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“Adapted” Habitat Evaluation Procedure and Choice Experiment: substitutes or complements?

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Abstract:

Originally developed to evaluate the environmental cost of development plans, the “adapted” Habitat Evaluation Procedure (HEP) seeks to value environmental costs and benefits through a non-monetary metric, the habitat unit. The environmental benefits of creating or restoring a natural area are evaluated on the basis of the number of habitat units equivalent to an improved supply of ecosystem services. But such a plan may generate other benefits for the inhabitants of nearby towns, recreational benefits for instance. These benefits can be measured by a traditional economic valuation method, such as a choice experiment (CE). We used the “adapted” HEP and a CE on the same study site to test the potential complementarity of the two methods and to identify the potential risks and benefits of such a double valuation.

Keywords: “adapted” habitat evaluation procedure, choice experiment, ecosystem services, Rhine River, wetland restoration.

JEL : Q51 – Q57.

“Adapted” Habitat Evaluation Procedure and Choice Experiment: substitutes or complements?

1. Introduction

The “adapted” Habitat Evaluation Procedure (HEP) method was originally developed to assess the environmental cost of development plans (Dumax, 2009; Dumax and Rozan, 2011). Its aim was to help decision-makers take into account environmental considerations when creating development plans for sensitive natural areas. The method has since been extended to assess actions that are beneficial to the environment (Dumax and Rozan, 2012). Based on an approach similar to those developed by Cowling *et al.* (2008) and Haines-Young *et al.* (2012), this method based the evaluation on marginal changes in ecological indicators. The underlying hypothesis is that environmental benefits (shown as gains in ecosystem services) generated by compensation or restoration measures do have an impact on human well-being (Costanza *et al.,* 1997; de Groot *et al.,* 2002; Haines-Young and Potschin, 2010). However, as this impact is sometimes indirect, people are not necessarily aware of the source of their improved well-being (Czajkowski *et al.,* 2009). The benefits provided by ecosystems, especially when they are non-market, often remain unrecognized (Harrison *et al.*, 2010; Busch *et al.*, 2012). They are then difficult to assess using traditional economic methods, and this can be a substantial threat to the development of restoration measures, which nonetheless remain necessary. This is, in particular, one of the reasons why wetlands (studied in this article) have not been estimated at their true worth resulting in their progressive disappearance (Gren *et al.*, 1994; Turner *et al.,* 2000; Balmford *et al.,* 2002; de Groot, 2006; Daily *et al.,* 2009).

The “adapted” HEP method uses a non-monetary metric, the habitat unit, to measure the environmental benefits of supplying additional ecosystem services. Given that these are local services, we assume that these improvements benefit the local population. However, they originate from complex ecological functions and, therefore, the beneficiaries in question are not necessarily aware of the source of their improved well-being. Hence, it seems that integrating the ecological data into the economic assessment would be an effective means of associating these benefits with the decision-making process (Cowling *et al.*, 2008; Daily *et al.*, 2009; Turner *et al.,* 2000; Cordier *et al.,* 2014).

In addition to ecological benefits, the presence of a natural site may be a source of social benefits (e.g. recreational) for the inhabitants of the local communities. Such benefits, being more readily perceived by the inhabitants, can be measured with a more traditional economic valuation method such as for example a Choice Experiment (CE). This raises two questions. What benefits do inhabitants actually perceive? Can a CE be combined with “adapted” HEP to include the elements that the latter may miss or is there a risk of double counting?

The objective of this article is to test the complementarity of these two methods. By so doing, we seek to contribute to a better integration of ecosystem services into the processes of planning, management, and decision making in natural areas (de Groot *et al.*, 2010a). Section 2 presents the study site, which was common to both methods. The results of the “adapted” HEP method applied to the Erstein Polder (Alsace, France) are presented in section 3, whilst section 4 deals with the use of the CE. As will be seen, the CE was designed in such a way as to test hypotheses concerning people’s awareness of these benefits. The results are then discussed in the fifth and final section.

2. Study area

The Erstein Polder was the study area, excluding a zone which is unaffected by restoration and will serve as an animal sanctuary. This polder comprises a portion of the Rhine alluvial forest of some 600ha, located 20km south of Strasbourg, and completely protected by dikes from flooding by the Rhine and the Ill rivers. It was initially designed to lower the Rhine flood levels and protect downstream areas against bicentennial floods. The Rhine alluvial forest is currently threatened (Lefeuvre, 1992; Piéguay *et al.,* 2003) and the remaining portions must be protected[1]. Given this goal, the way these retention areas operate was reviewed and additional annual re-floodings, called "ecological floodings", were integrated into polder management. The objective was to restore the structure and functioning of these wetlands with their high biological productivity and species wealth (Dumax and Rozan, 2013).

