1998 and the corresponding loss of welfare and their WTP to reduce the risk of an event like the 1998 spill from ever happening again. This approach was extensively pre-tested in three rounds of interviews with 64 local people (the pre-test reports are available on request from the authors). The sequence of WTP questions is presented in Box 1.

Box 1: Estimation of the debits: sequence of WTP questions to prevent future accidents similar to the 1998 toxic spill from happening again.

To avoid a new similar accident from happening again in the future and damaging the Doñana, measures can be taken to protect the National Park, reducing the risk of irreversible damage to nature and wildlife. These measures include, for instance, the restriction or even prohibition of polluting activities in the surroundings of Doñana. These measures cost money.

Q. Do you believe it is necessary to take additional measures to protect the Doñana National Park so the risk of irreversible damage to nature and wildlife is reduced? [Yes, No, Don't know/not sure]

Q. Would you be willing to pay in principle on behalf of your entire household to ensure that accidents like the toxic spill in 1998 will not happen again in the future? [Yes/No]

Q. Would you be willing to pay €X per year in addition to your household's current taxes to ensure that accidents like the toxic spill in 1998 will not happen again in the future? (Note that this money will be spent exclusively on the protection of the Doñana National Park and please keep your disposable household income in mind when answering this question) [Yes/No] (X is randomly changed across respondents)

Q. If you are not willing to pay this amount, are you willing to pay €Y per year? [Yes/No] (Y is randomly changed across respondents)

Q. Are you also willing to pay €Z per year? [Yes/No] (Z is randomly changed across respondents)

Q. What is the maximum amount you would be willing to pay per year over and above your current taxes?

The WTP elicitation format used was a double bounded dichotomous choice and the payment vehicle a national tax. Besides guaranteeing respondents that their money will be spent only on the protection of the National Park, a budget reminder was also included. Six different starting bids were used ranging from 5 to 50 Euros, based on the open-ended pre-test results, and were randomly allocated across the sample respondents. In addition to standard demographic and socio-economic respondent characteristics, information was also collected about respondent visitation behaviour to the National Park, knowledge and perception of the 1998 spill and any compensatory measures taken afterwards, and the importance attached to the Doñana National Park. These kinds of behavioural, perception and attitudinal responses are generally expected to influence public WTP for the environmental good involved. Of particular interest is whether the respondent has ever been to (or plans to visit) the Park. This information is used to distinguish between users and non-users. In our case, the majority of the sample (60%) had never visited the Doñana National Park. For the sample who has visited the Park, the average number of times that the park was visited is 4.8 times. Seventy four percent of the sample planned to visit the Doñana National Park in the future (79% of the respondents who visited before and 70% of those who never visited before).

When asked which features respondents appreciate most in the Doñana National Park, one third of the sample considered the variety of species most important. Slightly fewer respondents (29%) stated that they believe the Park's natural environment in general is the most important. One in every five respondents considered the animals the most important feature of the Doñana. Although considered highly charismatic, the Iberian lynx was mentioned by only 10% of the sample population. A majority of almost 60% of the sample stated that the preservation of the Doñana is (very) important. Half of the sample furthermore believed that the Park needs more protection than currently provided. A minority of just over 10% considered the preservation of the Doñana not important, whereas almost 20% thought that the Park is currently sufficiently protected.

Another set of questions prior to the WTP questions focused on people's perception of the mining accident in 1998. About 70% of the sample remembered the accident, while only 4% claimed to have been personally affected by the spill, of which seven respondents were miners, who lost their jobs after the mine was closed, and one was a farmer whose land was expropriated during the recovery works after the accident. Four respondents felt they were personally harmed because the environment was damaged. A large majority of the sample (72%) said that the Doñana National Park was damaged or severely damaged as a consequence of the mining accident.

More than 60% of the sample stated to be willing to pay in principle to prevent accidents similar to the one that occurred in 1998 from happening again in the future. An analysis of the underlying reasons why respondents are not willing to pay was carried out in order to distinguish legitimate zero bidders from protest bidders (see Table 5).

Table 5: Reasons why respondents are not willing to pay, distinguishing between legitimate zero and protest bidders

	Frequency	Percent of total sample
Legitimate zeros		
I don't think this is important	3	0.9
I cannot afford to pay extra	38	10.9
I prefer to spend money on other things	2	0.6
I already pay enough, I don't want to pay more	98	28.0
I contribute through other organizations	2	0.6
Total Legitimate zeros	**143**	**40.9**
Protest answers		
The polluter should pay	53	15.1
I don't trust the system	20	5.7
Total Protest answers	**73**	**20.9**

Protest bidders are respondents who object against the WTP question, but may or may not hold positive values for the resource in question. Legitimate zero bidders are respondents who are not willing to pay because of theoretically expected reasons like no or low preference for the resource or the change or having insufficient income. Most frequently heard protest answers in this study are that the polluter should pay and mistrust whether the money will actually be spent to prevent a disaster like the one in 1998 from happening again. Despite thorough pre-testing, the protest rate in this study is quite high (20%), mainly due to the fact that in this specific case there was one specific identifiable polluter responsible for the environmental damage caused (15% of the sample protested because they felt that the polluter should pay), making it hard to convince respondents in the survey to pay for something they neither are nor feel responsible for[3].

