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The water springs protection on the Vittel impluvium : monetary valuation of environmental and social services and of the impacts on the local economy

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Résumé de la thèse

Le site de production des eaux de Vittel® fait figure de pionnier dans la prise en compte des enjeux environnementaux dans la production d'eau en bouteille. Afin de préserver la qualité des ressources en eau, l'entreprise Nestlé Waters a développé un partenariat avec l'Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE). Les actions entreprises ont des effets bénéfiques sur la biodiversité, les paysages, affectant ainsi le bien-être des populations. Le lien entre le bien-être humain et la qualité de son environnement est formalisé à travers le concept de services écosystémiques (SE).

Ces SE sont parfois mal pris en compte dans les décisions économiques, du fait qu'ils ne soient pas échangés directement sur un marché. La science économique a développé un panel de méthodes d'évaluation dont l'objet est de leur assigner une valeur monétaire. Cela permet de les intégrer à la prise de décision, notamment à travers la mise en place de Paiements pour Services Environnementaux (PSE).

La notion de paiement pourrait nous faire penser que l'évaluation monétaire a un rôle à jouer pour établir la bonne fourniture de services. Mais, habituellement, les paiements sont rarement alignés sur la valeur des services environnementaux, et plutôt établis par négociation. Mais l'évaluation monétaire peut également être utilisée pour évaluer les co-bénéfices de ces programmes. Ces co-bénéfices peuvent représenter une part substantielle des bénéfices totaux. Ne pas les prendre en compte peut conduire à une sous-estimation importante des effets d'une politique.

L'objectif de ce projet de thèse est d'étudier les co-bénéfices du PSE de Vittel. Dans le premier chapitre, j'ai mené un Dicrete Choice Experiment (DCE) pour étudier les préférences de la population locale autour de Vittel : l'idée était de tester différents scénarios d'activités récréatives. Chaque scénario était notamment composé d'attributs liés aux mesures agro-environnementales mises en œuvre sur le bassin versant de Vittel. Les personnes interrogées expriment des préférences pour certaines caractéristiques environnementales, comme la présence d'un cours d'eau ou la non-utilisation de pesticides, qui est une mesure importante du PSE. Dans le chapitre deux, j'ai mis en œuvre un autre DCE qui visait, cette fois, à cibler les non-utilisateurs des ressources en eau. Les résultats ont montré que les préférences pour les attributs environnementaux étaient très hétérogènes. J'ai estimé un modèle à classes latentes avec quatre classes. Les individus des classes 1 et 3 sont prêts à payer un montant important sur la facture d'eau pour interdire les pesticides. Les répondants de la deuxième

classe ont un CAP élevé pour certaines mesures environnementales (interdiction des pesticides, restauration des cours d'eau etc.). Enfin, les personnes regroupées dans la quatrième classe n'avaient que des préférences pour l'interdiction des pesticides et la restauration des cours d'eau.

Dans le troisième chapitre, j'ai réalisé une analyse hédonique sur le département des Vosges. L'objectif était d'évaluer l'influence des différentes utilisations du sol sur les prix des logements. J'ai défini cinq catégories : agriculture, forêts, prairies, zones urbaines et « autres ». Les résultats montrent que les prairies influencent de manière significative les prix des logements, mais sont moins significatifs pour les maisons situées à l'intérieur de l'impluvium de Vittel. Néanmoins, un effet positif de l'agriculture est observé.

Enfin, le dernier chapitre fournit un article relatif aux enquêtes réalisées dans le cadre de la thèse : les deux DCE et une troisième enquête relative aux préférences des touristes en matière de gestion des paysages forestiers et agricoles dans la région de Vittel. Cette dernière enquête complète ce qui a été fait dans les chapitres 1 et 2 pour les populations locales et non-locales.

Summary of the thesis

The Vittel® water production site is a pioneer in taking environmental issues into account in the production of bottled water. In order to preserve the quality of water resources, the company Nestlé Waters has developed a partnership with INRAE. The actions undertaken have beneficial effects on biodiversity and landscapes, thus affecting the well-being of populations. The link between human well-being and the quality of its environment is formalized through the concept of ecosystem services (ES).

These ES are sometimes poorly taken into account in economic decisions, due to the fact that they are not exchanged directly on a market. Researchers in economics have developed a range of evaluation methods whose purpose is to assign them a monetary value. This makes it possibleto integrate them into decision-making, in particular through the implementation of Payments for Environmental Services (PES).

The notion of payment could make us think that monetary evaluation has a role to play in establishing the correct provision of services. But, typically, payments are rarely aligned with the value of environmental services, and rather established through negotiation. Monetary valuation can also be used to assess the co-benefits of these programs. These co-benefits can represent a substantial part of the total benefits. Not taking them into account can lead to a significant underestimation of the effects of a policy.

The objective of this thesis project is to study the co-benefits of Vittel's PES. In the first chapter, I conducted a Discrete Choice Experiment (DCE) to study the preferences of the local population around Vittel: the idea was to test different scenarios of recreational activities. Each scenario was notably composed of attributes linked to the agro-environmental measures implemented on the Vittel watershed. Respondents expressed preferences for certain environmental features, such as the presence of a watercourse or the non-use of pesticides, which is an important measure of the PES. In chapter two, I implemented another DCE, which aimed, this time, at targeting non-users of water resources. The results showed that preferences for environmental attributes were very heterogeneous. I estimated a latent class model with four classes. Individuals in classes 1 and 3 were willing to pay a significant amount on the water bill to ban pesticides. Respondents in the second class had a high WTP for certain environmental measures (ban on pesticides, restoration of waterways, etc.). Finally, people grouped in the fourth class only had positive preferences for banning pesticides and restoring waterways.

In the third chapter, I carried out a hedonic analysis on the Vosges department. The objective was to assess the influence of different land uses on housing prices. I defined five categories: agriculture, forests, grasslands, urban areas and “others”. The results show that meadows significantly influence housing prices, but are less significant for houses located inside the Vittel impluvium. Nevertheless, a positive effect of agriculture is observed. Finally, the last chapter provides an article relating to the surveys carried out as part of the thesis: the two DCEs and a third survey related to the preferences of tourists in terms of management of forest and agricultural landscapes in the Vittel region. This last survey completes what has been done in chapters 1 and 2 for the local and non-local populations.

Résumé long de la thèse

Le site de production des eaux de Vittel® fait figure de pionnier dans la prise en compte des enjeux environnementaux dans la production d'eau en bouteille. Afin de préserver la qualité des ressources en eau, l'entreprise Nestlé Waters a développé un partenariat avec l'Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE). La question (générale) de recherche était alors la suivante: "quels sont les changements à mettre en oeuvre dans l'activité agricole du site de l'impluvium et dans quelles conditions les réaliser, pour réduire le taux des nitrates sous les racines des plantes cultivées et des prairies et pour le maintenir durablement sous le seuil des 10 mg par litre?". S'engage alors, en 1989, le programme de recherche Agriculture Environnement Vittel (AGREV), dont la première phase, AGREV 1 aboutit à la rédaction d'un cahier des charges1 qui définit un certain nombre de nouvelles pratiques, comme par exemple, la suppression de la culture du maïs ou le compostage de l'ensemble des déjections animales. Ce cahier des charges s'inscrit dans le cadre d'un arrangement contractuel (qui prend la forme d'une convention). Le contrat vise alors à internaliser une externalité négative (la pollution de l'eau) en modifiant l'activité principale de production (ici agricole). Internaliser les externalités revient alors à faire intégrer au pollueur le coût de cette pollution dans son raisonnement économique, notamment via ses coûts de production et in fine, via le prix de ses produits. Le service environnemental apparaît alors comme un outil permettant de limiter les externalités négatives en les internalisant. Les services environnementaux sont produits de manière intentionnelle et leur coût de production n'est pas nul pour celui qui le fournit. Il faut donc inciter les producteurs potentiels de services à les produire en les rémunérant. Les actions entreprises ont des effets bénéfiques sur la biodiversité, les paysages etc. affectant ainsi le bien-être des populations. Le lien entre le bien-être humain et la qualité de son environnement est formalisé à travers le concept de services écosystémiques (SE).

Les rapports sur l'état des écosystèmes se sont succédé ces dernières années: tous partagent le constat d'une détérioration des écosystèmes, ainsi que d'un déclin de la biodiversité. Ces rapports pointent également le risque de dépassement d'un seuil, appelé « seuil critique », au-delà duquel la capacité de ces écosystèmes à fournir des services contribuant au bien-être humain serait compromise et ce, alors même que la participation des écosystèmes au bien-être humain est aujourd'hui largement documentée dans la littérature scientifique.

Ces SE sont parfois mal pris en compte dans les décisions économiques, du fait qu'ils ne

soient pas échangés directement sur un marché. La science économique a développé un panel de méthodes d'évaluation dont l'objet est de leur assigner une valeur monétaire. Cette valeur est définie en termes de compromis que les individus sont prêts à accepter entre différentes situations. La valeur d'un bien ou d'un service s'apprécie donc à partir de la quantité maximale d'un autre bien (ou d'une somme d'argent) qu'un individu serait prêt à abandonner ou recevoir en échange d'une amélioration (ou d'une dégradation) du bien ou service considéré. La valeur économique totale (VET) d'un bien environnemental peut alors être décomposée selon une classification standard. Cette classification montre que la VET d'un bien environnemental inclut des valeurs dites "d'usage" et des valeurs dites de "non-usage". Les valeurs d'usage incluent les valeurs d'usage direct du bien environnemental (usage de consommation commerciale ou non, ou d'utilisation non destructrice du bien) et les valeurs d'usage indirect qui découlent notamment de ses fonctions écologiques. Les valeurs de non-usage font référence à la valeur que les individus accordent au bien même s'ils ne l'utilisent pas. Il s'agit des valeurs d'option, liées au bien-être retiré de la conservation d'une possibilité d'usage (ou non usage) futur, des valeurs de legs, liées au bien-être retiré de la transmission d'un bien environnemental aux générations futures et des valeurs d'existence liées au bien-être retiré de la préservation de la valeur intrinsèque de la nature, en dehors de toute considération humaine.

Assigner une valeur à ces services permet de les intégrer à la prise de décision, notamment à travers la mise en place de Paiements pour Services Environnementaux (PSE). Les PSE s'inscrivent dans le cadre du développement d'instruments économiques visant à préserver les écosystèmes: ces derniers constituent l'une des trois grandes familles d'outils de protection de l'environnement, avec les instruments réglementaires de types « command and control » et les instruments d'information. Les concepts de SE et les mécanismes de types PSE ne peuvent être dissociés. Cependant, l'origine des deux notions est distincte: alors que la notion de SE a une portée plutôt analytique, mettant en avant dans la littérature l'idée que les services rendus par la nature ne sont pas suffisamment pris en compte, voire ignorés; le concept de PSE, a, quant à lui une dimension plus opérationnelle, liée à l'efficacité des politiques de conservation dans les pays en développement.

La notion de paiement pourrait nous faire penser que l'évaluation monétaire a un rôle à jouer pour assurer la bonne fourniture de services. Mais, habituellement, les paiements sont rarement alignés sur la valeur des services environnementaux, et plutôt établis par négociation. Mais l'évaluation monétaire peut également être utilisée pour évaluer les co-bénéfices de ces programmes. Ces co-bénéfices peuvent représenter une part substantielle des bénéfices totaux. Ne pas les prendre en compte peut conduire à une sous-estimation

importante des effets d'une politique.

Pour estimer les valeurs liées aux SE, différentes méthodes d'évaluation sont disponibles, souvent classées en deux catégories : les méthodes basées sur les préférences révélées et les méthodes basées sur les préférences déclarées. Les premières consistent à estimer des valeurs non marchandes en observant un comportement réel qui est lié d'une manière ou d'une autre à un bien ou à un attribut environnemental, tandis que les secondes consistent à poser directement aux individus des questions liées à leurs préférences dans le cadre d'une enquête et à déduire des valeurs à partir de leurs réponses déclarées. Dans ce manuscrit, j'utilise à la fois des méthodes de préférences déclarées (Discrete Choice Experiment (DCE) et binary choice question) et révélées (méthode des prix hédoniques). Le DCE appartient à la famille des méthodes des préférences déclarées. Cette méthode a, par le passé, été utilisée pour l'évaluation d'un large ensemble de SE ou pour examiner le choix des agriculteurs d'adopter des pratiques respectueuses de l'environnement.

Dans le premier chapitre, j'ai mené un Dicrete Choice Experiment (DCE) pour étudier les préférences de la population locale autour de Vittel : l'idée était de tester différents scénarios d'activités récréatives. Chaque scénario était notamment composé d'attributs liés aux mesures agro-environnementales mises en œuvre sur le bassin versant de Vittel (absence de pesticides, présence de haies etc.). Compte tenu du fait que l'objectif était de sonder la population locale autour de l'impluvium de Vittel (et de fait des deux municipalités de Vittel et Contrexéville), un périmètre d'un rayon d'environ 15 kilomètres autour de cette zone a été établi, correspondant au bassin de vie de Vittel. Dans ce périmètre, les municipalités (sauf les plus grandes Vittel, Contrexéville et Mirecourt) ont été sélectionnées aléatoirement. L'enquête se divise en trois parties: 1. un recueil de données sur les individus enquêtés: caractéristiques sociodémographiques (âge, diplôme, professions et catégories socioprofessionnelles (PCS), etc.) et attitudes (sensibilité aux enjeux environnementaux, attachement au territoire, etc.) ; 2. des informations détaillées sur les sorties récréatives: fréquence, distance, mode de déplacement, lieu identifié précisément sur carte interactive, etc. ; 3. Une expérimentation par les choix sur les activités récréatives (loisirs) de la population locale (promenade, cueillette, chasse, etc.) et ses préférences vis-à-vis de certaines caractéristiques environnementales et sociales (paysage, biodiversité, etc.) Les personnes interrogées expriment des préférences pour certaines caractéristiques environnementales, comme la présence d'un cours d'eau ou la non-utilisation de pesticides, qui est une mesure importante du PSE.

Dans le chapitre deux, j'ai mis en œuvre un autre DCE qui visait, cette fois, à cibler les non-

utilisateurs des ressources en eau. J'ai inclus les répondants qui vivent à différentes distances de la zone du projet. Les répondants qui vivent loin de la zone du projet ne sont pas censés avoir une valeur d'usage direct mais seulement une valeur de non-usage du projet. Cependant, il a également été démontré dans la littérature qu'il peut exister un effet de la distance sur les valeurs de non-usage. Même si les services environnementaux et sociaux ne profitent pas directement aux individus, ils préfèrent que ces services soient rendus proches de leur lieu de vie. Par conséquent, nous considérerons dans notre analyse les locaux (usagers potentiels) et les non-locaux (non-usagers) vivant à différentes distances de la zone du projet. L'hypothèse à tester est que le CAP des enquêtés diminue à mesure que la distance qui les sépare du bien ou du site auquel ils accordent de la valeur diminue. Les résultats ont montré que les préférences pour les attributs environnementaux étaient très hétérogènes. J'ai estimé un modèle à classes latentes avec quatre classes. Les individus des classes 1 et 3 sont prêts à payer un montant important sur la facture d'eau pour interdire les pesticides. Les répondants de la deuxième classe ont un CAP élevé pour certaines mesures environnementales (interdiction des pesticides, restauration des cours d'eau etc.). Enfin, les personnes regroupées dans la quatrième classe n'avaient que des préférences pour l'interdiction des pesticides et la restauration des cours d'eau. Nous avons également étudié un éventuel effet de la distance sur les préférences des non-utilisateurs en matière d'attributs environnementaux. Cependant, les résultats sont modérés et semblent indiquer que la distance n'a d'importance que pour une petite partie des personnes interrogées (réparties dans la classe 3).

Dans le troisième chapitre, j'ai réalisé une analyse hédonique sur le département des Vosges en utilisant, d'une part les données de la base Perval sur les transactions immobilières, entre 1998 et 2021 (Notaires de France). L'objectif était d'évaluer l'influence des différents usages du sol (en utilisant les données Corine Land Cover pour les années 1990, 2000, 2006, 2012 et 2018) sur les prix des logements (10 801 observations après nettoyage des données). J'ai défini cinq catégories : agriculture, forêts, prairies, zones urbaines et « autres ». Différentes spécifications sont utilisées: d'une part la distance entre les logements et les différents usages du sol; d'autre part la part de chaque usage du sol dans des « zones-tampons » plus ou moins larges (250m, 500m et 1km). Un des objectifs était de vérifier l'hypothèse selon laquelle il pourrait exister un effet de ces usages du sol dans l'impluvium et de comparer avec l'ensemble du département des Vosges. Les résultats montrent, entre autres, que les prairies influencent de manière significative les prix des logements, mais sont moins significatifs pour les maisons situées à l'intérieur de l'impluvium de Vittel. Néanmoins, un effet positif de l'agriculture est observé. Ce chapitre permet de compléter les résultats des deux premiers chapitres (basés sur

une méthode de préférences déclarées) à une échelle différente et avec une méthode de préférences révélées.

Enfin, le dernier chapitre fournit un article relatif aux enquêtes réalisées dans le cadre de la thèse : les deux DCE et une troisième enquête relative aux préférences des touristes (ou excursionnistes) en matière de gestion des paysages forestiers et agricoles dans la région de Vittel. Cette dernière enquête complète ce qui a été fait dans les chapitres 1 et 2 pour les populations locales et non-locales. Elle a été notamment été menée via les lieux touristiques de Vittel et de sa région (comme les offices de tourisme). Elle fournit des informations sur le profil des visiteurs, les raisons de leur visite, les dépenses effectuées dans les commerces, leur conaissance des actions menées par Agrivair sur l'impluvium, et enfin, sur leurs Consentements à Payer (CAP) pour que les actions entreprises continuent d'être menées. Cette enquête répond à l'autre enjeu essentiel de la thèse, à savoir mesurer l'impact sur l'économie locale (commerces, tourisme etc.) des mesures de préservations de la qualité de l'eau et de la biodiversité prises sur l'impluvium. Les bases de données issues de ces enquêtes constituant un des principaux apports de la thèse, elles sont stockées dans un entrepôt de données (https://entrepot.recherche.data.gouv.fr/dataverse.xhtml?alias=PHD-BETA) et accessibles pour des travaux ultérieurs.

L'objectif de ce projet de thèse était d'étudier les co-bénéfices du PSE de Vittel, *i.e.* les bénéfices qui s'ajoutent à la qualité de l'eau. Ce travail s'appuie sur notamment sur différentes enquêtes, réalisées à des échelles variées (autour de l'impluvium de Vittel, mais aussi à une échelle plus large) et auprès de différents publics (population locale autour de l'impluvium de Vittel, touristes de la région etc.). Les résultats montrent que ces différentes populations sont prêtes à payer, à des degrés divers, pour bénéficier des retombées environementales et sociales des mesures prises sur l'impluvium de Vittel. La thèse montre aussi un effet positif sur l'économie locale, notamment via l'activité touristique.

Pour autant, la thèse ne fournit pas d'Analyse Coût-Bénéfices (ACB) du PSE de Vittel. Étant donné que les PSE ont commencé à être mis en œuvre dans les années 1980, cette thèse fournit une sorte de processus d'évaluation ex post d'un programme de PSE particulier. L'évaluation des avantages et des coûts *potentiels* devrait néanmoins être réalisée ex ante afin de prendre des décisions plus éclairées. C'est pourquoi nous pouvons considérer ce travail comme un premier pas vers une évaluation économique plus systématique des programmes de PSE, afin de fournir aux décideurs des outils leur permettant de décider s'ils constituent le meilleur instrument pour la préservation de l'environnement.

Abstracts and keywords of the chapters

Chapitre 1: The Impact of Water Protection Measures in the Vittel Impluvium on Recreational Values: A Choice Experiment with Local Residents

Abstract

Because agriculture jointly provides multiple ecosystem services (ES), actions undertaken for the protection of spring water catchment areas by mineral water companies may produce positive externalities. By implementing environmentally friendly measures in contracting with farmers and forest managers, private water companies do not only create value for themselves and their consumers, but also contribute to the local population welfare with increased level of biodiversity and ES (e.g., recreation and tourism, aesthetic and scenic beauty, cultural heritage) as co-benefits of the protection of water quality. This paper aims at assessing the environmental and social preferences of the local population of Vittel (France) and surroundings, the area where Nestlé Waters produces the natural mineral waters of Vittel®, Contrex® and Hépar®, applying a discrete choice experiment (DCE). We considered "common" recreational areas (i.e., countryside and forest) along with relevant attributes identified in previous studies (e.g., facilities such as picnic tables or information signs, hiking and biking paths) and attributes based on specific measures (e.g., no use of pesticides, presence of hedgerows) implemented by Agrivair, a subsidiary of Nestlé Waters dedicated to the ecological issues in the impluvium. We found that people would prefer to avoid areas with pesticides and even those where they do not know if pesticides are used, for their recreational activities. The preference for hedgerows is shown to be low, sometimes negative, highlighting potential trade-off between biodiversity and recreation activities.

Keywords: Mineral Water Company; Vittel; Water quality protection; Environmental and recreational co-benefits; Discrete Choice Experiment.

Chapitre 2: The non-use value of improving water quality and biodiversity: Preferences for watershed protection measures

Abstract

This paper measures the non-use values of water and biodiversity protection in a watershed in eastern France. It is generally assumed that measures to protect water quality generate direct use values for water consumers, and that the use and non-use values of biodiversity improvement are difficult to disentangle. We conducted a discrete choice experiment with a non-local population to estimate the willingness to pay for restrictions on pesticide and fertilizer use on agricultural land, hedgerow protection and planting, watercourse restoration and sustainable forest management. We first estimate a mixed logit, which shows significant positive preferences for measures that have positive impacts on water quality and biodiversity, but with strong heterogeneity in preferences for the different environmental attributes. An in-depth latent class analysis shows more moderate results. We find that the monetary attribute has a small significant effect for the majority of respondents. While individuals show strong opposition to the status quo and clear preferences for environmental attributes, their marginal WTP is only significantly different from zero for the pesticide ban. While we identify a group of people who are strongly opposed to the environmental project, they are still willing to pay for a pesticide ban, as is the rest of the survey sample.

Keywords: Environmental co-benefits, non-use values (NUVs), distance decay, mixed logit, latent class model.

Chapitre 3: Do payment for environmental services (PES) schemes increase housing prices in rural areas? hedonic pricing of environmental amenities

Abstract

This paper investigates the influence of different land uses on housing prices in the Vosges department. We use the perval database and the corine land cover data to assess land use preferences around houses. Results for the Vosges department are compared to the impluvium area around the Vittel municipality, where a private compagny implements a payment for ecosystem services (PES) scheme to preserve water quality. This PES directly impacts the land use by developping grasslands area, or modifying agricultural landscapes. In this article, we tested boththe effect of distance to various land uses (forest, agriculture, grasslands etc.) as well a the landuse domination in some radius (250m, 500m, 1km) around houses. Using a Poisson model, weshow that grasslands have a positive effect on house prices in les Vosges. In addition, forest areas seem to have a positive influence on prices as well, but only when using the 1km buffer. That may suggests a potential appeal for forest as a recreational area.

Keywords : Hedonic analysis, payment for environmental services, environmental co-benefits

Chapitre 4: Data production on environmental preferences for agri-environmental measures in the Vittel impluvium

Abstract

Implementing measures to preserve the quality of spring water (controlling agricultural uses, restricting the use of pesticides, planting hedgerows, etc.) generates benefits beyond the water resource. Indeed, residents can benefit from landscapes and recreational sites shaped by these measures. Economic valuation techniques make it possible to quantify these co-benefits in monetary terms. Some of these techniques elicit preferences through surveys, such as the discrete choice experiment method (DCE). More globally, surveys are known to be useful in the nonmarket valuation field. This paper presents the data obtained from different survey exercises: two DCEs and a questionnaire distributed to tourists in the Vittel region.

Keywords: Data production, discrete choice experiment, environmental preferences

Content

Remerciements 2

Résumé de la thèse 4

Summary of the thesis 6

Résumé long de la thèse 8

Abstracts and keywords of the chapters 13

Content 17

List of figures 22

List of tables 22

General introduction 24

1. Ecosystem services : a concept between economics and ecology 24
2. From ecosystem services (ES) to payment for environmental services (PES) 25
3. The importance of co-benefits 27
4. Monetary valuation of ecosystem services: a brief history 27
5. Economic valuation of preferences: non-market valuation methods 31
6. Organization of the manuscript 33
7. References 35

Chapitre 1 : The Impact of Water Protection Measures in the Vittel Impluvium on Recreational Values: A Choice Experiment with Local Residents 49

The Impact of Water Protection Measures in the Vittel Impluvium on Recreational Values: A Choice Experiment with Local Residents 50

1. Introduction 51
2. Methodology 55

2.1. Recreation activities and DCE 55

2.2. Study area and experimental design 57

2.3. Survey 62

3. Empirical analysis 64
3.1. The random utility model 64
3.2. Econometric specifications 66
3.3. Descriptive statistics 67
4. Estimation results 71
4.1. Estimation results of the CL model 72
4.2. Estimation results of the MXL model 74
4.3. Estimation of marginal willingness to travel 77
5. Conclusion 80
6. Annex 81
7. References 112
Chapitre 2 The non-use value of improving water quality and biodiversity:Preferences for watershed protection measures 129
The non-use value of improving water quality and biodiversity: Preferences for watershed protection measures 130
1. Introduction 131
2. Methodology 134
2.1. DCE and watershed management 134
2.2. Study area and experimental design 134
3. Empirical Analysis 139
3.1 Econometric Models 139
3.2 Descriptive statistics 139
4. Estimation results 146
4.1. CL and MXL models 146
4.2. Latent class analysis 151
5. Discussion and conclusion 154
6. Annex 157
7. References 171

Chapitre 3 : Do payment for environmental services (PES) schemes increase housing prices in rural areas? hedonic pricing of environmentalamenities 179

Chapitre 3 : Do payment for environmental services (PES) schemes increasehousing prices in rural areas? hedonic pricing of environmental amenities 180

1. Introduction 181

2. Material and method 185

2.1. Analytical framework 185

2.2. Econometric analysis 186

2.2.1. Specification 186

2.2.2. Estimation procedure 188

3. Data description 188

3.1. Case study 188

3.2. Measuring distances to amenities 195

3.3. Computation of buffers 195

3.4. House characteristics 196

4. Analysis of econometric results 196

5. Discussion and conclusion 204

6. Annexes 206

7. References 209

Chapitre 4 : Data production on environmental preferences for agri-environmental measures in the Vittel impluvium 219

Data production on environmental preferences for agri-environmental measuresin the Vittel impluvium 220

1. Presentation of data from a survey of residents' recreational preferences in theVittel region (France) 221

2. Presentation of data from a survey on the estimation of non-use values associated with the implementation of water quality and biodiversity protection measures in the Rupt de Mad watershed (France). 229

3. Presentation of survey data on tourist preferences for forest and agricultural landscape management and impact on the local economy in the Vittel region (France) 236

Acknowledgements 248

4. Annex 249
5. References 256
General conclusion 257
1. Additional work on PES schemes is nedeed 257
2. Objective of the thesis 258
3. Main results 258
4. Limitations and perspectives 261
5. Bibliography 262

List of figures

Figure 1-1: Map of the municipalities included in the sample 63

Figure 1-2: Sample, number of observations and choices 69

Figure 2-1: a) Outline of the Rhine-Meuse Basin (BRM) in blue and b) the Rupt de Mad watershed in red 135

Figure 2-2: Sample, observations and geographical distribution 143

Figure 3-1: “Zones de revitalisation rurale” in les Vosges (source: authors) 135

Figure 4-1: Municipalities selected in the Vittel impluvium 222

Figure 4-2: Distribution of respondents over the French territory 231

List of tables

Table 1-1 : Attributes common to the countryside and the forest 58
Table 1-2 : Attributes specific to the countryside and to the forest 58
Table 1-3 : Choice set example where last visited site was in the countryside 62
Table 1-4 : Sample and randomly selected municipalities 64
Table 1-5 : The recreational activities of the sample of visitors used for the DCE 68
Table 1-6 : Round-trip distances to the recreational site in km (visitor sample) 70
Table 1-7 : Share of "local" visits during the last five years 70
Table 1-8 : Demographic and socio-economic statistics 70
Table 1-9 : Estimation results of the CL model: preferences for recreational attributes 73
Table 1-10 : Estimation results of the MXL model 75
Table 1-11 : Marginal willingness to travel for recreational attributes 77
Table 2-1 : Description of the attributes of the DCE 137
Table 2-2 : Choice set example 139
Table 2-3 : Demographic and socio-economic statistics 144
Table 2-4 : Descriptive summary of DCE results 145
Table 2-5 : Estimation results of the CL and MXL models 147
Table 2-6 : Mean WTP for each attribute by distance category 149
Table 2-7 : Determinants of individuals WTP for each attribute 150
Table 2-8 : Estimation results of the LCM 152
Table 2-9 : Marginal WTP estimates 153
Table 3-1 : Share of rural/urban municipalities in Grand-Est departments 189
Table 3-2 : Evolution of grassland share in the impluvium before PES implementation 191
Table 3-3 : Evolution of land use in les Vosges (2000-2018) 192
Table 3-4 : Descriptive statistics 194
Table 3-5 : Poisson model with distance variables 198
Table 3-6 : Poisson model with share variables (250m) 200
Table 3-7 : Poisson model with share variables (1km) 202
Table 4-1 : Description of the attributes used in the choice experiment 223
Table 4-2 : Respondents municipalities of residence 225
Table 4-3 : Socio-economic characteristics of respondents 226
Table 4-4 : Sensibility of respondents to environmental issues and attachement to the territory 227

Table 4-5 : Descriptive statistics about the visits in the forest or in the countryside 227
Table 4-6 : Socio-economic characteristics of respondents 232
Table 4-7 : Respondents sensitivity to environmental issues 234
Table 4-8 : Attributes and levels proposed in the DCE 235
Table 4-9 : Sample characteristics 238
Table 4-10 : Respondents characteristics (standard deviations between brackets) 239
Table 4-11 : Visits characteristics (standard deviation between brackets) 242
Table 4-12 : Local context knowledge (Standard deviation between brackets) 245
Table 4-13 : Willingness to pay [random amount/person between €0.50 and €10] an additional amount on the restaurant bill? 245
Table 4-14 : willingness to pay [random amount/night/person between €0.5 and €5] an additional amount on the price of a hotel night 246
Table 4-15 : Maximum willingness to pay - tax per person on restaurant bill 246
Table 4-16 : Maximum willingness to pay - tax per person on the price of a hotel night 247

General introduction

1. Ecosystem services : a concept between economics and ecology

Reports on the state of ecosystems have followed one another in recent years (Commissariat général au développement durable, 2020a; IPBES, 2019; TEEB, 2010), all sharing the observation that ecosystems are deteriorating and that biodiversity is declining. These reports also point at the risk of exceeding a « critical » threshold, beyond which the capacity of these ecosystems to provide services contributing to human well-being would be compromised (Commissariat général au développement durable, 2020a; TEEB, 2010; MEA 2005). However, the participation of ecosystems in human well-being is now widely documented in the scientific literature (Hernández-Blanco et *al.* 2022; Wang et *al.* 2021, Costanza et *al.* 1997, among others). However, many topics are still to explore, such as how to better integrate ecosystem valuation in decision-making (Marre et *al.* 2016; Laurans et *al.* 2013) or how to deal with the co-benefits associated with ecosystem management (Le Coent et *al.* 2023).

The *ecosystem service* (ES) concept links human well-being to the quality of the environment, connecting economics (« services ») and ecology (« ecosystems ») (Dufour et *al.* 2016). On the one hand, the term "ecosystem" has been introduced in the literature by the British ecologist A.G. Tansley (1935) after asking the botanist A.R Clapham about a « suitable word to denote the physical and biological components of an environment considered in relation to each other as a unit » (Willis, 1994). On the other hand, the vision of nature as a provider of service goes back at least to the XIXth century (Administration des eaux et forêts, 1808), even if the idea that humans benefit from nature dates back at least to Plato (cited in Serpentié et *al.* 2012 and Daily, 1997). In economics, these services are at the core of three different approaches, each one corresponding to different research fields: ecological economics, environmental economics, and services economics (Aznar, 2002).

a) In the ecological economics approach, environmental services are defined as services provided by nature to human, and not produced by human (Aznar, 2002). This is the definition defended in the seminal paper by Costanza et *al.* (1997). The consequence is that the intentionality of the service is irrelevent here, because humans are not at the origin of its provision (Aznar, 2002).

b) Environmental economics is based on the notion of externalities. A lot of externalities' definitions have been proposed since the apparition of the concept with Sidgwick (1887) and Marshall (1890) at the end of the XIXth century (Grolleau and Salhi, 2009). These definitions have in common the unintentional nature of externalities (Dorfman, 1993; Baumol et Oates, 1988; Catin, 1985; Hill, 1977). Cornes and Sandler (1996) even emphasize that this external effect is "often ignored by the one who generated it". As a consequence, it does not induce any additional production cost from the economic actor at the origin of the externality (Aznar; 2002) and is not subject to any market transaction (Froger et *al.* 2012; Picard; 1998 cited by Mollard, 2003). These market failures may ultimately lead to suboptimal situations (Spash; 2021). "Service-externality" (Aznar et *al.* 2009; Aznar 2002) or "internalization services" (Jeanneaux et *al.* 2011) are then seen as a way to internalize externalities, typically throught payments for environmental sevices (PES) (Hernandez and Benoit, 2011).

c) The services economics (Gadrey, 2000; Delaunay and Gadrey, 1987; Hill, 1977) approach distinguish clearly services from externalities, based on the notion of intentionality (Hill, 1977): externalities are « unsolicited » services. On the contrary, in order to talk about services, the provider must act intentionally and with the agreement of the beneficiary.

Interest of economists, on the one hand, and ecologists and biologists on the other hand, for each others' disciplines is not new, resulting, for instance, in the development of bioeconomic models of fisheries in the 1950's (Schaefer 1957; Scott 1955; Gordon, 1954). The idea of services provided by nature is explicitly mentioned in 1970's[1] with different terms: "environmental services" (SCEP, 1970), "public-services functions of the ecosystem" (Holdren and Ehrlich, 1974), which are close to the notions "public services of the global ecosystem" (Ehrlich et *al.* 1977), "nature's services" (Westman, 1977) and "ecosystem services" (Ehrlich and Ehrlich, 1981). Numerous publications trace back the origin of the notion of ES and its economic roots (Méral, 2016; Froger et *al.* 2015, 2012; Serpentié et *al.* 2012 among others).

2. From ecosystem services (ES) to payment for environmental services (PES)

Pesche et *al.* (2011) indicated that the emergence of ES and PES concepts are clearly distincts. Le Coq et *al.* (2016) date back the developement of the first PES initiatives to the mid-1990s. At this time, PES programs are seen as an alternative to existing tools for conservation, such

[1] It followed early work from Marsh (1864), Osborn (1948), Vogt, (1948) or Leopold (1949). [2] Wunder adjusted its own definition in Wunder (2015).

as Integrated Development and Conservation Projects (IDCP): IDCP were biodiversity conservation projects associated with rural development components (Huges and Flintan, 2001). IDCP worked as indirect incentives: the idea was to change the logic of local production by developping alternative livelihoods that represented a weaker risk for biodiversity, such as agroforestry, weaving or ecotourism (Huges and Flintan, 2001). However, they have been criticized for their complexity, the lack of awareness of local knowledge and practices or a poor objective definition (Brandon, 2001; Ferraro, 2001).