Initially, the polder's 600ha[2] comprised 95% woodland (alluvial forest) i.e. 570ha and 5% waterbodies (ponds and Giessen, which are streams exclusively fed by upwelling groundwater) i.e. 30ha. The restoration consisted of building water intakes and drains to control the polder's impoundment (Mission de suivi scientifique du polder d'Erstein [Scientific monitoring body for the Erstein Polder], 2004). Concurrently with these hydraulic improvements, ecological measures were implemented. The internal hydraulic system of the polder was re-created. Old river reaches were restored and ponds and wetlands created, together with shelter islets for the large fauna during impoundment. The size of the environments was not changed. The only difference was that woodland areas became flood-prone.

3. Applying the "adapted" HEP method to the case of the Erstein Polder

The "adapted" HEP method was used ex-post here in the case of wetland restoration. As with the original method (USFWS, 1980), it consisted of using a non-monetary metric, the habitat unit, to measure the difference between the situations before and after the intervention on the study site. This approach assumes that the quality of habitats can be described numerically using a quality index (Habitat Suitability Index). This index was calculated specifically for each quality indicator of the selected environment.

The procedure followed was broadly the same as in the first application of the "adapted" HEP procedure (see in particular Dumax and Rozan, 2011). A first difference concerned some simplification. The ecosystem services studied were identical in the initial and final states. The selection of quality indicators and indices[3] and of the habitat units was undertaken for both the initial and final states. The net benefit, in habitat units, could then be estimated directly. A second difference concerned the use of species. Originally, in the "adapted" HEP method, fauna and flora species were used as proxies for the evaluation. A species was selected for each ecosystem service and was linked to a quality indicator. But, in some cases, it may not be possible to find species that are sufficiently

[1] The Erstein Polder forest is designated as a "protection forest" and 180ha in its eastern part have also been designated as a natural reserve since 1989. The eastern, north-western and western borders of the polder have been a game and wildlife reserve since 1983. Finally, the Erstein Polder is part of a Natura 2000 area and a Ramsar wetland "Upper Rhine/Oberrhein".

[2] 1 ac =0.40 ha.

[3] "Quality indicators" are elements selected to represent environmental quality (micropollutant presence, hydrobiological quality of waterways etc.). "Indices" measure the level of these indicators compared with a reference level.

representative of the relevant service. We therefore by-passed the species by linking quality indicators directly to the ecosystem services identified.

3.1. Identification of ecosystem services and quality indicators

The first stage of the "adapted" HEP method consists of measuring the difference between the study zone in its initial state (in our case, the situation in 2003 before ecological floodings of the polder) and its final state (in our case the situation in 2008 following these floodings). Our work relied on a five-year scientific monitoring programme by the Erstein Polder scientific monitoring mission studying the ecological impact of impoundment. This programme collected ecological data to assess if the three aims of the ecological floodings had been achieved. These aims were as follows (Mission de suivi scientifique du polder d'Erstein, 2004):

- identify the risks of groundwater pollution through pollutant monitoring;
- clarify the impact of flooding on habitat, flora and fauna using fauna and flora indicators;
- analyse the polder's capacity to restore some of the original or specific functions of flood-prone alluvial areas.

Using the relevant literature (Piégay *et al.,* 2003; Futsec *et al.,* 2000; Balmford *et al.*, 2008; de Groot *et al.*, 2010b), we associated a coherent ecosystem service to each of these objectives (Table 1). To enable comparison, the same ecosystem services were studied in the initial and final states. We selected three: "pollution control" which was used to identify pollution risks (impoundment could bring pollution from the river even though alluvial forests play a purification role through the strong interactions between soil and groundwater), (2) "habitat and biodiversity provisioning" which depends on the biological quality of the ponds and the Giessen as well as the alluvial forest (flooded habitats are generally richer in terms of biodiversity; fauna and flora monitoring may provide a good indicator of these services), and (3) "regulation of water supply" which concerns the supply and quality of surface and ground water (the depolluting capacity of woodlands is greater than that of grassland and cultivated areas). Quality indicators were then associated with each of the ecosystem services in order to monitor changes in the quality of the services supplied.