[3] There exist no straightforward guidelines for the classification of refusals in stated preference research into legitimate and protest responses. Often the classification is arbitrary and subjective. Respondents who feel they already pay enough taxes are classified here as legitimate zero bidders. These respondents explicitly stated that they were not willing to pay extra for the specific good in question, but instead that their contribution should be taken from their current tax payments, implying a re-allocation of existing tax revenues. These respondents hence seem to value the good in question, but are not willing to pay anything extra to obtain it. This is therefore interpreted as a legitimate zero vote. In previous Spanish valuation work these respondents are usually categorised as protest bidders (personal communication Professor Pere Riera, Universitat Autònoma de Barcelona).

Accounting for the high share of legitimate zero bidders (41% of the total sample) and excluding protest bidders from the analysis, average WTP to prevent the Doñana from being exposed to the risk of a toxic spill as in 1998 in the future is around 5 Euros per household per year based on the double bounded CV questions and 9 Euros per household per year based on the open-ended follow-up maximum WTP question (Table 6). In this report, we use this latter value as the monetary indicator of the debits of the mining accident, corresponding to less than 0.05% of the sample's average disposable annual household income[4]. The difference between the single and double bounded WTP values is statistically not significant (t=0.035; p<0.972), whereas the difference between the double bounded and the open-ended WTP value is at the 10% significance level (t=1.878; p<0.061). Respondents who visited the Doñana ('users') are willing to pay slightly, but significantly, more for its future protection (€11.3) than respondents who never visited the National Park ('non-users') (€7.6)[5]. The most important reason why respondents are willing to pay the stated amount of money is to protect flora, fauna and habitats (55%), followed by the prevention of accidents like the toxic spill and other risky activities in the area (25%). Five percent of all respondents are willing to pay because they consider this more generally a good cause. The protection of the lynx as charismatic species is mentioned by 3%.

Table 6: Estimation of the debits: Household WTP to protect the Doñana National Park from exposure to risks like the 1998 toxic spill

	Single bounded DC (€/household/year)	**Double bounded DC** (€/household/year)	**Maximum WTP** (€/household/year)
Mean	4.8	4.6	9.2
95% confidence interval	-7.1 – 16.8	-0.8 – 8.9	7.3 – 11.0
Median	4.8	4.9	0.0
Minimum	2.5	2.5	0
Maximum	75	75	100
N	276	276	272

It is important to point out once again that this value is used in this study as the estimated amount of money that the Doñana spill damage should be compensated for. According to the ELD this does not mean that the liable agent should invest this amount of money in compensating the environment, but that the compensatory measures should generate welfare benefits worth as much as this amount. Thus, the figure reflects the value of the welfare loss, not the costs of the compensatory measures.

[4] In order to avoid what has been labelled instrumental 'ordering effects' or 'sequence bias' in CV research (we first asked the WTP question related to the debits, and then to the credits, not the other way around in a split sample procedure), respondents were given the opportunity to rethink and change their stated WTP amounts at the end of the questionnaire after they answered all WTP questions, i.e. for both the debits and credits. Respondents might answer differently had they known they would be asked three WTP questions in a row and also to account for possible fatigue when answering the last WTP questions. Only 19 respondents (5%) wished to change their previously stated open-ended maximum WTP amount. However, these changes did not affect the average WTP values in a statistically significant way for either the debits or credits. Here, we present the slightly modified WTP values, i.e. the final WTP responses including the 19 respondents who changed their WTP reply.

[5] Based on the open-ended WTP question - using either the t-test or the non-parametric Mann-Whitney test; test results are available upon request from the authors - in view of the fact that splitting the sample results in a too low number of observations (per bid and interval level) to estimate single or double bounded CV values.

5 Determining the Credits

5.1 Introduction

A subsequent WTP question was asked in order to value the compensatory measures taken after the toxic spill in 1998, i.e. the creation of the Green Corridor of Guadiamar, now a SPA. In the survey an attempt was made to assess whether this compensation was considered sufficient by the public as an important stakeholder group to offset the perceived (potential) welfare loss as a result of the environmental damage due to the toxic spill. The benefits generated by the Green Corridor can be summarised as follows:

- Recovery of the damaged area of the Guadiamar River;
- Creation of a new recreation area, and
- Creation of a green passage for animals, linking the protected area of the Doñana National Park with the protected area of Sierra Morena.

In the survey, we focused on the Green Corridor as a compensatory measure for the environment, not so much the human use related aspects of the Green Corridor, e.g. recreation, in order to get a value, which resembles the estimated equivalent surplus measure as closely as possible. Follow-up questions were introduced in order to identify respondents' motivation underlying the payment. Based on questions related to respondent recreational use of the Green Corridor, a distinction is made again between user and non-user values. In order to further distinguish between the different types of benefits listed above, the WTP question for the Green Corridor was split into two separate WTP questions. First, respondents were asked for their WTP to conserve and manage the Green Corridor in the future to ensure the environment is compensated for the damage caused by the toxic spill and, second, respondents were asked for their WTP for the extra benefit provided by the Green Corridor as a passageway for animals. Box 2 includes both WTP questions and the context in which they were elicited.