In opposition to indirect incentives, PES schemes appeared as a more efficient way to acheive conservation in the long term (Ferraro and Kiss, 2002; Ferraro, 2001). Three emblematic PES programs started to be implemented in different geographic areas: the Vittel watershed (Perrot-Maitre, 2006), New York (Heal and Chichilnisky, 1998) and the Costa Rica (Le Coq and Saenz Segura, 2016). These PES implementations are often presented as success stories (Laurans et *al.* 2011). The most well-known definition is probably Wunder's one[2] (2005), but plenty of others exist (Wunder, 2015; Sattler and Matzdorf, 2013).

Wunder (2005) define a PES as « a voluntary transaction where a well-defined ES (or a landuse likely to secure that service) is being 'bought' by a (minimum one) ES buyer from a (minimum one) ES provider if and only if the ES provider secures ES provision (conditionality) ». The fact that the definition (and many others) suggests the idea of a payment could make us think that monetary valuation has a role to play to establish the right provision of services. But as Karsenty (2013) puts it « payments are not aligned with the (calculated) value of environmental services, but are established through negotiation and should, in theory, cover at least the opportunity cost of restrictions or changes in use (the net cost of foregoing an activity) ». For example, in the Vittel PES' case, the activity (in the bottled water sector) of a private compagny, Nestlé Waters, was threatened by agricultural diffuse pollution due to intensive agricultural practices. Because of the diffuse character of pollution, individual responsabilities of farmers in water quality were difficult to establish: indeed, natural factors (precipitations, soil quality and so on) can affect the degree of pollution (Depres et *al.* 2008). In addition, all farms were not located at the same distance from the springs, which makes difficult to assess the role of each farm in pollution (Perrot-Maitre, 2006). The result of the bargaining process, described by Depres et *al.* (2008) and Perrot-Maitre (2006) confirmed the idea defended by Karsenty (2013): individual payments are not indexed to the improvement of water quality, but rather on the investments needed and the cost of adoption of new farming practices.

3. The importance of co-benefits

Does this imply that nonmarket valuation is useless in the context of PES implementation ? Actually, monetary valuation can also be used to assess the *co-benefits* of such schemes *i.e* benefits which « accrue as a side effect of targeted policies » (Pearce, 2000). They are also known as secondary benefits, policy spillover effects or ancillary benefits (Pearce, 2000). Assessing these co-benefits is particularly important: they can represent a substantial part of total benefits. Not taking them into account could lead to an important underestimation of the total benefits of a policy (Hérivaux et Grémont, 2019) in cost-benefit analysis, for instance (Le Coent et *al.* 2023). Besides, the population enjoying these benefit is wider than just the local population (Hérivaux and Le Coent, 2021). Ignoring this can lead to underestimate the real number of beneficiaries as well.

4. Monetary valuation of ecosystem services: a brief history

As indicated above, the rise of the ecosystem services' term and the use of monetary valuation methods is closely intertwined with the history of environmental and ecological economics. The rise of environmental economics is indissociable from the independent research organization *Ressources For the Future* (RFF). RFF was founded in 1952 in order to « support the conservation, development, and use of natural resources » (Wichman and Wietelman, 2019). RFF's original research programs were organized around major groups of natural resources, including land, energy and minerals, and water resources (Wichman and Wietelman, 2019). But the history of environmental valuation methods is anterior to the development of RFF: in 1947, ten economists were contacted by the National Park Service (NPS) about a potential assessement of the benefits of national parks in the USA. Almost all of them discouraged such an attempt, because of the difficulty to measure these benefits, especially in monetary terms. However, one of them, Harold Hoteling, accepted the challenge, laying the foundations of the Travel Cost Method (TCM). The results of these investigations were presented by an economist of the land and recreational planning division, Roy A. Prewitt (1949):

« […] it might be better to forget the words "economic value of recreation" and focus attention on the <u>expenditures induced</u> (emphasis, in original). People spend money to be able to enjoy a certain experience (recreation) and there are economic effects arising from the impact of this expenditure upon the economy. It is on this area only that an objective approach can be made toward a solution or an answer to the question of recreational values ».

The NPS finally did not follow up Hoteling's proposal (Hanemann, 2006; Pearce, 2002) but Hoteling efforts were finally rewarded: in 1956, the State of California hired an economic consulting company to estimate recreational benefits associated with a water-related project. This company decided to apply Hotelling's idea: they implemented and conducted a survey, targeting lake visitors in the Sierras, collecting data on how far they had traveled and how much they had spent. Thanks to these data, they were able to establish a demand curve, and to determine consumer's surplus (Hanemann, 2006; Pearce, 2002). Trice and Wood's paper (1958), that mention Hoteling's work, is known as the first published application of the TCM (Banzhaf, 2010; Hanemann, 2006).

Ciriacy-Wantrup (1947), proposed an alternative solution, based on interviews: addressing the issue of soil conservation measures, he realized that these measures induced nonmarket benefits and wanted to derive a demand curve for it: he suggested to ask people their willigness to pay for these benefits (Hanemann, 2006; Pearce 2002). This work (with the one of Bowen (1943)) built the foundations of the Contingent Valuation Method (CVM). The first application was undertaken by Davis (1963). The TCM and the CVM became the first members of the two big families of non-market valuation methods: the Revealed Preference Methods (RPM) and the Stated Preference Methods (SPM). The 1960 and 1970 decades were prosperous times for environmental economists (Méral, 2021) for several reasons: first, the rise of the environmental movement, fighting against ecosystem loss, came with the need of a better understanding of environmental issues and values (White, 1969). This was fuelled by various events and publications, like Rachel Carson's classic book, Silent Spring[2] (Carson, 1962) and the groundbreaking club of Rome report The limits to growth (Meadows et *al.* 1972).

At the same time, Krutilla (1967) and Weisbrod (1964) contributed to the environmental valuation development by defining nonuse and option values. This generated a debate between economists to know if these values should be included in cost-benefit analyses: Rosenthal and Nelson (1992) argued that existence value should not: one of their worries, among others, was the difficulty to capture it accurately. Kopp (1992) directly addressed these criticisms. Weikard (2005) followed Rosenthal and Nelson (1992) views, and went even

[2] Excerpts of the book were published in the *New Yorker* magazine, that contributed to its diffusion. See Tortell (2020).

further, writing that bequest value should not be used to evaluate public projects. He stated that the distinction between use and nonuse values (NUV) is somewhat unclear, and that a bequest value is intrinsically related to some use: « If a good has no actual or potential use for some individual now or in the future, then it does not have a bequest value. Ultimately bequest value must be based on a use value for someone ». This point raises the question of the empirical definition and measurement of NUV. The difficulty is that users of an environmental good can also have a NUV (Marre, 2015). Strategies to target nonusers and NUV are discussed in Marre (2015), Johnston et *al.* (2005) and Cummings and Harrison (1995). The issue is important in environmental economics, as such values may be substantial (Marre, 2015; Kling et *al.* 2012). One of the most striking example results from the *Exxon Valdez* oil spill in 1989 (Kling, 2012): Hausman et *al.* (1995) assessed recreational use value damages due to the black tide and find an estimated value of $3,8 million, while Carson et *al.* (2003), focused on passive use value : the estimation was, this time, much higher: between $4,9 billion and $7,19 billion. In the middle of the 1980's NUV started to be included in the what is called the total economic value (TEV) framework (Méral, 2021; Pearce 2002), that became the classic representation of environmental values in economics.

At the end of the 1980' some authors started to emancipate themselves from the traditional environmental and ressources economics that draws from the neoclassical approach to give birth to ecological economics (EE) (Méral, 2021; Froger et *al.* 2012; van den Bergh, 2001; Costanza, 1989). According to the EE, the economic system at the heart of the neo-classical analysis is just a subsystem of a more global one, the biosphere. The objective in EE is to find metrics and indicators that take in consideration the functionning of that biosphere, in interaction with socio-economic dynamics (Méral, 2021; O'Hara, 2001). As a result, valuation exercises using only market values are considered to be too restrictive (O'Hara, 2001; Odum and Odum, 2000). Berta et *al.* (2021) sum up ecological economists views about values and valuation:

« […] ecological economics has been built on the idea of value pluralism, positing several intrinsic and incommensurable environmental values that cannot be reduced to a common economic one. Environmental economics, on the contrary, quickly assigned price or monetary valuation the decisive role it already played in resources allocation within neoclassical and welfare economics ».

Berta et *al.* (2021), p.18

This citation is quite explicit about ecological economists' worries. They reject this tendency to reduce value to its monetary expression, *i.e* value monism, that can only capture one of the numerous relevant dimensions of nature's value (Söderbaum, 2000; Georgescu-Roegen, 1982). The plural nature of environmental values leads to other critisisms from ecological economists as these values don't necessarily share a common unit of measurement. Nature is seen as *icommensurable* (Funtowicz et *al.* 2002; Martinez-Alier et *al.* 1998) and environmental values may be only weakly comparable (Martinez-Alier et *al.* 1998) and even in conflict with each other (Funtowicz et *al.* 2002; Martinez-Alier et *al.* 1998). Pascual et *al.* (2017) and Gómez-Baggethun and Martín-López (2015) share examples of values that can be considered in valuation processes.

This tendency to use money as a valuation language was not restricted to economists: natural scientists started to adopt the monetary metric, as it was easily understandable for policy makers (Gómez-Baggethun and Martín-López, 2015). In ecological economics, if relations between researchers from natural sciences, such as Costanza, Ehrlich or Jansson and economists existed from the begining (Méral, 2021; Røpke 2004), some ecological economists wanted to preserve their specificities with respect to standard economic analysis.

Spash (2020, 2013) clarified the different existing positions:

First, scholars from natural sciences mainly defended a « New Environmental Pragmatism »: the objective of such an approach is to influence policy makers in order to protect biodiversity and ecosystems. This is the line with authors like Costanza and Daily;

The second one « New Resource Economics », follows neoclassical economic standards, accepting market prices as valid indicators of value. In line with Perrings (2006; 1997), they use mathematical formalism to « understand, model and predict the dynamics of coupled ecological–economic systems » (Perrings, 2006);

Finally, « Social Ecological Economics » is the one that stands out the most openly from economic orthodoxy, linking economics with a range of other disciplines such as philosophy, geography, politics and the natural sciences. As a result, value pluralism is accepted and multi-criteria analysis is necessary. This approach is promoted by Spash (2013).

If Spash classification is a subject of debates (see Lundgren, 2022 and Levrel and Martinet, 2021), the importance taken by the monetary valuation of ecosystem services after Costanza et *al.* (1997) publication is greatly acknowledged (Méral, 2021; Plumecocq, 2014; de Groot

et *al.* 2012), with « new environmental pragmatists » having important responsabilities in that trend (Gómez-Baggethun and Martín-López (2015)). Nevertheless, the opposition against monetary valuation (see Norgaard and Bode, 1998) or even against valuation as a whole remained important: the most famous example is probably Heal (2000), following Vatn and Bromley (1994), who stated that: « Valuation is neither necessary nor sufficient for conservation. We conserve much that we do not value, and do not conserve much that we value ». To be fair, the use of ecosystem services valuation in decision-making is rather limited (Marre et *al.* 2016; Laurans et *al.* 2013). On the other hand (monetary) valuation is defended by authors such as Costanza et *al.* (1998), Daly (1998) and Herendeen (1998). One topic of controversy between supporters and opponents of monetary valuation concerns the issue of nature's commodification *i.e.* the « expansion of market trade to previously non-marketedareas » (Gomez-Baggethun and Ruiz-Pérez, 2011) that could ultimately lead to the privatization or financialization of the environment (Smessaert et *al.* 2020). This sparked a debate on several aspects, including ethical concerns (Martin-Ortega et *al.* 2019; Gomez Baggethun and Ruiz-Pérez, 2011). Some authors see monetary valuation as a *degree* of commodification (Hahn et *al.* 2015) or as a process that can lead to it (Gomez Baggethun and Ruiz Pérez, 2011). However it does not mean that the two terms are equivalent (Costanza et *al.* 2014), as the first is necessary but not sufficient to acheive the second (Gomez-Baggethun and Ruiz Pérez, 2011).

5. Economic valuation of preferences: non-market valuation methods

Environmental and ecological economists tried to adress some of these criticisms, by developping an alternative framework, based on deliberative processes. Deliberative Monetary Valuation (DMV) can be seen as a range of approaches polarized between two archetypes: Deliberated Preferences (DP) and Deliberative Democratic Monetary Valuation (DDMV) (Kenter, 2020; Kenter et *al.* 2016). Kenter et *al.* (2016), describes the former as an adaptation of stated preferences methods to include deliberation processes to enhance individual preferences, while the latter elicit group values. Deliberative exercices based on stated preferences, such as discrete choice experiment, (DCE) can be found in Lliso et *al.* (2020) and Kenter (2016).

DCE fall into the SP methods category, that encompasses many different methods used in various disciplines (Holmes et *al.* 2017; Carson and Louviere, 2011). Ben Akiva et *al.* (2019) retraced the history of SP elicitation starting with Leon Thurstone's paper (1931). Interest in

SP methods originated with the theory of conjoint measurement pioneered by Luce and Tukey (1964) and Luce and Suppes (1965), and was further developed as conjoint analysis by market researchers like Louviere (1988). From a methodological point of view, It led to a semantic debate. Carson and Louviere (2011) tried to define a common nomenclature for SP methods: First, the term « conjoint analysis » (CA) was introduced to the marketing literature by Green and Rao (1971), and refers to the specific method of eliciting preferences derived from conjoint measurement (CM). The latter designates a « formal mathematical theory of ordered relations on sets of attribute levels that allowed one to identify and test various algebraic functional forms of decision rules » (Carson and Louvière, 2011). Therefore CM is not a behavioral theory of choice and do not rely on error theory, unlike random utility theory (RUT), that underpine DCE (Louvière et *al.* 2010). Carson and Louviere (2011) proposed the name « discrete choice experiment » to distinguish this method from other elicitation techniques, sometimes used in other disciplines. RUT was first developped by Thurstone (1927) and applied to econometrics by McFadden (1974), who developped the *conditional logit model* (CLM). CLM exhibits independence from irrelevant alternatives (IIA) (Ben-Akiva et *al.* (2019); Holmes et *al.* (2017)). This property states that the ratio of choice probabilities between two alternatives in a choice set is unaffected by other alternatives in the choice set. While this hypothesis might be relevant in some cases, it is not always the case, as pointed out by Chipman (1960) and Debreu (1960). Besides, with the CLM, parameters are assumed to be identical across respondents, *i.e.* respondents have homogeneous preferences (Hernandez and da Costa, 2022; Amiri et *al.* 2022).

To overcome these limitations, other models were developped: unlike the CLM, the mixed logit model (MLM) is based on the assumption that parameters are randomly distributed in the population. Then, preferences heterogeneity can be captured by estimating the mean and variance of the random parameter distributions (Holmes et *al.* 2017). While the CLM lack of correlation between alternatives consistent with the IIA property, the MLM allow for correlations among the stochastic part of utility. As a result MLM does not exhibit IIA (Holmes et *al.* 2017; Train, 2009). Train (2009), provides a detailled presentation of the MLM.

The MLM is not the only model to move away from the IAA assumption. The latent class model (LCM) offers an other alternative: in the LCM, individuals are sorted into a set of classes: the class assignment is unknown from the researcher (Greene and Hensher, 2003). One issue with the LCM is the number of classes: one common solution to choose is to use information criterias such as the Bayesian information criterion (BIC) and consistent Akaike

information criterion (CAIC) (Pacifico and Woo, 2013). Weller et *al.* (2020) remind us that there is no consensus about the best criteria to be used. Besides, interpratibility of the results has to be taken into account as well.

DCE is now widely used in environmental valuation. However, they (and stated preference methods in general) have historically faced some criticisms[3]: one of the main criticisms is associated to the possible *hypothetical biais* resulting from DCE : this biais can be defined as the difference between stated, hypothetical behaviour and actual behaviour in real markets (Haghani et *al.* 2021; Wuepper et *al.* 2019). Hopefully, DCE practicioners have developped tools to mitigate it, like cheap talk or consequentiality scripts (Wuepper et *al.* 2019).

Alternatively, reaserchers who want to avoid SP methods can rely on RP ones: this time preferences are not investigated through surveys. Preference elicitation comes from observing an actual behavior that is linked in some way to an environmental good: for example, the hedonic price method (HPM) often consider the housing market (Taylor, 2017). The choice of housing may depend on neighborhood amenities, in addition to house characteristics (the landscape for example: see Legras, 2016). Implicit prices for amenities of interest are therefore revealed through observable market transactions. Of course, as a consequence, one of the limits of this method is that, because it relies on housing transaction data, the HPM can only capture use values. On the contrary SP methods can be helpful to assess both use and nonuse values.

In the literature, some studies have compared SP and RP (Matos et *al.* 2013; Adamowicz et *al.* 1994), and, in particular DCE and HPM (Phaneuf et *al.* 2013). In this thesis, we follow this path, using both DCE and HPM to investigate environmental preferences. More specifically, the objective of this manuscript is to use various nonmarket valuation methods to value the co-benefits of the PSE scheme implemented on the Vittel watershed.

6. Organization of the manuscript

The manuscript is organized as follow: the first chapter aims at investigating the preferences of the local population around Vittel in term of agri-environmental measures: using a DCE, we asked respondents to choose between different recreational sites. The objective of this first

[3] Others limitations include the *cognitive burden* associated with an heavy cognitive process when responding the DCE.

chapter is to specifically investigate use values of the local population for environmental characteristics, that are similar to the one implemented in the Vittel PSE.

The second chapter uses the same method as the first, a DCE, but with a specific focus on nonuse values *i.e* the value individuals place on an environmental good even if they don't actually use or come in contact with it, or expect to do it in the future (Segerson, 2017; Crowards, 1997). The first two chapters allow us to estimate the two components of the TEV: use values and nonuse values.

The third chapter is an application of the HPM on the Vosges departement. We used data from the Perval database that identify housing transactions from 1998 to 2021. To investigate what land use characteristics could impact house prices, we used the corine land cover (CLC) database that gives us the variation of land uses in the department for different periods (1990, 2000, 2006, 2012, 2018). We also look at the impact of different land uses on house prices in the Vittel watershed, to compare the trend with the rest of the department. This paper provides an alternative to SP methods.

The fourth and last chapter concerns data production describing the different databases constructed during the thesis project and giving dome descriptive statistics. These databases represent one of the main outputs of the PhD and this paper is a way to enhance this data.

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Chapitre 1 : The Impact of Water Protection Measures in the Vittel Impluvium on Recreational Values: A Choice Experiment with Local Residents

The Impact of Water Protection Measures in the Vittel Impluvium on Recreational Values: A Choice Experiment with Local Residents

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1. Introduction

Nestlé waters is the world leader in the sector of bottled water. In France, eight brands of mineral natural or spring waters are distributed by Nestlé Waters (Perrier®/Perrier Fines Bulles®, Vittel®, Hépar®, Contrex®, S. Pellegrino®, Nestlé Pure Life® and Acqua Panna®). Among these brands, Vittel® is probably one the most emblematic; and the brand name has always been "*strongly associated with images of health and vitality*" (Perrot-Maître 2006). The water springs are located on a watershed, called the Vittel impluvium,[4] which covers more than 10 000 ha. (Hellec, 2015; Frogneux and Benoît, 2019). More than the half of the land is used for the agricultural activity (Hellec, 2013; Frogneux and Benoît, 2019) and the forest surface represents 22% of the watershed (Frogneux and Benoît, 2019).

In 1988, the production unit of Vittel noticed a "*deterioration in the quality of its mineral water, a slow but notably significant increase in nitrates*". (Déprés *et al*., 2005). The main cause was identified as "n*onpoint source pollution from intensive farming practised in the fields surrounding the Vittel springs*" (Déprés *et al.*, 2005). One of the reasons of that pollution was identified as the production of corn, which is considered as an important factor in nitrate increase in groundwater (Deffontaines and Brossier, 1997; Perrot-Maître and Davis, 2001).

To address this problem, several alternatives were available to Nestlé Waters (see Déprés *et al*. 2005 for the details). One of these alternatives consisted in achieving contractual arrangement with farmers. After a collaboration between the French National Institute of Agronomic Research (INRA), Agrivair (a subsidiary of Nestlé Waters dedicated to these ecological issues), and local farmers, some concrete measures were adopted to guarantee the water quality: cessation of corn culture, composting of animal waste, etc. By doing so, the Vittel case became the "*first recognized initiative*" of Payment for Environmental Services (PES) in France (Hernandez and Benoit, 2011). The originality is that the PES scheme is supported by a private actor, Nestlé Waters-Agrivair and corresponds to a situation where direct payments by service beneficiaries are made to service providers, in which both providers and beneficiaries are private entities (Greiber, 2011). OECD (2005) and Perrot-Maître (2010) share the same conclusion: "*in the presence of market failure, private transactions and voluntary approaches are more efficient, effective, equitable and sustainable than government approaches and need to be encouraged*" (Perrot-Maître, 2010). If

[4] Since ancient Roman times, the impluvium is the area in which rainwater is infiltrated.

traditionally, market failures justify public intervention, Coase (1960) stated that these private arrangements might lead to an efficient solution when dealing with environmental issues, if transaction costs are sufficiently low (see Déprés et *al.* (2008) for a discussion about the transaction costs' issue in the Vittel case). Accordingly, "Coasean" PES (Diswandi, 2017; Wunder et *al.* 2020; Bingham, 2021) correspond to "those that emerge from contractual transactions between private actors (i.e., providers and users of a service) in the absence of overt government intervention" (Bingham, 2021). Thompson (2021), detailed characteristics of such schemes, also called "user-financed" or "privately-funded" PES (Bingham 2021; Ezzine-de-Blas, 2016) and Ezzine-de-Blas (2016) gave some examples. If the Vittel arrangement is often cited as a real-world application of the Coase theorem (Déprés et *al.* 2005, 2008; Engel, 2016; Karsenty, 2017, Deryugina, 2021). Bingham (2021), argue that it cannot be called "perfectly Coasean" because the bargaining process constitutes a substantial departure from the theory. Besides, he conceded that user-financed agri-environmental watershed PES, as the Vittel Case, remain rare, and review cases that share similar aspects, but has also distinctive characteristics. Among them, The Volvic watershed management program offers an interesting comparison point (and contrast) with Vittel, still involving a private company, (Danone) but adopting a different approach (Chevrier et *al.* 2017; Trémolet et *al.* 2019). More generally, if private sector experiences in land reclamation and ecosystem recovery are more and more frequent (see Mulongoy and Fry, 2016), The scarcity of empirical case studies of Coasean PES is at odds with the importance of the theorem in the neoclassical and institutional economics, which the PES relies on (Bingham, 2021; Hecken and Bastiaensen, 2010).

According to the United Nations Economic Commission for Europe (UNECE, 2007) "*Economic analysis is an essential tool for efficient decision-making regarding the establishment of PES schemes. It provides a coherent framework that allows a comparison of the costs and benefits of changes in water-related ecosystem services in an integrated manner*". These benefits are larger than water quality preservation (Hérivaux and Grémont, 2015, 2019; Hérivaux and Maréchal, 2019) and the attention about co-benefits that results from PES schemes is rising (Leonardi *et al*. 2018). One of the reasons for that is that they enforce the acceptability and effectiveness of the overall scheme (Leonardi *et al*. 2018). These benefits can be observed at a local or a global level, and in some cases, "*a local activity has national or global implications*" (Lipper *et al*. 2009). Identifying these benefits is therefore an important issue.

For example, in the case of Vittel, according to Perrot-Maître (2010), "*the impairment of the water quality would have eventually led to the closing down the natural mineral water business in the region that would also have affected the economy",* including local farmers, employment and more global economic activity. The development of the local biodiversity is another good example of a positive externality: "[…] *successful PES schemes re-enforce the multifunctional role of ecosystems (through co-benefits) and highlight the economic and social benefit, which increase the acceptability and effectiveness of the overall scheme*". In the case of Vittel, "*measures specifically targeting biodiversity protection were also supported by Nestlé, insofar as these were functional to the realisation of the core objective of sustainable farming practices to maintain high-quality mineral drinking water*" (Dupuis and Vinuales, 2013). The economic literature that aims at valuing marginal benefits of ES that results from particular management actions or policy interventions (Christie and Rayment, 2012; Bateman et *al.* 2013), such as watershed management practices (Garcia- Llorente et *al.* 2012; Clarke et *al.* 2015; Castro et *al.* 2016a, 2016b), is growing. In the context of optimal watershed management, Dixon (1987, 2000) discussed the role of economists in a multidisciplinary approach, arguing that the monetary value of environmental benefits (and costs) of these management practices should be included within the analysis (Valatin et *al.* 2022). Accordingly, valuation papers often try to assign a monetary value to ES related to watershed management (Garcia-Llorente et *al.* 2012; Clarke et *al.* 2015; Castro et *al.* 2016b). In the literature, the concept of ES has numerous definitions. A major difference between these definitions lies in the existing relation between "services" and "benefits" (Nahlik et *al.* 2012). Some authors assume that the two notions are equivalent (Costanza et *al.* 1997; MEA, 2003; Harrington et *al.* 2010), while, for others (Boyd and Banzhaf, 2007; Fisher et *al.* 2009) benefits and services are distinct, the latter representing the point where human well-being "is directly affected" (Fisher et *al.* 2009), often by combination of ecological processes of an ecosystem and of other forms of capital or resources (Boyd and Banzhaf, 2007; Fisher et *al.* 2009; Lamarque et *al.* 2011; INRA, 2017). Following the first approach, recreation is a cultural ES, *i.e.,* a "nonmaterial benefit obtained from ecosystems" (MEA, 2003). Considering the second framework, recreation is *only* a benefit, jointly produced (Fisher et *al.* 2009) with water quality preservation, through more environmental friendly practices. Because outdoor recreation partially rely on the characteristics of the natural environment (alongside with others forms of capital), considering recreational activities is also a mean to estimate the value people give to some of its components, such as biodiversity or landscapes.

In order to give a value to the environmental and social benefits jointly provided with the preservation of water quality, we propose to use a discrete choice experiment (DCE). This method, "*generally considered as* […] appropriate […] *for the valuation of multi-attribute nonmarket goods*" (Tu *et al*., 2016), is based on the idea that any environmental good can be described in terms of attributes, and in terms of levels these attributes can take (Hanley *et al*., 2001; Birol and Koundouri, 2008).

We test various scenarios of recreational activities considering diversity of landscapes (*i.e*., countryside and forest) and thus different recreational sites. We made that distinction between forest and the countryside for at least two reasons. First, forest and agricultural lands cover a majority of the impluvium. Second, both are common settings for recreation. While most of attributes are common to both scenarios, some are also specific to the forest and others to the countryside.

The other originality of our study is that, besides "classical" attributes characterising the recreation location choice such as recreation facilities (*e.g*., picnic tables, bins, information signs) or marked hiking and biking trails, we specifically test attributes related to the different measures set up by Agrivair, such as absence of pesticide use, less intensive livestock production, less cereal cultivation with the introduction of crop rotation,[5] hedgerows planting in fields, water course maintenance. The absence of pesticides for protecting water springs are perceived by recreational users as a cleaner air. The reduction of livestock and cereal fields imply land use changes and thus landscape changes while hedgerows and mixed tree species in forests are specifically described as habitats for biodiversity. This design of DCE makes it possible to estimate the willingness to pay (WTP) for these different environmental and social attributes in order to elicit their different use values and to study the relationships between users' recreational preferences and the water company environmental objectives.

Furthermore, for some attributes, *e.g*., pesticides, people are not aware about their presence or not. Hence, we test whether this information issue has an impact on their choice of recreational site.

This paper is organised as follows: in the next section, we present our methodology by describing the literature related to recreation activities and DCE, the experimental design, and

[5] From the beginning of contractualisation between Agrivair and farmers, the suppression of maize cultivation was part of the good agricultural practices.

the survey carried out in region of Vittel in France. In section 3, we present the empirical application. In section 4, we detail the estimation results. Section 5 concludes the paper.

2. Methodology

2.1. Recreation activities and DCE

Nonmarket valuation, as based on individual choices and preferences underlying those choices, is one (but not the only) way that researchers and practitioners have sought to define and measure the values that individuals assign to environmental goods and services. Standard economic theory defines value in terms of the trade-offs that individuals are willing to make between different situations. The value of a good or a service, estimated as the variation of its quantity (or the improvement or a degradation of its quality in a case of environment and natural resources), is the maximum amount of another good that an individual would be willing to give up in exchange of an improvement of that is being valued.

We apply a stated preference approach, *i.e.*, DCE where the respondents reveal their preferences by choosing between different alternatives. According to Holmes *et al.* (2017), "*there has been an explosion of interest*" in DCE during the past two decades. The method began to be applied in the early 80's (Da Costa and Hernandez, 2019) with the works of Louviere and Hensher (1983, 1989), and Louviere and Woodworth (1983). DCE progressively became more popular than any other environmental valuation methods (Guijarro and Tsinaslanidis, 2020) including contingent valuation (Mahieu *et al.* 2014; Guijarro and Tsinaslanidis, 2020). The paper that "*generated attention in the environmental economics community*" (Carson and Czajkowski, 2014) was the one of Adamowicz *et al*. (1994), who used both a DCE and revealed preference data about recreational trip destinations to value environmental amenities.

Since then, the DCE technique had been used in ES valuation, including recreation (Boxall and Macnab, 2000; Christie et *al.* 2007; Hasan-Basri et *al.* 2015). Extensive farming systems can favour recreation and generate many positive externalities and has oven been evaluated by stated preference methods (Novikova, 2014). DCE have been suitable to investigate preferences for agricultural landscapes characteristics (Grammatikopoulou et *al.* 2012; Häfner et *al.* 2018; Schaak and Musshoff, 2020). DCE has also shown to be useful to understand farmers' decisions, such as the choice to adopt environmentally friendly practices (Chèze *et al.* 2018) or agricultural production technologies (Jaeck and Lifran 2012).

In this paper, we implement a DCE to estimate the use values associated with different attributes of recreational activities for the local population around the Vittel impluvium. We use choices of recreational sites to collect information about respondents' preferences for recreational activities according to some relevant attributes already identified in previous studies (*e.g.*, facilities such as picnic tables or information signs, hiking paths, see *e.g.*, Abildtrup et *al.* 2013) and attributes based on specific measures implemented by Agrivair *(e.g.*, no use of pesticides, hedgerows planting). We consider two types of recreational sites: the countryside and the forest. Respondents are asked to choose between two hypothetical sites, one referring to the countryside and the other one referring to the forest, and a status-quo alternative, which is the last visited forest or countryside. Before the experimental part of the survey, the respondents had to indicate if their last visit was in a forest or in the countryside, and to describe the site based on the attributes considered in the DCE. Previous studies suggest that the decision of using labelled or unlabelled alternatives is important (Jin et *al.* 2017; Hensher et *al.* 2015; Doherty et *al.* 2011; Blamey et *al.* 2000). Both labelled and unlabelled DCE present advantages and disadvantages (Chakir et *al.* 2016; Blamey et *al.* 2000). In a recreation site choice context, one of the main advantage of using labels is that it helps reflecting better the "emotional context" (Blamey et *al.* 2000) in which the decision choice occurs, making the choice situation more realistic (Kruijshaar et *al.* 2009; de Bekker-Grob et *al.* 2010). For example, in recreation studies, an individual can have a predisposition to favour a site because of (good) memories from a past visit (Blamey et *al.* 2000). Besides, the label itself conveys information (de Bekker-Grob et *al.* 2010; Blamey et *al.* 2000), and these labels may be used by respondents as a way to infer information that they perceive as missing (de Bekker-Grob et *al.* 2010). On the other hand, individuals sometimes largely, or even only, rely on the name of the alternative when making a choice (Doherty et *al.* 2011, Müller et *al.* 2020). Nevertheless, Doherty et *al.* (2011) argue that it does not disqualify labelled DCE as they are likely to be "the correct mechanism to model realistic choices". The choice between labelled and unlabelled DCE ultimately depends on the research question, on the type of respondents (de Bekker-Grob et *al.* 2010) and on the objective of the study (Blamey et *al.* 2000). Because the first option present several advantages in recreational site choice studies (Blamey et *al.* 2000; Doherty et *al.* 2011), we chose to use three labelled alternatives: the "last forest or countryside visited" scenario (*i.e.*, the status quo), the "(hypothetical) countryside" scenario, and the "(hypothetical) forest" scenario.

2.2. Study area and experimental design

We may expect the local population to derive value from the Vittel impluvium as a recreational site for several reasons. First, forests (Hummel 1992, Lindhagen 1996, Roovers et *al.* 2002) and the countryside (Goossen and Langers 2000; De Vries et *al.* 2007) are generally popular places for recreation in Europe, and France is not an exception (Peyron et *al.* 2002). The impluvium is located in a rural area with a non-negligible forest surface,[6] which is largely appreciated by local residents as a recreational site. Secondly, at the local level (in Lorraine), forest frequentation is historically more important than, on average, in the rest of France (Abildtrup et *al.* 2012). Concerning rural areas, the inhabitants can benefit from a preserved natural environment, with six natural parks in the Grand Est region,[8] which are appreciated by residents (Tardieu and Tuffery, 2019; INSEE, 2010) and share common characteristics with the Vittel impluvium in terms of land cover (Tardieu et Tuffery, 2019) and recreational facilities.[7]

A literature review was the first step to select the relevant attributes. Because the Vittel case is known as the first example of PES in France (Hernandez and Benoit, 2011), the scientific literature on that case is quite important (see Perrot-Maître, 2006, Chia and Raulet Croset, 1994, among others). These papers help to identify the services jointly produced by water protection measures, like the preservation of biodiversity or landscape quality. Moreover, the existing literature on DCE for recreational activities gave us some inspiration to think about the levels to consider in our study (Carson *et al.* 1990, Boxall *et al.*, 1996, Bateman *et al.*, 2003 and Christie *et al.*, 2007).

The following tables present the eight attributes selected in our DCE and the attribute levels. Some of the selected attributes are common to the forest and to the countryside (Table 1.1); some others are specific either to the countryside or to the forest (Table 1.2).

[6] Nestlé Waters' private forest is located near the city of Vittel, at the heart of the catchment basin that encompasses some 10,000 hectares, approximately 25% of which are covered with forest. [8] https://www.pnr-lorraine.com/comprendre/le-parc/les-parcs-naturels-de-la-region-grand-est/

[7] https://www.meusetourism.com/en/take-a-deep-breath/the-lorraine-regional-country-park.html

Attribute	Level	Meaning
Facilities		Presence of picnic tables, bins, information signs, etc.
		Absence of picnic tables, bins, information signs, etc.
Marked hiking and biking trails		Presence of marked hiking and biking trails
		Absence of marked hiking and biking trails
Water streams		Presence of water streams
		Absence of water streams
Pesticides		Use of pesticides
		Non use of pesticides
Distance	From 1 to 70 km	Two-ways distance from the residence to the recreational site. The greater the distance to be covered, the higher the cost.