Table 1. Ecosystem services and quality indicators

Objectives	Ecosystem services	Quality indicators
Identify pollution risks	Pollution control	Soil micropollutants
		Sediment micropollutants
		Mineral micropollutants (groundwater)
		Organic micropollutants (groundwater)
		Micropollutants (surface water)
Impact of flooding on habitat, fauna and flora	Habitat and biodiversity provisioning	Flora wealth and types of species
		Vegetal species characterisation
		Health monitoring of ligneous species
		Large fauna
		Abundance of amphibian populations
		Importance of amphibian populations
		Fish population
Restoration of alluvial area functions	Water regulation and supply	Soil hydromorphic profile
		Eutrophication level bioindication
		QAS[4]-Water: General biological potential (groundwater)
		QAS-Water: Drinking water production (groundwater)
		QAS- Water: General biological potential (surface water)
		QAS-Water: Drinking water production (surface water)
		Hydrobiological quality

3.2. Calculation of Habitat Suitability Indices (HSIs)

The Habitat Suitability Indices (HSIs) of each indicator were calculated using the initial and final state measurements provided by the scientific monitoring mission[5]. Table 2 shows an example of HSIs for the "pollution control" service of the "woodland" habitat. It reads as follows: a chrome concentration between 100 and 150 ppm (parts per million) means that the index is of poor quality (level 1). A good quality environment corresponds to a concentration between 0 and 50 ppm (level 3, which is referred to as the "optimal level").

[4] Quality Assessment System.

[5] The measurements in question may be found in the scientific monitoring report (Mission de suivi scientifique du polder d'Erstein 2004, 2009).

Table 2. HSIs for the “soil micropollutants” indicator

Chromium (Cr)		Lead (Pb)	
Concentration	**Index level**	**Concentration**	**Index level**
0-50	3	0-20	5
50-100	2	20-40	4
100-150	1	40-60	3
> 150	0	60-80	2
		80-100	1
		> 100	0

Cadmium (Cd)		Mercury (Hg)	
Concentration	**Index level**	**Concentration**	**Index level**
0.0-0.5	4	0.0-0.2	5
0.5-1.0	3	0.2-0.4	4
1.0-1.5	2	0.4-0.6	3
1.5-2.0	1	0.6-0.8	2
> 2.0	0	0.8-1.0	1
		> 1.0	0

Note: the concentration unit is the ppm.

The HSI calculations are shown in table 3. For each indicator, the HSI corresponds to the initial or final state level divided by the optimal level. It should be noted that several samples of each pollutant were collected from each zone. Initial and final state levels equal the mean value for each zone.

Table 3. HSI calculations for the “soil micropollutants” indicator

Sampling zone	Optimal level		2003 levels	2003 HSIs	2008 levels	2008 HSIs
Zone 1	Cr	3	3	1	3	1
	Pb	5	5	1	3.83	0.76
	Cd	4	4	1	4	1
	Hg	5	4.5	0.9	3.66	0.73
Zone 2	Cr	3	3	1	3	1
	Pb	5	4.5	0.9	4.83	0.96
	Cd	4	4	1	4	1
	Hg	5	4.5	0.9	4.83	0.96
Zone 3	Cr	3	3	1	3	1
	Pb	5	5	1	4.83	0.96
	Cd	4	4	1	4	1
	Hg	5	4.5	0.9	4.66	0.93
Zone 4	Cr	3	3	1	3	1
	Pb	5	4.5	0.9	4.75	0.95
	Cd	4	4	1	4	1
	Hg	5	3	0.6	5	1
Zone 5	Cr	3	3	1	3	1
	Pb	5	4	0.8	4.66	0.93
	Cd	4	4	1	4	1
	Hg	5	2	0.4	5	1

Note: the concentration unit is the ppm.

Habitat units were calculated as the product of the HSIs and the size of the relevant environment (in ha). They were then summed to find the number of units which can be attributed to the polder before and after the implementation of ecological flooding. The net benefit of restoration was estimated by subtracting the habitat units in the initial state from the habitat units in the final state for each indicator. In our example, for the “soil micropollutants” indicator in the “woodland” habitat, the size of the environment was 570ha. This area was multiplied by the HSIs measured for the site in 2003 and 2008 (Table 4).