The WTP questions related to the credits were elicited in an open-ended way as additional money amounts over and above the previously stated open-ended maximum WTP values for the protection of the Doñana National Park. The payment vehicle was again national taxation.

Box 2: Estimation of the credits: sequence of WTP questions to conserve the Green Corridor and the passageway for animals.

The Green Corridor of Guadiamar was created to compensate the environment for the damage caused by the toxic spill. The corridor consists of a total of 5,000 hectares of protected nature, such as rivers, forests and lagoons, around the Guadiamar River [show the card with the two photos of the Green Corridor].

Q. Do you believe that the Green Corridor of Guadiamar has compensated the environment sufficiently for the damage caused by the toxic spill in 1998? [Not at all/No/Somewhat/Yes/Yes, more than enough/Don't know, not sure]

Q. The conservation and management of the Green Corridor of Guadiamar costs money. Would you be willing to pay in principle on behalf of your entire household for the management of the Green Corridor of Guadiamar to ensure the environment is compensated for the toxic spill in 1998? [Yes/No]

Q. What is the maximum amount you would be willing to pay every year in addition to your household's current taxes for the conservation and management of the Green Corridor of Guadiamar to ensure the environment is compensated for the toxic spill in 1998? (Note that this amount is to be added to the money amount you are willing to pay to ensure that accidents like the toxic spill in 1998 will not happen again in the future. As before, please keep your disposable household income in mind when answering this question)

Q. Can you explain why you are willing to pay this specific amount of money for the Green Corridor of Guadiamar?

Q. If you are not willing to pay, can you briefly explain why not?

The Green Corridor offers an additional benefit to the environment: it is a green passage by which animals like the lynx can travel freely between the Doñana and the protected area of Sierra Morena, thus increasing the natural space in which they live.

Q. How important is it for you that animals can travel freely between the Doñana and Sierra Morena? [Not important at all/Not important/Somewhat important/Important/Very important]

Now that you have been informed that the Green Corridor offers this additional benefit for wildlife, would you like to change the amount of money you just said you would be willing to pay for the management of the Green Corridor in order to ensure this additional benefit is conserved? [No/Yes, I'd like to pay …]

5.2 Estimating the credits

Contrary to the Doñana National Park, the Green Corridor is known by the public to a much lesser extent. Only one third of the sample was aware of the existence of the Green Corridor and that it was created as a consequence of the mining incident in 1998. Almost nobody (5%) ever visited the Green Corridor. A majority of around 85% of the sample felt that more measures should have been taken after the accident to reduce the environmental damage due to the spill. The share of the sample who believed that the Green Corridor has compensated for the damage caused by the incident is 40%.

Almost 80% of the sample stated they were not willing to pay in principle to manage and conserve the Green Corridor of Guadiamar. In the same way as for the debit estimation, the share of legitimate zero and protest bidders was identified. The results are shown in Table 7. We again observe a relatively high number of protest answers (26% of the total sample, mainly because respondents believe that the polluter should pay (18%).

Table 7: Reasons for zero willingness to pay		
	Frequency	**Percent of total sample**
Legitimate zeros		
I don't think this is important	4	1.1
I cannot afford to pay extra	46	13.1
I prefer to spend money on other things	1	0.3
I already pay enough. I don't want to pay more	130	37.1
Take this from the money I already said I would pay for the protection of the Doñana	1	0.3
Total Legitimate zeros	**182**	**52.0**
Protest answers		
The polluter should pay	62	17.7
I don't trust the system	25	7.1
I don't have enough information	3	0.9
Total Protest answers	**90**	**25.7**

Follow-up questions allowed us to better understand the reasons why the sample is or is not willing to pay for the Green Corridor. Thirty percent of these respondents wanted to see the Green Corridor protected for its own sake, and 42% wanted to conserve the Green Corridor as a way of protecting the National Park of Doñana. An additional 13% wanted to pay extra for the Green Corridor to prevent future accidents. Only 3% wanted to pay because they value the recreational opportunities and facilities provided by the Green Corridor.

Concerning the valuation of the passageway benefit provided by the Green Corridor, 77% of the sample considered it important that animals can travel freely between the two protected areas, but only 15% of all the respondents is actually willing to pay for this benefit. Adding up the two WTP values, an average WTP result of 5 Euros per household per year (Table 8) is found. This is about half the average value found for the potential welfare loss if an accident similar to the 1998 toxic spill would happen again now. The observed difference between mean WTP for the debit and credit is statistically significant at the 1% level using either the t-test (t=3.825; p<0.001) or the non-parametric Mann--Whitney test (Z=-3.936; p<0.001). Also the difference between average WTP for the Green Corridor and the animal passageway is statistically significant, but only at the 10 % level based on the t-test (t=1.775; p<0.077). Respondents who visited the Green Corridor ('users'), mainly for recreational walking (50%), picnicking (34%) or fishing (16%), are willing to pay significantly more for its conservation and management (€9.4/household/year) than respondents who never visited ('non-users') (€4.4/household/year)[6].

Table 8: Estimation of the credits: max WTP to conserve the Green Corridor (€/household/year)		
	Maximum WTP for Green Corridor as compensation	**Maximum WTP for animal passageway**
Mean	3.1	2.1
95% confidence interval	2.2 – 3.9	1.3 – 2.8
Median	0.0	0.0
Minimum	0	0
Maximum	40	40
N	256	229

[6] The outcome of the Mann-Whitney Z is –2.534 (p<0.011).