Table 1-1 : Attributes common to the countryside and the forest

Countryside specific attribute	Level	Meaning
Hedgerows and biodiversity		Absence of hedgerows
		Low presence of hedgerows and biodiversity
		High presence of hedgerows and biodiversity
Agricultural land use		Breeding (visible livestock)
		Growing (e.g., wheat, maize)
		Grassland
		Mixed agricultural land use
Forest specific attribute	**Level**	**Meaning**
Tree species		Forest composed exclusively of coniferous trees (e.g., pines, firs)
		Forest composed exclusively of deciduous trees (e.g., oak, beech)
		Mixed forest (deciduous and coniferous)

Table 1-2 : Attributes specific to the countryside and to the forest

In order to see if the chosen attributes and levels were relevant and the questionnaire understandable for members of the local population, two focus groups were organized, on June 3, 2019. These sessions included a presentation of the survey, the completion of the questionnaire, a session with questions, comments and suggestions from the respondents and finally the participants had to write on a paper what was the attribute they appreciate the most during a recent recreational trip in the area.

One session took place during the morning, the other during the afternoon with six people in each group. Among the 12 respondents, all were local residents, six worked for Agrivair, three for Nestlé Waters, and the others were farmers or peasants. Based on comments and discussion with the participants, we were able to make some modifications (on form and substance) in order to make the questionnaire as clear and as relevant as possible.

Notably, we made some modifications of the attributes levels and how they were presented. For example, considering the fact that corn cultivation has a negative impact on water quality, we first chose to include a corn attribute in the design. However, during the focus-group period, some respondents argued that looking only at this particular culture was too restrictive. Consequently, we decided to include other forms of agricultural land use, like the presence of livestock or grasslands.

Regarding the number of attribute levels, half of the attributes (*i.e.*, facilities, marked hiking and biking trails, water streams, and pesticides) are binary. These attributes correspond to the presence or the absence of the attribute on the recreational site. We chose to use more levels for three attributes, considering their complexity (*i.e.,* hedgerows and biodiversity, agricultural land use, and tree species). The first two are specific to the countryside, the last one only concerns the forest:

Finally the distance attribute has eight modalities: 1, 5, 10, 15, 25, 35, 50 or 70 km. The information collected about the distance that people accept to travel will be used to estimate the monetary value they give to the attributes by converting travel distance to travel costs. We chose to use the round-trip distance that respondents travel to go to a recreational site as an indirect monetary attribute. This procedure has several advantages: first, not using a direct monetary attribute reinforces the realism of the choice situations, as individuals are not always used to pay to have access to a recreational site (Rulleau et *al.* 2010). Moreover, the distance is seen as an important attribute that can strongly influences people decision when choosing

a recreational site (Agimass et *al.* 2018). Finally, a monetary value can still be derived from the distance attribute afterwards (Hanley et *al.* 2002).

Researchers use an experimental design "*to map attributes and levels into sets of alternatives to which respondents indicate their choices*" (Johnson *et al.* 2013). The design aims at isolating the effects of individual attributes on the choices (Hanley *et al.* 1998). "*Efficient experimental designs maximize the precision of estimated choice-model parameters for a given number of choice questions*" (Johnson *et al.* 2013). In our case, we generated 24 choice sets, which were allocated to three blocks with eight choice sets to reduce the number of choices per respondent. An efficient statistical design was estimated applying NGENE (ChoiceMetrics 2014). We used the literature and focus groups to define expected effect (signs) of the different attributes.

Each choice set was composed of three alternatives: a status-quo option, a "forest" alternative and a "countryside" one. Including a status-quo alternative in DCE is generally recommended (Penn et *al.* 2019; Marsh et *al.* 2011; Hensher, 2010; Adamowicz and Boxall, 2001) for various reasons, such as making choice tasks more realistic or avoiding forced choices that can lead to biased welfare estimates. Different possibilities, presented by Hess and Rose (2009), are offered to researchers when they decide to propose such an option. One of them is to include one alternative (or more) describing respondents recent experience with the good of interest (Hess and Rose, 2009). Several studies illustrated this case where the alternative is respondents-specific (Banzhaf et *al.* 2002; Hensher and Greene, 2003; Hensher, 2004; Birol et *al.* 2009; Barton and Bergland, 2010; Tu et *al.* 2016; Glenk 2011), and more specifically for the assessment of recreation preferences (Banzhaf et *al.* 2002; Tu and Abildtrup, 2016). We used an experienced status quo that allows to reduce the hypothetical character of choice sets, by making it more familiar and realistic (Bradley 1988; Glenk, 2011; Haghani et *al.* 2021). In a valuation context, familiarity with the environmental good is known to be a good predictor of response reliability (Loomis and Ekstrand, 1998). Using respondents' knowledge to construct alternatives raises the question of the level of information available to respondents about the good to be valued.[8]

[8] This issue has been addressed by the information economics literature: Nelson (1970, 1974) and Darby and Karni (1973) set up the "Search, Experience, Credence" (SEC) classification framework, based on the availability of information (about the products and services) to consumers.

Information is an important issue in recreation site choices: information levels, sources (and therefore credibility) and timing but also the ability of an individual to use this information are key factors (Pigram and Jenkins, 2006)[9]. However, because respondents do not always have all the information when they select a recreational site (see Adamowicz et *al.* 1997), stated preference survey instruments have to be designed to consider uncertainty. Methods available to do so had first been discussed in the contingent valuation field, as Arrow et *al.* (1993) recommended to include a "no-answer" option in such surveys (Haab and McConnell, 2002). Different possibilities are offered to researchers in order to deal with uncertainty : the inclusion of a "don't know" or a "not sure" options (as an alternative to yes or no answers) or the use of a certainty scale in follow-up questions are common solutions (Samnaliev et *al.* 2006; Balcombe and Fraser 2009). Some authors decided to use both (Samnaliev et *al.* 2006; Whitehead and Cherry, 2007). However, Balcombe and Fraser (2009) indicated that "don't know" options are quite rare in DCE. Exceptions can be found in MacDonald et *al.* 2005; Balcombe and Fraser 2009; Tu and Abildtrup 2016). In our DCE design, we chose to include it within our respondent-specific status quo, as a level by letting the respondent indicate if not knowing the attribute level of the specific site visited the last time.

In our study, the status quo is based on information about the last visit made by the respondents in a forest or in the countryside during the last 12 months (or during the last five years if no visits have been made last year) with a recreational goal. If the respondents did have no recreational trips during the last five years, they did not answer to the DCE. The two others alternatives are generated on a hypothetical basis, but with the same attributes. Table 1.3 shows an example of a choice set. Each attribute is illustrated with a pictogram, even in the status-quo alternative. The choice of using monochrome pictograms and not photos was motivated by the desire to not influence the answers.

[9] The treatment of that information is made through a complex process called "cognition" that involves "acquisition, coding, storage, recall and manipulation of information" (Walmsley, 2003). Two sorts of knowledge derives from that cognition process: "figurative knowledge", resulting from direct contact with a situation or a good (with a recreational site for example) and operative knowledge, coming from known situations to infer knowledge about situations yet to be experienced (Walmsley, 2003). More specifically, the link between the information available to an individual and his/her recreation behaviour has been addressed since the late 70's (Aldskogius, 1977; Lime and Lucas, 1977; Schreyer et al. 1984).

Please select one of the scenarios (at the bottom of the page, under the table) as if you had the choice before your last visit between these three options.			
Attributes	Last visited forest or countryside scenario (status quo)	Countryside scenario	Forest scenario
Facilities			
Marked hiking and biking trails			
Water streams			
Pesticides			
Agricultural land use			
Tree species			
Hedgerows and biodiversity			
Distance	22 km	15 km	20 km

Your choice : ◯ ◯ ◯

Table 1-3 : Choice set example where last visited site was in the countryside

2.3. Survey

This step concerns the practical implementation of the survey. The first issues are sampling and the geographical targeting. Considering the fact that the aim was to survey the local population around the two municipalities Vittel and Contrexéville, we established a perimeter of 15 kilometres, corresponding to the Vittel life area. In that perimeter, municipalities (except

the largest ones, *i.e.*, Vittel, Contrexéville and Mirecourt), were randomly selected[10], see Figure 1.1. The following step was to establish a rule to construct a 600 household's sample: we chose to survey 5% of the households in the three largest municipalities (in red in Figure 1.1) and 10% in the others (in yellow) (see Table 1.4). Originally, 13 municipalities and 624 households were included in the sample. Because of the containment linked to the coronavirus pandemic, we were only able to survey 588 respondents. Figure 1.1 shows the municipalities that belong to the sample, and the sites that respondents visited for a recreational purpose during the last five years (inside and outside the impluvium).

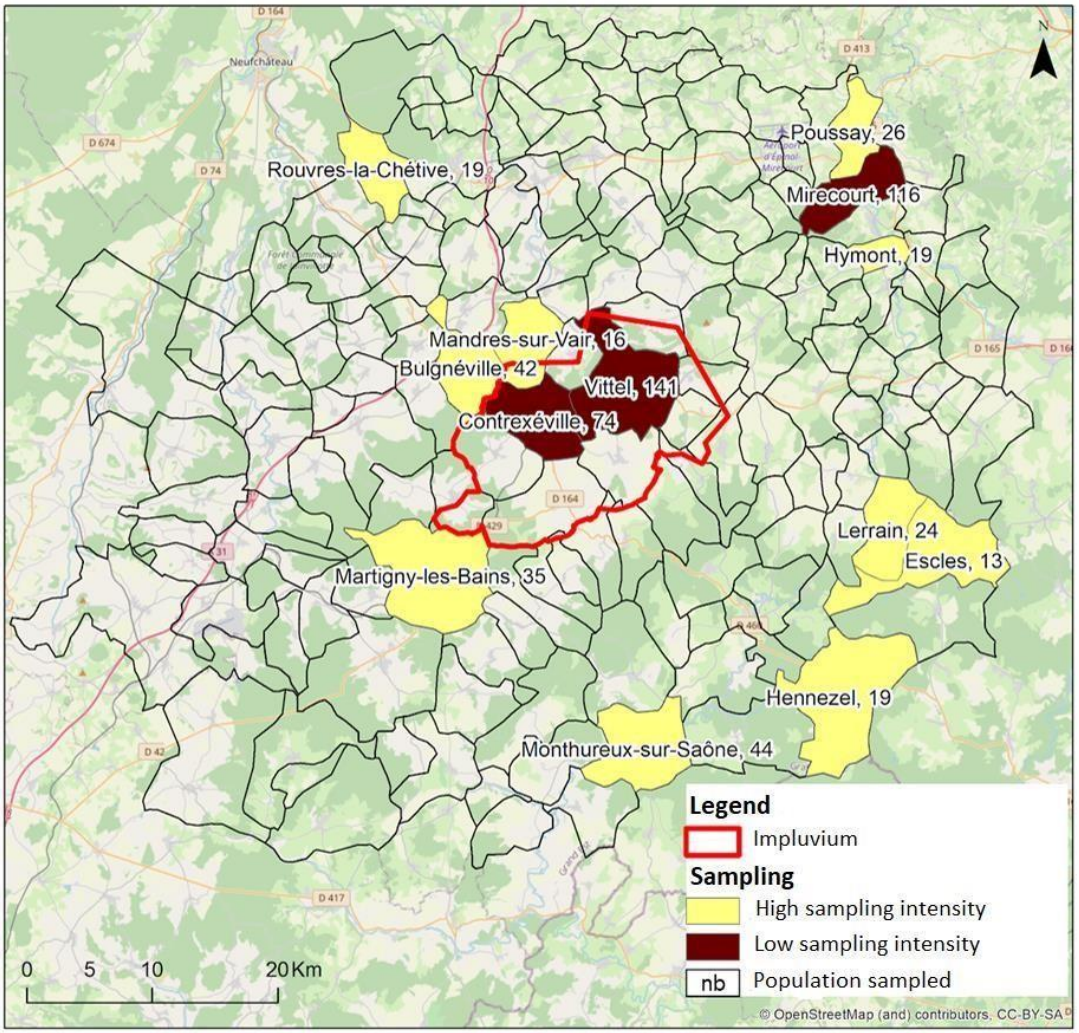


Figure 1-1:Map of the municipalities included in the sample

[10] The reason for focus the interviews in randomly selected municipalities with in the 15 km zone was to reduce the travelling of the interviewers between interviewed households. This was the reason for increasing the sampling rate outside the main towns (Contrexéville, Mirecourt, and Vittel).

Municipality	Number of inhabitants	Number of households	5% of the households	10% of the households	Final sample after survey
Mirecourt	5,285	2,561	128		116
Vittel	5,192	2,702	135		141
Contrexéville	3,232	1,577	79		74
Monthureux-sur-Saone	862	383		38	44
Mandres-sur-Vair	464	162		16	16
Poussay	698	311		31	26
Rouvres-la-Chétive	452	192		19	19
Hymont	477	219		22	19

Note. Total number of municipalities = 13.

Table 1-4 : Sample and randomly selected municipalities

We worked with the company Wood'up to implement the survey. As we chose to do it in face to face, two surveyors were hired to visit the respondents with tablets. This process allows them to answer potential questions and to help respondents with the tablets if necessary. To make sure that the households were randomly selected, we constructed a random protocol. Following this idea of randomization, the person allowed to answer to the questionnaire was the last adult (available) in the household to have celebrated his or her birthday. In order to facilitate the implementation of the survey, a flyer of presentation of the survey had been distributed in the selected municipalities. Finally, feedbacks were organized on a regular basis with the surveyors to monitor the progress of the survey.

3. Empirical analysis

3.1. The random utility model

DCE has a theoretical grounding in Lancaster's characteristics theory of value (Lancaster, 1966), and an econometric basis on random utility models (RUM, Thurstone, 1927; Mcfadden, 1973; Manski, 1977): RUM aims at modelling the choices of individuals among discrete sets of alternatives j. These models assume that the preferences of an individual among the available alternatives can be described by a utility function.

In a given sample with N respondents, each respondent n faces T choice situations. Every choice situation has a choice set of J alternatives. The total utility for respondent n choosing alternative j in the choice set in situation t is U_{njt}. This utility depends on a component that the researcher can observe, called the deterministic part of utility attributes (V_{njt}) and a random component that is not observed ($_{nj}$):

$$Unjt = Vnjt \qquad njt, \quad n = 1, \dots, N, \quad j = 1, \dots, J \quad t = 1, \dots, T \tag{1}$$

The deterministic part V_{njt} is a function of X_{njt} the vector of attributes relating to alternative j, and other observed factors such as individual characteristics Z_n:[11]

$$V_{njt} = V(X_{njt}, Z_n) \tag{2}$$

At this stage, the functional specification V_{njt} is very general. However, it is useful to give a linear form to the deterministic part and to separate the price attribute from the non-price attributes to compute preference space and WTP space, as done in Train and Weeks (2005).

The random error term $_{njt}$ is i.i.d. as a Gumbel law (or type I extreme value).[12] The relative contribution of each attribute X_{knt} to the overall utility U_{njt} can be represented by a parameter β_{kn}, while the parameters γ_l are associated with the l individual characteristics Z_n. From here on, we consider that the utility parameters to be estimated are embedded in a vector of parameters θ_n, associated with the regressors $R_{njt} = (X_{njt}, Z_n)$.

The individual n chooses the alternative i in each choice set t that brings the highest utility:

$$U_{nit} \geq U_{njt}, \quad \forall i, j \in t, \quad i \neq j. \tag{3}$$

Unlike the utilities, only the choice preferred by the individual n is observed. Hence, we intend to estimate the probability of individual n choosing alternative i for each choice set t:

$$p_{njt} = \Pr(U_{nit} \geq U_{njt}) = \Pr(\varepsilon_{njt} - \varepsilon_{nit} \leq V_{nit} - V_{njt}), \tag{4}$$

[11] In our empirical application, we also add fixed effects specific to the municipalities where the household is living to account for unobserved heterogeneity related to municipalities.

[12] The Gumbel density of the error term of utility is exp (− $_{njt}$) exp[−exp (− $_{njt}$)] and the cumulative distribution isexp [−exp (− $_{njt}$)], with a variance of $\pi^2/6$.

where the new error term $\epsilon_{nit} = {}_{njt} - {}_{nit}$ is i.i.d. with a logistic cumulative distribution

$$F(\epsilon_{nit}) = \frac{\exp(\epsilon_{nit})}{\sum_{j=1}^{J} \exp(\epsilon_{njt})}.$$

3.2. Econometric specifications

To explain the choices of the respondents and to interpret the results different econometric models can be used according to Train (2003), the multinomial logit model, also called the conditional (multinomial) logit (CL) is the most frequently used model to explain discrete choices. The probability of household n choosing alternative i can be written as:

$$P_n(i) = \frac{\exp(\theta R_{ni})}{\sum_{j=1}^{J} \exp(\theta R_{nj})} \quad (5)$$

This model relies on the assumption of independence of irrelevant alternatives (IIA). This assumption states that the odds of the probability of any two alternatives chosen by the respondent are independent of the presence of any other alternatives in the choice set (Hensher et *al.* 2005). Moreover, the CL model assumes that the utility functions across respondents are identical, which means that preferences must be homogeneous. Other models, such as the mixed logit (MXL) models, try to address these issues by allowing parameters to vary randomly over individuals. It is generally assumed that preferences vary across respondents but not across choices of the same respondent. Hence, "*a clustered specification is applied that allows for repeated choices for each individual*" (Revelt and Train, 1998). In our study, we estimate both CL and MXL models to test the robustness of our results.

The probability of an individual *n* to choose alternative i conditional on knowing θ_n can be expressed by:

$$P_n(i|\theta_n) = \frac{\exp(\theta_n R_{ni})}{\sum_{j=1}^{J} \exp(\theta_n R_{nj})} \quad (6)$$

In the case of multiple choices for each respondent, the logit probability refers to the probability that the individual *n* makes a sequence of T choices specified as $t = \{1, \dots, T\}$.

Knowing the probability of each choice as presented by equation (6), the logit probability of the observed sequence of T choices is given by:

$$P_n\left(j_{n1},\dots,j_{nT_n}|\theta_n\right) = \prod_{t=1}^{T_n} P_n(j_{nt}|\theta_n) \tag{7}$$

where j_{nt} represents the alternative chosen by individual n in choice situation t. The unconditional logit probability that individual n makes the observed sequence of choice j is integrated over the distribution of θ:

$$L_n(\theta) = \int P_n(j_{n1}, \dots, j_{nT_n}|\theta_n) f(\theta_n|\mu, \Sigma) d\theta \tag{8}$$

In a MXL model, the mean μ and the variance–covariance matrix Σ of the distribution of utility parameters θ_n can be specified with a continuous distribution, such as normal, lognormal or triangular. The log-likelihood is maximized using maximum simulated likelihood methods (Train, 2003). In our paper, we used the statistical software STATA MP 16 and the mixlogit package (Hole, 2007).

Note that the CL model can be written from equation (5) by replacing θ_n by θ, where preferences are considered as homogenous and θ is the same for all individuals. We use the clogit command of STATA, which manage fixed effects and thus well adapted to our dataset where individuals makes a sequence of T choices.

3.3. Descriptive statistics

The results presented here are based on 588 fully completed questionnaires. First, we present some statistics about respondents' preferences in terms of type of recreational site (countryside or forest), favourite characteristics, etc.

During the last five years period, 208 out of 588 respondents (*i.e.*, 35% of the sample) did not visit neither the countryside nor the forest. Table 5 shows for the recreational activities of the 379 respondents who did at least one visit either over the last 12 months or during the last five years.[13] Among these, 94.7% actually did at least one visit during the last 12 months. A little bit less than the half of them (45%) visited the forest and the countryside several times. 39%

[13] We dropped one individual who had been interviewed in Metz, a city not located in the study area.

only visited the forest and 16% only visited the countryside. Among people who made at least one visit per year, the average number of visits (nine respondents did not answer the question), either in a forest or in the countryside over the last year is 30.42.

Visits	Number (relative frequency)
No visit (the last 12 months, but during the last fiveyears)	20 (5.3%)
At least one visit (last 12 months)	359 (94.7%)
Recreational sites for all visitors	
Several visits in the forest and the countryside	170 (44.9%)
At least one visit exclusively in the forest	148 (39.1%)
At least one visit exclusively in the countryside	61 (16.1%)
Mean number of visit (regardless of the type of site)	30.42/individual/year (min=0 ; max=350)

Note. Total number of observations = 379.

Table 1-5 : The recreational activities of the sample of visitors used for the DCE

Figure 1.2 summarizes choices made by the respondents in the DCE. Out of these 3032 choices (*i.e.*, 379 individuals responding to eight choice sets), the (hypothetical) alternative "countryside" had been chosen 869 times (Figure 3). It represents about 28.7% of the choices versus 26.5% for the hypothetical forest. That means that the status quo is clearly the favourite option (about 44.8% of the choices). This prevalence of the status quo has been termed "status-quo effect" or "status quo bias" by Samuelsson and Zeckhauser (1988). This dominance of the status quo is not systematic (Hanley et *al.* 2006) but not uncommon neither in DCE studies (Hartman et *al.* 1990, 1991; Boxall et *al.* 2009, Lanz and Provins, 2015), and has even found to be stronger in other papers (Hartman et *al.* 1990, 1991; MacDonald et *al.* (2005); Barton and Bergland, 2010; Lanz and Provins, 2015).

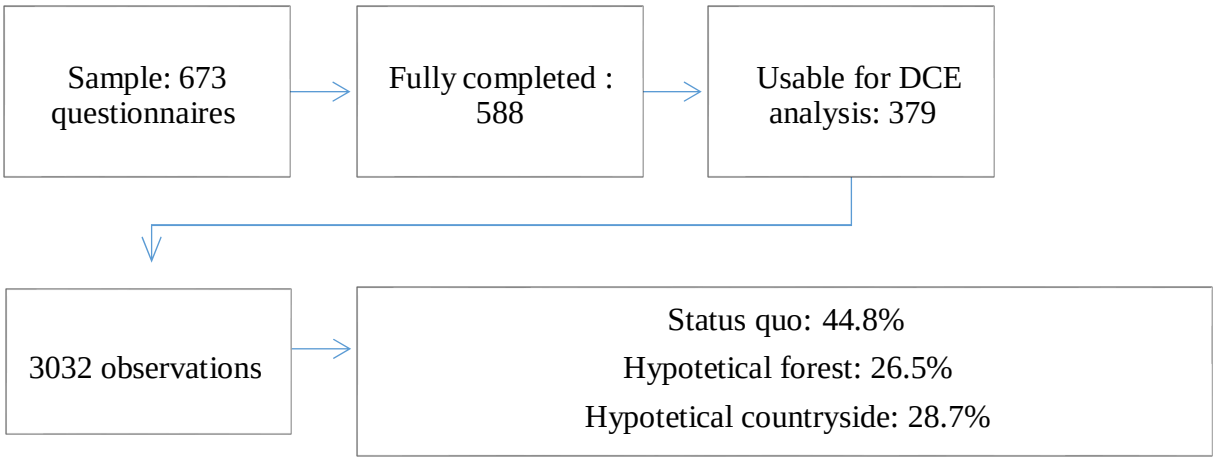


Figure 1-2: Sample, number of observations and choices

Furthermore, 35 out of the 379 respondents (9.21%) did not consider all the attributes when choosing. Distance[14] and facilities were the most ignored characteristics. In addition to the question relative to attribute non-attendance (ANA), other validation or "follow up" questions (Byrd et *al.* 2017; Kataria et *al.* 2017; Melo Guerrero et *al.* 2020) were included, in order, for example, to investigate status-quo bias: we found that 11,08% of respondents systematically chose that status-quo option. This result has to be compared with the one of other studies: using a choice modelling approach to assess customers' services standards in urban water, MacDonald et *al.* (2005) found that the share of respondents that systematically chose the status-quo option was slightly inferior to 20% (with 6 choice tasks). In environmental valuation, Meyerhoff and Liebe (2009) concluded that respectively 59% and 49% of their two samples always chose that option. They compared these results about changes in forest biodiversity with those of Lehtonen et *al.* (2003) who wrote that "only" 14% of respondents always chose the status quo. Even closer to our subject, Horne et *al.* (2005) examined visitors' preferences for forest management regimes, and found that 21% of surveyed sample always selected the current situation. Compared to these studies, the share of systematic status quo in our study appears quite reasonable. When they justified this systematic behaviour, more than the half of respondents (57%) argue that the status quo always presented the best characteristics according to them.

Then, we focused on the travel distances (table 6), as these data will be crucial to give a monetary value to the environmental and social services (using a travel cost methodology). We chose not to consider a few respondents who travelled on very important distances

[14] As in other studies (Christie et *al.* 2007; Rulleau et *al.* 2010), the distance attribute was presented as the last one in the choice sets, but when we presented the attributes, we emphasized on the fact distance was costly (in time and money) and therefore important.

(outliers), and could not be considered as recreationists[15]. Table 1.6 reports the average travel distances for the sample and for reduced samples where visitors travelling more than 160 km and 80 km, respectively were excluded. These thresholds are considered as appropriate to call these people "recreationists" (Ghanem, 2017).

	N	Mean	Std dev.	Min	Max
All distances	378	50.02	128.78	0	1600
Distances ≤ 200 km	366	33.44	50.67	0	200
Distances ≤ 160 km	347	24.56	34.46	0	160
Distances ≤ 80 km	323	17.16	20.66	0	80

Table 1-6 : Round-trip distances to the recreational site in km (visitor sample)

Table 1.7 gives the share of individuals who made recreational visits during the last five years (379 respondents, 10 did not give the location of their visits), depending on whether the destination was inside their municipality of residence or not. For more than two-thirds of them, it was not the case.

Location of the site	Visitors	Percentage (%)
Out of the municipality of residence	258	69.7
In the municipality of residence	112	30.3
Total	369	100

Table 1-7 : Share of "local" visits during the last five years

Finally, in Table 1.8, we present the main demographic and socio-economic characteristics.

Variable	Obs.	Mean	Std Dev.	Min	Max
Age of respondents	378	50	14.95	20	88
Gender (=1 if Male)	379	0.58		0	1
Number of children	379	0.89	1.17	0	6
Education level					
Degree (in ascending order)	379	1.07	1.27	0	6
Non-respondent	379	0.021		0	1

[15] Unlikely that the last visit had only outdoor recreation as objective.

Others	379	0.048	0	1
General Certificate of Secondary Education	379	0.385	0	1
High school diploma	379	0.235	0	1
High school diploma + 2 years	379	0.179	0	1
High school diploma + 3 years	379	0.084	0	1
High school diploma + 4 years and 5 years	379	0.040	0	1
Doctorate	379	0.008	0	1
socio-professional category				
Manager	379	0.108	0	1
Intermediate profession	379	0.034	0	1
Worker	379	0.055	0	1
Employee	379	0.346	0	1
Self-employed	379	0.106	0	1
Retired	379	0.235	0	1
Unemployed	379	0.095	0	1
Childhood in the life area of Vittel (yes=1)	379	0.69	0	1
Work in the life area of Vittel (yes=1)	379	0.69	0	1

Table 1-8 : Demographic and socio-economic statistics

4. Estimation results

Based on the responses to the DCE, we estimated the RUM. The estimated parameters indicate how the attributes (characteristics) of a recreational site influence the utility of visiting the site. In other words, if the estimated parameter is positive it is an attractive characteristic for an average visitor and if it is negative, the attribute has a negative impact on the utility/preferences of the visitor.

We estimated simple econometric specifications in which the indirect utility is a linear function of parameters. From the general deterministic part V_{njt} defined in equation (2), we started with a basic specification with the attributes as explanatory variables, as well as an alternative specific constant (ASC_{SQ}), associated with the status-quo alternative (SQ). This variable equal to 1 when the last visited site is preferred to other alternatives, and to zero

otherwise. We also introduced a variable referred to as $FOREST$ that indicates when the respondent chose either the "forest scenario" or the status-quo alternative when she/he visited a forest during the last recreational visit. We called ASC_F its associated parameter. In the following specification of the utility part V_{njt}, we separate the distance attribute ($DIST$) and the other attributes X to make the analysis of WTT (Willingness to Travel) clearer:[16]

$$V_{njt} = ASC_{SQ} \times SQ + ASC_F \times FOREST + \beta X_{njt} - \alpha DIST \quad (9)$$

In a second specification, we augmented the model with respondent characteristics Z_n as interactions with the SQ dummy as well as interaction terms between $DIST$ and the fixed municipality-specific effects ($MUNICIP$) in order to account for unobserved local heterogeneity (such as other recreational opportunities):

$$V_{njt} = ASC_{SQ} \times SQ + ASC_F \times FOREST + \beta X_{njt} - \delta DIST \times MUNICIP + \gamma Z_n \times SQ \quad (10)$$

We do not introduce all municipality variables in the regression because the number of individual observations per municipality is sometimes small and the number fixed effects would be high. Instead, we preferred test the effect of the larger municipality in our sample (*i.e.*, Vittel, Contrexéville, Mirecourt) and to gather the other smaller municipalities in one category.

4.1. Estimation results of the CL model

Table 1.9 presents estimation results of the CL model, with the basic specification (9) in the first two columns, and the specification (10) in the last two columns. For the estimation, we removed the 12 individuals who stated distances strictly greater than 200km (for the round trip) because we consider that these trips are exceptional recreation activities that people do not repeat several weekends during the year.[17] Higher pseudo R squared and smaller AIC and BIC confirm that a model augmented with the crossed terms fits the data better than a model considering only attributes of the DCE.

[16] We do not have a monetary attribute in our experiment but instead we asked the respondent to state the distance to travel towards the recreation site, making it possible to compute a WTT.

[17] In our study, we investigate the attractivity of the impluvium for the local population. We decide not to consider recreational sites at more than 100km as local substitutes for residents.

Variable	Coef.	se	Coef.	se
SQ	0.802***	(0.0685)	0.512*	(0.263)
Contrexéville x SQ			-0.496***	(0.168)
Mirecourt x SQ			-0.132	(0.170)
Small municipalities x SQ			-0.0593	(0.127)
Vittel x $DIST$			-0.0539***	(0.00408)
Contrexéville x $DIST$			-0.0903***	(0.00929)
Mirecourt x $DIST$			-0.0111***	(0.00254)
Small municipalities x $DIST$			-0.00765***	(0.00135)
$DIST$	-0.0200***	(0.00114)		
$FOREST$	-0.245**	(0.123)	-0.156	(0.130)
Facilities	-0.0222	(0.0499)	-0.0112	(0.0534)
FacilitiesDK	-0.267**	(0.115)	-0.234*	(0.124)
Trails	0.133**	(0.0523)	0.118**	(0.0570)
TrailsDK	0.0483	(0.117)	0.00596	(0.124)
Waterruns	0.219***	(0.0516)	0.202***	(0.0555)
WaterrunsDK	-0.0499	(0.156)	-0.168	(0.158)
Pesticides	-0.443***	(0.0624)	-0.431***	(0.0667)
PesticidesDK	-0.396***	(0.0862)	-0.335***	(0.0931)
Crops	-0.0188	(0.149)	-0.0898	(0.158)
Livestock	0.00682	(0.122)	-0.170	(0.130)
Mixed parcel	0.176*	(0.0988)	0.0785	(0.105)
Deciduous forest	0.342***	(0.101)	0.311***	(0.108)
Mixed forest	0.183**	(0.0874)	0.142	(0.0920)
HedgerowsDK	-0.0389	(0.140)	-0.134	(0.149)
Lowhedgerows	-0.00262	(0.107)	0.101	(0.114)
Lotsofhedgerows	0.00781	(0.120)	-0.0177	(0.127)
SQ x Male			-0.177**	(0.0883)
SQx Age			0.00833**	(0.00406)
SQx Children			-0.0686*	(0.0406)
SQ x Degree			0.248***	(0.0442)
SQx Manager			-1.003***	(0.225)
SQ x Worker			-0.567**	(0.223)
SQ x Employee			-0.0921	(0.136)
SQ x Retired			-0.238	(0.183)
SQ x Self-employed			-0.394**	(0.178)
SQx Childhood			0.286***	(0.0956)
SQ x Work_territory			-0.158	(0.0977)
Log likelihood	-2764		-2552	
chi-squared	905.9		1313	
Prob > chi2	0.000		0.000	
Pseudo R-squared	0.141		0.205	
AIC	5565.61		5175.36	
BIC	5700.14		5430.17	

Notes. SD means standard deviation. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Observations: 8,760 = 365 individuals x 3 alternatives x 8 choice sets. Selection of observations forrecreation trips corresponding to distances ≤ 200 km.

Table 1-9 : Estimation results of the CL model: preferences for recreational attributes

The results show that the coefficient associated with the attribute Facilities is not significantly different from zero. Therefore, we cannot conclude that the presence of facilities on a recreational site contribute to visitors' welfare. Even if some past studies suggest that respondents often value recreational facilities (De Valck et *al.* 2017; Hasan-Basri 2015), others are more nuanced, pointing out that individuals can associate the provision of facilities with a risk of artificialization (Rulleau et *al.* 2010). However, not knowing about the presence of facilities decreases the utility of interviewed people. As expected, trails and water runs are appreciated for recreation. On the contrary, the value of the coefficient associated with Pesticides is negative, as well as the value for PesticidesDK, which means that people who answered to the DCE prefer not to have recreation activities on sites where they do not know if pesticides are used. If we have a closer look to the characteristics that are specific to the countryside (agricultural land use, hedgerows and biodiversity), we see that none of the different levels have a significant impact on recreational preferences. However, concerning the forest attribute, the results show a preference for forest exclusively composed of deciduous trees compared to those composed of coniferous.

To investigate how location may influence the effect of distance on respondents' utility, we created interaction terms between the variable DIST, that represents the round-trip distances to recreational sites, and the municipalities of the sample. All the coefficients of these interaction terms are negative, which means that, as expected, the distance has a negative impact on utility. However, the negative effect of distance on utility is significantly larger for Contrexéville and Vittel than for the other municipalities. Finally, we also generated interactions between ASC_{SQ} and the socio-economic variables, as a way to account for observed or "systematic" heterogeneity (Hasan-Basri, 2015). Most of the interaction terms are significantly different from zero. Among others, having grown up on the territory where you live has a positive impact on choosing the (same) last visited site. Older people also keep on the same site as well as people with a higher degree of study. There are also significant differences of preference according to the socio-professional category of interviewed individuals.

4.2. Estimation results of the MXL model

In the estimation of the MXL model, we assumed normal distributed parameters for all attributes except the distance and interaction terms for which we assumed non-random parameters.