Table 4. Number of habitat units for the "soil micropollutants" indicator

Sampling zone	2003 HSIs	2003 Habitat units	2008 HSIs	2008 Habitat units
Zone 1	1	570	1	570
	1	570	0.76	436.62
	1	570	1	570
	0.9	513	0.73	417.24
Zone 2	1	570	1	570
	0.9	513	0.96	550.62
	1	570	1	570
	0.9	513	0.96	550.62
Zone 3	1	570	1	570
	1	570	0.96	550.62
	1	570	1	570
	0.9	513	0.93	531.24
Zone 4	1	570	1	570
	0.9	513	0.95	541.5
	1	570	1	570
	0.6	342	1	570
Zone 5	1	570	1	570
	0.8	456	0.93	531.24
	1	570	1	570
	0.4	228	1	570
Total	-	10,431	-	10,950

This gave us respectively 10,431 and 10,950 habitat units for 2003 and 2008, i.e. a gain of 0,519 units. This figure represents the contribution of the "woodland-soil micropollutant" indicator to improving the site's ecological quality following its restoration.

3.3. Estimating the net benefit

Overall, for the two habitats (i.e. woodlands and waterbodies), for the complete set of indicators and hence for the three ecosystem services included in this study, the net environmental benefit was found to be 521 habitat units. In other words, the restoration measures implemented in the Erstein Polder led to the creation of 521 habitat units. They derive from the improved supply of ecosystem services due to the improvement in environmental quality. The increase in site quality was relatively low since it represented less than 2.5% of the total number of units which can be attributed to the site (21,000) but it was in line with the results expected by the scientists in charge of monitoring. The indicators were measured during the fifth year of monitoring after the polder impoundment, which is a very short lapse of time for benefits to appear. More significant changes are expected in the future (Mission de suivi scientifique du polder d'Erstein, 2009) if the impoundments continue at a sufficient level.

4. Applying CE to the case of the Erstein Polder

The CE draws on Lancaster's characteristics approach (1966), which posits that the satisfaction that consumers derive from the consumption of a good comes from the consumption of its different characteristics or attributes. This economic valuation method examines the behaviour of people in response to changes in the quality of environmental goods or services (Adamowicz *et al.,* 1998). It relies on data collection and a survey of the relevant population. The latter are given hypothetical scenarios, designed by the researcher, and they select the one they prefer (Bateman *et al.,* 2002).

This approach identifies not only which attributes of the good are valuable for the population but also the specific value of these attributes. More precisely, the CE seeks to identify the trade-offs made by each individual with respect to the attributes and to give them a monetary value in order to determine the willingness to pay (WTP).

The CE method was applied to the Erstein Polder site with the aim of undertaking a methodological comparison.

4.1. Experimental design

The attributes and their levels were selected on the basis of the literature (VNF, 2004; Schmitt, 2009) and discussions with experts. On the basis of the results of Gordon *et al.* (2001) and the recommendations of Bateman *et al.* (2002), five attributes were selected. In October 2013, pre-surveys were undertaken with 35 people residing in Erstein, Nordhouse and Plobsheim, the three towns located near the polder, to test the relevance of the attributes selected and choose their levels. These levels were defined as shown in Table 5.

Table 5. Attributes and levels

Attributes	**Levels**
Flood protection	No contribution to flood protection*
	Full contribution to flood protection
	Partial contribution to flood protection
Characterisation and diversity of typical Rhine alluvial forest species (fauna and flora)	Disappearance of typical Rhine alluvial forest species*
	Maintenance of typical Rhine alluvial forest species
	Enrichment of typical Rhine alluvial forest species
Water quality	Average IBGN score between 9 and 12 (average)*
	Average IBGN score between 13 and 16 (good)
	Average IBGN score between 17 and 20 (very good)
Average number of days closed to the public per year	None*
	On average 11 days per year closed to the public
	On average 49 days per year closed to the public
Increase in the average annual water bill	3%*
	3.5%
	4%
	4.5%

Reference levels are denoted *. They relate to the pre-Polder situation. Intermediate levels relate to the current situation and higher levels reflect a hypothetical situation with more significant ecological flooding.