6 Aggregation of the debits and credits

An important next step is to aggregate the individual household WTP values in the sample across the whole population from which the sample was drawn. Despite explicit testing of possible distance-decay effects in the valuation of the debits and credits, no such effect could be found here, possibly due to the limited variation in distances in the sampling procedure. Distance-decay effects are based on the economic principle that demand for an environmental good decreases the further away someone lives from it (distance increasing the cost of use of that resource and increasing the availability of substitutes). Should such an effect exist, it has to be accounted for when delineating the size of the economic market in the aggregation procedure, i.e. determining the population affected by an environmental change (see Bateman et al., 2006). Although no distance-decay effects are found, we do find significant differences between respondents who have and who have not visited the Doñana National Park and Green Corridor, and these differences will be accounted for in the aggregation procedure. Also no significant differences are found between respondents living in urban and rural areas or in the provincial capitals and outside these capital cities (test results are available from the authors upon request).

Due to the fact that the sample is too small with too little geographical variation to justify unconditional aggregation across the whole region of Andalusia (however representative the sample seems to be for the whole region), we aggregate the estimated economic values for the debits and credits across the whole population in the provinces of Huelva, Sevilla, Cádiz, and Córdoba (1.3 million households (INE, 2008)). Accounting furthermore for the fact that respectively 21 and 26% of the sample population is not willing to pay for the prevention of any future risks like the 1998 toxic spill to the Doñana National Park and the conservation of the Green Corridor[7], an aggregated annual economic value results of 9.4 and 4.5 million Euro.

A final step in the aggregation procedure is the assessment of the relevant time horizon and appropriate discount rate for both the debits and the credits for the purpose of their comparison in time, and the possible implications for the discounting of the past, current and future flow of 'costs' (debits) and 'benefits' (credits). Under the assumption that the baseline situation has been completely restored in and around the Doñana National Park as a result of the immediate intervention measures after the toxic spill and the recovery of the damaged area of the Guadiamar River in the past 10 years, the present value for the debits is based on this 10 year time period (given the lack of more detailed information about the exact restoration and recovery of the whole area).

In the case of the Green Corridor, however, one could argue that the future flow of credits due to the recovery of the damaged area of the Guadiamar River, the creation of a new recreation area and a passageway for animals is much longer, perhaps even infinite. Again, given the lack of more detailed information, we assume a five times longer lifetime, i.e. 50 years, for the credits for the purpose of illustration in this case study[8]. We furthermore

[7] The legitimate zero bidders are accounted for in the average WTP values.

[8] The WTP questions specified the time intervals (annual payments), but not the time horizon over which respondents were asked to pay, adding to the uncertainty related to the appropriate lifetime of the debits and the credits. One could argue that based on the formulation of the WTP questions in the survey, respondents are expected to pay for the rest of their life for the proposed protection and conservation of the Doñana National Park and the Green Corridor. That is, based on the WTP questions, the time horizon is the same for both the debits and credits, even though the environmental damage has been or will be restored to the original baseline level after a number of years. Respondents are asked to pay for the rest of their life to avoid something like the 1998 spill from

assume that the credits related to the creation of the Green Corridor only manifest themselves five years after the toxic spill given the time ecosystems need to recover and develop. Based on an arbitrary fixed low discount rate of 2% (given the public (non-profit) nature of the funding resources), this yields a present value of the debits of 85.9 million Euro and 130.6 million Euro for the credits. The development of the discounted values for the debits and credits using two different discount rates (2 and 4%) is presented in Figure 3[9]. Hence, although the economic value of the debits outweigh the economic value of the credits at individual household and aggregated regional level, the discounting procedure results in a one and a half times higher total value for the credits when taking into account the appropriate time horizon over which the debits and credits accrue.