	Mean		SD	
Variable	Coef.	se	Coef.	se
SQ	0.917	(0.635)		
Contrexéville x SQ	-0.892***	(0.335)		
Mirecourt x SQ	-0.553	(0.419)		
Small municipalities x SQ	-0.358	(0.269)		
Vittel x $DIST$	-0.0947***	(0.00724)		
Contrexéville x $DIST$	-0.135***	(0.0132)		
Mirecourt x $DIST$	-0.0256***	(0.00523)		
Small municipalities x $DIST$	-0.0159***	(0.00268)		
$FOREST$	-0.116	(0.232)	2.236***	(0.164)
Facilities	-0.0806	(0.0816)	0.161	(0.164)
FacilitiesDK	-0.466	(0.364)	2.787***	(0.369)
Trails	0.0795	(0.0897)	0.291*	(0.169)
TrailsDK	0.119	(0.340)	1.236***	(0.328)
Waterruns	0.196**	(0.0922)	0.138	(0.226)
WaterrunsDK	-0.200	(0.398)	-0.591	(0.619)
Pesticides	-0.834***	(0.117)	0.996***	(0.161)
PesticidesDK	-0.456*	(0.253)	2.406***	(0.227)
Crops	-0.181	(0.251)	0.0479	(0.319)
Livestock	-0.362*	(0.199)	-0.780***	(0.201)
Mixed parcel	0.455**	(0.184)	0.549*	(0.297)
Deciduous forest	0.543***	(0.185)	1.264***	(0.221)
Mixed forest	0.366**	(0.146)	0.244	(0.197)
HedgerowsDK	-0.256	(0.398)	1.842***	(0.371)
Lowhedgerows	0.498***	(0.186)	-0.158	(0.255)
Lotsofhedgerows	-0.299	(0.207)	0.600**	(0.272)
SQx Male	-0.711***	(0.215)		
SQx Age	0.0100	(0.0103)		
SQ x Children	-0.112	(0.0944)		
SQ x Degree	0.323***	(0.100)		
SQx Manager	-1.104**	(0.553)		
SQ x Worker	-1.109*	(0.568)		
SQ x Employee	-0.338	(0.375)		
SQ x Retired	-0.186	(0.476)		
SQx Self-employed	-1.024**	(0.490)		
SQx Childhood	0.708***	(0.225)		
SQ x Work_territory	-0.324	(0.222)		
Log likelihood	-2106			
Chi-squared	891.1			
Prob > chi2	0.000			
AIC	4318.31			
BIC	4693.44			

Notes. SD means standard deviation. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Observations: 8,760 = 365 individuals x 3 alternatives x 8 choice sets.

Table 1-10 : Estimation results of the MXL model

We can notice that the MXL model fits the data better than the CL models (in Table 1.9) for a number of reasons. First, most of estimates (mean and standard deviation) of the random parameters associated with the attributes are significantly different from zero, thus confirming the presence of individual heterogeneity in preferences. Second, comparing loglikelihood and statistics such as AIC and BIC between the different models shows the superiority of MXL on CL models with the highest log-likelihood and the lowest AIC and BIC.

Besides, the robustness of the results is quite strong, considering both the sign and the value of the coefficients. Nevertheless, a few changes can be observed: the coefficient of livestock relative to grassland is now significantly different from 0 and negative, meaning that the individual utility is decreasing with livestock. The coefficient associated with a low level of hedgerows is significantly positive, indicating a preference for a low level of hedgerows (and biodiversity) relative to no hedgerow. However, interviewed people do not seem to value a high level of hedgerows even if heterogeneity of preferences for this attribute is large as indicated by its significant standard deviation. Rambonilaza and Dachary-Bernard (2007), pointed out that density of linear elements, like hedgerows, was important to make a substantial contribution to landscape attractiveness. In the other hand, van Zanten et *al.* (2016) argue that landscape preferences are place specific and can vary across region. As a confirmation, when deriving WTP estimates for landscape improvements under Agri Environmental Schemes (AES), Campbell et *al.* (2006), found that among eight landscapes attributes, hedgerows was the least valued (Birol and Koundouri, 2008; Campbell et *al.* 2006). Moreover, the coefficients of Deciduous forest and Mixed forest are now both significantly positive relative to Coniferous forest.

Finally, the values of the interaction terms between the distance attribute and the municipalities are still negative and highly significant, which confirms the robustness of that result. This attribute allows us to calculate marginal willingness to travel (MWTT) for each attributes of recreational sites.

4.3. Estimation of marginal willingness to travel

As we explained above, we chose to use the round-trip distance between the residence and the recreational site as an indirect monetary attribute. Therefore, we can estimate the marginal willingness to travel, or MWTT (EFESE, 2020). The MWTT is calculated as a ratio of the coefficient β_k associated with the non-monetary attribute X_k and the coefficient α associated with the variable $DIST$. Thus, the MWTT can be written as follows:

$$MWTT = -\frac{\beta}{\alpha} \tag{11}$$

We calculated this ratio for the same attributes presented in the MXL model. The values are given for the three largest municipalities (Vittel, Mirecourt and Contrexéville) and for the small municipalities. MWTT as well as their estimated confidence intervals are reported in Table 1.11, and the confidence intervals are estimated with the delta method.

Municipalities	**Vittel**	**Contrexéville**	**Mirecourt**	**Small Municipalities**
Common attributes (forest/countryside)	**Value of MWTT for the attribute [confidence interval at 95%]**			
Facilities	-0.85 [-2.55 ; 0.85]	-0.60 [-1.78 ; 0.59]	-3.15 [-9.56 ; 3.27]	-5.07 [-15.30 ; 5.17]
FacilitiesDK	-4.92 [-12.44 ; 2.60]	-3.44 [-8.76 ; 1.87]	-18.19 [-47; 10.63]	-29.28 [-75.34 ; 16.79]
Trails	0.84 [-1.02 ; 2.70]	0.59 [-0.72 ; 1.89]	3.11 [-3.82 ; 10.03]	5 [-6.08 ; 16.07]
TrailsDK	1.26 [-5.79 ; 8.30]	0.88 [-4.05 ; 5.82]	4.65 [-21.51 ; 30.81]	7.49 [-34.40 ; 49.37]
Water runs	2.07 [0.16 ; 3.98]	1.45 [0.08 ; 2.82]	7.65 [0.29 ; 15.02]	12.32 [0.68 ; 23.96]
WaterrunsDK	-2.12 [-10.36 ; 6.12]	-1.48 [-7.26 ; 4.29]	-7.83 [-38.4 ; 22.74]	-12.60 [-61.96 ; 36.77]
Pesticides	-8.81 [-11.45 ; -6.16]	-6.17 [-8.15 ; -4.20]	-32.59 [-48.17 ; -17.02]	-52.46 [-74.14 ; -30.79]

Table 1-11 : Marginal willingness to travel for recreational attributes

To convert these values in terms of WTP, we can simply use a cost per kilometer travelled: 0,55€/km, as given by the French 2020 mileage scale.[18] Then marginal WTP (MWTP) for each attribute is given by the following formula:

$MWTP = Distance \times 0.55€ / km$	(12)

MWTT for facilities are not significantly different from 0. MWTT for trails are positive but close from 0, and with large confidence intervals. Respondents show a real preference for the presence of water runs, but the value differ depending on the municipality of residence. Indeed, while inhabitants of Vittel and Contrexéville have relatively weak MWTT, those of Mirecourt and other municipalities express stronger MWTT, 7.65 km (approximatively 4.20€) and 12.32 km (or 6.78€). We found the same distinction for the "pesticides" attribute: Residents of Vittel and Contrexéville have smaller MWTT to go to a recreational site where pesticides are not used, 8.89 km (4.89€) and 6.17 km (3.39€) respectively, when this value is much more important for individuals who live in Mirecourt (32.59 km or 17.92€) or in the other rural municipalities (52.46 km or 28.85€). We can notice that people who live in these small rural municipalities also have an important MWTT to a site where they know that pesticides are not used (relatively to a site where they don't know if this kind of products is used), *i.e.*, 28.69 km (15.78€) but with a large confidence interval. In this respect, the heterogeneity for all these attributes is important.

Considering agricultural land use, the MWTT for mixed land use is higher for Mirecourt and the small municipalities than for Vittel and Contrexéville: Inhabitants of Mirecourt are ready to pay almost 10€ (or 17.79 km) and residents of the other rural municipalities, almost 16€ (28.64 km). The values for a low level of hedgerows are even more important, respectively 19.46 km (10.70€) for Mirecourt and 31.32 km (17.23€) for smaller rural municipalities, respectively. Lastly, MWTT for a forest attributes are also more important for the same

[18] We have taken a value per km of 0.55€ according to the French 2020 mileage scale for the mileage allowance at real costs for a car with a fiscal power of 5CV on the following website: https://impots.dispofi.fr/baremekilometrique/bareme-2020.

municipalities, 21.23 km (11.68€) and 34.17 km (17.79€) for a forest with exclusively deciduous trees, and 14.31 km (7.87€) and 23.03 km (12.67€) for a mixed forest.

To enforce the validity of our results, we also asked respondents to design their "ideal" forest or countryside, depending on where their last visit took place. After the DCE, we proposed them to rank the five most important attributes for them, following the approach used by Balcombe and Fraser (2014), who advocated for the use of that exercise in DCE. One small difference is that these authors strictly kept the same attributes than in the DCE, while we add other characteristics: it allowed us to see if some attributes not included in the DCE were important to respondents. Alternatively, Filyushkina et *al.* (2017) presented the same type of "ideal forest" exercise in a recreational context, but based on drawings.

We divided our sample in two parts: if respondents' last visit took place in the forest, they had the opportunity to select their five favourite forest attributes. If they went to the countryside, they did the same for this recreational setting. Concerning the forest, the hiking and biking trails was the attribute more often ranked first. In terms of number of appearances in the top five, the trails are also the most appreciated one. Concerning the countryside, the facilities were more often ranked first and appeared in the top five more frequently as well. These results may be quite surprising, regarding the estimations of the CL and MXL models. Both in the CL and in the MXL model, the coefficient associated to facilities is not significantly different from zero. This result may reflect the fact that facilities are indeed more appreciated in the countryside than in the forest. As a confirmation, the attribute "facilities" is only the fifth (out of eleven) in terms of number of appearances in the top five for the forest. This could explain non-significance, but it does not mean that facilities are not valued. As Balcombe and Fraser (2014) put it, ranking questions allow respondents to "place a lower value on particular attributes without assuming that they have zero value". The same reasoning can be applied for the favourite attribute in the forest (hiking and biking trails). We can therefore conclude that our results display important heterogeneity, depending on the recreational setting.

Besides, several studies (see Caparrós et *al.* (2008) for a review) indicated that results obtained from a ranking and from a choice exercise may not be similar. This can be due to a different cognitive process between the two tasks (Boyle et *al.* (2001); Holmes and Boyle (2001)).

5. Conclusion

This paper aimed at providing results of a DCE used to evaluate the environmental and social preferences of the local population of Vittel (France) and surroundings. We detailed the construction process of the DCE based on the recreational activities practiced by the residents (sport, landscape observation etc.) when they go to the forest or in the countryside. Focusing on these activities is a way to capture the direct use values potentially modified by the environmental friendly practices implemented on the impluvium of Vittel (non-use of pesticides, hedgerows plantation etc.). The contribution of our study to the literature is twofold: first, we specifically include in the DCE attributes linked to the different measures set up by a private actor, Agrivair, such as absence of pesticides, or hedgerows plantation. Furthermore, because people are not aware about the presence or not of some characteristics on the site they visit, *e.g.*, pesticides, we test whether this information issue has an impact on their choice of recreational setting.

The results show that the status quo (*i.e.*, the last visited forest or countryside) is the favourite scenario. Among the hypothetical ones, the "countryside scenario" is, by a small margin, the most chosen. Concerning the number of visits during the last 12 months, almost the half of the respondents who visited nature for recreational purpose did several visits in the forest and the countryside. The mean number of visits, regardless the type of recreational area, is about 30 visits/person/year. The estimation results show that the presence of some attributes, like water runs, on recreational sites, are particularly appreciated by respondents. In other cases, like for mixed agricultural land use, preferences are quite heterogeneous. Besides, the calculation of WTP for the different attributes indicates some (important in some cases) variations between Vittel and Contrexéville, on the one hand, and smaller municipalities in the other hand. Both results seem to exhibit heterogeneity among respondents in terms of recreational preferences.

6. Annex

Questionnaire chapitre 1

Message d'accueil

Bonjour. Nous vous remercions d'accepter de répondre à ce questionnaire, qui a pour cadre un projet de recherche : ce dernier porte sur l'évaluation des services environnementaux et sociaux **dans votre région**. Il s'agit donc de mesurer le bien-être que vous apportent la nature et les pratiques humaines qui y prennent place.

Evaluer ces services permet de **mieux protéger votre environnement** et **d'améliorer votre cadre de vie.**

Nous nous intéressons en particulier aux activités récréatives (loisirs) de la population locale (promenade, cueillette, chasse etc.) et à ses préférences vis à vis de certaines caractéristiques environnementales et sociales (paysage, biodiversité etc.)

Il n'y a pas de bonnes ou de mauvaises réponses, mais il est important que vous répondiez à toutes les questions. La durée moyenne de réponse au questionnaire est d'environ 30 minutes. Nous vous rappelons que vos réponses seront strictement anonymes.

Caractéristiques socio-économiques

Q0) l'enquêteur renseigne ici son identifiant ainsi que l'adresse de l'enquêté.

Identifiant de l'enquêteur : ☐

Adresse de l'enquêté : ☐

Q001) l'enquêteur signale ici s'il peut effectuer l'enquête.

○ Oui

○ Non car l'enquêté est absent

○ Non car l'enquêté refuse de répondre

Si réponse a) à la question précédente

Q02) L'enquêteur a répondu « oui » à la question précédente. Il renseigne ici le numéro de téléphone ou l'adresse e-mail de l'enquêté.

Q1) Etes-vous :

Veuillez sélectionner une réponse ci-dessous :

- ○ a) Un homme
- ○ b) Une femme
- ○ c) Ne souhaite pas répondre

Q2) En quelle année êtes-vous né(e) ?

Q3) Où habitez-vous ? (Indiquez le nom de la commune et le code postal).

Commune :

Code postal :

Q4) Quel est votre diplôme le plus élevé ?

Veuillez sélectionner une réponse ci-dessous :

- ○ a) Aucun ou inférieur au bac
- ○ b) Bac
- ○ c) BTS, DUT ou équivalent bac+2
- ○ d) Licence ou équivalent bac+3
- ○ e) Master ou équivalent bac+4
- ○ f) Master 2 ou équivalent bac+5
- ○ g) Doctorat ou équivalent bac+8
- ○ h) Ne souhaite pas répondre
- ○ i) Autre :

Q5) Quelle est votre profession et catégorie socioprofessionnelle ?

- ○ a) Agriculteur exploitant
- ○ b) Artisan, commerçant, chef d'entreprise
- ○ c) Cadre et profession intellectuelle supérieure
- ○ d) Profession intermédiaire
- ○ e) Employé
- ○ f) Ouvrier
- ○ g) Retraité
- ○ h) Autre personne sans activité professionnelle
- ○ i) Ne sait pas
- ○ j) Ne souhaite pas répondre

Q6) De combien de personnes est composé votre ménage ? Précisez le nombre d'enfants.

Nombre de personnes : ☐

Dont enfants : ☐

Q7) Parmi les personnes qui composent votre ménage, combien possèdent un revenu ?

☐

Q8) Dans quel type de logement vivez-vous ?

Veuillez sélectionner une réponse ci-dessous :

- ○ a) Une maison
- ○ b) Un appartement
- ○ c) Autre : ☐

Q9) Ce logement comprend-t-il un jardin ?

Veuillez sélectionner une réponse ci-dessous :

- ○ a) Oui

○ b) Non

Q10) Avez-vous grandi, au moins partiellement, sur le territoire sur lequel vous vivez ?

Veuillez sélectionner une réponse ci-dessous :

○ a) Oui

○ b) Non

Q11) Travaillez-vous sur le territoire sur lequel vous vivez ?

Veuillez sélectionner une réponse ci-dessous :

○ a) Oui

○ b) Non

Q12) Comment qualifieriez- vous votre degré d'attachement au territoire sur lequel vous vivez ?

Veuillez sélectionner une réponse ci-dessous :

○ a) Très faible

○ b) Faible

○ c) Moyen

○ d) Fort

○ e) Très fort

Si réponse d) ou e) à la question 12

Q13) Quels symboles caractérisent cet attachement ?

○ a) Un site naturel

○ b) Un ou des monuments

○ c) Une commune particulière

○ d) Un attachement familial

○ e) Un paysage agricole

○ f) Un paysage forestier

○ g) Autre : ☐

Si réponse d) ou e) à la question 12

Q14) Dans l'attachement que vous portez à votre territoire, le paysage qui vous entoure a-t-il une importance :

○ a) Très faible

○ b) Faible

○ c) Moyenne

○ d) Forte

○ e) Très forte

Q15) Vous estimez vous sensible aux enjeux environnementaux ?

Veuillez sélectionner une réponse ci-dessous :

○ a) pas du tout sensible

○ b) peu sensible

○ c) Moyennement sensible

○ d) Très sensible

○ e) Extrêmement sensible

Q16) Parmi les actions suivantes, lesquelles effectuez-vous ?

Cochez-la ou les réponse(s) :

○ a) Achat fréquent de produits bio

○ b) Achats fréquent de produits recyclés

○ c) Appartenance et/ou don à une association de défense de l'environnement

○ d) Participation à des manifestations en faveur de la préservation de l'environnement

○ e) Autre : ☐

Q17) Est-ce que votre ménage possède :

Cochez-la ou les réponse(s) :

○ a) Une voiture

○ b) Une moto/un scooter

○ c) Un vélo électrique

○ d) Aucun véhicule motorisé

○ e) Un vélo classique

Q18) Sur les 12 derniers mois, avez-vous effectué une ou plusieurs sorties (à partir de votre résidence principale et dans une journée), à des fins de loisirs, en forêt et/ou à la campagne ?

Veuillez sélectionner une réponse ci-dessous :

○ a) Non

○ b) Oui, plusieurs sorties, en forêt et à la campagne

○ c) Oui, plusieurs sorties en forêt

○ d) Oui, une seule sortie en forêt

○ e) Oui, plusieurs sorties à la campagne

○ f) Oui, une seule sortie à la campagne

Si réponse b), c) ou e) à la question 18

Q18a) Vous avez effectué plusieurs sorties en forêt et / ou à la campagne au cours des 12 derniers mois. Précisez combien.

Si réponse a) à la question 18)

Q19) Vous avez répondu « non » à la question précédente. Avez-vous effectué, au cours des 12 derniers mois, une sortie à des fins de loisirs dans un espace naturel autre que la forêt ou la campagne ?

Veuillez sélectionner une réponse ci-dessous :

- ○ Oui, dans un parc urbain
- ○ Oui, autour d'un lac
- ○ Oui, dans un jardin partagé
- ○ Oui, dans un Parc Naturel Régional (PNR)
- ○ Non
- ○ Autre :

Si réponse a) question 18

Q20) Vous ne vous êtes rendus ni en forêt ni à la campagne au cours des 12 derniers mois. Vous y êtes-vous rendus au cours des 5 dernières années ?

Veuillez sélectionner une réponse ci-dessous :

- ○ a) Non
- ○ b) Oui, plusieurs fois, en forêt et à la campagne
- ○ c) Oui, une seule fois, en forêt
- ○ d) Oui, une seule fois, à la campagne
- ○ e) Oui, plusieurs fois, en forêt
- ○ f) Oui, plusieurs fois à la campagne

Si réponse a) à la question 20

Q21) Vous avez répondu non à la question précédente. Pourquoi ?

- ○ a) Cela ne m'intéresse pas
- ○ b) Je n'ai pas le temps d'y aller

○ c) Y aller est trop coûteux

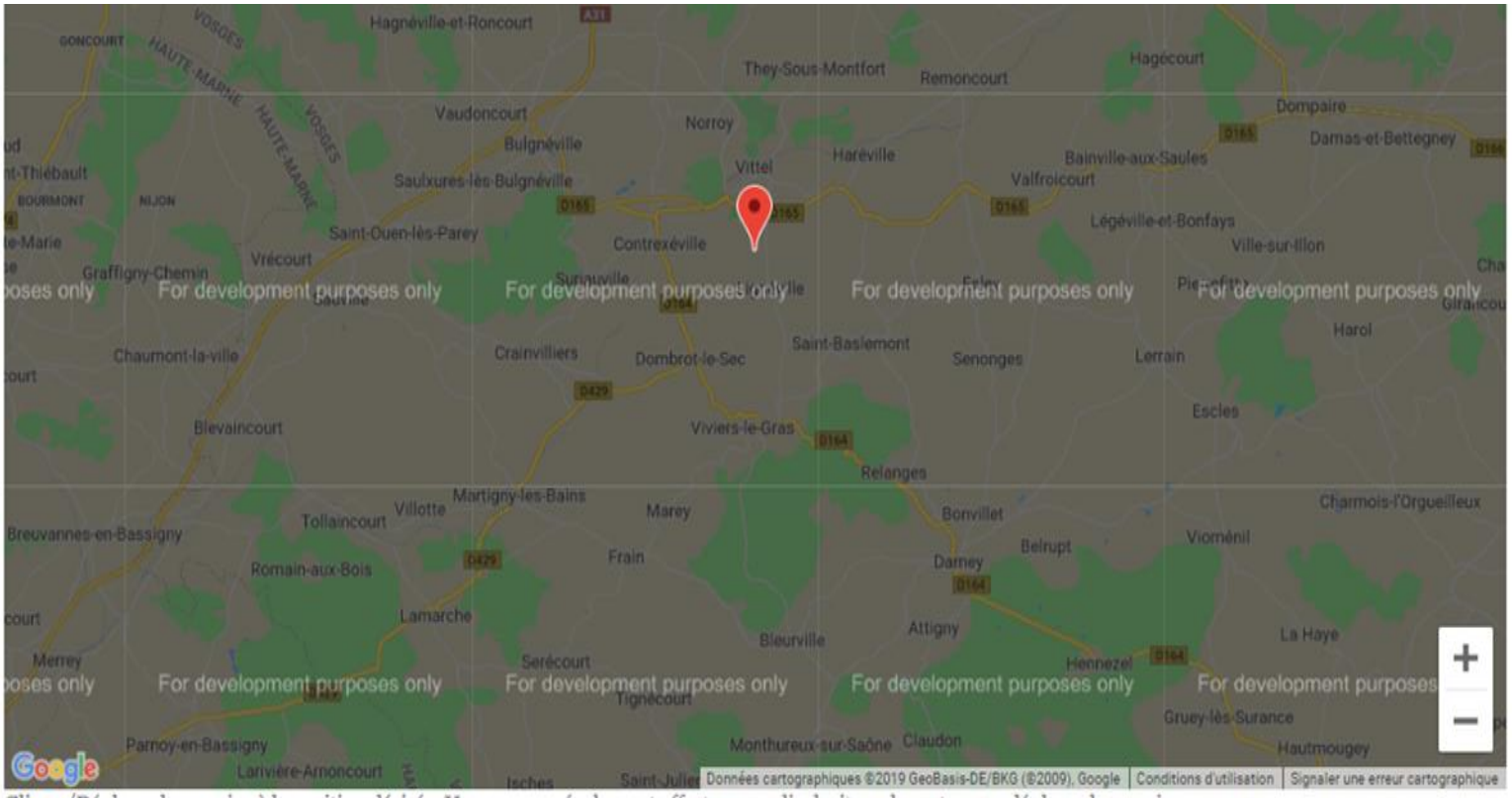
○ d) Je n'ai aucun moyen de locomotion pour m'y rendre

○ f) Autre : ☐

Si scénario 1 : réponse a) à la question 18 et réponse c) ou d) à la question 20

Ou scénario 2 : réponse d) ou f) à la question 18

Q22) Vous avez effectué « une seule sortie » en forêt ou à la campagne (au cours des 12 derniers mois ou des 5 dernières années, selon vos réponses aux questions précédentes). Précisez sur la carte ou cette sortie a-t-elle eu lieu. Merci de chercher sur la carte ci-dessous en glissant/déplaçant la punaise (approximativement) vers la position désirée. Si vous avez effectué un circuit, précisez le point central de votre visite.



Glisser/Déplacer la punaise à la position désirée. Vous pouvez également effectuer un clic droit sur la carte pour déplacer la punaise.

Si scénario 1 : réponse a) à la question 18 et réponse c) ou d) à la question 20

Ou scénario 2 : réponse d) ou f) à la question 18

Q23) Avez-vous trouvé le lieu que vous cherchiez sur la carte ?

○ Oui

○ Non

Si réponse b) à la question 23

Q24) Vous avez répondu « non » à la question précédente. Indiquez ci-dessous, le plus précisément possible, de quel lieu il s'agit (donnez notamment, si vous le connaissez, le non de la commune. S'il s'agit d'un parcours, écrivez : entre (nom du lieu 1) et (nom du lieu 2)

Si réponse b) e) ou f) à la question 20

Q25) Vous avez effectué plusieurs sorties en forêt et/ou à la campagne au cours des 5 dernières années. Précisez combien.

Si scénario 1 réponse b) à la question 18

Ou scénario 2 réponse b) à la question 20

Q26) Vous avez effectué plusieurs visites, en forêt et à la campagne (au cours des 12 derniers mois ou des 5 dernières années selon vos réponses aux questions précédentes). La dernière a-t-elle eu lieu :

Veuillez sélectionner une réponse ci-dessous :

○ En forêt

○ A la campagne

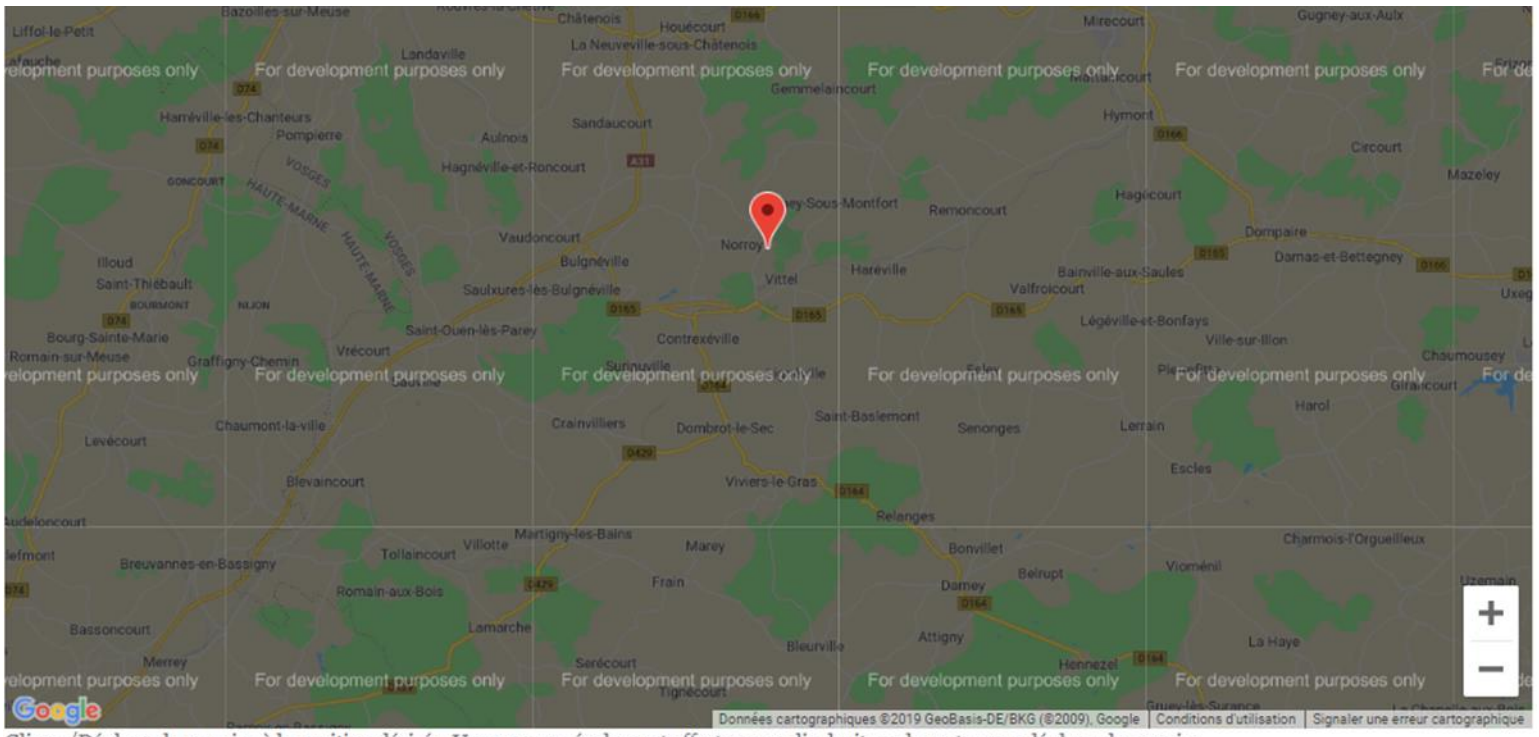
Si scénario 1 : réponse a) à la question 18 et réponse b) à la question 20 et a) ou b) à la question 26

Ou scénario 2 : réponse a) à la question 18 et e) ou f) à la question 20

Ou scénario 3 : réponse b) à la question 18 et a) ou b) à la question 26

Ou scénario 4 : réponse c) ou e) à la question 18

Q27) Vous avez effectué plusieurs visites en forêt et/ou à la campagne (au cours des 12 derniers mois ou des 5 dernières années, selon vos réponses aux questions précédentes). Où la dernière a-t-elle eu lieu ? Merci de chercher le site sur la carte ci-dessous en glissant/déplaçant la punaise (approximativement) vers la position désirée. Si vous avez effectué un circuit, indiquez le point central de votre visite.



Glisser/Déplacer la punaise à la position désirée. Vous pouvez également effectuer un clic droit sur la carte pour déplacer la punaise.

Veuillez sélectionner une réponse ci-dessous :

- ○ a) En forêt
- ○ b) A la campagne

Si scénario 1 : réponse a) à la question 18 et réponse b) à la question 20 et a) ou b) à la question 26

Ou scénario 2 : réponse a) à la question 18 et e) ou f) à la question 20

Ou scénario 3 : réponse b) à la question 18 et a) ou b) à la question 26

Ou scénario 4 : réponse c) ou e) à la question 18

Q28) Avez-vous trouvé le lieu que vous cherchiez sur la carte ?

- ○ Oui

○ Non

Si réponse b) à la question 28

Q29) Vous avez répondu « non » à la question précédente. Indiquez ci-dessous, le plus précisément possible, de quel lieu il s'agit (donnez notamment, si vous le connaissez, le non de la commune. S'il s'agit d'un parcours, écrivez : entre (nom du lieu 1) et (nom du lieu 2)

Si scénario 1 : réponse a) à la question 18 er b), c), d), e) ou f) à la question 20

Ou scénario 2 : réponse b), c), d), e) ou f) à la question 18

Q30) Lors de votre dernière visite en forêt ou à la campagne, comment vous êtes-vous rendus sur le site ?

Veuillez sélectionner une réponse ci-dessous :

○ En voiture
○ A moto/scooter
○ En transports en commun
○ A pied
○ A vélo électrique
○ A vélo classique

Si réponse a) à la question 30

Q31) De quel type de voiture s'agit-il ?

Veuillez sélectionner une réponse ci-dessous :

○ Voiture diesel
○ Voiture essence
○ Voiture Gaz de Pétrole Liquéfié (GPL)
○ Voiture électrique
○ Voiture hybride

Si réponse a) à la question 30

Q32) Pouvez-vous indiquer (approximativement) la consommation du véhicule utilisé pour 100 km effectués ?

Si vous ne connaissez pas la consommation de votre véhicule, indiquer simplement la mention « je ne sais pas »

Si réponse a) à la question 30 et « je ne sais pas » à la question 32

Q33) Lors de votre dernière visite en forêt ou à la campagne, vous vous êtes rendu sur le site en voiture. Il s'agissait :

Veuillez sélectionner une réponse ci-dessous :

- ○ D'une petite voiture (exemple : Renault Clio, Peugeot 208, Citroën C3 etc.)
- ○ D'une voiture de taille moyenne (exemple : Peugeot 308, Citroën C4, Ford Focus etc.)
- ○ D'une grande voiture (Renault Espace, Renault Kangoo etc.)

Si scénario 1 : réponse a) à la question 18 et b) ou c) ou d) ou e) ou f) à la question 20 et a) ou b) à la question 30

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18 et a) ou b) à la question 30

Q34) Combien d'adultes y avait-il dans/sur le véhicule lors de votre dernière visite en forêt ou à la campagne ?

Si scénario 1 : réponse a) à la question 18 et b) ou c) ou d) ou e) ou f) à la question 20 ou

scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q35) Quel a été (approximativement) votre temps de trajet jusqu'à la dernière forêt ou campagne visitée ?

Heure(s) **:**

Minute(s) :

Si scénario 1 **:** réponse a) à la question 18 et b) ou c) ou d) ou e) ou f) à la question 20 ou

scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q36) Quelle distance (aller-retour, en kilomètres) avez-vous approximativement parcouru pour vous rendre sur le site (et en revenir) lors de votre dernière visite en forêt ou à la campagne ?

Si réponse b) ou c) ou e) à la question 18

Q37) Vous avez effectué plusieurs sorties en forêt et/ou à la campagne au cours des 12 derniers mois. Précisez combien de visites vous avez effectué dans la dernière forêt ou campagne que vous avez visité.

Si scénario 1 : réponse a) à la question 18 et b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q38) Combien de temps a duré votre dernière sortie en forêt ou à la campagne ? (il s'agit du temps passé sur place, ne comptez pas le temps de trajet).

Veuillez sélectionner une réponse ci-dessous :

○ Moins de 30 minutes

○ Entre 30 minutes et une heure

○ Entre une heure et deux heures

○ Plus de deux heures

○ Vous ne savez pas

Si scénario 1 : réponse a) à la question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q39) Quelles ont été vos activités lors de votre dernière sortie ?

Cochez-la ou les réponse(s)

○ Promenade

○ Cueillette

○ Observation de la faune et/ou de la flore

○ Chasse

○ Observation du paysage

○ Activité sportive

○ Pique-nique

○ Ramassage de bois

○ Autre : ☐

Si scénario 1 : réponse a) à la question 18 et b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

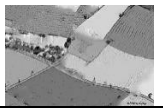
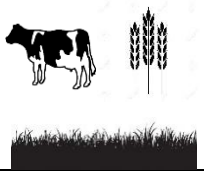
Q40) Nous réalisons le questionnaire auquel vous répondez actuellement afin de mieux connaître les préférences de la population locale concernant les activités récréatives (loisirs). Dans ce but, nous avons distingué, deux types d'espaces récréatifs : la forêt et la campagne. Nous allons vous demander de choisir, selon vos préférences, entre différents scénarios : ces scénarios seront composés de différentes caractéristiques, et reflètent ce que vous pouvez trouver (ou non) en forêt et où à la campagne. Les caractéristiques pourront prendre différents niveaux, qui seront illustrés par un pictogramme. Certaines caractéristiques seront communes à la forêt et à la campagne (présence de sentiers de randonnée balisés par exemple) et d'autres seront spécifiques à la première ou à la seconde (la caractéristique "occupation des parcelles agricoles" sera, par exemple, spécifique à la campagne). Voici les caractéristiques communes aux 2 types d'espaces (les attributs spécifiques à la campagne et à la forêt seront décrits dans les pages suivantes).