The CE consisted of proposing two alternatives to the reference situation. We used a fractional factorial design to establish the choice sets (Kuhfeld, 2000; Huber and Zwerina, 1996; Zwerina *et al.,* 1996). The design software Ngene gave us a sub-set of 18 choice sets which were then separated into three blocks using the process suggested by Louviere (1988). The three different versions of the questionnaire, each containing six choice sets, were then allocated randomly and uniformly to the respondents. An example of a choice set is shown in table 6. The vocabulary used to describe the scenarios was tested at the end of October 2013 with 35 inhabitants of Erstein, Nordhouse and Plobsheim.

Table 6. Example of a choice set

Attributes	**Alternative 1 (reference)**	**Alternative 2**	**Alternative 3**
Flood protection	No protection	Full contribution	Partial contribution
Characterisation and diversity of typical Rhine alluvial forest species (fauna and flora)	Species disappearance	Species maintenance	Species disappearance
Water quality	IBGN score between 9 and 12 Average quality	IBGN score between 9 and 12 Average quality	IBGN score between 17 and 20 Very good quality
Average number of days per year closed to the public	Never closed	49 days	Never closed
Increase in the average annual water bill	3%	4.5%	3%
Choice	☐	☐	☐

The final questionnaire comprised three parts. The first addressed the individual's knowledge and uses of the Polder site. The second comprised the choice sets and follow-up questions. And the third concerned the socio-economic characteristics of the respondent. This questionnaire was tested in November 2013 with fifteen people in survey conditions.

4.2. Surveys and data

The survey was undertaken in November 2013 with a representative sample of residents from Erstein, Nordhouse and Plobsheim which are local to the polder. In all, 394 people were interviewed face to face in their homes. The survey plan was based on the proportion of inhabitants from each of the three towns (66% Erstein, 24% Plobsheim and 10% Nordhouse). All residential areas were covered to ensure that the sample was representative. Since people gave their opinion on six choice sets, 2,364 observations were available for econometric analysis.

4.3. Econometric modelling

The econometric modelling of the responses used a McFadden conditional logit model (1974). The Random Utility Theory postulates that the utility obtained by a rational individual i from alternative j is:

$$U_{\mathrm{ij}} = V_{\mathrm{ij}} + \varepsilon_{\mathrm{ij}}$$

where V_{ij} and $\varepsilon_{\mathrm{ij}}$ are respectively the systematic and random components of utility. It is assumed that i chooses alternative g over h in a choice set if $U_{\mathrm{ig}} > U_{\mathrm{ih}}$, i.e. that:

$$P_{\mathrm{ig}} = Pr\left(U_{\mathrm{ig}} > U_{\mathrm{ih}}\right) = Pr\left(V_{\mathrm{ig}} - V_{\mathrm{ih}} > \varepsilon_{\mathrm{ih}} - \varepsilon_{\mathrm{ig}}\right)$$

The $\varepsilon_{\mathrm{ij}}$ are usually assumed to be independent and identically Gumbel distributed, so that P_{ig} can be expressed as:

$$P_{\mathrm{ig}} = \frac{exp\left(V_{\mathrm{ig}}\right)}{\sum_j exp\left(V_{\mathrm{ij}}\right)}$$

Different models car be used to estimate this probability. The conditional logit assumes similar preference structure for all respondents and P_{ig} does not depend on individual characteristics. The results are presented in table 7.

Table 7. Results of the conditional logit model.

Variables	Coefficients	s.e.
Protection 2	0.3173***	0.0653
Protection 3	0.1802*	0.0961
Diversity 2	0.3606***	0.0502
Diversity 3	0.1265	0.0841
Quality 2	0.0575	0.0774
Quality 3	0.1279**	0.0536
Closure 2	0.0621	0.0767
Closure 3	-0.1031**	0.0454
Price	-17.7778***	5.2384
ASC 1	2.5953***	0.2150
ASC 2	2.2691***	0.2135
Number of observations	2,364	
Log-likelihood	-2,027.57	
Pseudo-R^2	0.05	

Note: *** significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.

We note first that both Alternative Specific Constants (ASC) are significant and positive. Even if all other attributes were kept constant, respondents chose a change in the situation over the reference situation. The monetary attribute coefficient is significantly negative as expected. Furthermore, the two "Protection" level coefficients are significant and positive. Therefore their presence in an alternative increased the likelihood of its selection over the reference situation. The "Diversity 3" coefficient is not significant. The respondents did not, therefore, consider the restoration of habitats and specific Rhine alluvial forest species to be important. The "Quality 2" coefficient is not significant either unlike the "Quality 3" coefficient. Therefore, there had to be a significant improvement in water quality for this attribute to influence responses. Finally, the "Closure 2" coefficient is not significant whereas "Closure 3" is both significant and negative. A few days closure did not have an impact on the choices selected by the respondents, but a significant increase was viewed negatively.