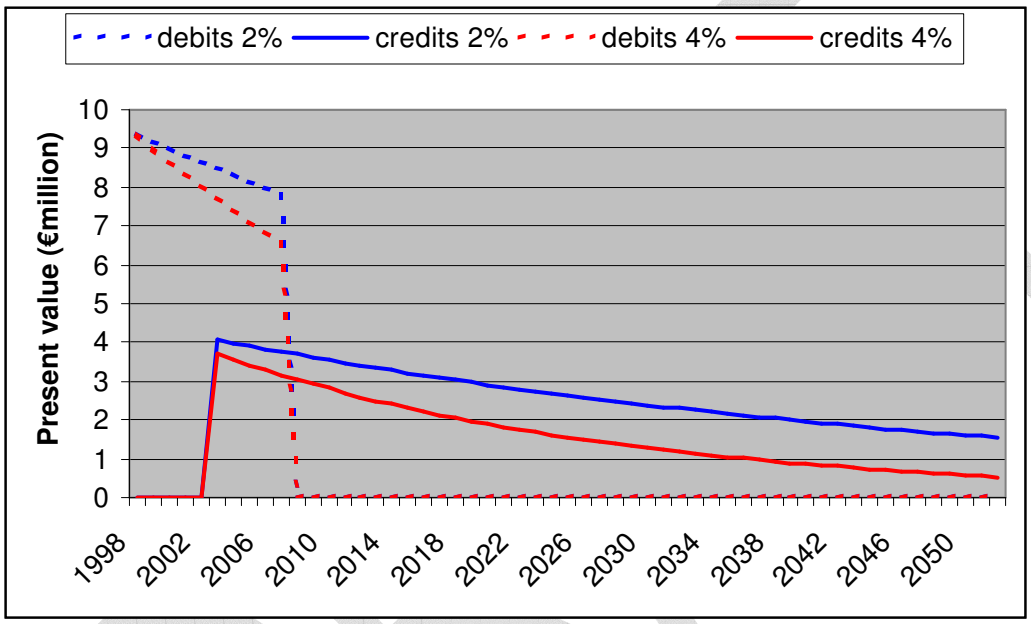


Figure 3: Development of the discounted aggregated economic values for the debits and credits.

7 Discussion and conclusions

The main objective of this REMEDE case study was to illustrate the application of a value based equivalency method in the context of the ELD. An important starting point for any economic valuation exercise is the availability of sufficient information about the environmental change in question (*in casu* damage). Any assessment of environmental damage costs starts with and is based upon an environmental impact assessment, requiring the input (knowledge, expertise and information) from environmental experts. One could argue that the value-to-value approach hence follows the resource-to-resource evaluation and is in this sense complementary to the latter in practical ELD cases. Especially where also the economic welfare implications of environmental damage are expected to play a major role in environmental liability jurisdiction or where significant discrepancy is observed between the (human) population affected by the environmental resource damage and their debits (costs)

ever happening again. At the same time they are also asked to pay 'forever' for the flow of benefits provided by the Green Corridor.

[9] Using a 4% discount rate results in present values for the debits and credits, which are much closer, namely 79.1 and 82.6 million Euros respectively. The internal rate of return, i.e. the discount rate where the present value of the debits equals the present value of the credits, is around 4.3%.

on the one hand and the (human) population affected by the physical resource compensation and their credits (benefits) on the other hand.

Although the incident examined in this case study occurred relatively long ago (10 years) and in a well-documented (partly protected and monitored) area, the ecological (resource and service) information available to us for analysis within our time and budget constraints proved insufficient to carry out a full environmental assessment of the damage and the subsequent remediation and compensation measures. Of course, such a limited scope was to be expected from a case study, but had the incident occurred today, the resources to be made available for analysis under the ELD would have been disproportionately larger. Consequently, this case study focused on the evaluation of one particular compensatory measure only, the Green Corridor of Guadiamar, and did not include a full assessment of a range of possible remediation options given that the compensatory measures were already in place for many years. In combination with the limited resources for the case study (which was initially planned and budgeted in REMEDE as a desk study based on secondary data), the scope of the non-market valuation study is very limited, making it hard if not impossible to arrive at clear-cut conclusions based on a thorough examination of the role and usefulness of stated preference research in the ELD. For this, the study was simply too basic in both design and set-up. For the results to furthermore play a useful role in actual environmental liability jurisdiction, the link between the environmental impact assessment of the damage, remediation and compensation and the economic values found in this study has to be examined in more detail than was possible within the time and financial boundaries of this case study.

Although the valuation design followed basic good-practice recommendations for non-market valuation, *inter alia* after the Exxon Valdez compensatory damage assessment (e.g. an incentive-compatible double bounded discrete choice WTP elicitation format), and was thoroughly pre-tested, the small sample size impedes the use of split sample procedures, which would have allowed us to (more) explicitly test for important issues in stated preference research like the effect of information provided on responses, sensitivity to scope, temporal stability, instrument bias, and distance-decay effects.

The information set in the survey was developed in close collaboration with local environmental experts from the Estación Biológica de Doñana and kept very simple in order to limit the cognitive burden of survey participation. The sample consisted furthermore of local residents living within a radius of 175 kilometres of the 1998 toxic spill, who were expected to be reasonably to very well informed about the incident and the public debate afterwards given the (international) media attention it received (71% of the sample population remembered the incident). The necessary financial resources to follow up this survey with more detailed questions about the specific goods and services (damaged, restored and remediated) valued by respondents were lacking.

The average economic value found for the protection of a National Park of the status of the Doñana (€9 per household per year or 0.05% of disposable household income) is considered relatively low given the economic values found in a national travel cost study related to the Doñana National Park (producing use values which are twice as high). However, the result found in this case study has to be seen in the light of the limited scope of the sample procedure including only local residents. In view of the national and international importance of the Doñana National park, a national or even international study would have been more appropriate, testing in a more comprehensive way for possible distance-decay effects to assess the spatial distribution of those to which the debits and credits accrue (also referred to

as the appropriate 'market size' of beneficiaries). The only difference we detected at local and regional level was the difference in stated WTP between those respondents who visited (users) and those who never visited (non-users) either the Doñana National Park or the Green Corridor. The former are willing to pay significantly more than the latter. We account for this difference in the aggregation procedure.