Caractéristiques	Niveau des caractéristiques	Signification
Equipements		**présence** de tables de pique-nique, de poubelles, ou encore de panneaux d'information sur les essences d'arbres, etc.
		**absence** de tables de pique-nique, de poubelles, ou encore de panneaux d'information sur les essences d'arbres, etc.
Sentiers de randonnée balisés		**présence** de sentiers pédestres et cyclistes
		**absence** de sentiers pédestres et cyclistes
Cours d'eau		**présence** de cours d'eau
		**absence** de cours d'eau
Pesticides		**utilisation** de pesticides
		**non utilisation** de pesticides
Distance	entre 1 et 70 km	**distance** à effectuer pour se rendre sur le site. **Plus elle est importante, plus le coût nécessaire (temps + argent) pour l'effectuer est important.**

Si scénario 1 : réponse a) question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q41) Voici les caractéristiques spécifiques à la campagne :

Caractéristiques	Niveau des caractéristiques	Signification
Haies et biodiversité		**absence** de haies
		**faible présence** de haies et de biodiversité
		**forte présence** de haies et de biodiversité
Occupation des parcelles agricoles		**élevage** (animaux visibles lors de votre sortie)
		**cultures** (blé, maïs etc.)
		**prairie**
		**occupation mixte**

Si scénario 1 : réponse a) question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q42) Voici la caractéristique spécifique à la forêt :

Caractéristique	Niveau de la caractéristique	Signification
Type(s) d'essence(s)		forêt **composée exclusivement de résineux** (pins, sapins etc.)
		forêt **composée exclusivement de feuillus** (chêne, hêtre etc.)

		forêt **mixte** (feuillus + résineux)

Si scénario 1 : réponse a) question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q43) Au cours des questions suivantes, nous nous intéresserons aux caractéristiques de la dernière forêt ou campagne que vous ayez visitée. Lors de votre dernière visite en forêt ou à la campagne, y avait-il des équipements type tables de pique-nique, poubelles, panneaux d'information sur les essences d'arbres etc ? Veuillez sélectionner l'icône correspondante :

Veuillez sélectionner une réponse ci-dessous :

○ 

○ 

○ Vous ne savez pas

Si scénario 1 : réponse a) question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q44) Lors de votre dernière visite en forêt ou à la campagne y avait-il des sentiers de randonnée balisés ? Veuillez sélectionner l'icône correspondante :

Veuillez sélectionner une réponse ci-dessous :

○ 

○ 

○ Vous ne savez pas

Si scénario 1 : réponse a) question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q45) Y avait-il un cours d'eau dans la dernière forêt ou campagne que vous ayez visité ? Veuillez sélectionnez l'icône correspondante :

Veuillez sélectionner une réponse ci-dessous :

○ 

○ 

○ Vous ne savez pas

Si scénario 1 : réponse a) question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q46) Des pesticides étaient-ils utilisés sur le site de votre dernière visite en forêt ou à la campagne ? Veuillez sélectionner l'icône correspondante :

Veuillez sélectionner une réponse ci-dessous :

○ 

○ 

○ Vous ne savez pas

Si scénario 1 : réponse a) à la question 18 et b) à la question 20 et b) à la question 26

Ou scénario 2 : réponse a) à la question 18 et d) à la question 20

Ou scénario 3 : réponse b) à la question 18 et b) à la question 26

Ou scénario 4 : réponse f) à la question 18

Ou scénario 5 : réponse a) à la question 18 et f) à la question 20

Ou scénario 6 : réponse e) à la question 18

Q47) Lors de votre dernière visite à la campagne, comment étaient occupées les parcelles agricoles ? Veuillez sélectionner une icône ci-dessous :

Veuillez sélectionner une réponse ci-dessous :

○ 

○ 

○ 

○ 

○ Vous ne savez pas

Si scénario 1 : réponse a) à la question 18 et b) à la question 20 et a) à la question 26

Ou scénario 2 : réponse b) à la question 18 et a) à la question 26

Ou scénario 3 : réponse a) à la question 18 et c) à la question 20

Ou scénario 4 : réponse d) à la question 18

Ou scénario 5 : réponse a) à la question 18 et e) à la question 20

Ou scénario 6 : réponse c) à la question 18

Q48) Quelles essences d'arbres composaient la dernière forêt que vous ayez visité ? Veuillez sélectionner l'icône correspondante :

Veuillez sélectionner une réponse ci-dessous :

○ 

○ 

○ 

○ Vous ne savez pas

Si scénario 1 : réponse a) à la question 18 ou b) à la question 18 et b) à la question 26

Ou scénario 2 : réponse b) à la question 20 et b) à la question 26

Ou scénario 3 : réponse a) à la question 18 et d) à la question 20

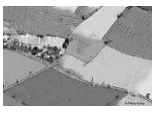
Ou scénario 4 : réponse f) à la question 18

Ou scénario 5 : réponse a) à la question 18 et f) à la question 20

Ou scénario 6 : réponse e) à la question 18

Q49) Lors de votre dernière visite à la campagne, y avait-il des haies (on considère ici que la présence de haies entraîne systématiquement la présence de biodiversité) ? Veuillez sélectionner une icône ci-dessous.

Veuillez sélectionner une réponse ci-dessous :

○ 

○  

○   

○ Vous ne savez pas

Si scénario 1 : réponse a) à la question 18 et b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q50) Ceci est un exemple de choix que vous aurez à effectuer lors des 8 questions suivantes. Vous devez effectuer ce choix selon vos préférences, en fonction des caractéristiques proposées. Pour cela, vous devrez sélectionner, en bas de la page, le scénario choisi. Le scénario "dernière forêt ou campagne visitée" présente les caractéristiques du dernier site que vous avez visité. Les icônes qui apparaîtront dans cette colonne sont donc celles que vous aurez sélectionné au cours des questions précédentes. Vous devrez comparer ces caractéristiques à celles qui vous sont proposées dans les scénarios "campagne" et "forêt" pour faire votre choix. Pour les caractéristiques qui n'apparaissent pas ici (densité de la forêt, par exemple, le cas échéant), imaginez qu'elles sont également similaires à celles de la dernière forêt ou campagne visitée. De la même manière, veuillez considérer que le contexte (vacances, week-end etc.) et la finalité (promenade, cueillette etc.) de votre sortie sont les mêmes. Ce qui est présenté ici est juste un exemple. Quand vous avez compris la démarche à suivre, passez directement à la question suivante, sans choisir de scénario. La question est présentée comme ceci : "veuillez sélectionner un des scénarios comme si vous aviez eu le choix, avant votre dernière visite, entre ces trois options".

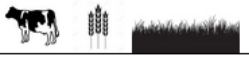
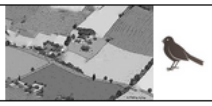
Caractéristiques	Scénario "dernière forêt ou campagne visitée"	Scénario "campagne"	Scénario "forêt"
Equipements			
Sentiers de randonnée balisés			
Cours d'eau			
Pesticides			
Occupation des parcelles agricoles			
Type(s) d'essence(s)			
Haies et de biodiversité			
Distance (aller-retour)	33 km	20 km	1 km

	scénario "dernière forêt ou campagne visitée"	scénario "campagne"	scénario "forêt"
Votre choix :	○	○	○

Si scénario 1 : random 2 = 1[1] et réponse a) à la question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : random 2 =1 et réponse b) ou c) ou d) ou e) ou f) à la question 18

Q51 : Veuillez sélectionner un des trois scénarios (en bas de la page, sous le tableau) comme si vous aviez eu le choix, avant votre dernière visite, entre ces trois options.

caractéristiques	Scénario "dernière forêt ou campagne visitée"	Scénario "campagne"	Scénario "forêt"
niveau d'équipements			
présence de sentiers de randonnée balisés			
présence de cours d'eau			
utilisation de pesticides			
occupation des parcelles agricoles			
type(s) d'essence(s)			
présence de haies et de biodiversité			
distance (aller-retour)	33 km	30 km	15 km

scénario "dernière forêt ou campagne visitée" scénario "campagne" scénario "forêt"

Votre choix :

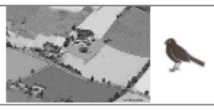
Si scénario 1 : random 2 = 2 et réponse a) à la question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : random 2 =2 et réponse b) ou c) ou d) ou e) ou f) à la question 18

Q51bloc2 : Veuillez sélectionner un des trois scénarios (en bas de la page, sous le tableau) comme si vous aviez eu le choix, avant votre dernière visite, entre ces trois options.

[1] La variable « random 2 » est comprise entre 1 et 3 : les enquêtés sont aléatoirement répartis entre les blocs 1, 2 et 3 et les ensembles de choix présentés sont donc différents selon les blocs, mais le type de question reste le même que pour la question 51. Nous ne présenterons donc pas toutes les questions ici, mais seulement un ensemble de choix par bloc (les enquêtés effectuent 8 choix).

Veuillez séléctionner un des trois scénarios (en bas de la page, sous le tableau) comme si vous aviez eu le choix, avant votre dernière visite, entre ces trois options.

Caractéristiques	Scénario "dernière forêt ou campagne visitée"	Scénario "campagne"	Scénario "forêt"
Equipements			
Sentiers de randonnée balisés			
Cours d'eau			
Pesticides	Vous ne savez pas		
Occupation de parcelles agricoles			
Type(s) d'essence(s)			
Haies et biodiversité			
Distance (aller-retour)	11 km	35 km	1 km

scénario "dernière forêt ou campagne visitée" scénario "campagne" scénario "forêt"

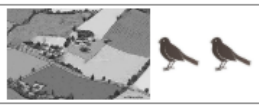
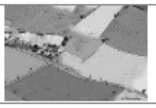
Votre choix : ○ ○ ○

Si scénario 1 : random 2 = 3 et réponse a) à la question 18 et réponse b) ou c) ou d) ou e) ou f) à la question 20

Ou scénario 2 : random 2 =3 et réponse b) ou c) ou d) ou e) ou f) à la question 18

Q51bloc3 : Veuillez sélectionner un des trois scénarios (en bas de la page, sous le tableau) comme si vous aviez eu le choix, avant votre dernière visite, entre ces trois options.

Veuillez séléctionner un des scénarios (en bas de la page, sous le tableau) comme si vous aviez eu le choix, avant votre dernière visite, entre ces trois options.

Caractéristiques	Scénario "dernière forêt ou campagne visitée"	Scénario "campagne"	Scénario "forêt"
Equipements			
Sentiers de randonnée balisés			
Cours d'eau			
Pesticides	Vous ne savez pas		
Occupation des parcelles agricoles			
Type(s) d'essence(s)			
Haies et biodiversité			
Distance (aller-retour)	44 km	10 km	25 km

scénario "dernière forêt ou campagne visitée" scénario "campagne" scénario "forêt"

Votre choix : ○ ○ ○

Si réponse a) aux questions 51, 52, 53, 54, 55,56, 57 et 58 (bloc 1, 2 ou 3)

Q59) Vous avez systématiquement opté pour le scénario "dernière forêt ou campagne visitée". Quelles sont les raisons principales de ce choix ?

Cochez-la ou les réponses

- ○ Le nombre de caractéristiques à comparer était trop important, choisir le scénario "dernière forêt ou campagne visitée" nécessitait moins de réflexion
- ○ Les caractéristiques des scénarios "forêt" et "campagne" ne me convenaient pas
- ○ Je ne comprenais pas ce que l'on me demandait
- ○ Les autres alternatives étaient trop éloignées (distance trop importante)
- ○ L'option "dernière forêt ou campagne visitée" présentait systématiquement les meilleures caractéristiques selon moi
- ○ Autre : [ ]

Si scénario 1 : réponse a) à la question 18 et réponse b) ou c) ou d) e) ou f) à la question 20

Ou scénario 2 : réponse b) ou c) ou d) ou e) ou f) à la question 18

Q60) Lors de vos choix entre les différents scénarios, avez-vous pris en compte toutes les caractéristiques ?

Veuillez sélectionner une réponse ci-dessous :

- ○ Oui
- ○ Non

Si réponse b) à la question 60

Q61) Vous avez répondu "non" à la question précédente. Quelle(s) est/sont la/les caractéristique(s) que vous n'avez pas pris en compte ?

Cochez-la ou les réponse(s)

- ○ Equipements
- ○ Sentiers de randonnée balisés
- ○ Cours d'eau
- ○ Pesticides
- ○ Type(s) d'essence(s)

○ Haies et biodiversité

○ Occupation des parcelles agricoles

○ Distance

Si scénario 1 : réponse a) à la question 18, réponse b) à la question 20 et réponse a) ou b) à la question 26

Ou scénario 2 : réponse a) à la question 18 et e) ou f) à la question 20

Ou scénario 3 : réponse b) à la question 18 et réponse a) ou b) à la question 26

Ou scénario 4 : réponse c) ou e) à la question 18

Q62) Vous avez effectué plusieurs visites en forêt et/ou à la campagne (au cours des 12 derniers mois ou des 5 dernières années selon vos réponses aux questions précédentes). La forêt ou la campagne la plus visitée au cours de cette période était-elle la même que la dernière que vous ayez visité ?

Veuillez sélectionner une réponse ci-dessous :

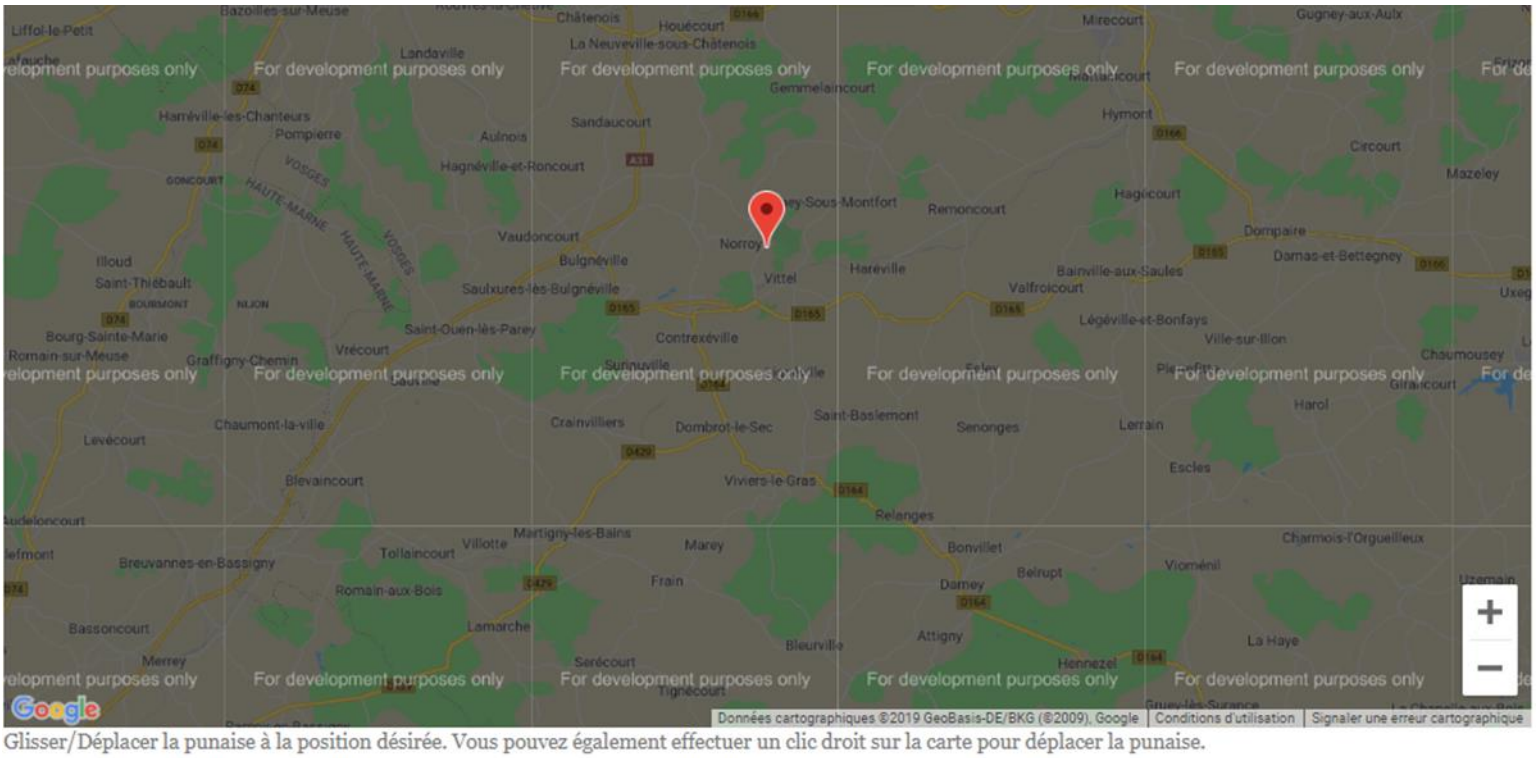
○ Oui

○ Non

Si scénario 1 : réponse a) à la question 18 et réponse b), e) ou f) à la question 20 et réponse b) à la question 62

Ou scénario 2 : réponse b), c) ou e) à la question 18 et réponse b) à la question 62

Q63) Vous avez effectué plusieurs sorties en forêt et/ou à la campagne, veuillez indiquer sur la carte où se trouve la forêt et ou la campagne la plus visitée (au cours des 12 derniers mois ou des 5 dernières années selon vos réponses aux questions précédentes) (indiquez le point central de votre visite). Merci de chercher le site sur la carte ci-dessous en glissant/déplaçant la punaise à la position désirée.



Glisser/Déplacer la punaise à la position désirée. Vous pouvez également effectuer un clic droit sur la carte pour déplacer la punaise.

Si scénario 1 : réponse a) à la question 18, réponse b) à la question 20 et a) ou b) à la question 26 et b) à la question 62

Ou scénario 2 : réponse a) à la question 18 et réponse e) ou f) à la question 20 et réponse b) à la question 62

Ou scénario 3 : réponse b) à la question 18 et réponse a) ou b) à la question 26 et réponse b) à la question 62

Ou scénario 4 : réponse c) ou e) à la question 18 et b) à la question 62

Q64) Avez-vous trouvé le lieu que vous cherchiez sur la carte ?

○ Oui

○ Non

Si réponse b) à la question 64

Q65) Vous avez "répondu "non" à la question précédente. Indiquez ci-dessous, le plus précisément possible, de quel lieu il s'agit (donnez notamment, si vous le connaissez, le nom de la commune). S'il s'agit d'un parcours, écrivez "entre (nom du lieu 1) et (nom du lieu 2)".

Si scénario 1 : réponse a) à la question 18 et réponse b), e) ou f) à la question 20 et réponse b) à la question 62

Ou scénario 2 : réponse b), c) ou e) à la question 18 et b) à la question 62

Q66) Vous avez indiqué sur la carte où se situait la forêt ou la campagne que vous avez le plus visité. Combien de fois vous êtes-vous rendus sur place (au cours des 12 derniers mois ou des 5 dernières années, selon vos réponses aux questions précédentes) ?

Si scénario 1 : réponse a) à la question 18 et b), e) ou f) à la question 20 et b) à la question 62

Ou scénario 2 : réponse b), c) ou e) à la question 18 et b) à la question 62

Q67) Quel a été votre temps de trajet jusqu'à la forêt ou la campagne la plus visitée (au cours des 12 derniers mois ou des 5 dernières années, selon vos réponses aux questions précédentes) ?

Si scénario 1 : réponse a) à la question 18 et réponse b), e) ou f) à la question 20 et réponse b) à la question 62

Ou scénario 2 : réponse b), c) ou e) à la question 18 et b) à la question 62

Q68) Quelle distance (aller-retour, en kilomètres) avez-vous effectué pour vous rendre dans la forêt ou la campagne la plus visitée (et en revenir) (au cours des 12 derniers mois ou des 5 dernières années, selon vos réponses aux questions précédentes) ?

Si scénario 1 : réponse a) à la question 18, réponse b) à la question 20 et réponse a) à la question 26

Ou scénario 2 : réponse a) à la question 18 et c) ou e) à la question 20

Ou scénario 3 : réponse b) à la question 18 et a) à la question 26

Ou scénario 4 : réponse c) ou d) à la question 18

Q69 : Si vous pouviez choisir les caractéristiques de la forêt idéale, quelles seraient-elles ? Veuillez choisir 5 caractéristiques parmi les 11 proposées, par ordre de préférence : mettez en numéro 1 la caractéristique la plus importante à vos yeux et en numéro 5 la moins importante.

a. Présence d'animaux
b. Possibilité de se restaurer à proximité
c. Présence d'essences d'arbres que vous appréciez
d. Beauté du paysage
e. Présence d'équipements (tables de pique-nique, poubelles etc.)
f. Proximité du site par rapport à votre domicile
g. Accessibilité (routes, parkings, aménagements pour les handicapés etc.)
h. Présence de sentiers de randonnée balisés
i. Absence de pesticides
j. Présence de cours d'eau
k. Autre (à préciser dans la question suivante)

Si réponse k) à la question 69

Q70) Vous avez sélectionnez l'option "autre" lors de la question précédente. Précisez maintenant votre réponse.

Si scénario 1 : réponse a) à la question 18, réponse b) à la question 20 et réponse b) à la question 26

Ou scénario 2 : réponse a) à la question 18 et réponse d) ou f) à la question 20

Ou scénario 3 : réponse b) à la question 18 et b) à la question 26

Ou scénario 4 : réponse e) ou f) à la question 18

Q71) Si vous pouviez choisir les caractéristiques de la campagne idéale, quelles seraient-elles ? Veuillez choisir 5 des 11 caractéristiques proposées, par ordre de préférence: mettez en numéro 1 la caractéristique la plus importante à vos yeux et en numéro 5 la moins importante.

a. Absence de pesticides
b. Présence de Haies et de biodiversité
c. Présence de cours d'eau
d. Présence de terres agricoles exploitées
e. Proximité du site par rapport à votre domicile
f. Présence de sentiers de de randonnée balisés
g. Beauté du paysage
h. Présence d'équipements (tables de pique-nique, poubelles etc.)
i. Présence d'un lieu de restauration
j. Présence d'animaux (élevage ou autre)
k. Autre (à préciser dans la question suivante)

Si réponse k) à la question 71

Q72) Vous avez sélectionnez l'option "autre" lors de la question précédente. Précisez maintenant votre réponse.

Q73) L'épidémie de Covid-19 est toujours en cours. Au vu de cette épidémie, diriez-vous que vous avez confiance en l'avenir ?

Veuillez sélectionner une réponse ci-dessous :

○ Non, je n'ai pas du tout confiance en l'avenir
○ Non, je n'ai plutôt pas confiance en l'avenir
○ Je n'ai ni plus ni moins confiance en l'avenir
○ Oui, j'ai plutôt confiance en l'avenir
○ Oui, j'ai tout à fait confiance en l'avenir

Q74) L'épidémie de Covid 19 est toujours en cours. Envisagez-vous de modifier la fréquence de vos futures sorties à des fins récréatives, en forêt ou à la campagne, par rapport à la période où le Covid était absent ?

Veuillez sélectionner une réponse ci-dessous :

○ Oui, je sortirai beaucoup moins qu'avant
○ Oui, je sortirai moins souvent

○ Non la fréquence de mes sorties ne changera pas

○ Oui, je sortirai plus souvent

○ Oui, je sortirai bien plus qu'avant

Q75) L'épidémie de Covid 19 modifiera-t-elle votre mode de déplacement (voiture, vélo, à pied…) pour vous rendre en forêt ou à la campagne, à des fins récréatives ?

Veuillez sélectionner une réponse ci-dessous :

○ Oui

○ Non

○ Vous ne savez pas

Q76) Quel est le revenu mensuel net de votre foyer ?

○ moins de 1500€

○ 1500-1999€

○ 2000-2499€

○ 2500-3499€

○ 3500-4999€

○ 5000-6999€

○ plus de 7000€

○ ne souhaite pas répondre

Nous avons conscience du caractère très personnel de la question. Pour autant, pour l'analyse des résultats de l'enquête, il est très important que vous répondiez à cette question. Merci de votre compréhension.

Q77) Comme nous l'avons précisé dans le processus de rétractation, vous bénéficiez d'un droit d'accès, de rectification, d'opposition et d'effacement des informations qui vous concernent. Souhaitez-vous bénéficier de ce droit ?

Veuillez sélectionner une réponse ci-dessous :

○ Oui

○ Non

Q78) Souhaitez-vous avoir accès aux résultats de l'enquête ?

Veuillez sélectionner une réponse ci-dessous :

○ Oui

○ Non

Message de fin

Merci beaucoup pour votre participation !

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Chapitre 2 The non-use value of improving water quality and biodiversity: Preferences for watershed protection measures

The non-use value of improving water quality and biodiversity: Preferences for watershed protection measures

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1. Introduction

In this paper, we estimate preferences for different measures to protect water resources and biodiversity, focusing on the preferences of non-users. The usefulness of ecosystem service (ES) valuation for measures to protect and restore aquatic environments has recently been recognised in France (Amigues and Chevassus-au-Louis [2011]). While water management policies initially focused mainly on water quality and availability, the good ecological status of water bodies has gradually become an important issue, in particular with the publication of the European Water Framework Directive (WFD) in 2000. Although the WFD does not explicitly mention the notion of ES (Amigues and Chevassus-au-Louis [2011]), actions taken to achieve good water status have a direct impact on ecosystems (Salvetti, [2013]; CGDD, 2014). However, the WFD can be seen as the starting point for the use of economic analysis in water management in France (MEDD [2005]), in particular through cost-benefit analysis (CBA) (MEDD [2005]; Salvetti [2013]; CGDD [2014]; Feuillette et *al.* [2015, 2016]). Such analysis includes environmental benefits (and costs) for which non-use values (NUVs) can be significant (MEDD [2005]).

Over the years, the measurement of NUVs has become an important issue and environmental economists have developed valuation methods to account for these values (Adamowicz et *al.* [1998]; Pearce [2002]; Banzhaf [2016]). Historically, the contingent valuation method (CVM) has been widely used to value NUVs (Bateman and Langford [1997]; Adamowicz et *al.* [1998]; Colarullo and Perez [2003]; Kafy et *al.* [2018]), although the method has been questioned (Desvouges et *al.* [1993]; Desvouges et *al.* [2010]). Comparing the ability of CVM and discrete choice experiments (DCE) to assess such values, Adamowicz et *al.* [1998] concluded that DCE performed well. In addition, Alpizar et *al.* [2001] suggest that DCE is less subject to the warm glow effect than CV when making such valuations.

Following Adamowicz et *al.* [1998], some authors estimated only NUVs: for example, Windle and Rolfe [2005] assessed only NUVs for the protection of the Fitzroy estuary in central Queensland, Australia. Others, such as Johnston et *al.* [2005] and Moore et *al.* [2018], chose to examine both. An advantage of this approach is that it allows comparisons to be made between the two groups (users and non-users). Whether researchers want to estimate use values only or both use values and NUVs, they need to decide how to define non-use and non-users in order to distinguish them from use (and therefore users).

Traditionally, the literature has identified two approaches to determining NUVs (Marre et *al.* [2015]; Johnston et *al.* [2003]). The first is to target a population that will certainly never use (e.g. because of distance) and then ask them about their willingness to pay (WTP). The second is to have both users and non-users in the sample and estimate values for both groups. Both approaches raise definitional issues (Marre et *al.* [2015]; Johnston et *al.* [2005]). In general, the literature defines non-users as individuals who have not used a resource in a defined historical period, and do not expect to use it in a similar way in a defined future period (Johnston et *al.* [2003]). Users, on the other hand, are typically defined in terms of their participation in (recreational) activities at the site of interest during a defined period of time: There is no consensus on the time period to be considered: Moore et *al.* [2018] conducted a DCE in the Chesapeake Bay estuary in the United States, estimating the WTP for improvements in five environmental attributes for a sample of users and non-users. The former were defined as individuals who participated in recreational activities at the Bay within the last five years. Amiri et *al.* [2022] considered the same time lag in their DCE study specific to recreational use values, while Farber and Griner [2000] considered the last two years. Finally, Tu et *al.* [2016] focused on the last 12 months. Alternatively, in a DCE on salt marsh restoration efforts in Rhode Island, Johnston et *al.* [2005] distinguished between recreational nonusers (who did not visit the site for recreational purposes) and complete non-users (who did not use the site for recreational purposes and also did not drive by (regularly) or live within sight of the Rhode Island salt marsh). Respondents who did not fall into either of these categories were considered users.

Numerous applications of stated preference methods have been used to assess non-market values of watersheds or river basins (Loomis [1997]; Duberstein and de Steiguer [2003] and Thurston et *al.* [2009]). If contingent valuation has been widely used in the past (Duberstein and de Steiguer [2003]) and is still being used (Abebe et *al.* [2019]), the DCE method has become popular for conducting such valuations. Case studies of DCE assessed preferences for watershed/river basin ES can be found all over the world (Kaval [2019]): in Europe (Garcia Llorente et *al.* [2012]; da Costa et *al.* [2019], Amiri et *al.* [2022]), in the United States (Shrestha and Alavalapati [2004]; Chaikaew et *al.* [2017]; Aguilar et *al.* [2018]) or in Asia (Cheng et *al.* [2021]; Khan et *al.* [2019; 2021].

Most of this literature investigated local population preferences for ES or land use management (Amiri et *al.* [2022]; Cheng et *al.* [2021]; da Costa et *al.* [2019] Chaikaew et *al.* 2017; Garcia Llorente et *al.* [2012]). However, some authors used a different strategy: Aguilar

et *al.* [2018] conducted a national survey on ES from forested watersheds and attitudes towards payment for environmental services (PES) programmes. Moore et *al.* [2018] conducted a DCE on water quality improvements in the Chesapeake Bay, surveying residents of the 17 eastern states and the District of Columbia to enable NUV assessment: about 70% of respondents were non-users of the Chesapeake Bay or watershed lakes. However, the authors found no distance decay in WTP.

The existence of distance decay in NUVs, where the value decreases with distance to the environmental good being valued, has been widely discussed in the literature (Glenk et *al.* [2020]; Johnston et *al.* [2015]) and the empirical results are mixed (Johnston et *al.* [2015], Schaafsma et *al.* [2013]). Farber and Griner [2000] tested the existence of a distance effect for both users and non-users in a study of watershed quality improvements for two streams in western Pennsylvania. They found that non-users placed low and statistically insignificant values on stream improvements, and that these values were unrelated to distance from the streams. They interpreted this as consistent with a 'purist' interpretation of NUVs, which suggests that NUVs must be spatially independent to be clearly distinguished from use values. Hanley et *al*. [2003] tested whether the distance decay effect is different for a single environmental good (the Mimram River) than for a larger set of goods (all rivers in the Thames region). Specifically, they estimate Tobit regressions where the dependent variables are positive WTP as a function of individual characteristics and distance to the environmental good, depending on use values and NUVs.

Our study aims at assessing preferences and in particular NUVs for environmental improvement projects in a specific watershed using a DCE. We want to know if these values exist and what their amplitude is for each of the following water and biodiversity protection measures: reduction of use of pesticides and fertilisers, protection and planting of hedgerows, restoration of watercourses and sustainable forest management. Another focus is the existence of a distance effect on environmental preferences, by interviewing people who live either near or far from the watershed. Assessed WTP is useful for public decision-makers to know which protection measures to target, and could help to guide and calibrate public taxes or subsidies.

2. Methodology

2.1. DCE and watershed management

Our study assesses preferences for NUVs of watershed water and biodiversity protection measures by targeting non-users. We use a stated preference approach, *i.e.* DCE, in which respondents reveal their preferences by choosing between different alternatives. According to Holmes et *al.* [2017], « there has been an explosion of interest » in DCE during the past two decades. The method began to be applied in the early 80s (Da Costa and Hernandez, [2019]) with the works of Louviere and Hensher [1983] and Louviere and Woodworth [1983]. DCE gradually became more popular than all other environmental valuation methods (Guijarro and Tsinaslanidis [2020]), including contingent valuation (Mahieu et *al.* [2014]; Guijarro and Tsinaslanidis [2020]). The paper that "generated attention in the environmental economics community" (Carson and Czajkowski [2014]) was the one of Adamowicz et *al.* [1998], who used both a DCE and revealed preference data on recreational destinations to value environmental amenities.

As written previously, DCE investigated preferences for watershed/river basin ES in a variety of context and countries (Kaval [2019]): in Europe (Garcia Llorente et *al.* [2012]; da Costa et *al.* [2019], Amiri et *al.* [2022]), in The United States (Shrestha and Alavalapati [2004]; Chaikaew et *al.* [2017]; Aguilar et *al.* [2018]) or in Asia (Cheng et *al.* [2021]; Khan et *al.* [2021, 2019]). Even if these watersheds/river basins might share some characteristics, every site is unique and different factors, such as land use/ land cover features, may influence ES provision (Postel et Thompson [2005]; Smith et *al.* [2006]; FAO [2006]).

2.2. Study area and experimental design

We designed the DCE to estimate the economic value of protecting water quality and biodiversity in a particular watershed, focusing on the NUVs. However, groundwater protection has direct use values for water consumers, and biodiversity protection may increase recreational value for local landscape users. Therefore, to estimate the NUVs, we identified a specific watershed in a rural area with low population density and clearly defined water users. To make our scenarios as realistic as possible, we specified hypothetical measures for the Rupt de Mad watershed located in the Rhin-Meuse Basin (Figure 2.1), which is currently part of a project to improve biodiversity and water quality. Residents consuming drinking water

from this watershed were then excluded from the sample (residents of Metz and surrounding municipalities).

a)

b)



Figure 2-1: a) Outline of the Rhine-Meuse Basin (BRM) in blue and b) the Rupt de Mad watershed in red

We surveyed a representative sample of residents in the area covered by the Rhin-Meuse water agency. Water agencies (Agences de l'eau) are French public institutions created in 1964 to manage and preserve water resources and the aquatic environment. Inspired by foreign initiatives (Brun [2012]; Barraqué et Laigneau [2017]), the French water policy remains somewhat unique (Feuillette et *al.* [2015]): in fact, the 1964 law is also the origin of other governance structures, such as the basin committee (Brun [2012]; Feuillette et *al.* [2015, 2016]). The French territory is divided into six river basins, and each one has a consultative structure (Comités de bassin) and an executive one (Agence de l'eau). According to the polluter-pays principle, the agencies receive royalties from water users (compagnies, households, etc.) depending on the level of water pollution and the extraction of resources (Brun [2012]; Feuillette et *al.* [2015]). These fees are then used to finance projects to improve water management and quality at the level of the river basin. This reciprocity is referred to as the "water-pay-water" principle (Brun [2012]; Barraqué and Laigneau [2017]). Such projects are selected according to criteria defined in a multiannual programme and validated by a basin committee (Brun [2012]; Feuillette et *al.* [2015]). The water agency therefore has a credible framework for introducing hypothetical protection scenarios.

In our questionnaire, we first presented the context of the watershed improvement projects to the respondents, *i.e.* the role of the Rhin-Meuse water agency in the protection of water resources and biodiversity. We explained that they participate in the financing of projects to promote practices that are more favourable to water quality (less intensive use of pesticides, etc.) and the protection of biodiversity. The respondents are informed that such measures contribute to improve the quality of the raw water, thus reducing the cost of water treatment, which benefits consumers in Metz and the surrounding communes. As these residents are excluded from the analyses, our sample only includes respondents who do not directly benefit from improved water quality.