4.4. Calculating the willingness to pay (WTP)

For each individual, the WTP for a level of an attribute is the amount that must be deducted from their income, after adjusting the level of the attribute, so as to keep their utility constant. The utility provided by each alternative is compared with its level in the reference situation (Bennett and Adamowicz, 2001). The WTP are presented in table 8.

Table 8: WTP for attribute levels

Attribute levels	WTP	s.e.
Protection 2	0.0178***	0.0052
Protection 3	0.0101	0.0069
Diversity 2	0.0203***	0.0070
Diversity 3	0.0071	0.0055
Quality 2	0.0032	0.0040
Quality 3	0.0072*	0.0042
Closure 2	0.0035	0.0046
Closure 3	-0.0058*	0.0031

Note: *** significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.

The values obtained are WTP per household per year. They are expressed as the percentage water bill increase that respondents would be prepared to pay in return for a policy that would lead to a given level of an attribute. The average annual water bill is €420 for a consumption of $120m^3$ (Barbier and Montginoul, 2013), so this figure must be multiplied by the WTP values obtained above in order to derive the WTP in euros.

Generally, respondents were only willing to pay to increase the level of flood protection if total protection was guaranteed. The WTP for level 3 (partial protection) is not significant. The same was true for water quality. The WTP is only significant for a net improvement in water quality. They were prepared to pay to maintain species diversity globally. But they did not wish to favour the return of particular wetland-specific species. Finally, the recreational aspect only becomes negative when the number of closed days becomes too high.

5. Discussion/conclusion

This article presents the application of two methods to assess environmental benefits (CE and "adapted" HEP) to the same study site. We conclude that the two methods do not evaluate the same benefits. Given this, are the two methods complementary? Which method is best adapted to include which benefit? And is there a risk of double-counting?

One hypothesis was that it would be difficult for respondents to give a monetary value to ecological benefits that they might not necessarily perceive given their complexity (deGroot, 2006; Daily *et al.,* 2009). In that case, the "adapted" HEP method seemed more appropriate. But as this method is based on an ecological equivalence, it might not be adequate when, for example, assessing the recreational benefits of a site, in which case it would appear more appropriate to use the CE method (Hanley and Barbier, 2009).

Our results appear to confirm these two hypotheses. The results of the conditional logit applied to the CE data show that the coefficient of "Diversity 3" is not significant unlike the coefficient of "Diversity 2". Precise elements such as the restoration measures intended to develop fauna and flora species characteristic of the environment with a substantial ecological value do not appear to be recognized by the population: people value fauna and flora protection globally but not the specificity of the Rhine wetland. Yet, this biodiversity represents a genuine gain ecologically which, it turns out, can be apprehended using the "adapted" HEP method. A similar result is found with the water quality attribute: the coefficient of "Quality 2" is not significant in the CE whereas the coefficient of "Quality 3" is. Again, the population seems to value a significant improvement in water quality but not a smaller variation.

On the other hand, the higher level of the attribute relating to site closure and access "Closure 3", which means substantially restricting access to the site and hence to recreational or hunting activities, is clearly significant and negative. The substantial recreational benefit revealed by this estimate is not taken into account by the "adapted" HEP method. Similarly, the coefficients of the "Protection" attribute levels are significant. People value the increase in downstream flood protection levels but the "adapted" HEP method also fails to take this element into consideration.

In conclusion, our results show that, in the case of natural zone restoration, certain benefits are well perceived by the population (flood protection and recreational activities for instance) whereas others are not always (such as species diversity and water quality). It would seem therefore appropriate to combine the "adapted" HEP and CE in order to include all benefits. But in this case the CE model must be designed so as to avoid any risk of double-counting and this would be facilitated if the magnitude of the benefits associated with each ecosystem service were taken into account beforehand.

However, the use of a latent class model (Rulleau *et al.,* 2015) appears to show that benefit perception may vary as a function of certain socio-demographic criteria such as whether a person is a hunter and their sensitivity to environmental protection. This heterogeneity may complicate the combination of the two methods and requires further investigation.

References

Adamowicz, V., Louviere, J., Swait, J., 1998. Introduction to Attribute-Based Stated Choice Methods. Edmonton: Advanis.

Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K., Turner, R.K., 2002. Economic reasons for conserving wild nature. Science 297 (5583), 950–53. *DOI: 10.1126/science.1073947*

Balmford, A., Rodrigues, A., Walpole, M., ten Brink, P., Kettunen, M., Braat, L., de Groot, R., 2008. Review on the Economics of Biodiversity Loss: Scoping the Science. Tech. rep., Final report for the European Commission.

Barbier, R., Montginoul, M., 2013. 120 m^3 - Le consommateur en question. Sciences Eaux et Territoires 10.

Bateman, I., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Tannis, H., Jones-Lee, M., Loomes, G., Mourato, S., Özdemiroglu, E., Pearce, D. W., Sugden, R., Swanson, J., 2002. Economic Valuation with Stated Preference Techniques: A manual. Cheltenham: Edward Elgar.

Bennett, J., Adamowicz, V., 2001. Some Fundamentals of Environmental Choice Modelling. In J. Bennett and R. Blamey (eds), The Choice Modelling Approach to Environmental Valuation. Cheltenham: Edward Elgar, 37-72.

Busch, M., La Notte, A., Laporte, V., Erhard, M., 2012. Potentials of quantitative and qualitative approaches to assessing ecosystem services. Ecological Indicators 21, 89-103. *DOI:10.1016/j.ecolind.2011.11.010*

Cordier, M., Pérez Agundez, J., Hecq, W., Hamaide, B., 2014. A guiding framework for ecosystem services monetization in ecological-economic modeling. Ecosystem Services 8, 86-96. *DOI:10.1016/j.ecoser.2014.03.003*

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260. *DOI:10.1038/387253a0*

Cowling, R.M., Egoh, B., Knight, A.T., O'Farrell, P.J., Reyers, B., Rouget'll, M., Roux, D.J., Welz, A., Wilhelm-Rechman, A., 2008. An operational model for mainstreaming ecosystem services for implementation. Proceeding of the National Academy of Sciences of the United States of America 105 (28), 9483-9488. *DOI:10.1073/pnas.0706559105*

Czajkowski, M., Buszko-Briggs, M., Hanley, N., 2009. Valuing changes in forest biodiversity. Ecological Economics 68, 2910–2917. *DOI:10.1016/j.ecolecon.2009.06.016*

Daily, G., Polasky, S., Goldstein, J., Kareiva, P., Mooney, H., Pejchar, L., Ricketts, T., Salzman, J., Shallenberger, R., 2009. Ecosystem services in decision making: time to deliver. Frontiers in ecology and the environment 7 (1), 21-28. *DOI:10.1890/080025*

de Groot, R., Wilson, M., Boumans, R., 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics 41, 393–408. *DOI:10.1016/S0921-8009(02)00089-7*

de Groot, R., 2006. Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. Landscape and Urban Planning 75(3-4), 175-186. *DOI:10.1016/j.landurbplan.2005.02.016*

de Groot, R., Alkemade, R., Braat, L., Hein, L., Willemen, L., 2010a. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7, 260-272. *DOI:10.1016/j.ecocom.2009.10.006*

de Groot, R., Fisher, B., Christie, M., Aronson, J., Braat, L., Haines-Young, R., Gowdy, J., Maltby, E., Neuville, A., Polasky, S., Portela, R., Ring, I., 2010b. Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation. In Kuma, P. (Ed.), The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. London: Earthcan, Chapter 1.

Dumax, N., 2009. Les mesures compensatoires: un indicateur du coût environnemental. Ph.D. thesis, Université de Strasbourg.

Dumax, N., Rozan, A., 2011. Using an adapted HEP to assess environmental cost. Ecological Economics 72, 53-59. *DOI:10.1016/j.ecolecon.2011.09.020*

Dumax, N., Rozan, A., 2012. La méthode HEP « adaptée » pour la valorisation des actions bénéfiques en faveur de l'environnement – Année 1, Tech. Rep., ONEMA.

Dumax, N., Rozan, A., 2013. La méthode HEP « adaptée » pour la valorisation des actions bénéfiques en faveur de l'environnement – Année 2, Tech. Rep., ONEMA.

Futsec, E., Lefeuvre, J.-C., 2000. Fonctions et valeurs des zones humides. Paris: Dunod.