Illustrative in this case study is the important role of aggregation and discounting of the debits and credits as this may yield completely different results than those found at individual household level, where the original WTP values are elicited. Even though the debits outweigh the credits on average on individual household level - for both 'users' and 'non-users' - when accounting for a different time horizon for the debits and credits, we find that the credits outweigh the debits in the longer term at lower discount rates (<4.3%), suggesting that the environmental damage is compensated in the long term. Although underresearched in this case study, also the spatial distribution of those who lose and gain due to the environmental damage and remediation and compensation measures is expected to influence the final outcome of the total economic value of the debits and credits, depending for example on demographic population characteristics such as population density and the values held by the population of beneficiaries for the environmental goods and services involved. While where compensation takes place may not matter in a resource-to-resource approach, the spatial distribution of debits (costs) and credits (benefits) can be an important issue from an economic welfare perspective in a value-to-value approach if this distribution is skewed.

Finally, the polluter pays principle, the main driving force behind the ELD, is also one of the most important reasons undermining the validity and reliability of stated preference research -such as the one presented in this report - in situations where there is a clearly identifiable polluter or pollution source (*in casu* the company who owned the mine responsible for the toxic spill). Although systematic reporting and analysis of protest response is lacking in the CV literature, the polluter should pay is to our knowledge one of the most frequently heard protest reasons. According to the NOAA Panel, a valuation expert panel established after the Exxon Valdez oil spill, a high level of protest against the WTP question invalidates the survey results. In this case study, we find around 15-20% of the total sample population protesting against the WTP question, especially for the compensation measure, i.e. the conservation of the Green Corridor. Although clear-cut guidelines about what is an acceptable protest rate in stated preference research are lacking, the general approach is to minimize protest response. The percentages found in this study are considered high enough to warrant a careful interpretation of the values found for the debits and credits in view of the fact that they exclude a substantial share of the sample population (the conventional procedure in stated preference research to address protest response). More effort should have gone into the development of a more incentive-compatible WTP question, for instance emphasising that although the polluter will pay, the environmental costs will ultimately be borne by the public through an increase of taxes (public revenues financing clean-up and remediation) and product price levels (of companies generating environmental externalities which are internalized via damage compensation fines).

We believe that non-market valuation has a role to play in the ELD and its jurisprudence in cases where socio-economic welfare considerations are an integral part of the compensation mechanism, but based upon and directly linked to the environmental resource-to-resource procedure. As for any academic research, the economic values generated by this type of social survey research have to be used and interpreted with the necessary care and in the context in which they are elicited. The NOAA panel's burden of proof may have to be revisited 15 years after their publication and updated (see an earlier update, Bateman et

al.,2002), and a similar set of requirements for stated preference values has to be further developed and applied in the context of the ELD. This includes the need to gain more insight in the anthropocentric non-use values partly underlying in our view the ELD, where rights are implicitly assigned to the environment and European citizens to an improved state of the environment or at least the status quo as embodied in the ELD.

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Appendix: The survey instrument

Below is an English translation of the original questionnaire, which was implemented entirely in Spanish.

I.D.

2007-10-22 Interviewer: ……..…..
Date: ……. City: ……...

Good morning/afternoon. My name is ..... I work as an interviewer for the University in an independent, non-commercial research project which aims to know public's opinion of some aspects related to Doñana.

Do you live in this city/village?

- *If No, thank for the attention and stop the interview.*
- *If Yes, continue.*

Would you mind answering some questions about Doñana? The interview will only last 10 minutes. All information gathered from this survey will be treated as absolutely confidential and will only serve research purposes.

1. Have you ever visited the Doñana National Park?

0. No, never.	1. Yes, once.	2. Yes, I have been there _____ times in my life.

2. Do you think you will visit Doñana in the future?

0. No.	1. Yes.	2. Do not know.

3. What is, in your opinion, the most important feature of the Doñana National Park?

Don't read the answers. Allow the respondent to answer spontaneously and only afterwards choose the most appropriate from the list (select several if necessary). In case of doubt, write it down in point 5.

1. Animals.
2. The lynx.
3. Nature/ environment/ habitat.
4. Variety / diversity / biodiversity (of species).
5. Other (specify):_____

4. How important is the preservation of the Doñana National Park for you in relation to other important issues in your region, such as unemployment, security and public health, education or other environmental problems such as water scarcity?

0. Not important at all.	1. Is not important.	2. Somehow important.	3. Important.	4. Very important.

5. Do you think the Doñana National Park needs further protection than it currently has?

0. No.	1. Yes.	2. Do not know. *(go to question 7)*

6. Can you explain why?

Don't read the answers. Allow the respondent to answer spontaneously and only afterward choose the most appropriate from the list (select several if necessary). In case of doubt, write it down in points 2 or 6.

If he/she answered No to question 5	If he/she answered Yes to question 5
1. Current situation is fine / it is currently well protected.	1. To protect the animals.
2. Other (specify):_____	2. To protect the lynx.
_____	3. To protect fauna and flora / nature/ environment / habitat.
_____	4. To avoid accidents.
	5. To protect against human action (agriculture, mining, urbanization or hunting).
	6. Other (specify):_____

In 1998 a mining accident took place in Aznalcóllar. As a consequence, large amounts of toxic water and mud were spilled into the Guadiamar River, 50km North of the Doñana National Park. All fish in the Guadiamar River died, a part of the park was affected and nature and wildlife of Doñana were threatened.