The attributes included in the DCE were selected through a literature review and discussion with stakeholders and agricultural scientists (Table 1.1). These included five attributes related to agricultural and forest land uses, the dominant land uses in the catchment: pesticide use, watercourse restoration, type of fertilizer used on agricultural land, hedgerows and forest management. The sixth attribute, the mean of payment, was an increase in the annual water bill (corresponding to the current practice of financing environmental measures) between 1 and 55 €. The levels of the different attributes refer to environmental measures that the project plans to implement or not: for example, watercourse restoration (narrowing of streams to allow faster water flow, planting of trees, etc.) may or may not be included in the project. The number of levels considered depends on the attribute: attributes related to pesticides, renaturation and forest management have only two levels each, while hedgerows management and fertilizer application have three levels. Including an additional level for these attributes allowed us to consider a variety of possible management practices.

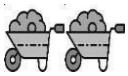
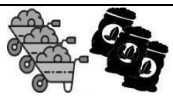
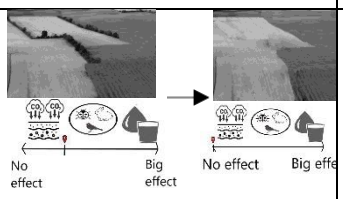
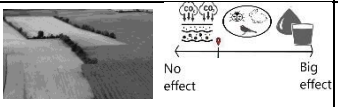
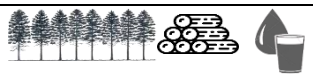
Characteristics	Levels	Meaning
Pesticides		The project plans to ban the use of pesticides.
		The project does not plan to ban the use of pesticides.
Renaturation of watercourses		The project does not involve the restoration of a watercourse.
		The project involves the renaturation of a watercourse (narrowing the stream to allow water to flow more quickly, planting trees, etc.). This will encourage the development of aquatic and terrestrial biodiversity.
Type of fertilizer		Organic fertilizer is applied at low rates to all agricultural land (100%). No negative impacts on biodiversity and water quality are observed.
		Significant application of organic fertilizer to part of agricultural land. Local negative impacts on water quality and biodiversity.
		Maximum amount of organic and chemical fertilizer allowed by law. Overall negative impact on water quality.
Hedgerows		Without the project, hedgerow clearance will continue. Negative impact on landscape, carbon sequestration, biodiversity (birds, insects, etc.) and water quality.
		Maintain hedgerows to avoid negative impacts on water quality, carbon sequestration and biodiversity (birds, insects, etc.) and plant species.
		Planting hedges. Significant positive impact on landscape, water quality, carbon sequestration and biodiversity (birds, insects, etc.) and plant species.
Forest management		Forest management for timber production and protection of water resources.
		Forest management with the aim of producing timber and protecting water resources, as well as preserving biodiversity.
Increase in annual water bill	Increase between €1 and €55 1, 5, 10, ..., 55€ (12 values) if no project: 0€	Increase in the annual water bill to fund the project.

Table 2-1 : Description of the attributes of the DCE

Researchers use an experimental design “to map attributes and levels onto sets of alternatives from which respondents indicate their choices” (Johnson et *al.* [2013]). The design aims to isolate the effects of individual attributes on choices (Hanley et *al.* [1998]). In our case, we generated 24 choice sets, which were divided into three blocks of eight choice sets to reduce the number of choices per respondent. An efficient statistical design was estimated using NGENE (ChoiceMetrics [2014]). The design was estimated using priors based on a previous study in the same region (Amiri et *al.* [2022]) and discussions with stakeholders.

Table 2.2 shows an example of a choice card: respondents are given three alternatives. The status quo is based on the absence of an environmental project. Including a status quo alternative in the DCE is generally recommended (Penn et *al.* [2019]; Marsh et *al.* [2011]; Hensher [2010]) for various reasons, such as making choice tasks more realistic or avoiding forced choices that can lead to biased welfare estimates.

Please choose one of the three options below:

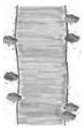
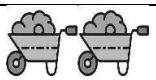
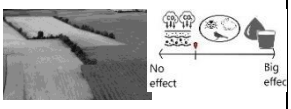
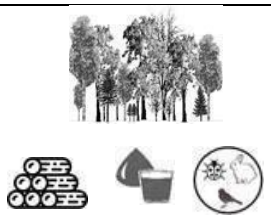
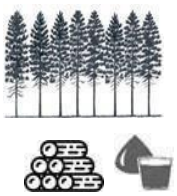
Characteristics	Absence of project	Project A	Project B
Pesticides			
Renaturation of watercourses			
Type of fertilizer			
Hedgerows			
Forest management			
Increase of annual water bill	0€	50€	20€
Your choice:	□	□	□

Table 2-2 : Choice set example

3. Empirical Analysis

DCE has its theoretical foundation in the new Lancaster's Theory of Value (Lancaster [1966]), and its econometric basis is the Random Utility Model (RUM, Thurstone [1927]; Mcfadden [1973]; Manski [1977]): RUM aims at modelling the choices of individuals among discrete sets of alternatives j. It assumes that preferences for the different alternatives can be described by a utility function. In a given sample of N respondents, each respondent n faces T choice situations. Each choice situation has a choice set of J alternatives. The total utility for respondent n choosing alternative j in the choice set in situation t is U_{njt}. This utility depends on a component that the researcher can observe, called the deterministic part of the utility attributes (V_{njt}) and a random component that cannot be observed (ε_{nj}):

$$U_{njt} = V_{njt} + \varepsilon_{njt}, \quad n = 1, \dots, N, \qquad j = 1, \dots, J \quad t = 1, \dots, T \tag{1}$$

The deterministic part V_{njt} is a function of X_{njt}, the vector of attributes relating to alternative j, and other observed factors such as individual characteristics Z_n:

$$V_{njt} = V(X_{njt}, Z_n) \tag{2}$$

The random error term ε_{njt} is i.i.d. as a Gumbel law (or type I extreme value).[19] The relative contribution of each attribute X_{knt} to the total utility U_{njt} can be represented by a parameter β_{kn}, while the parameters γ_l are associated with the l individual characteristics Z_n. From here on, we consider that the utility parameters to be estimated are embedded in a vector of parameters θ_n, associated with the regressors $R_{njt} = (X_{njt}, Z_n)$.

The individual chooses the alternative i in each alternative in each choice set that provides the highest utility:

$$U_{nit} \geq U_{njt}, \quad \forall i, j \in t, \quad i \neq j. \tag{3}$$

.

In contrast to utilities, only the choice preferred by individual n is observed. Therefore, we want to estimate the probability that individual n chooses alternative i for each set of choices t:

$$p_{nit} = \Pr(U_{nit} \geq U_{njt}) = \Pr(\varepsilon_{njt} - \varepsilon_{nit} \leq V_{nit} - V_{njt}), \tag{4}$$

where the new error term $\epsilon_{nit} = \varepsilon_{njt} - \varepsilon_{nit}$ is i.i.d. with a logistic cumulative distribution:

$$\mathrm{F}(\epsilon_{nit}) = \frac{\exp(\epsilon_{nit})}{\sum_{j=1}^{J} \exp(\epsilon_{njt})}$$

3.1 Econometric models

According to Train [2003], various econometric models can be used to explain respondents' choices and to interpret the results. The conditional (multinomial) logit (CL), the most

[19] The Gumbel density of the error term of utility is $\exp(-\varepsilon_{njt})\exp[-\exp(-\varepsilon_{njt})]$ and the cumulative distribution is $\exp[-\exp(-\varepsilon_{njt})]$ with a variance of $\pi^2/6$.

commonly used model to explain discrete choices, can be described by the probability that an individual n chooses alternative i in choice situation t :

$$P_{nt}(i) = \frac{\exp(R_{nit}\theta)}{\sum_{j=1}^{J}\exp(R_{njt}\theta)} \quad (5)$$

However, the CL model assumes independence of irrelevant alternatives (IIA) and that respondents' utility functions are identical, implying that preferences must be homogeneous, so that the parameter associated with the regressors are constant: θ

Other models, such as mixed logit (MXL) models, attempt to address these issues by allowing parameters to vary randomly across individuals (θ_n). It is generally assumed that preferences vary between respondents, but not between choices made by the same respondent. Therefore, « a clustered specification is applied that allows for repeated choices for each individual » (Revelt and Train [1998]).

The conditional probability of the MXL model can me written as following:

$$Pnt(i|\theta n) = \frac{\exp(R\underline{nit}\underline{\theta n})}{\sum_{j=1}^{J}\exp(R_{njt}\theta_n)} \quad (6)$$

In the case of multiple choices for each respondent, the logit probability refers to the probability that the individual *n* makes a sequence of *T* choices specified as $t = \{1,\dots, T\}$. Knowing the probability of each choice as presented by equation (6), the logit probability of the observed sequence of T choices conditioned on θ_n is given by:

$$P_n(j_{n1}, \dots, j_{nT_n}|\theta_n) = \prod_{t=1}^{T_n} P_{nt}(j_{nt}|\theta_n) \quad (7)$$

In our study, although we use the CL and MXL models to test the robustness of our results, our DCE data are analysed using a Latent Class Model (LCM) (see for example Greene and Hensher [2003]). Unlike the MXL model, which assumes continuous heterogeneity, the LCM is based on a discrete distribution, where heterogeneity is captured by class membership. The latter model is preferred to identify different groups of respondents whose preference variations are attributed to individual characteristics.

First, a fractional multinomial logit is used to determine the probability for an individual n to be in class c, based on her/his individual characteristics Z_n:

$$\pi_{nc} = \frac{\exp(Z_n\theta_c)}{\sum_{c=1}^{C}\exp(Z_n\theta_c)}, c = 1, \dots, C \quad (8)$$

For each class q, the probability of choosing alternative i is estimated using a CL model:

$$P_n(i|c) = \frac{\exp(R_{ni}\theta_c)}{\sum_{j=1}^{J}\exp(R_{nj}\theta_c)} \quad (9)$$

Compared to equation (6), equation (9) means that a CL model is estimated for each class c, so that the parameters vary between classes (θ_c).

In the case of multiple choices for each respondent, the logit probability refers to the probability that individual n makes a sequence, I_T of T choices, given by $I_T = \{i_t, \dots, i_T\}$. The likelihood for individual n choosing the sequence I_T is then given by:

$$L_n = \sum_{c=1}^{C}\pi_{nc}\prod_{t=1}^{T}P_{nt}(i_t|c) \quad (10)$$

In our paper we used the statistical software STATA MP 18 and the lclogit2 command (Yoo [2020]). We also used the mixlogit package (Hole [2007]) and the clogit command. All of these commands handle fixed effects and are therefore well suited to our dataset, where individuals make a sequence of T choices.

3.2 Descriptive statistics

The descriptive statistics on individual characteristics presented in Table 2.3 are based on the 977 questionnaires that were suitable for analysis. Figure 2.2 shows the step of managing the responses to the questionnaires and summarizes the choices made by the respondents in the DCE. Out of 1093 questionnaires, 1006 were fully completed. We also removed people who didn't understand the DCE exercise, based on their self-reports on follow-up questions to the DCE.

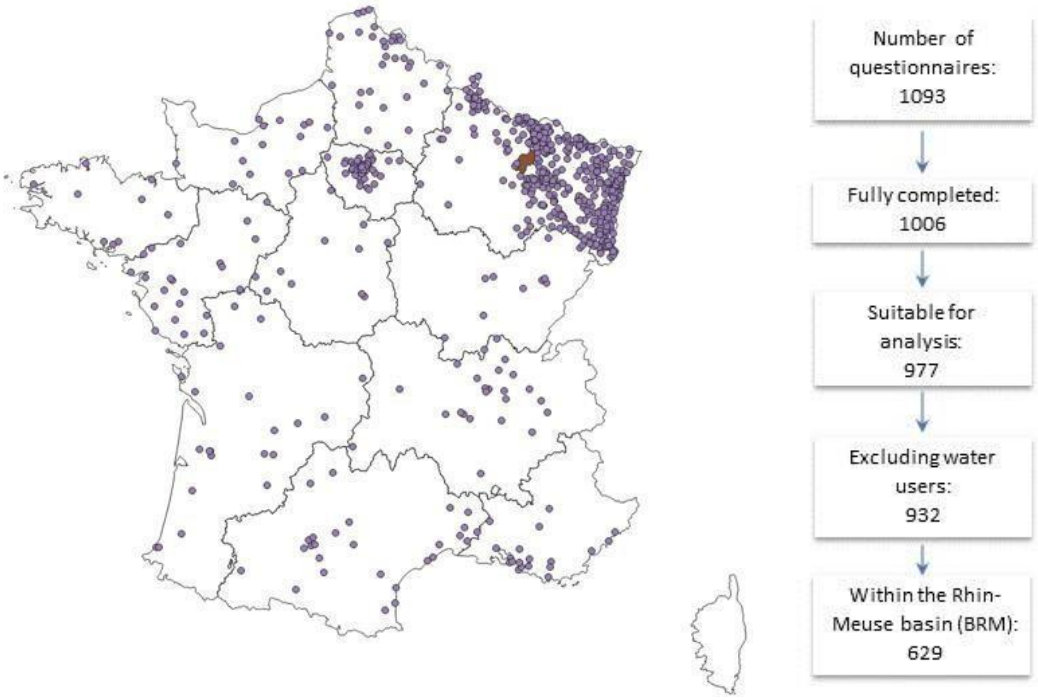


Figure 2-2: Sample, observations and geographical distribution

Initially, the survey and the DCE were only intended for people living in the Rhine-Meuse Basin (BRM), where everyone pays the same charges directly on their water bill, which is collected by the water authority. However, people outside the BRM were also interviewed. This allows us to test whether the latter have understood the lack of credibility of the payment method, since they are not affected by the BRM agency taxes, but by those of their water agency.

Because we focused on NUVs, we removed from the sample individuals who were identified as water users.[20] 47 respondents, from 13 different municipalities were in this case. We also separated people who are not located in the BRM, because they are not likely to pay for environmental projects through a water bill increases.

[20] See https://www.regie-eau-mm.fr/espace-usagers/communes-desservies-2250.html

		ALL (977 indiv.)	BRM (674 indiv.)	Out of BRM (303 indiv.)
Variable	Modality	Share (%)		
Gender	Men	46.88	47.63	45.21
	Women	53.12	52.37	54.79
Age	[18-24 years old]	10.64	9.94	12.21
	[25-29 years old]	6.55	4.19	9.57
	[30-34 years old]	8.50	8.01	9.57
	[35-39 years old]	7.27	7.27	7.26
	[40-44 years old]	9.01	9.05	8.91
	[45-49 years old]	10.24	10.39	9.90
	[50-54 years old]	8.29	8.31	8.25
	[55-59 years old]	9.21	8.61	10.56
	[60-64 years old]	10.13	11.42	7.26
	[65-69 years old]	12.18	13.20	9.90
	[70-75 years old]	6.65	7.12	5.61
	[>75 years old]	1.33	1.48	0.99
Education	General certificate of secondary education	22.31	22.55	21.78
	High school diploma	28.86	29.23	28.05
	High school diploma + 2 years	23.23	24.04	21.45
	High school diploma + 3 years	10.34	9.35	12.54
	High school diploma + 4 and +5 years	5.83	6.08	5.28
	Doctorate	8.19	7.57	9.57
		1.23	1.19	1.32
Occupation	Farmer	0.20	0	0.66
	Independent	2.35	1.78	3.63
	Manager	9.01	8.31	10.56
	Retired	25.90	28.04	21.12
	Worker	6.14	6.53	5.28
	Employee	28.05	27.75	28.71
	Intermediary	12.08	11.87	12.54
	No activity	16.27	15.73	17.49
Percentage of bottled water drinkers	Never	18.01	17.36	19.47
	Occasionally	44.22	45.10	42.24
	Mostly	22.82	22.85	22.77
	Always:	14.94	14.69	15.51

Table 2-3 : Demographic and socio-economic statistics

The survey provided us with information on the socio-economic profile of the respondents: A slight majority of respondents were women (53.12%). People aged between 65 and 69 were the most represented in the sample (12.18%). Just over half of the respondents (51.17%) did not have a high level of education (high school diploma or less). Looking at the sample without excluding water users (from Metz and the surrounding area) and people living outside the Rhin-Meuse basin, the proportion of "mixed" water drinkers (people who drink both

bottled water and tap water) is somewhat comparable to that observed at national level (67.04% in our study versus 74% at the national level[21]).

After excluding the inhabitants of Metz and surrounding areas whose tap water comes from the Rupt de Mad catchment area (45 respondents), we can analyse the results of the DCE. Some statistics on their choices are given in Table 2.4.

Variable		ALL (932 indiv.)	Within BRM (629 indiv.)	Outside BRM (303 indiv.)
Choice (in %)	No Project Project A Project B	15.55 46.08 38.37	15.62 45.47 38.91	15.39 47.36 37.25
Average payment for a project (in €)	No Project Project A Project B	0 25.05 24.10	0 24.35 23.60	0 26.45 25.19
Attribute non-attendance (in %)	Did you consider all the attributes when choosing between the different projects?	87.66	86.80	89.44
Non-attendance, which attribute? (in %)	Price	4.72	5.25	2.63
	Pesticide	2.58	3.02	1.65
	Watercourse restoration	2.04	2.23	1.65
	Fertilizers	3.97	4.93	1.98
	Hedgerows	4.08	4.45	3.30
	Forest management	2.79	2.86	2.64
Reasons of systematic SQ (in number of choices)	Water quality and biodiversity protection are not important to me	32	16	16
	The characteristics of projects A and B did not suit me	48	24	24

Table 2-4 : Descriptive summary of DCE results

Respondent giving the following reasons for always choosing the status quo were excluded from the sample: (i) Protest responses: “These projects should not be financed by increasing water bills”, “These costs must be borne by the landowner”, “I already pay too much for my water”, or (ii) misunderstanding : “The number of attributes to be compared was too large”, “I didn't understand what was being asked of me”. The analysis of non-attendance in attributes showed that a large majority of respondents took all characteristics into account when answering the DCE, regardless of whether they lived in the BRM or not.

[21] See CIE (2022

4. Estimation results

4.1. CL and MXL models

Based on the responses to the DCE, we report the estimation results of the CL and MXL models in Table 2.5. First, we take advantage of having data from respondents outside the BRM to test whether they view the DCE differently, in particular knowing that the tax on the water bill is only introduced for people inside the BRM. To do this, we introduce the interaction term (water bill x BRM) in both logit models (in columns 1 and 3). A significantly negative parameter (added to the negative parameter of the water bill) indicates that respondents inside the BRM are more sensitive to the price and will therefore have a lower WTP than respondents outside the BRM.

Secondly, we make an initial investigation into the existence of a distance decay effect on the status quo (*i.e.* the choice of no project) on the sub-sample of respondents inside BRM. One hypothesis to be tested was that the further individuals are from the Rupt de Mad watershed, the less concerned they are about improving environmental quality. We calculated distances (denoted dist) using the centroid of the respondent's municipality of residence (Farber and Griner, [2000]; Campbell et *al.* [2008, 2009]; Rolfe and Windle [2012]; Johnston and Ramachandran [2014]) and considered straight line distances to the nearest point of the Rupt de Mad watershed, as this may be appropriate for assessing NUVs where access to the site of interest is not required (De Valck et *al.* [2017]; Holland and Johnston [2017]). After excluding two respondents living in proximity to the watershed, the main econometric estimates concerned 627 individuals (*i.e.*, 15 048 observations = 627 × 3 alternatives × 8 choice sets). We introduce the variable dist and its squared term $dist^2$. Both variables are significantly different from zero in models (2) and (4). The negative sign of the parameter of dist indicates that people further away from the study site reject the 'no project' alternative. The positive effect of $dist^2$ means that this effect is non-linear and decreases with distance.

Table 5. Estimation results of the CL and MXL models

	(1)	(2)	(3)		(4)		(5)	
Variables	CL	CL	MXL, Mean	MXL, SD	MXL, Mean	MXL, SD	MXL, Mean	MXL, SD
Water bill	-0.0100***	-0.0132***	-0.0133***		-0.0200***		-0.0203***	
	(0.00128)	(0.000946)	(0.00197)		(0.00151)		(0.00151)	
Water bill x BRM	-0.00290**		-0.00655***					
	(0.00145)		(0.00219)					
ASC	-0.751***	-0.386***	-0.855***		-0.843***		-0.406**	
	(0.0537)	(0.127)	(0.0690)		(0.0866)		(0.176)	
ASC x dist		-0.00908***					-0.0110**	
		(0.00346)					(0.00481)	
ASC x dist^2		4.14e-05**					5.04e-05*	
		(1.98e-05)					(2.75e-05)	
Ban pesticides	0.430***	0.445***	0.565***	1.455***	0.593***	1.408***	0.593***	1.414***
	(0.0266)	(0.0328)	(0.0611)	(0.0655)	(0.0735)	(0.0789)	(0.0734)	(0.0788)
Watercourse restoration	0.272***	0.301***	0.335***	0.948***	0.384***	0.978***	0.393***	0.980***
	(0.0265)	(0.0329)	(0.0494)	(0.0577)	(0.0616)	(0.0715)	(0.0619)	(0.0715)
No negative effect of fertilizer	0.126***	0.109**	0.187***	0.410***	0.188***	0.343*	0.190***	0.431***
	(0.0362)	(0.0446)	(0.0537)	(0.116)	(0.0652)	(0.180)	(0.0665)	(0.132)
Local negative effect of fertilizer	0.0716**	0.0353	0.0754	0.563***	0.0338	0.538***	0.0413	0.541***
	(0.0363)	(0.0448)	(0.0543)	(0.0844)	(0.0665)	(0.104)	(0.0668)	(0.104)
Hedgerow plantation	0.0849**	0.111**	0.0818	1.008***	0.124*	1.056***	0.119	1.070***
	(0.0363)	(0.0449)	(0.0608)	(0.0738)	(0.0753)	(0.0893)	(0.0760)	(0.0908)
Hedgerow conservation	0.0627*	0.0678	0.104**	0.330**	0.122**	0.151	0.122**	0.201
	(0.0370)	(0.0457)	(0.0508)	(0.139)	(0.0611)	(0.446)	(0.0616)	(0.233)
Forest management for water and biodiversity	0.129***	0.148***	0.138***	0.877***	0.174***	0.873***	0.174***	0.875***
	(0.0263)	(0.0328)	(0.0479)	(0.0587)	(0.0592)	(0.0715)	(0.0594)	(0.0716)
Nb. observations	22,320	15,048	22,320		15,048		15,048	
Nb. individuals	930	627	930		627		627	
Log likelihood	-7263	-4852	-6715		-4490		-4484	
Chi-squared	1822	1317	632.9		449.1		463.6	
Prob > chi2	0.0000	0.0000	0.0000		0		0.0000	

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Number of draws used to simulate of the MXL model = 1000.

Table 2-5 : Estimation results of the CL and MXL models

Focusing on the MXL results based on the sample of respondents within the BRM, we can first note that all the standard deviations associated with the mean coefficients of the random variables are significantly different from zero, indicating the existence of a strong heterogeneity of preferences for the different environmental attributes.

The parameter ASC associated with the SQ, *i.e.* the 'no project' alternative, is significantly negative, implying that respondents preferred to choose a project rather than the SQ. As expected, the coefficients associated with the attributes "ban on pesticides", "restoration of watercourse" and "no negative effect of fertilizer" are positive (all highly significantly different from zero). The overall negative effect on water quality resulting from the use of both organic and chemical fertilizers is rejected by individuals. Hedgerow maintenance and hedgerow planting are strongly preferred to hedgerow clearing without the project. Finally, forest management that favours biodiversity (in addition to timber production and water conservation) is valued by the respondents.

We then calculated individual WTP for environmental attributes using the individual-level parameters corresponding to the attribute variables and the (constant) monetary attribute parameter (Revelt and Train [2000]; Train [2009], chapter 11) from the MXL results (Table 5, column 4). The WTPs are based on the monetary attribute included in the DCE, *i.e.* the increase in the annual water bill used to finance environmental projects.

Distance category (dummy variable)	Sample (%)	Mean WTP						
		Ban pesticides	Watercourse restoration	No negative effect of fertilizer	Local negative effect of fertilizer	Hedges plantation	Hedges conservation	Forest management for water and biodiversity
]0 ; 10]	3.03	12.85	19.35	12.45	1.29	3.55	6.66	19.61
]10 ; 20]	6.06	27.45	12.22	10.01	3.46	7.94	5.57	4.70
]20 ; 30]	14.83	33.88	16.46	9.59	1.87	7.33	6.19	6.87
]30 ; 50]	11.64	22.32	23.91	11.47	-0.27	10.73	5.89	7.75
]50 ; 70]	7.81	50.92	17.80	10.90	2.09	12.31	6.50	7.11
]70 ; 100]	16.91	36.91	17.66	10.28	3.07	8.27	6.19	9.67
]100 ; 125]	11.16	25.42	17.98	9.59	2.38	-0.50	6.02	11.70
]125 ; 150]	26.16	30.79	20.05	9.20	2.16	6.00	5.53	5.76
]150 ; 200]	10.21	32.53	22.01	10.43	4.91	11.54	5.84	12.09

Notes. Number of individuals = 627. The mean distance is 86.46 with a minimum of 1.26 and a maximum of 186.53.

Table 2-6 : Mean WTP for each attribute by distance category

Table 2.7 shows the individual WTP regression results for the seven different environmental attributes of our CE. These allow us to pre-test different hypotheses, such as the existence of distance decay (see Table 2.6) and the effect of individual characteristics, and in particular to know whether bottled water drinkers and non-drinkers have different WTP for these attributes. For example, we find that relative to the “always” drinker of bottled water the occasional drinkers seem to have a higher WTP for water course restoration, no negative effect of fertilizers and forest biodiversity measures.

Variables	Ban pesticides	Watercourse restoration	No negative effect of fertilizer	Local negative effect of fertilizer	Hedges plantation	Hedges conservation	Forest management for water and biodiversity
dist_cat20	18.54	-8.594	-2.727*	3.370	3.998	-1.175	-17.47**
	(13.62)	(11.97)	(1.563)	(3.276)	(11.91)	(0.867)	(8.281)
dist_cat30	22.21*	-4.410	-3.276**	1.518	2.684	-0.552	-15.16**
	(12.33)	(11.38)	(1.397)	(2.886)	(10.94)	(0.784)	(7.511)
dist_cat50	13.67	3.648	-1.356	-0.151	5.866	-0.886	-13.61*
	(13.22)	(11.75)	(1.493)	(2.863)	(11.12)	(0.822)	(7.715)
dist_cat70	27.10***	1.473	1.270	-1.733	8.756	0.664	-4.407
	(9.991)	(5.476)	(1.013)	(2.391)	(6.613)	(0.485)	(5.380)
dist_cat100	15.10	-2.697	-3.159**	3.999	-0.0498	-0.979	-9.800
	(12.97)	(11.74)	(1.428)	(3.002)	(11.34)	(0.817)	(7.581)
dist_cat125	16.48	-1.902	-3.273**	2.462	-4.487	-0.714	-10.24
	(12.19)	(11.60)	(1.626)	(2.887)	(11.45)	(0.802)	(7.518)
dist_cat150	18.19	-1.754	-3.649***	1.976	0.540	-1.239	-16.58**
	(11.83)	(11.41)	(1.391)	(2.725)	(10.88)	(0.778)	(7.274)
dist_cat200	19.32	-0.651	-2.554*	3.962	5.505	-1.038	-10.99
	(12.84)	(11.66)	(1.536)	(2.979)	(11.37)	(0.810)	(7.866)
Young adult	2.972	2.074	-0.347			0.717***	5.304*
	(4.786)	(3.198)	(0.794)			(0.269)	(2.903)
Middle-aged			-1.537*	-2.137**		0.381	
			(0.785)	(1.058)		(0.271)	
Older	16.45*	7.858**		6.145***	9.854*		3.950
	(9.878)	(3.566)		(1.837)	(5.049)		(2.886)
Degree	4.781***	1.707*	0.0140		0.274	-0.0975	1.403*
	(1.437)	(0.997)	(0.177)		(1.065)	(0.0805)	(0.719)
No activity			1.263				
			(0.783)				
Retired			-0.588				
			(0.787)				
Worker						0.398	
						(0.418)	
Employee							-3.156
							(2.786)
Intermediary	11.15*				5.756		-5.566*
	(6.294)				(4.906)		(3.220)
Manager		7.490		3.952*	6.108	0.905**	
		(6.056)		(2.258)	(5.722)	(0.439)	
Never drink	-2.699	1.385	0.362	-0.869	4.221	0.00691	4.048
	(8.155)	(4.762)	(0.881)	(1.625)	(5.124)	(0.390)	(4.246)
Occasionally drink	5.487	6.913*	1.736**	0.216	4.585	0.294	6.462*
	(6.988)	(4.026)	(0.708)	(1.441)	(4.327)	(0.335)	(3.539)
Almost drink	-7.530	6.714	0.904	-1.833	7.107	0.380	5.345
	(7.908)	(4.317)	(0.809)	(1.562)	(4.794)	(0.371)	(3.954)
Constant	-5.898	8.477	12.13***	0.499	-2.300	6.438***	12.39
	(11.57)	(11.16)	(1.409)	(2.788)	(10.12)	(0.761)	(7.697)
R-squared	0.057	0.032	0.040	0.048	0.024	0.036	0.040

Notes. Number of individuals = 627. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2-7 : Determinants of individuals WTP for each attribute

4.2. Latent class analysis

In addition to the CL and MLX models, we decided to estimate a latent class model (LCM) in order to have more information about the heterogeneity of the attributes (Table 2.8). The LCM can be seen as an extension of the MLX with one notable difference (Greene and Hensher [2003]). Whereas the MLX accounts for preference heterogeneity by allowing utility parameters to vary randomly (and continuously) across individuals, the LCM classifies individuals into a (discrete) number of classes, with a probability of belonging to a particular class. The number of classes is determined based on information criteria, such as Bayesian Information Criteria (BIC) and Akaike Information Criteria (AIC). A comparison between MLX and LCM can be found in Greene and Hensher [2003], and applications to environmental issues in Neves do Prado and Abildtrup [2022] and Schaak and Musshoff [2019], among others.

We therefore analyse respondents' choices using a four-class LCM. Based on the determinants identified for individual WTP, we tested different individual characteristics to include in the part of the model that explains the probability of belonging to a particular class. These characteristics are distance categories, age categories, level and type of bottled water drinker. We selected the preferred number of classes by repeatedly estimating the LCM with different numbers of classes, optimising the BIC and AIC.

By comparing the BIC and AIC during the repeated rounds of LCM estimation, we did not find an optimal criterion, but rather that the change in BIC and AIC decreased significantly between classes four and five (with no convergence for six classes), and we therefore decided that a four-classes model would be most appropriate for analysing respondents' choices. On these four classes, one attracts a majority of respondents (55%) and the other three are more or less equal, ranging from 12% to 16.7%. Estimation results of the LCM are presented in Table 2.8. Furthermore, Table 2.9 presents estimates of marginal WTP associated with each environmental attribute along with 95% confidence intervals computed with Krinsky and Robb [1986] method.[22]

[22] Although the delta method is the most common method for calculating standard errors of partial effects, it uses a first-order Taylor series expansion of a nonlinear function of parameters evaluated at a given point of approximation, which may not be accurate (Krinsky and Robb [1986]; Dowd et *al.* [2014].

	Choice			
Variables	Class 1	Class 2	Class 3	Class 4
Water bill	-0.0435***	-0.00250*	-0.0295**	-0.146***
	(0.00777)	(0.00133)	(0.0127)	(0.0214)
ASC	1.770***	-1.707***	0.715	-3.701***
	(0.363)	(0.132)	(0.657)	(0.549)
Ban pesticides	0.465**	0.184***	3.940***	0.509**
	(0.237)	(0.0525)	(0.851)	(0.206)
Watercourse restoration	0.119	0.408***	-0.208	0.672***
	(0.195)	(0.0421)	(0.448)	(0.222)
No negative effect of fertilizer	0.395	0.115**	0.190	0.173
	(0.251)	(0.0573)	(0.535)	(0.293)
Local negative effect of fertilizer	0.430*	0.0280	-0.653	-0.174
	(0.244)	(0.0570)	(0.517)	(0.238)
Hedgerow plantation	0.166	0.168***	0.331	-0.230
	(0.262)	(0.0590)	(0.559)	(0.232)
Hedgerow conservation	0.295	0.0389	0.365	0.377
	(0.247)	(0.0574)	(0.371)	(0.324)
Forest management forwater and biodiversity	0.117	0.142***	0.578	-0.0781
	(0.200)	(0.0421)	(0.398)	(0.186)
Class share	12.0%	55.5%	16.7%	15.7%
	Membership probability			
	Class 1	Class 2	Class 3	Class 4
dist_cat2050	0.255	-0.0734	1.337*	
	(0.556)	(0.402)	(0.792)	
dist_cat70	-0.513	0.217	0.918	
	(0.766)	(0.536)	(0.614)	
dist_cat100150	0.0519	0.0184	1.295*	
	(0.542)	(0.384)	(0.776)	
never drink	0.367	0.253	0.271	
	(0.459)	(0.386)	(0.515)	
Occasionally drink	-0.781**	0.101	0.248	
	(0.384)	(0.282)	(0.386)	
Old	-0.293	1.980	1.690	
	(1.671)	(1.223)	(1.291)	
Degree	-0.396***	0.135	0.159	
	(0.147)	(0.0882)	(0.113)	
Constant	0.789	0.757*	-2.178**	
	(0.625)	(0.455)	(0.856)	
Log likelihood	-4049.97			

Notes. Nb. observations = 15,048. Nb. of choices = 5,016. Nb. individuals =627.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2-8 : Estimation results of the LCM

The positive and highly significant coefficient ASC indicates that individuals in Class 1 prefer the status quo overall (*i.e.* no environmental project), but have a significant preference for a ban on pesticides (at the 5% level) and for the use of organic fertilisers with local negative

impacts on water quality and biodiversity (significant only at the 10% level). Respondents with a lower level of education and those who drink bottled water more than occasionally are more likely to belong to this pro-status quo class.

Class 2 is that with a negative but small coefficient associated with the monetary attribute, and only at the 10% level. Individuals in this class show strong opposition to the status quo and clear preferences for environmental attributes such as no pesticides, water restoration, hedgerow planting or forest management that favours timber production, water quality and biodiversity conservation. However, their marginal WTP for all attributes is not significantly different from zero at the 5% level (see Table 2.9). WTP is only significantly different from zero at the 10% level[23] and only for the absence of pesticides, water restoration, hedgerow planting and forest management that benefits the environment.

Class 3 is only concerned with the pesticide attribute, but with a strong preference (and a mean value of €133.72, see Table 9). This class has a predicted share of 16.7% of the sample. We can see that the respondents who are not in this class are the furthest away from the site (dist_cat200).

Finally, class 4 includes people with a high and significantly negative coefficient for the monetary attribute. They only have a significant preference for banning pesticides and restoring watercourses (at the 5% level) and are willing to pay a low amount.