Gordon, J., Chapman, R., Blamey, R., 2001. Assessing the Options for the Canberra Water Supply: an Application of Choice Modelling. In J. Bennett and R. Blamey (eds), The Choice Modelling Approach to Environmental Valuation. Cheltenham: Edward Elgar, 73-92.

Gren, I.M., Folke, C., Turner, K. and Batemen, I., 1994. Primary and secondary values of wetland ecosystems. Environmental and Resource Economics, 4 (1), 55–74. *DOI:10.1007/BF00691932*

Haines-Young, R., Potschin, M., 2010. The links between biodiversity, ecosystem services and human well-being. In Raffaelli, D., Frid, C. (Eds.), Ecosystem Ecology: A New Synthesis, BES Ecological Reviews Series. Cambridge: Cambridge University Press.

Haines-Young, R., Potschin, M., Kienast, F., 2012. Indicators of ecosystem service potential at European scales: Mapping marginal changes and trade-offs. Ecological Indicators 21, 39-53. *DOI:10.1016/j.ecolind.2011.09.004*

Hanley, N., Barbier, E.B., 2009. Pricing Nature: Cost-Benefit Analysis and Environmental Policy. Edward Elgar, Cheltenham.

Harrison, P.A., Vandewalle, M., Sukes, M.T., Berry, P.M., Bugter, R., de Bello, F., Feld, C.K., Grandin, U., Harrington, R., Haslett, J.R., Jongman, R.H.G, Luck, G.W., da Silva, P.M., Moora, M., Settele, J., Sousa, J.P., Zobel, M., 2010. Identifying and prioritising services in European terrestrial and freshwater ecosystems. Biodiversity and Conservation 19, 2791-2821. *DOI:10.1007/s10531-010-9789-x*

Huber, J., Zwerina, K., 1996. The Importance of Utility Balance in Efficient Choice Designs. Journal of Marketing Research 33, 307-317.

Kuhfeld, W.F., 2000. Multinomial Logit, discrete choice modelling: An introduction to designing choice experiments, and collecting, processing and analysing choice data with the SAS system. SAS Institute Inc.

Lancaster, K., 1966. A new approach to consumer theory. Journal of Political Economy 74, 132-157.

Lefeuvre, A., 1992. Le plan de protection des forêts rhénanes. Bulletin de la "Société Industrielle de Mulhouse" sur la nature 824, 281-286.

Louviere, J., 1988. Analyzing Individual Decision Making: metric conjoint analysis. Newbury Park: Sage Publications.

McFadden, D., 1974. Conditional logit analysis of qualitative choice behaviour. In P. Zarembka (ed), Frontiers in econometrics. New York: Academic Press, 105-142.

Mission de suivi scientifique du polder d'Erstein, 2004. Synthèse des connaissances à l'état initial. Tech. rep., Voies Navigables de France.

Mission de suivi scientifique du polder d'Erstein, 2009. Synthèse générale : le polder a-t-il retrouvé la fonctionnalité d'une zone alluviale inondable ?. Tech. rep., Voies Navigables de France.

Piégay, H., Pautou, G., Ruffinoni, C., 2003. Les forêts riveraines des cours d'eau : écologie, fonctions et gestion. Tech. rep., Institut pour le développement forestier.

Rulleau, B., Dumax, N., Rozan, A., 2015. Eliciting preferences for wetland services: a way to manage conflicting land uses. Mimeo.

Schmitt, L., Lebeau, M., Trémolières, M., Defraeye, S., Coli, C., Denny, E., 2009. Le "polder" d'Erstein : objectifs, aménagements et retour d'expérience sur cinq ans de fonctionnement et de suivi scientifique environnemental (Rhin, France). Ingénieries Special issue, 67-84.

Turner, K., van den Bergh, J., Söderqvist, T., Barendregt, A., van der Straaten, J., Maltby, E., van Ierland, E., 2000. Ecological-economic analysis of wetland: scientific integration for management and policy. Ecological Economics 35, 7-23. *DOI:10.1016/S0921-8009(00)00164-6*

USFWS, 1980. Habitat Evaluation Procedures. Tech. rep., U.S. Fish and Wildlife Service.

VNF, 2004. Inauguration du Polder d'Erstein - Dossier de presse. Strasbourg: Voies Navigables de France.

Zwerina, K., Huber, J., Kuhfeld, W. F., 2004. A General Method for Constructing Efficient Choice Designs. Tech. rep., SAS Institute Inc.