SHOW CARD 1: **This map shows the location of the accident along the river *(show the dark area on the map)*. As you can see, here is Doñana *(point out Doñana in the map).* Photos show images of the river a few days after the accident.**

7. Do you remember the accident?

0. No.	1. Yes.

8. Were you personally affected by the accident?

0. No. *(go to question 10)*	1. Yes.

9. Could you briefly explain why?

Don't read the answers. Allow the respondent to answer spontaneously and only afterward choose the most appropriate from the list (select several if necessary). In case of doubt, write it down in point 3.

1. Because I or someone from my family worked at the mine.
2. Because I or someone from my family are farmers in the area. Specify if their land was expropriated:_____
3. Other (specify):_____

10. Do you think the Doñana National Park was affected by the toxic spill?

0. Not at all.	1. No.	2. Somehow.	3. Yes.	4. Yes, very much.	5. Doesn't know.

11. Do you think that sufficient measures were taken after the accident to reduce the damage to the Doñana National Park and its surroundings?

0. No.	1. Yes.	2. Do not know.

To avoid a new similar accident from happening again in the future and damaging the Doñana, some measures can be taken to protect the National Park, reducing the risk of irreversible damage to nature and wildlife. These measures include, for instance, the restriction or even prohibition of polluting activities in the surroundings of Doñana. These measures cost money.

12. Do you think it is necessary to take further measures to protect Doñana National Park, so the risk of irreversible damage to nature and wildlife is reduced?

0. No.	1. Yes.	2. Do not know.

13. Would you, in principle, be willing to pay to ensure that accidents like the toxic spill of 1998 will not happen again in the future?

0. No. *(go to question 20)*	1. Yes. *(go to question 14)*

14. Would you be willing to pay 5 € per year in addition to your household's current taxes to ensure that accidents like the toxic spill of 1998 will not happen again in the future?

Please, take into account your current income when answering.

This money would be exclusively and with all guarantees used to avoid accidents affecting Doñana.

0. No. *(go to question 15)*	1. Yes. *(go to question 16)*

15. You are not willing to pay 5 € per year, but are you willing to pay 2.5 € per year?

0. No. *(go to question 17)*	1. Yes. *(go to question 17)*

16. And 7.5 € per year?

0. No. *(go to question 17)*	1. Yes. *(go to question 17)*

17. What is the maximum amount you would be willing to pay per year?

I would be willing to pay_____ € per year maximum. (If zero, go to question 20)

18. Can you briefly explain why you would be willing to pay that amount of money?

Don't read the answers. Allow the respondent to answer spontaneously and only afterward choose the most appropriate from the list (select several if necessary). In case of doubt, write it down in point 7.

1. To avoid accidents.
2. To protect the lynx.
3. To protect fauna and flora / nature/ environment / habitat.
4. To avoid accidents.
5. To protect against human action (agriculture, mining, urbanization or hunting).
6. Because it is a good cause.
7. Other (specify):_____

Imagine that you are asked to help to decide how to spend that additional money collected to provide further protection to Doñana.
SHOW CARD 2:

19. In your opinion, what this additional money should be first and mainly be spent?

Read the list of possibilities. ONLY ONE OPTION IS POSSIBLE.

1. In the protection only of the species in danger of extinction, such as the lynx and the imperial eagle.
2. In the protection of all animals: the lynx and the eagle, but also mongoose, badgers, rabbits, geese, flamingos and others.
3. In the protection of the natural environment: wetlands, dunes, forest, etc.
4. In the protection of animal species and the natural environment (all categories from 1 to 3).
5. In other things (specify):_____

20. Could you please tell me why you would not be willing to pay?

Don't read the answers. Allow the respondent to answer spontaneously and only afterward choose the most appropriate from the list. In case of doubt, write it down in point 7. Choose one option only.

1. I don't think it is important to assure further protection to the Doñana National Park.
2. I cannot afford it.
3. I prefer to spend my money in something else.
4. I think I already pay enough money to the administration to take care of this things and I don't want to pay extra money for this.
5. The responsible of the polluting activities should pay, not me.
6. I don't trust that the money would be used for further protection to the Doñana National Park.
7. Other (specify):_____

Right after the accident in 1998, a dam was built in the Guadiamar River to avoid the toxic spill to get into the Doñana National Park and the toxic mud was removed. After this emergency measure, the Green Corridor of Guadiamar was created. The Green Corridor consists of the recovery of 40 km along the Guadiamar River and a total of 5,000 hectares of its surroundings.
SHOW CARD 3:* On this map you can see the location of the Green Corridor of Guadiamar (*show the corridor on the map).

21. Did you know that a Green Corridor was created in the Guadiamar as a consequence of the toxic spill of 1998?

0. No.	1. Yes.

22. Have you ever visited the Green Corridor of Guadiamar?

0. No, never. *(go to question 24)*	1. Yes, once.	2. Yes, I have been there _____ times.

23. When you go to the Green Corridor of Guadiamar, what kind of activities do you do?

Choose several if needed.

1. Walking.	5. Bird watching.
2. Picnic.	6. Leisure fishing.
3. Biking.	7. Enjoy the landscape.
4. Horse riding.	8. Other (specify):_____

The Green Corridor of Guadiamar was created to compensate the environment for the damage cause by the toxic spill. The corridor consists of a total of 5,000 hectares of protected nature as river forests and lagoons, around the Guadiamar River.
KEEP ON SHOWING CARD 3: point out the photographs of the Corridor.