	Class 1	Class 2	Class 3	Class 4
Ban pesticides	**10.69****	*73.83**	**133.72****	**3.48****
	(0.001; 24.41)	(-186.50; 495.05)	(79.76; 447.95)	(0.76; 6.39)
Watercourse restoration	*2.73**	*163.52**	-7.07	**4.60****
	(-6.71; 12.06)	(-416.49; 1057.62)	(-42.82; 53.41)	(1.80; 7.39)
No negative effect of fertilizer	9.08	45.91	6.47	1.18
	(-2.23; 23.06)	(-92.50; 318.90)	(-66.33; 50.20)	(-2.91; 5.31)
Local negative effect of fertilizer	*9.90**	11.23	-22.17	-1.19
	(-1.08; 23.79)	(-81.81; 131.52)	(-126.63; 18.20)	(-4.30; 2.21)
Hedgerow plantation	3.82	67.14	11.25	-1.57
	(-8.49; 16.93)	(-184.07; 487.91)	(-30.03; 120.14)	(-5.05; 1.55)
Hedgerow conservation	6.78	15.59	12.39	2.58
	(-4.51; 19.85)	(-77.88; 161.72)	(-21.50; 65.37)	(-2.03; 6.65)
Forest management forwater and biodiversity	2.68	*57.09**	19.62	-0.53
	(-6.60; 12.95)	(-128.24; 367.55)	(-12.07; 96.24)	(-2.95; 2.20)

Notes. 95% confidence intervals in parentheses computed by the Krinsky and Robb method(performed with 100,000 draws). ** $p<0.05$ (in bold), * $p<0.1$ (in italics).

Table 2-9 : Marginal WTP estimates

[23] Estimation of 90% confidence intervals are available from the authors.

5. Discussion and conclusion

This paper analyzes the NUV of water and biodiversity protection in a watershed in eastern France. While measures to protect or improve water quality are usually considered to generate direct use values for water consumers, we show that non-water consumers may also have positive preferences for measures that have positive impacts on water quality and biodiversity. Our latent class analysis of our DCE data, produced quite contrasting results.

First, different classes of respondents were identified. The first (Class 1), whose respondents are highly and significantly opposed to the environmental project. However, they are willing to pay a significant amount (€10.69) per year on the water bill to ban pesticides. The second (Class 2), for which the monetary attribute has little significant effect on their choice and for which their WTP (for banning pesticides, restoring watercourses, planting hedges and managing forests) is high but estimated with a large confidence interval, due to weakly significant coefficient on the monetary attribue. Class 3, whose members are closest to the site and who are willing to pay a very high amount (€133.72) for pesticides ban. Class 4 have only positive preferences for in pesticide ban and watercourse restoration and are only willing to pay low amounts (€3.48 and €4.60, respectively).

Although they capture a large amount of heterogeneity between people, these results can be compared with previous studies found in the literature. In France, several studies have investigated WTP for the preservation of groundwater quality (Hérivaux and Rinaudo [2016]; Rinaudo and Aulong [2014]; Hérivaux [2011]; Rinaudo [2008]; Grappey [1999] Stenger and Willinger [1995], Rozan et *al.* [1996]). For example, Stenger and Willinger [1995] used CVM to calculate water users' conservation values for the Alsatian aquifer threatened by various pollutants (nitrates, herbicides, mercury). They found that the average conservation value was about 700FF/household/year (about €110 in 1996). This estimate was extended to non-users (Rozan et *al.* [1996]). These non-users were potential future users as they were located close to the aquifer and the quality of their current water resource was also threatened by pollution. This second study showed that the WTP of the non-users was 60% of the conservation value of the users).

Hérivaux [2011] investigated public perception and WTP for groundwater quality improvement in a part of the Meuse alluvial aquifer near Liège (Belgium). Even though the

proportion of water users was close to zero (1.5%), the author emphasised that people living above the aquifer were more likely to contribute to groundwater quality improvement (72% compared to 62% for the others), and WTP amounts were likely to be higher for households living closer to the Meuse. Nevertheless, the main motivation for contributing to the protection measures was the possibility of passing on a better quality groundwater body to future generations. In monetary terms, the average WTP is 46.9 €/household/year if only positive WT are considered and 40.1 €/household/year if real zeros are included.

Interestingly, some studies focused on areas close to our area of interest: Hérivaux and Rinaudo [2016] and Rinaudo [2008], conducted a study in eastern France (Meurthe et Moselle and Vosges), where the Lower Triassic sandstone aquifer is located. In contrast to other studies presented here, the aquifer was facing over-exploitation rather than pollution. Nevertheless, the study provides interesting information: firstly, if most respondents used this water for recreational or other purposes, the main motivation to pay was related to non-use (transfer of quality drinking water to future generations), confirming Rinaudo and Aulong [2014]. In this case, respondents had a higher WTP than others. In addition, the binary variable indicating respondents' agreement with the statement "I am willing to pay for this aquifer as I would be willing to pay for any other aquifer in France" was significant. The average WTP was 39.5€/household/year if true zeros were included and 45€/household/year if they were not.

We also investigated a possible distance decay effect on non-users' preferences for environmental attributes. However, the results are moderate and seem to indicate that distance matters only for a small proportion of respondents (allocated in Class 3).

We hypothesised that the respondents' water consumption habits would influence the results, *i.e.* if you buy bottled water, you might be very concerned about water quality and therefore have strong preferences for water conservation measures, even if you do not consume the protected groundwater. We did not find a clear effect of consuming bottled water. This may be due to different effects. For example, some people may consume bottled water out of convenience and not because they are concerned about water quality, or some respondents may choose not to consume bottled water to reduce resource use because they are concerned about the environment, which may correlate with preferences for water protection measures. Future studies should look more closely at the factors that determine preferences for water quality and protection. The fact that drinking water protection measures can have significant

NUVs has important implications for the regulation of water resources. In particular, it could justify the French delegation of water and biodiversity protection to the regional water agencies, as it allows for a more comprehensive spatial consideration and the integration of water and biodiversity concerns in the regulation, although not all measures have the same value. In fact, water protection measures include NUVs that are not only related to the quality of water for consumption, and we find that it is not only local residents who benefit from protection measures. Some inhabitants living far from the Rupt de Mad water catchment area (even more than 100 km) have a positive WTP for some protection measures, although this is mostly limited to the ban on pesticides and the restoration of watercourses.

We found that all respondents considered a pesticides ban to be an important environmental measure, complementing the findings of Amiri et *al.* [2022] who found an important utility value of pesticides bans in recreational areas. Therefore, French water authorities should prioritize pesticides bans as a measure to protect water and biodiversity, in order to be in line with public preferences. In this paper, we have assumed that the WTP for water protection of individuals who do not consume water from the protected catchment area in the scenarios proposed in the DCE reflect NUVs. This is based on the assumption that respondents did not consider that they would one day benefit from the improved water quality, for example by moving to the area served by the protected resources. However, we believe that this assumption will generally not be violated as very few will have this perception. Furthermore, even if the assumption is violated, our results still show that the value of water protection does not only benefit current drinking water consumers. Similarly, we assume that the respondents are not (future) recreational users of the watershed. However, the lack of a strong distance decay effect suggests that respondents did not consider the catchment as a potential recreational site.

6. Annex

Questionnaire chapitre 2

Message d'accueil

Bonjour. Nous vous remercions d'accepter de répondre à ce questionnaire, qui a pour cadre un projet de recherche : ce dernier cherche à évaluer la valeur que vous accordez à des actions menées par l'agence de l'eau de votre territoire et qui visent à protéger les ressources en eau et la biodiversité (lutte contre la pollution de l'eau, préservation des milieux aquatiques etc). Ce type d'enquêtes permet d'estimer la valeur que les gens accordent à ces actions et ainsi de peser sur les décisions publiques. Il n'y a pas de bonnes ou de mauvaises réponses, mais il est important que vous répondiez à toutes les questions. La durée moyenne de réponse au questionnaire est d'environ 20 minutes. Vos réponses seront strictement anonymes.

1) **Etes-vous :**

Veuillez sélectionner une réponse ci-dessous

A. Un homme
B. Une femme
C. Ne souhaite pas répondre

2) **Quel âge avez-vous ?**

Veuillez sélectionner une réponse ci-dessous

A. Moins 18 ans
B. 18-24 ans
C. 25-29 ans
D. 30-34 ans
E. 35-39 ans
F. 40-44 ans
G. 45-49 ans
H. 50-54 ans
I. 55-59 ans

J. 60-64 ans
K. 65-69 ans
L. 70-75 ans
M. plus de 75 ans

3) **Où habitez-vous ? (indiquez le nom de la commune et le code postal).**

Commune: ☐
Code postal: ☐

4) **Parmi les actions suivantes, lesquelles effectuez-vous ?**

Cochez la ou les réponses

Cochez la ou les réponse(s)

A. Aucune
B. Achat fréquent de produits bio
C. Achat fréquent de produits contenant des matériaux recyclés (bouteilles, papier, stylos etc.) ou dont l'emballage est recyclé
D. Appartenance et/ou dons à une association de défense de l'environnement
E. Participation à des manifestations en faveur de la préservation de l'environnement
F. Autre : ☐

Si vous répondez "Autre", précisez votre réponse dans le cadre.

5) **Quel est votre diplôme le plus élevé ?**

Veuillez sélectionner une réponse ci-dessous:

A. Aucun ou inférieur au bac
B. Bac
C. BTS, DUT ou équivalent bac +2
D. Licence ou équivalent bac +3
E. Master ou équivalent bac +4
F. Master 2 ou équivalent bac +5
G. Doctorat ou équivalent bac + 8
H. Ne souhaite pas répondre
I. Autre :

Si vous choisissez "Autre", précisez votre réponse dans le cadre.

6) **Quelle est votre profession et catégorie socioprofessionnelle (PCS) ?**

Veuillez sélectionner une réponse ci-dessous

A. Agriculteur exploitant
B. Artisan, commerçant, chef d'entreprise
C. Cadre et profession intellectuelle supérieure
D. Profession intermédiaire
E. Employé
F. Ouvrier
G. Retraité
H. Autre personne sans activité professionnelle
I. Ne sait pas
J. Ne souhaite pas répondre

7) **De combien de personnes est composé votre ménage ? Précisez le nombre d'enfants**.

Nombre de personnes:
dont enfants:

8) **Parmi les personnes qui composent votre ménage, combien possèdent un revenu ?**

9) **Dans quel type de logement vivez-vous ?**

Veuillez sélectionner une réponse ci-dessous:

A. Une maison
B. Un appartement
C. Autre :

Si vous choisissez "Autre", précisez votre réponse dans le cadre:

10) **De manière générale, vous estimez-vous sensible aux enjeux environnementaux ?**

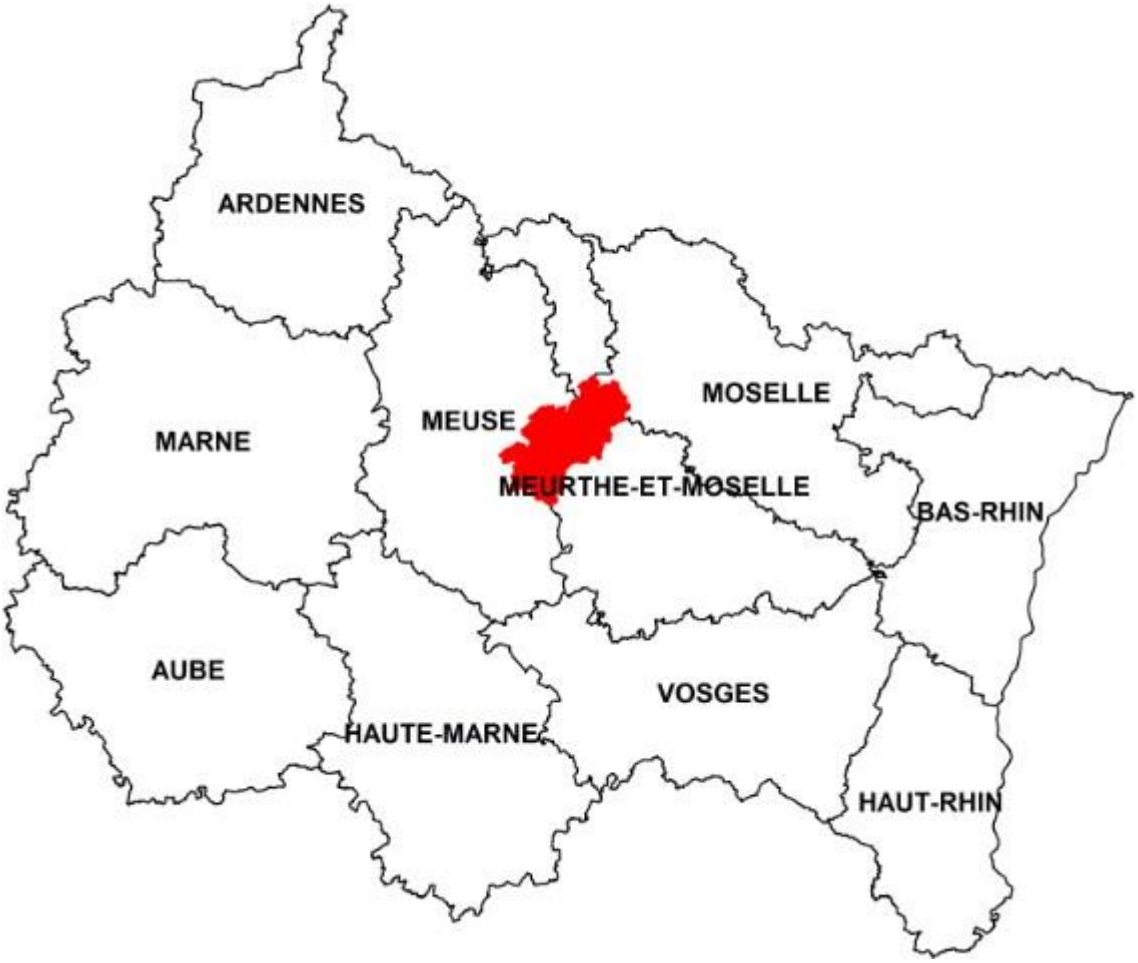
Veuillez sélectionner une réponse ci-dessous

A. Pas du tout sensible
B. Peu sensible
C. Neutre
D. Plutôt sensible
E. Très à extrèmement sensible

11) **Indiquez votre degré de sensibilité aux quatre types d'actions suivantes:**

	Pas du tout sensible	Peu sensible	Neutre	Plutôt sensible	Très à extrèmement sensible
Actions préservant laqualité des ressources en eau sur le territoire sur lequel vous vivez					
Actions préservant la biodiversité sur le territoire surlequel vous vivez					
Actions préservant laqualité des ressources en eau en dehors du territoire surlequel vous vivez					
Actions préservant la biodiversité en dehors duterritoire sur lequel vous vivez					

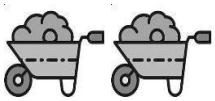
12) Nous souhaitons évaluer **la valeur que vous accordez aux actions de protections des ressources en eau et de la biodiversité (interdiction d'utiliser des pesticides, renaturation de cours d'eau etc.)** mises en place par l'agence de l'eau Rhin-Meuse sur un territoire spécifique (zone délimitée par le liseré rouge sur la carte). Ce territoire, de 385 km², est **le bassin versant du Rupt de Mad, un cours d'eau de 55 km, qui contribue à hauteur d'environ 70 % à l'alimentation en eau de la ville de Metz et alimente également une quinzaine de communes aux alentours.** Les mesures mises en place améliorent la qualité des eaux brutes (eaux de surface et eaux souterraines), diminuant ainsi les coûts de traitement de l'eau pour toutes les communes en question. Pour en savoir plus sur le contexte dans lequel s'inscrivent ces actions, passez à la question suivante.

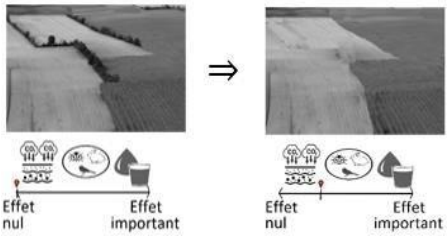
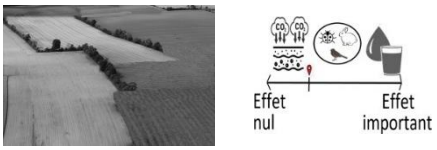
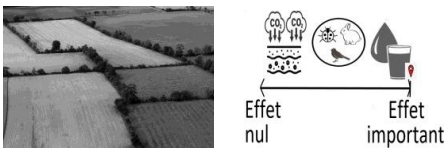
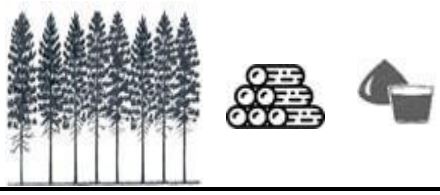


13) Les agences de l'eau sont des établissements publics ayant pour mission de **gérer et de préserver la ressource en eau, les milieux aquatiques et la biodiversité.** Dans ce but, elles participent au **financement de projets**, (comme, par exemple, la renaturation de cours d'eau) et accompagnent différents acteurs (collectivités, industriels, agriculteurs) afin de promouvoir des **pratiques plus favorables à la qualité de l'eau** (utilisation moins intensive de pesticides etc.).

Nous allons vous présenter, au cours des questions suivantes, différents projets de préservation de la qualité de l'eau et de la biodiversité. Vous devrez alors choisir, selon vos préférences entre le projet A, le projet B et l'option "absence de projet". Ces projets possèdent des caractéristiques (renaturation de cours d'eau, modalités de gestion de la forêt etc.) qui pourront prendre des "niveaux" différents: le projet A pourra, par exemple, prévoir la renaturation d'un cours d'eau, contrairement au projet B. Chaque niveau sera illustré par un pictogramme.

Nous partons du principe que toutes les actions prévues au cours d'un projet seront effectivement mises en œuvre et que votre contribution financière sera uniquement utilisée pour mener ce projet à bien. Gardez néanmoins à l'esprit que si vous décidez de choisir un projet, vous et votre foyer auront en conséquence moins d'argent à allouer à d'autres usages. Après avoir pris connaissance des caractéristiques des projets (présentées ci-dessous), passez directement à la page suivante: nous vous détaillerons la marche à suivre avec un exemple.

Caractéristiques	Niveau des caractéristiques	Signification
Pesticides		Le projet **prévoit d'interdire** l'utilisation de pesticides.
		Le projet **ne prévoit pas d'interdire** l'utilisation de pesticides.
Renaturation de cours d'eau		Le projet **ne prévoit pas** la renaturation d'un cours d'eau.
		Le projet **prévoit** la renaturation d'un cours d'eau (rétrécissement du lit du cours d'eau pour permettre un écoulement plus rapide, plantation d'arbres etc.). Cela permettra le développement de la biodiversité terrestre et aquatique.
Type(s) d'engrais		**Apport d'engrais organiques épandus sur toutes les surfaces agricoles (100%) à faible dose.** Aucun effet négatif sur la biodiversité et sur la qualité de l'eau n'est observé.
		**Apport important d'engrais organiques sur une partie des parcelles agricoles.** Effet localement négatif sur la qualité de l'eau et la biodiversité.

		**Apport en quantité maximale autorisée par la legislation d'engrais organiques et chimiques de synthèse.** Effet négatif global sur la qualité de l'eau.
Haies		Sans le projet, **l'arrachage de haies va continuer.** Effet négatif sur le paysage, la séquestration de carbone, la diversité des espèces animales et végétales (oiseaux insectes etc.) et la qualité de l'eau.
		**Conservation des haies afin d'éviter un effet négatif** sur la qualité de l'eau, la séquestration de carbone et la diversité des espèces animales (oiseaux, insectes etc.) et végétales.
		**Plantation de haies.** Effet positif important sur le paysage, la qualité de l'eau, la séquestration de carbone et la diversité des espèces animales (oiseaux, insectes etc.) et végétales.
Modalités de gestion de la forêt		Gestion de la forêt ayant pour objectifs **la production de bois et la protection des ressources en eau.**
		Gestion de la forêt ayant pour objectifs **la production de bois et la protection des ressources en eau, mais aussi la préservation de la biodiversité.**
Augmentation du montant annuel de la facture d'eau potable	Augmentation comprise entre 1€ et 55€	**Augmentation de la facture annuelle d'eau potable** servant à financer le projet en question.

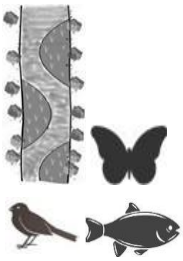
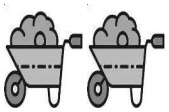
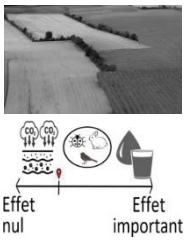
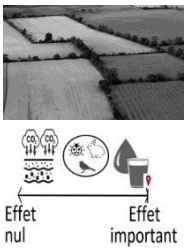
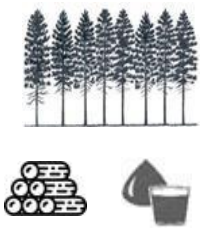
14) Comme nous vous l'avons expliqué précédemment, vous allez maintenant devoir choisir entre différents projets: le projet A, le projet B, et l'option "absence de projet". A travers cet exercice, nous souhaitons mieux connaître vos préférences quant aux mesures à mettre en œuvre pour protéger les ressources en eau et la biodiversité et ainsi fournir une aide à la décision publique. Vous aurez au total 8 choix à effectuer, selon vos préférences, en fonction des caractéristiques de chaque projet.

Les différentes options possibles seront présentées dans un tableau. Vous devrez indiquer, en dessous de chaque tableau, le projet choisi, en effectuant chaque choix, indépendamment du précédent. Un exemple est donné en bas de la page.

Quand vous aurez compris la démarche à suivre, passez directement à la question suivante, sans choisir de projet.

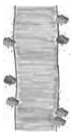
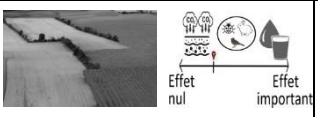
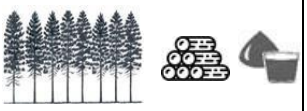
La question est posée de la manière suivante:

Veuillez sélectionner une des trois options (en bas de la page, sous le tableau).

Caractéristiques	Absence de projet	Projet A	Projet B
Pesticides			
Renaturation decours d'eau			
Type(s) d'engrais			
Haies			
Modalités de gestionde la forêt			
Augmentation du montant annuel de la facture d'eau potable		+50€	+20€

Votre choix : ⬭ ⬭ ⬭

15) Veuillez sélectionner une des trois options (en bas de la page, sous le tableau).

Caractéristiques	Absence de projet	Projet A	Projet B
Pesticides			
Renaturation de coursd'eau			
Type(s) d'engrais			
Haies			
Modalités de gestion de la forêt			
Augmentation du montant annuel de la facture d'eau potable		+20€	+25€
Votre choix:	◯	◯	◯

Questions 15 à 22: 8 ensembles de choix

Si réponse "absence de projet" aux questions 14 à 21

23) Vous avez systématiquement souhaité choisir l'alternative "absence de projet". Quelles sont les raisons principales de ce choix ?

Cochez la ou les réponses

A. La qualité de l'eau et la protection de la biodiversité ne sont pas importants pour moi
B. Ces projets ne devraient pas être financés par une augmentation de la facture d'eau
C. Les montants proposés étaient trop importants

D. C'est au propriétaire du terrain de supporter ces coûts
E. Je paie déjà trop pour ma consommation d'eau
F. Les caractéristiques des projets A et B ne me convenaient pas
G. Le nombre de caractéristiques à comparer était trop important. Ne pas choisir nécessitait moins de réflexion
H. Je ne comprenais pas ce que l'on me demandait
I. Autre : [ ]

24) Lors de vos choix entre les différents projets, avez-vous pris en compte toutes les caractéristiques ?

Veuillez sélectionner une réponse ci-dessous

A. Oui
B. Non

Si réponse B à la question 23

25) Vous avez répondu "non" à la question précédente. Quelle(s) est/sont la/les caractéristique(s) <u>que vous n'avez pas pris en compte</u> ?

Cochez la ou les réponses

A. Pesticides
B. Renaturation de cours d'eau
C. Type(s) d'engrais
D. Haies
E. Modalité de gestion de la forêt
F. Montant de l'augmentation de la facture d'eau potable

26) Vous avez dû choisir entre différentes alternatives (absence de projet, projet A et projet B au cours des questions. Qu'avez-vous pensé des choix à effectuer ?

Cochez la ou les réponses

A. Les caractéristiques qui composaient les alternatives (pesticides, renaturation de cours d'eau etc.) étaient pertinentes
B. Je pense que les réponses apportées vont aider à améliorer les politiques de préservation de la qualité de l'eau et de la biodiversité menées par l'agence de l'eau Rhin-Meuse
C. Les différences entre les alternatives étaient suffisamment visibles
D. Il y avait trop de caractéristiques (pesticides, renaturation de cours d'eau etc.)
E. Il y avait trop de choix à effectuer (8)
F. Les montants de l'attribut monétaire me semblaient réalistes

27) Consommez-vous de l'eau en bouteille ?

Veuillez sélectionner une réponse ci-dessous

A. Je ne consomme jamais d'eau en bouteille
B. Je consomme occasionnellement de l'eau en bouteille
C. Je consomme majoritairement de l'eau en bouteille
D. Je consomme uniquement de l'eau en bouteille

Si réponse B,C ou D à la question 26

28) Vous avez répondu que vous consommiez de l'eau en bouteille. Consommez-vous l'eau d'une ou plusieurs des marques suivantes ?

Cochez la ou les réponses

A. Marque de distributeur
B. Vittel
C. Cristaline
D. Contrex
E. Evian
F. Hépar
G. Volvic
H. Aucune de ces marques

29) Quel est le revenu mensuel net de votre foyer ?

Veuillez sélectionner une réponse ci-dessous

A. moins de 1500€
B. 1500-1999€
C. 2000-2499€
D. 2500-3499€
E. 3500-4999€
F. 5000-6999€
G. plus de 7000€
H. ne souhaite pas répondre

Nous avons conscience du caractère très personnel de la question. Pour autant, pour l'analyse des résultats de l'enquête, il est très important que vous répondiez à cette question. Merci de votre compréhension.

Merci beaucoup pour votre participation !

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Chapitre 3 : Do payment for environmental services (PES) schemes increase housing prices in rural areas? hedonic pricing of environmental amenities

Written with Jens Abildtrup and Serge Garcia

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1. Introduction

The attractiveness of rural areas and how to improve it has been questioned for a long time in France (Aznar, 2002; CREDOC, 2001). The identification of the drivers of local development is key for the design of appropriate regional policies, especially in terms of territorial planning (Berriet-Solliec et *al.* 2022; Aznar, 2002; Poncet and Belot, 1991). Since 1999, in France, the rural development policy has been officially recognized as the "second pillar" of the Common Agricultural Policy [24] (CAP) (Pham and Berriet-Solliec, 2018) and is supported by the *programme hexagonal de développement rural* (PHDR). This program, was, divided in several axes (until 2007) and then priorities, linked with various aspects of rural development: improving the competitiveness of agriculture and forestry, preserving or restoring ecosystems and biodiversity or improving the quality of life in rural areas (Pham and Berriet-Solliec, 2018; Allaire et *al.* 2018). Some of these objectives are more or less directly linked with the residential economy (Berriet-Solliec et *al.* 2022), which is an important issue in the rural world: since the period 1970-1980, the rural population is growing (MTECT, 2022; Perrier-Cornet, 2017; Bertrand, 2006; Perrier-Cornet, 2003; Perrier-Cornet and Soulard, 2003). However, that trend is not uniform: rural communities near cities benefit from urban sprawling and periurbanization dynamics, when other rural territories remain isolated (Perrier-Cornet, 2017; Bertrand, 2006; Perrier-Cornet and Soulard, 2003; Perrier-Cornet, 2003; Béteille, 1981). In this context, the valorization of territorial amenities can be key in rural development (MASA; 2021; Doré, 2008). The role of these amenities in the growth of the residential economy refers to the countryside as *« cadre de vie »* (Aznar, 2002; Perrier-Cornet, 2002). More broadly, rural economic structures face a shift from a development based on natural resources extraction (from mining and agriculture for instance) to a growth that relies on environmental quality (through tourism, for example) (Naranpanawa, 2019; Power, 1996).

In France, the development of the residential sphere (sometimes at the expense of agricultural land use) led to a shift in research programs, following Brun et *al.* (1992) and Cavailhès et *al.* (1994), less focused on agricultural economics and more on spatial, regional and urban

[24] This "second pillar" of the CAP is presented here: https://www.europarl.europa.eu/factsheets/fr/sheet/110/second-pilier-de-la-pac-la-politique-de-developpement-rural

economics: the microeconomic determinants of households' residential choices is one of the key issues (Aubert and Schmitt, 2014). Environmental amenities appear to be one of them. These amenities (landscape, climate etc.) can, in return, be degraded by residents and tourists (Legras, 2016).

However, originally, the term “amenities" doesn’t originally refer to the environment (MASA, 2021; Mollard et *al.* 2014). Economists started to use it in reference to nature[25] with the rise of environmental concerns in the 1970’s-1980’s (Mollard et *al.* 2014): Power (1996; 1988; 1980),started to define the theoretical framework on why amenities play an important role in rural economic growth patterns, alongside with Marcouiller (1998) and Marcouiller and Clendenning (2004). The notion even got into economic institutions with reports from OECD (2001; 1999; 1996; 1994). Finally, Power (2005) and Marcouiller and Clendenning (2004) discussed supply and demand from a theoretical perspective. These amenities are often public goods that are not traded on any market. To estimate their value, environmental economists have developed a range of nonmarket valuation, including the hedonic price method (HPM) (Lautrup et *al.* 2023; Osland et *al.* 2022; Power, 2005). Application to rural areas can be challenging[26]: the literature suggests that studies involving urban zones are more likely to identify significant amenity effects (Waltert and Schläpfer, 2010). Le Goffe (1996) pointed out that applying hedonics to agricultural territories implies to consider wide geographic scales, in order to take into account variability in environmental effects from farming. Another issue concerns data availability and quality: first, data concerning the real estate market in rural areas has not always been easily accessible or even reliable (Michalland and Volet, 1999). Second, finding data about some specific environmental attributes (water quality, biodiversity, landscape etc.) that can influence housing prices can be challenging as well (Le Goffe, 1996). As a consequence, the HPM seemed to be historically most applied in urban contexts (White and Leefers, 2007; Le Goffe; 1996). Nevertheless, over the years, substantial improvements have been made for hedonic characteristics (Casanova et *al.* 2017) as well as for environmental data[27] availability about rural territories.

[25] Other amenities were also considered: see Power (2005).

[26] The reasons why the hedonic price method is difficult to apply in rural areas are summed up in Michalland and Vollet (1999).

[27] The creation of the rural development observatory is a good example: see https://odr.inrae.fr/intranet/carto_joomla/

Rosen (1974) established the hedonic theoretical framework in the 1970's, but the idea of hedonic pricing can be traced back in the 1920-1930 decade (Court, 1939; Waugh, 1929). Concerning environmental amenities, early thoughts seemed to be about the role of climate on migration (Ullman; 1954; Bright and Thomas, 1941). After Rosen's seminal paper, the number of contributions using hedonics to value environmental amenities (or disamenities) quickly started to grow (Freeman, 1981). In France, one of the first applications was made by Verney (1976), who used property price models to assess the cost of nuisance from solid waste treatment units. Le Goffe and Delache (1997) and Le Goffe (2000) were among the firsts to apply it to the french rural context. The HPM has been applied to various topics related to the countryside: many studies investigate the impact of agriculture on rural tourism (Mollard et *al.* 2007; Vanslembrouck et *al.* 2005; Le Goffe, 2000; Le Goffe and Delache, 1997) or on residential properties (Osseni et *al.* 2019; Ready and Abdalla, 2005). The method is also useful to assess the impact of rural policies (Liljenstolpe, 2011). Some studies focus on peri-urban areas (Jensen et *al.* 2021; Sylla et *al.* 2019). Nature based solutions (NBS) (Bockarjowa and Botzen, 2017) and environmental management in general (Chen et *al.* 2022) can, through ecosystem services provision or preservation, have a substantial impact on residential prices, and participate in rural and peri-urban zones' attractivity. However, these spillovers are often unequally distributed and must be measured using spatial hedonic analysis. (Hu et *al.* 2022; Osland et *al.* 2020; Maslianskaïa-Pautrel and Baumont, 2016). The most common strategy is to measure the distance between residential properties and the nearest environmental amenitiy of each category, using geographic information systems (GIS). But as Maslianskaïa-Pautrel and Baumont (2016) emphasized on the fact that the price of a property is not only affected by environmental features located in one place, but also by the environmental endowments on neighboring places, *measures of spatial domination* of the characteristics in the area surrounding each building (see for instance Kong, et *al.* 2007), and *vista measures* regarding the oceanic view from each locations (Fu et al. 2019; Hamilton & Morgan, 2010) can be used. Very few studies, with the exception of Cavailhès et *al.* (2009), however, have been combining all three types of methods (distance, domination and vista measures).

That (reciprocal) effect of amenity improvement between neighboring housing induce a spatial multiplier effect: the direct effect of the improvement is amplified by the spillover[28] effects among surrounding properties (Maslianskaïa-Pautrel and Baumont, 2016b; Small and Steimetz, 2012). This multiplier is given by the coefficient of a weighted transformation of spatially lagged prices (Small and Steimetz, 2012).

Moreover, some authors notice the existence of diffusion effects of properties' prices (home buyers and sellers may use information from the nearest sales to determine their buying and selling prices) or of environmental externalities (an externality may impact individuals who live in other locations) that need to be addressed (Osseni et *al.* 2019).

In a nutshell, when conducting an hedonic valuation two types of spatial effects have to be controlled for: a) the spatial dependencies potentially present in the variables – spatial autocorrelation and spatial heterogeneity – b) the impact of spatial processes – spatial diffusion and the spatial multiplier phenomenons (Maslianskaïa-Pautrel and Baumont, 2016b).

In this article, we want to investigate the influence of agri-environmental measures related to a payment for environmental services scheme implemented in les Vosges (France). The private company, Nestlé Waters, that owns several mineral natural or spring waters' brands, such as Vittel®, Hépar®, Contrex® etc. had to cope, in the end of the 1980's, with a deterioration of the water quality, due to nitrates' pollution resulting from intensive farming (Amiri et *al.* 2022; Déprés et *al.* 2005). To address this issue, Agrivair (a subsidiary of Nestlé Waters dedicated to these ecological issues) started to collaborate with the French National Institute of Agronomic Research (INRA) and local farmers. Some concrete measures were adopted to guarantee water quality: cessation of corn culture, composting of animal waste, plantation of trees etc. Moreover, permanent grasslands cannot be turned over anymore. The Vittel case became the « first recognized initiative » of Payment for Environmental Services (PES) in France (Hernandez and Benoit, 2011). This PES therefore results in land use modifications that may be reflected in house prices. Previous hedonic studies have been conducted to examine the effect of nature-based solutions in an urban setting (Bockarjova and Botzen, 2017), or the impact rural policies on real estate prices (Liljenstolpe, 2011): this study contributes to the literature by assessing the influence of a PES scheme on such prices in a

[28] Small and Steimetz (2012) distinguish pecuniary spillovers from technological ones.

rural area: this kind of valuation is crucial in a context where the role of amenities is at the heart of economic rural development (MASA, 2021).