24. Do you think the Green Corridor of Guadiamar has sufficiently compensated the environment for the damage caused by the toxic spill in 1998?

0. Not at all.	1. No.	2. Somehow.	3. Yes.	4. Yes, more than enough.	5. Doesn't know.

25. The management of the Green Corridor of Guadiamar costs money. Would you be willing to pay, in principle, for the management of the Green Corridor of Guadiamar, to assure the compensation for the environment?

0. No. *(go to question 28)*	1. Yes. *(go to question 26)*

26. What is the maximum amount you would be willing to pay for the management of the Green Corridor of Guadiamar to assure the compensation for the environment?

This amount would be added to the one that you have stated before to avoid future accidents.

Please, take into account your current income when answering.

I would be willing to pay_____ € per year maximum. (if zero, go to question 28).

27. Can you briefly explain why you would be willing to pay that amount of money for the management of the Green Corridor of Guadiamar?

Don't read the answers. Allow the respondent to answer spontaneously and only afterward choose the most appropriate from the list (select several if necessary). In case of doubt, write it down in point 5.

1. To protect / preserve the Green Corridor.
2. To protect / preserve the Doñana.
3. To prevent accidents.
4. Because it is a leisure area / people can enjoy it.
5. Other (specify):_____

28. Could you please tell me why you would not be willing to pay an additional amount of money for the management of the Green Corridor of Guadiamar to assure the compensation for the environment?

Don't read the answers. Allow the respondent to answer spontaneously and only afterward choose the most appropriate from the list. In case of doubt, write it down in point 7. Choose one option only.

1. I don't think the Green Corridor is important.
2. I cannot afford it.
3. I prefer to spend my money in something else.
4. I think I already pay enough money to the administration to take care of this things and I don't want to pay extra money for this.
5. The responsible of the polluting activities should pay, not me.
6. I don't trust that the money would be use for the management of the Green Corridor.
7. Other (specify):_____

The Green Corridor offers an extra benefit for the environment: it is a green passage by which animals such as the lynx can travel freely between the Doñana and the protected area of Sierra Morena, thus increasing the natural space in which they can live.

SHOW CARD 4: show the picture of the connection between Doñana and Sierra Morena.

29. How important is it for you that animals can travel freely between Doñana and Sierra Morena?

0. Is not important at all.	1. Is not important.	2. Somehow important.	3. Important.	4. Very important.

30. Now that you know that the Green Corridor offers this extra benefit for the animals. Would you like to change the amount of money you just said you would pay for the management of the Green Corridor in order to assure this extra benefit?

This amount of money would be added to the previous one.

0. No.	1. Yes. I would like to pay_____ € per year, additional to what i have said for the management of the Green Corridor.

31. Now that you know that we have asked you three times to pay for three different goods, would you like to change the maximum money amounts that you said that you would be willing to add to your household's taxes?

SHOW CARD 5.

	New amounts
a. I don't want to modify the money amounts.	
b. Avoid future accidents.	**_____€ per year**
c. The management of the Green Corridor.	**_____€ per year**
d. Green passage for animals.	**_____€ per year**

32. Please, tell me the degree of your agreement/disagreement with the following statements.

a. The environment is the most important thing we have.

1. Absolutely agree.	2. Agree.	3. Don't agree/don't disagree.	4. Disagree.	5. Absolutely disagree.

b. The environment has the right to be protected regardless of the costs to society.

1. Absolutely agree.	2. Agree.	3. Don't agree/don't disagree.	4. Disagree.	5. Absolutely disagree.

c. The environment should be protected by law and not by asking people to pay for it.

1. Absolutely agree.	2. Agree.	3. Don't agree/don't disagree.	4. Disagree.	5. Absolutely disagree.

I am now going to ask you some questions about yourself to build up your statistical profile. This information will be treated absolutely confidentially.

33. How old are you? _____

34. How many people live in your household (including yourself)? _____people.

35. How many children (<18 years old)? ____children.

36. Education level (highest diploma):

1. No studies.	3. Secondary (bachillerato or FP superior).
2. Primary studies (EGB, Primaria, E.S.O., FP 1er ciclo).	4. University.

37. Are you:

1. Employee.	5. Searching for a job.
2. Director.	6. Retired.
3. Freelancer.	7. Housewife/husband.
4. Businessperson.	8. Student.

38. If the respondent answers 1 to 6 on question 37: in which sector do you work?

1. Agriculture.	5. Public administration.
2. Mining.	6. Education.
3. Trade and services.	7. Health.
4. Industry.	8. Other (specify):_____

39. Do you belong to any environmental organization?

0. No. *(go to question 41)*	1. Yes. Which? _____

40. Could you please tell me how much do you pay in average per year to this organization?
_____ € per year.

41. Could you tell me to which category from A to L on this table does your household's net income correspond?

Make sure that it is net income of the whole household.

I remind you that this information has only statistical purposes and it will be treated with absolute confidentiality. Besides, this questionnaire is absolutely anonymous.

Show INCOME CARD and make him/her choose from A to L.

A.	B.	C.	D.
E.	F.	G.	H.
I.	J.	K.	L.

42. The respondent is:

0. Male.	1. Female.