2. Material and method

2.1. Analytical framework

The HPM has been widely used in environmental economics. Following Rosen (1974), this technique based on revealed preferences aims at determining the marginal WTP for characteristics of a composite good (Osland et *al.* 2020; Osseni et *al.* 2019). The housing market is considered as appropriate, because the house and apartments prices are assumed to be a function of the capitalized values of all the attributes that can influence the housing value (house characteristics or environmental amenities) (Łaszkiewicz et *al.* 2022; Osland et *al.* 2020, Osseni et *al.* 2019).

Hedonic analysis consists in two related steps often referred to as a first-stage and second-stage analysis (Taylor, 2017). In a first-stage analysis, the hedonic price function is estimated using information about the sales prices of a differentiated product and its characteristics. Doing so, researchers are able to recover the implicit prices of these attributes and to elicit individuals's preferences for it, by estimating the willingness to pay (WTP) for environmental variables. These informations can then be combined with data on household characteristics to estimate demand functions for the characteristics or utility parameters (Marrouch and Sayour, 2021; Taylor, 2017). Accounting for spatial dependence of environmental amenities can be seen as a third step (Marrouch and Sayour, 2021). The literature seems mostly restricted to first stage analyses, mainly because second-stage one is data demanding and can generate endogeneity issues (Jensen et *al.* 2021; Taylor, 2017). Possible endogeneity sources and strategies to control for this biais are discussed by Osseni et *al.* (2021)

Let's assume Z represents a product with Z_1, Z_2, Z_n characteristics. Z is assumed to be sold in a perfectly competitive market, and its equilibrium price is $P(\underline{z})$. Consumer utility is defined over two goods: Z, and x, a composite product representing all other goods. The utility function of a consumer J is defined as :

$$Uj = (x, z1, z2, \dots, zn ; \alpha j) \quad (1)$$

The marginal rate of substitution between any characteristic z_i, and x, is equal to the rate at which the consumer can trade z_i for x in the market:

$$\frac{\partial P}{\partial zi} = \frac{\partial u/\partial zi}{\partial U/\partial x} \quad (2)$$

Besides these theoretical considerations, researchers have to decide what functional form of hedonic price function to consider. Little theoretical guidance exists for the choice of this functional form (Taylor, 2017) but non-linear ones appear to be more relevant (Bishop et *al.* 2020; Kuminoff et *al.* 2010; Ekeland et *al.* 2004). Even if Cropper et *al.* (1988) stated that simpler forms (such as linear, log-linear, or log-log) perform better when dealing with omitted variable bias, Kuminoff et *al.* (2010) challenged this finding: the found that including spatial fixed effects to control for omitted variables can solve this problem. In that case, more flexible specifications (such as quadratic Box-Cox) outperform other models. Moreover, nonlinear forms also allow the market equilibrium to reflect complementarities between amenities (Albouy et *al.* 2020). The *log-log* functional form seems to be the most frequently used in hedonic studies (Maslianskaïa-Pautrel and Baumont, 2016b). Aside from that, researchers must be careful about heteroskedasticity and (spatial and temporal) autocorrelation of standard errors (Bishop et *al.* 2020).

2.2. Econometric analysis

2.2.1. Specification

The traditional hedonic price model has been widely used to study price variations between different residential properties. According to our analysis framework, a general model could be represented as following:

$$f(P_i, X_i, A_i, \varepsilon_i) = 0 \quad (3)$$

Where where Pi is the value of residential property i, Xi is a vector of house characteristics, Ai is a vector of variables representing amenities, εi is an independent and identically distributed error term.

Economic theory does not specify which variables should be included in a hedonic regression, nor does it specify the functional form. The choice of functional form is an important empirical issue. There are many basic functional forms (*e.g.* linear, quadratic, log-linear, log-log) that can be applied to the hedonic price model. However, we find little guidance on the functional forms to be used, except that the price of a property is likely to vary non-linearly with some housing or location characteristics.

The first, simplest functional form is the linear form. The advantage is that the marginal effect directly expresses the implicit marginal price of an additional unit of the attribute:

$$P_i = \beta_0 + \beta_X X_i + \beta_A A_i + \varepsilon_i \quad (4)$$

A more general functional form that introduces non-linearity and thus more flexibility would be one where the explained variable is log-transformed and the list of explanatory variables could include linear, quadratic and logarithmic transformations of dwelling characteristics:

$$\ln(P_i) = \beta_0 + \beta_X \ln(X_i) + \beta_A A_i + \beta_A A_i^2 + \beta_D D_i + \beta_{AD} A_i \times D_i + \varepsilon_i \quad (5)$$

where D_i could be a dummy variable.

In the latter case, we use a Poisson regression model to estimate the positive value of the dependent variable (Cameron and Trivedi, 2005). We prefer a Poisson model to a log-transformed model because OLS-estimated parameters of the latter lead to biased estimates in the presence of heteroskedasticity (Manning and Mullahy, 2001; Santos Silva and Tenreyro, 2006).[29]

From the equation (5), the Poisson regression can be written as:

$$E(P_i|X_i, A_i, D_i) = \exp[\beta_0 + \beta_X \ln(X_i) + \beta_A A_i + \beta_A A_i^2 + \beta_D D_i + \beta_{AD} A_i \times D_i] \quad (6)$$

where P_i does not follow a specific distribution.

[29] Poisson regression is well known for dealing with count data. However, it is also an increasingly used specification for estimating multiplicative models where the dependent variable is non-negative, see for example its use for estimating a gravity equation in international trade.

2.2.2. Estimation procedure

In our case of the hedonic price model, we are likely to have many omitted variables that are a source of unobserved heterogeneity, leading to potential endogeneity bias. We could control for these issues by introducing various fixed effects. In particular, we should control for municipality specific effects γ_j and time effects λ_t. We can rewrite the error term as consisting of several components:

$$\varepsilon_{ijt} = \gamma_j + \lambda_t + \epsilon_{ijt} \quad (7)$$

where ϵ_{ijt} is the idiosyncratic error term. It is worth noting that there is no individual specific effect as we do not have a typical panel structure in the sense that the transaction for a dwelling is realised only once.

The estimation method used is the Poisson pseudo-maximum likelihood (PPML) implemented by the Stata command ppmlhdfe (Correia et *al.*, 2020).

3. Data description

3.1. Case study

In this article, we want to investigate the influence of agri-environmental measures related to a payment for environmental services scheme implemented in les Vosges (France), a french, mostly rural, department, in the Grand-Est region (table 3.1). The rural/urban distinction is given by the national institute of statistics and economic studies (INSEE), with the following classification[30]:

1) Rural municipalities out of the influence of an employment hub (pôle d'emploi, in french) also called autonomous rural municipalities;

2) Rural municipalities under the influence of an employment hub (*i.e* within an attraction area of more than 500 000 inhabitants), also called rural periurban municipalities.

[30] see https://www.insee.fr/fr/statistiques/5359123#consulter for additional classification details.

Grand-Est departments	Autonomous rural municipalities (%)	Rural periurban municipalities (%)	Autonomous + periurban municipalities (%)	Urban municipalities (%)
Meuse	52.8	21.5	74.3	25.7
Haute-Marne	34.1	33.2	67.3	32.7
Vosges	**40.1**	**27.3**	**67.4**	**32.7**
Ardennes	28.2	26	54.2	45.8
Aube	22.3	26.4	48.7	51.4
Marne	17.9	24.4	42.3	57.7
Moselle	11.1	22.5	33.6	66.5
Meurthe-et-Moselle	9.1	21	30.1	69.9
Bas-Rhin	11.4	18.4	29.8	70.3
Haut-Rhin	5.1	23.3	28.4	71.6
Grand-Est	16.2	22.8	39	61

Source: INSEE, population census (2018)

Table 3-1 : Share of rural/urban municipalities in Grand-Est departments

The Vosges are among the most rural departments in the Grand-Est region. In addition, a lot of municipalities are even classified in *"zone de revitalisation rurale"* (ZRR) (figure 3.1), which gather territories sharing some socio-economic characteristics, such as low population density, declining total (or working) population or a high proportion of agricultural jobs. The Vittel's watershed (or impluvium) (in blue) is located right in the biggest ZRR (in red), in the west of the department. Other municipalities are in white. Two-third of the territory belongs to that category (338 municipalities over 507).

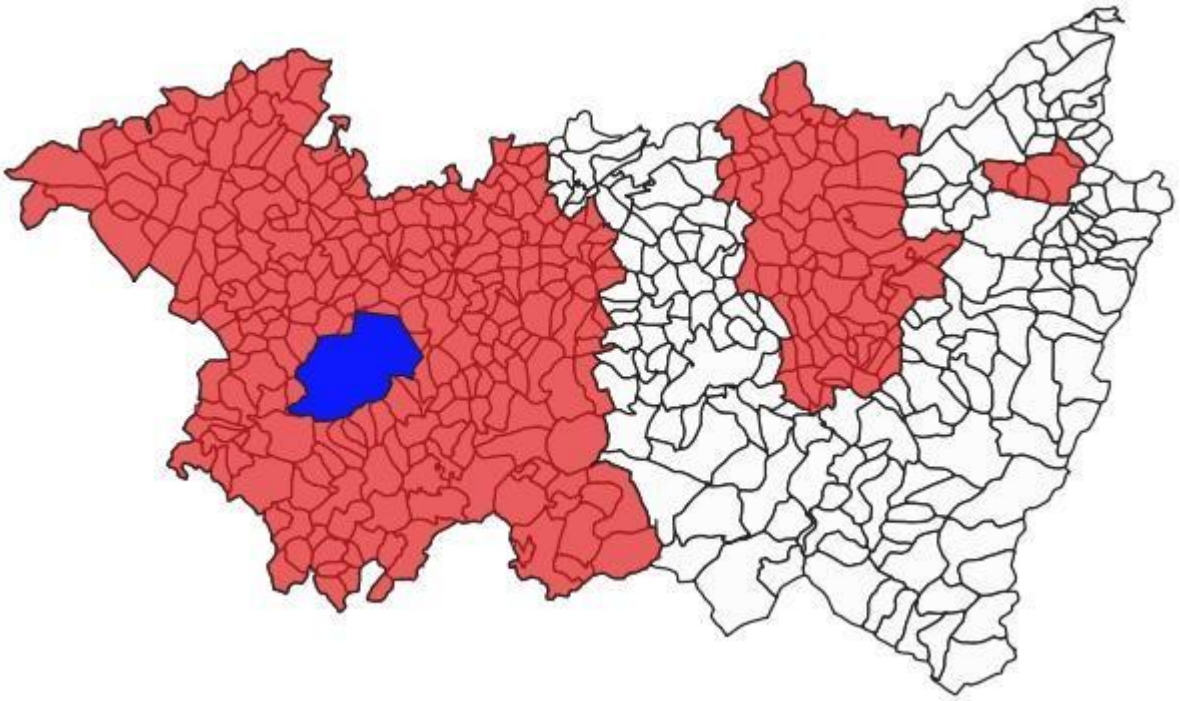


Figure 3-1: "Zones de revitalisation rurale" in les Vosges (source: authors)

It is more than the mean of the Grand-Est region[31] (52.3%) but less than in Meuse (94.6%), Haute-Marne (90.1%) or Ardennes (83.1%). Considering the rural character of the department, we may expect houses' location to be close to agricultural fields: Guilpart et *al.* (2022) have shown that the dominant land use at 150 m to residential buildings in the Vosges is grasslands (both permanent and temporary), as it is the case at the national level. We want to test the influence of that land use on hedonic pricing compared to other ones, such as agriculture or forest.

The evolution of grasslands in the Vosges is downward but rather stable[32] over the years. In the impluvium, the share of permanent grasslands (PG) is 56% but the situation vary between farmers: as turning over PG is prohibited for those who have signed PSE contracts, the share of PG among these farms is 65% against 41% for non-signatories farmers (Agrivair data,

[31] See: https://www.observatoire-des-territoires.gouv.fr/kiosque/zonage-les-zones-de-revitalisation-rurale-zrr

[32] See: https://grandest.chambre-agriculture.fr/fileadmin/user_upload/Grand-Est/049_Inst-Acal/RUBR-agro-environnement/Changement_climatique/8_0_ORACLE_Grand_Est_2020_theme_attenuation_agricole.pdf

2020). Older data about land use in the impluvium, especially grasslands and grasslands reversal are available in Roussel (1999), Deffontaines et *al.* (1993) and Gaury (1992). Deffontaines et *al.* (1993) indicate that historically, the maximum surface covered by grasslands has been reached in the 1970's. The table 3.2 sum up the evolution of grasslands on the impluvium before the PES implementation:

Year	1970	1979	1991	Evolution 1970-1991 (%)
Surface of permanent grasslands (ha)	2058	1789	1507	- 26.77
Surface of temporary grasslands (ha)	6	19	200	+ 3233
Total (ha)	2064	1808	1707	-17.3

Adapted from Gaury (1992)

Table 3-2 : Evolution of grassland share in the impluvium before PES implementation

In comparison the "surface toujours en herbe" represented almost 75% % of the useful agricultural area in the Vosges department in 1970, a very stable percentage until 1988 (Fiorelli, 1998).

Meadows are known to be a favorable land use for water quality (Rhin-Meuse basin committee 2021; Peyraud et *al.* 2012; Salles et *al.* 2009), but they produce many other ecosystem services, such as carbon sequestration, soil erosion limitation and biodiversity reserve (Rhin-Meuse basin committee 2021; Peyraud et *al.* 2012; Salles et *al.* 2009). The influence on both permanent and temporary grasslands on ecosystem services can vary according to management practices or fertilization levels. For temporary grasslands, it also depends on how often the meadow is turned (Thiébaud et *al.* 2001). As Le Goffe and Delache (1997), we make the hypothesis that grasslands (permanent grasslands in particular), symbolize more extensive agricultural systems, and may have a positive impact on house prices. Besides, it may represent a sign of landscape openness, especially in areas dominated by forests. Past evidences in the literature are quite mixed: Le Goffe and Delache (1997) found a positive but non significant effect of permanent meadows on rural cottages in

Brittany, while Vanslembrouck et *al.* (2005) found a significant effect for the same kind of study in Belgium. Osseni et *al.* (2019) investigated the effect of both temporary and permanent grasslands in Brittany at different spatial scales. They found a negative effect of both temporary and permanent grasslands at a very local scale, but positive at a larger one. In general, this land uses seems to have a rather positive but not always significant effect on prices like in Osseni et *al.* (2021). Nevertheless, exceptions can be found in Gibbons et *al.* (2014) and Liljenstolpe (2011).

Informations about meadows (and other land uses) come from the Corine Land Cover database, a biophysical land use inventory that maps homogeneous units of land use (or land use change) with a minimum surface area of 25 ha. Based on this nomenclature, we distinguished five different land uses: meadows, forest, agriculture, urban zones and others. The Vosges are dominated by forest areas, mainly divided between broad-leaved forests (23.11%) and coniferous forests (21.02%). In our analysis, we separated grasslands (26.51%) from lawns and natural pastures (0.27%), often located in accidental areas, and that can include rock surfaces and brambles. Details about our classification are available in annex 1. Concerning agriculture, the two main categories include non-irrigated arable land (11.79%) (mainly cereals, pulses and fodder crops) and complex cultivation patterns (4.23%).

Data are available for different years: 1990, 2000, 2006, 2012 and 2018. Because Agrivair, the structure in charge of the implementation of agri-environmental measures on the impluvium was created in 1992, we could have considered data from 2000 to 2018 to measure the effect of such measures on house prices. But as land use shares have not drastically changed over time in the Vosges (table 3.3), we focused on the 2012 year as a preliminary analysis.

Land uses/Year	2000	2006	2012	2018	Evolution 2000-2018
Meadows	21.12	27.67	26.51	25.82	+ 22.25
Forest	50.31	48.99	49.80	51.37	+2.11
Agriculture	20.56	15.80	16.22	15.45	-24.85
Urban	3.25	3.11	3.21	3.62	+11.38
Others	4.76	4.43	4.26	3.74	-21.43
Total	100	100	100	100	

Table 3-3 : Evolution of land use in les Vosges (2000-2018) Source: Corine Land Cover

The most important evolution of land use concerns agricultural plots, but still remains limited. The relative stability of the meadows share may be explained by the supportive policies implemented from 1970's in France in order to maintain grassland areas (Institut de l'élevage, 2007). More generally, land use evolutions are not so important over the period (2000-2018) and considering one specific year may not lead to important changes in the results.

Variable name	Nb of obs.	Mean	Std. Dev.	Min	Max
Cons_P_Houses_HT	10 801	116 496.9	65827.37	10 000	824543.3
Living_area (m²)	10 801	122.65	50.83	23	1000
Nbr_rooms	10 801	5.18	1.60	2	15
Nbr_bathrooms	10 801	1.21	0.46	1	5
Nbr_floors	10 801	1.95	.65	1	5
Dist_Houses_Forest (km)	10 801	0.58	0.40	0	2.14
Dist_Houses_Agriculture (km)	10 801	1.55	1.67	0	14.12
Dist_Houses_Meadows (km)	10 801	0.43	0.51	0	3.61
Dist_Houses_Urban_zones	10 801	0.28	0.72	0	5.49
Dist_Houses_other_land_ uses (km)	10 801	0.52	0.49	0	4.19
Dist_Houses_Chefs_lieux (km)	10 801	0.68	0.63	0.005	5.95
Shareforest_250m	10 801	0.06	0.16	0	1
Shareagri_250m	10 801	0.15	0.27	0	1
ShareMeadows_250m	10 801	0.17	0.26	0	1
Shareurban_250m	10 801	0.59	0.35	0	1
Shareothers_250m	10 801	0.03	0.10	0	1
Shareforest_500m	10 801	0.09	0.17	0	1
Shareagri_500m	10 801	0.17	0.24	0	1
ShareMeadows_500m	10 801	0.23	0.25	0	1
Shareurban_500m	10 801	0.46	0.31	0	1
Shareothers_500m	10 801	0.05	0.1	0	0.76
Shareforest_1km	10 801	0.15	0.18	0	1
Shareagri_1km	10 801	0.19	0.20	0	0.94
ShareMeadows_1km	10 801	0.27	0.23	0	0.94
Shareurban_1km	10 801	0.33	0.26	0	0.96
Shareothers_1km	10 801	0.06	0.08	0	0.43

Source: Perval/Corine Land Cover

Table 3-4 : Descriptive statistics

Our hedonic analysis is conducted using the Perval database (Notaires de France). Our transaction data covers the period 1998-2021 for the Vosges department, with 40 650 observations before cleaning. First, we removed observations with missing geographic coordinates (293 observations) and irrelevant ones (actually out of the Vosges). It led us to 40 316 observations. Then, we also removed houses located in the Vosges mountains, because touristic accommodation is highly represented in the area (INSEE, 2017). Even if houses in the Vosges mountains represented more than half of the observations, our sample remained important at this stage: 19 998 observations remained. Finally, we dropped observations with irrelevant housing characteristics (number of rooms, for example): the final sample has 10 801 observations.

3.2. Measuring distances to amenities

Distance to amenities were calculated using the Qgis nearest neighbour join (NNjoin) plugin, that joins two vector layers (the input and the join layer) based on nearest neighbour relationships. Distances were estimated between each land use category and the nearest houses. Distances to administrative centers (« chefs-lieux ») has also been calculated.

3.3. Computation of buffers

Buffers around houses were mapped using Qgis. It allows us to capture the *spatial domination* of land uses (Osland et *al.* 2022) within various radius. Several buffers were needed, because environmental amenities can have different effects at various spatial scales: Osseni et *al.* (2019) found that the effect of the same environmental amenity can differ at different spatial scales. In the land use context, we can imagine that some agricultural land uses cause disamenities (because of the smell of agricultural activities, for instance) that are overtaken by some positive effect at a larger scale (landscape diversification, for instance). In the literature different buffer sizes have been considered, and the number of buffers can vary: Buffers under 1km seem to be mostly used (Liljenstolpe, 2011; Kong et *al.* 2007; Irwin 2002), and, in particular, 500m (see Osland et *al.* (2022)) sometimes with other ones (Coinon et *al.*

2023; Liljenstolpe, 2011; Kong et *al.* 2007). Some studies use both smaller and bigger radius than 1km (Coinon et *al.* 2023; Ready and Abdalla 2005). Alternatively, Cavailhès et *al.* (2009) tested six different radius areas to take into account the depth of the landscape viewshed: 0-70, 70-140, 140-280, 280-1200, 1.2-6, and 6-40 km. The most important issue seems to consider different spatial scales. In this paper, we distinguish 3 different buffer sizes: 250m, 500m and 1km. It should allow us to capture very local effects as well as more extented ones.

3.4. House characteristics

We kept 5 main housing characteristics for our analysis: the constant house price, the surface (m^2), the number of rooms, the number of bathrooms and the number of floors. All the housing characteristics we kept had a filling rate over 90%. On the contrary, some other variables that could have been interesting for our analysis (presence of terrace or balcony for example) were poorly filled. Constant prices before tax were obtained using the INSEE house price index[33].

4. Analysis of econometric results

We estimated econometric results for our different specifications: distance to environmental amenities and spatial domination of these amenities within various size buffers. We used Poisson estimation with high-dimensional fixed effects (Correia et *al.* 2020). Poisson regression is an alternative for estimating linear regression applied to a log-transformed dependent variable. We used the Stata command *ppmlhdfe* (Correia et *al.* 2020) to deal with multiple fixed-effects (in our case, year of transaction and municipalities). This command automatically dropped observations that are either singletons or separated by a fixed effect: keeping these observations could lead to overstate statistical significance (Correia, 2015). In our analysis, 15 observations were in that case.

House characteristics are all significant at a 1% level. The coefficient associated with the number of floors is negative. Osseni et *al.* (2021) found the same result, but not significant. Regarding the distances to the different land uses, results are mixed: the distance between houses and meadows is negative and quite significant, which means that closer meadows are

[33] See: https://www.insee.fr/fr/statistiques/series/105071770

from the house, higher is the price. The coefficient for meadows with the square specification is nevertheless not significant. The distance to administrative centers is positive and significant, which may appear as counter-intuitive, especially in rural areas. However the square variable is negative and significant. If we take a close look at the results in the area where environmental measures take place, the distance to agriculture is positive and significant: this result may be surprising, considering the nonuse of pesticides on the impluvium. But agricultural practices can cause some disamenities (the smell or noise induced by some activities for example). One explanation can be the presence of methanisation units. If these units are located in all the Vosges[34], the presence of these units in the impluvium (in use or in construction) could overtake the positive influence of these agri-environmental measures. All the units in the department are related to farming activities (and not to water treatment plants, for instance) and a large majority of their inputs are livestock manure. Moreover, the digestate is used for spreading (ADEME, 2022). Bourdin et *al.* (2020) remind us that these buildings can be close to houses. They found that their development can be associated with some inconveniences: noise, smell, pollution but also risk of property depreciation. Moreover, the mistrust towards it can come from a feeling of place attachment to a territory that could be degraded, especially on a preserved area like the impluvium.

[34] See: https://www.vosgesmatin.fr/economie/2019/07/20/produire-de-l-energie-a-partir-de-dechets

Variables	Cons_P_Houses_HT	Cons_P_Houses_HT	Cons_P_Houses_HT
Log_living_area	0.560***	0.560***	0.560***
	(0.0271)	(0.0254)	(0.0254)
Log_nbr_rooms	0.288***	0.286***	0.286***
	(0.0181)	(0.0182)	(0.0182)
Log_nbr_bathrooms	0.187***	0.184***	0.184***
	(0.0157)	(0.0149)	(0.0148)
Log_nbr_floors	-0.223***	-0.207***	-0.206***
	(0.0243)	(0.0217)	(0.0217)
Log_Pop_Density			-
Dist_Houses_Agriculture		-0.0170	-0.0182
		(0.0205)	(0.0214)
Dist_Houses_Meadows		-0.118***	-0.124**
		(0.0426)	(0.0626)
Dist_Houses_Forest		-0.0753*	-0.0640
		(0.0453)	(0.0458)
dist_chef_lieu		0.0886***	0.0896***
		(0.0271)	(0.0279)
Dist_Houses_other_land_uses		-0.0878**	-0.0830**
		(0.0363)	(0.0370)
Square_Dist_Houses_Agriculture		0.00114	0.00127
		(0.00176)	(0.00184)
Square_Dist_Houses_Meadows		0.0376**	0.0414
		(0.0180)	(0.0379)
Square_Dist_Houses_Forest		0.0296	0.0241
		(0.0255)	(0.0258)
Square_dist_chef_lieu		-0.0160***	-0.0160***
		(0.00497)	(0.00503)
Square_Dist_Houses_other_LU		0.0181	0.0161

		(0.0121)	(0.0123)
Dist_Houses_Agri_Impluvium			0.286***
			(0.0918)
Dist_Houses_Meadows_Impluvium			0.0310
			(0.0980)
Dist_Houses_Forest_Impluvium			-0.240
			(0.175)
dist_chef_lieu_Impluvium			0.238*
			(0.141)
Dist_Houses_Others_Impluvium			-0.344***
			(0.131)
Sq_Dist_Houses_Agri_Impluvium			-0.0703**
			(0.0279)
Sq_Dist_Houses_Meadows_Impluvium			-0.000263
			(0.00265)
Sq_Dist_Houses_Forest_Impluvium			0.136
			(0.0851)
Sq_dist_chef_lieu_Impluvium			-0.195***
			(0.0618)
Sq_Dist_Houses_Others_Impluvium			0.211***
			(0.0561)
Constant	8.659***	8.720***	8.711***
	(0.123)	(0.115)	(0.118)
Observations	10,786	10,786	10,786
Pseudo-R-squared	0.534	0.540	0.541
Log likelihood	-8.910e+07	-8.780e+07	-8.770e+07
number of com	347	347	347

Table 3-5 : Poisson model with distance variables

The second part of our results consist in testing the influence of land use spatial domination on hedonic prices. Buffer areas were designed using Qgis: we defined 3 different buffer areas perimeters around houses: 250m, 500m and 1km. Results for 250m buffers and 1km buffers are reported below. The estimation for 500m buffers is in annex 2. Coefficients for land uses variables are expressed relatively to urban areas, which is the reference here. First, the meadows and agriculture shares close to houses has a positive impact on their prices: one interpretation possible is that it offers landscape diversification and openness: It seems that these positive effects of agriculture overtake its potential negative influence (smell, noise etc.). However, these effects are not robust in the impluvium. But the forest share (with the square specification) has a positive impact on house prices in the area. We could think that forest areas participate in landscape closeness when they are so close to homes. But Cavailhès et *al.* (2009) found that the view of trees is valued more than their mere presence. Results about forest share can be sensitive to forest density, species etc. In our case, the mean density of forest within the 250m radius is 5.8%, which is not enough to highly contribute to landscape closeness.

Variables	Cons_P_Houses_HT	Cons_P_Houses_HT
Log_living_area	0.560***	0.554***
	(0.0271)	(0.0258)
Log_nbr_rooms	0.288***	0.290***
	(0.0181)	(0.0178)
Log_nbr_bathrooms	0.187***	0.183***
	(0.0157)	(0.0149)
Log_nbr_floors	-0.223***	-0.210***
	(0.0243)	(0.0223)
shareMeadows_250m		0.251**
		(0.0979)
shareagri_250m		0.332***
		(0.114)
shareforest_250m		0.0829

		(0.0973)
shareothers_250m		0.109
		(0.140)
shareMeadows_250m_Impluvium		-0.124
		(0.254)
shareagri_250m_Impluvium		-0.440
		(0.376)
shareforest_250m_Impluvium		-0.134
		(0.179)
shareothers_250m_Impluvium		-0.699***
		(0.177)
Sq_shareMeadows_250m		-0.0430
		(0.108)
Sq_shareagri_250m		-0.167
		(0.107)
Sq_shareforest_250m		-0.0135
		(0.101)
Sq_shareothers_250m		0.0782
		(0.237)
Sq_shareMeadows_250m_Impluvium		-0.190
		(0.623)
Sq_shareagri_250m_Impluvium		0.357
		(0.463)
Sq_shareforest_250m_Impluvium		1.019***
		(0.197)
Sq_shareothers_250m_Impluvium		2.262***
		(0.362)
Constant	8.658***	8.602***
	(0.123)	(0.112)
Observations	10,787	10,787

Table 3-6 : Poisson model with share variables (250m)

Looking at the same model with 1km buffer, some results are consistent with the 250m radius. Meadows still have a positive impact on house prices, with a stronger and more significant coefficient, which means that it impacts house prices positively. This result even holds (less significantly, though) with the 500m radius (annex), which to indicate its robustness. The coefficient associated to the forest share is positive and slightly significant in a 1km radius: at that distance, the positive aspect on prices may be more linked to others forest benefits, such as recreational value of biodiversity spot. This could validate Nestlé Waters' efforts in terms of forest management: Since 1999, a partnership has been implemented between the company and the french national forestry office (ONF) to manage its private forest. One objective of the management plan is to deal with public reception: forest landscape management is taken into account, especially next to walking paths and trails (Deck, 2008). Finally, agriculture seems to have a positive influence on prices in the impluvium: at that distance, negative impacts of agricultural activities (noise, pollution, smell etc.) are probably less important than positive ones (landscape diversification etc.).

Variables	Cons_P_Houses_HT	Cons_P_Houses_HT
Log_living_area	0.560***	0.557***
	(0.0271)	(0.0263)
Log_nbr_rooms	0.288***	0.287***
	(0.0181)	(0.0180)
Log_nbr_bathrooms	0.187***	0.185***
	(0.0157)	(0.0153)
Log_nbr_floors	-0.223***	-0.211***
	(0.0243)	(0.0223)
shareMeadows_1km		0.441***
		(0.147)
shareagri_1km		0.356
		(0.226)
shareforest_1km		0.251*

		(0.147)
shareothers_1km		0.299
		(0.427)
shareMeadows_1km_Impluvium		0.392
		(0.412)
shareagri_1km_Impluvium		0.897***
		(0.233)
shareforest_1km_Impluvium		-0.351
		(0.268)
shareothers_1km_Impluvium		0.756
		(0.586)
Sq_shareMeadows_1km		-0.396
		(0.274)
Sq_shareagri_1km		-0.113
		(0.225)
Sq_shareforest_1km		-0.128
		(0.116)
Sq_shareothers_1km		0.536
		(1.230)
Sq_shareMeadows_1km_Impluvium		-0.381
		(0.657)
Sq_shareagri_1km_Impluvium		-1.941***
		(0.314)
Sq_shareforest_1km_Impluvium		0.851
		(0.533)
Sq_shareothers_1km_Impluvium		0.00191
		(1.335)
Constant	8.658***	8.482***
	(0.123)	(0.117)
Observations	10,787	10,787

Table 3-7 : Poisson model with share variables (1km)

5. Discussion and conclusion

This paper aimed at investigating the effect of agri-environmental measures, related to a PES scheme, on house prices. This article contributes to the literature in several ways:

First, hedonic analysis on rural territories are pretty scarces (White and Leefers, 2007; Le Goffe; 1996). Such papers may bring evidences about how crucial environmental amenities can be for rural development. Authors of recent reports (IGEDD, 2023; MASA, 2021) call for rural amenities to be valued and fairly remunerated. Rural hedonic studies can provide a scientific basis to such valuation. Besides, this article investigates PES spillovers and contributes to the literature on spillovers' valuation of environmental policies through hedonic pricing, following Maslianskaïa-Pautrel and Baumont (2016b) and Liu et *al.* (2020). Such environmental spillovers could have been generated by other entities, such as natural regional parks. But our analysis is mainly based on land uses that are not specific to one particular site. Moreover, the part of the "ballon des Vosges" park that is in les Vosges is located in the mountainous area, which was excluded from our analysis.

We used CLC and Perval data to assess how agri-environmental measures could influence house prices in the Vosges. We divided land use categories in five main groups: agriculture, forest, meadows, urban area and others. In hedonic studies investigating the impact of land use on real estate prices, other categorizations exist (Osseni et *al.* 2021). As the way categories are constructed may impact the results, they can obviously be discussed: for example, we put "annual crops associated with permanent ones" in agriculture, which makes sense, but we could also oppose permanent crops to temporary ones in two different categories, to see which one had the bigger impact on prices. We tested the influence of land uses on prices using distance and spatial domination. For the latter, we defined buffers around houses with various radius: 250m, 500m and 1km. It is quite similar to what already exists in the literature (Liljenstolpe, 2011, Irwin, 2002), we could have done differently: For example, Coinon et *al.* (2023) defined buffers from 500m to 5km. Considering bigger radius could indeed be interesting, as Osseni et *al.* (2019) indicate that farm activities can be spatially fragmented and rarely have all their plots grouped together in a single municipality. It suggests that effects of such activities may be felt at long distances from farm buildings. But as our results are still

preliminary, other buffers will maybe be considered. Distance to specific urban amenities, like schools, were for the moment, not included in the analysis: we used spatial fixed effects to control for omitted variables. In particular they are expected to capture elements that do not vary within the neighborhood (von Graevenitz and Panduro, 2015). Their use in hedonic analysis is discussed in von Graevenitz and Panduro (2015).

Our results show the positive influence of meadows on house prices. This is in line with Vanslembrouck et *al.* (2005) but not with Osseni et *al.* (2019) or with Liljenstolpe (2011). One explanation for Osseni et *al.* (2019) can be that permanent grasslands are mainly agricultural wetlands in Brittany. The negative effect can be associated with flood risk. For Liljenstolpe (2011) negative coefficients are associated with semi-natural grasslands and grazing land, while ours is specific to permanent grasslands. Cavailhès et *al.* (2009) found that crops and meadows seen between 70 and 280 m have a positive effect on house prices which is consistent with our 250m radius results. Finally, forests seem to have a positive effect considering the 1km buffer, which is consistent with Garrod and Willis (1992). Negative influence of forest can also be found (Vanslembrouck et *al.* 2005) but weaker feeling of closeness with this buffer could explain this result.

This study provides interesting results to discuss spillovers from PES schemes. In addition to direct environmental benefits (for water quality for instance), they have co-benefits for residents as well and may impact house prices. These co-benefits and environmental amenities in general must be taken into account in public policies and rightly valued, especially at a time where they are widely discussed at the political level[35] (IGEDD, 2023).

[35] See https://www.senat.fr/amendements/2020-2021/667/Amdt_1668.html

6. Annexes

Land use	CLC code	Category
Meadows	231	Pastures, meadows and other permanent grasslands under agricultural use
Forest	311	Broad-leaved forest
	312	Coniferous forest
	313	Mixed forest
Agriculture	211	Non-irrigated arable land
	222	Fruit trees and berry plantations
	242	Complex cultivation patterns
Urban areas	111	Continuous urban fabric
	112	Discontinuous urban fabric
	121	Industrial or commercial units and public facilities
	122	Road and rail networks and associated land
	124	Airports
Others	131	Mineral extraction sites
	132	Dump sites
	133	Construction sites
	141	Green urban areas
	142	Sport and leisure facilities
	243	Land principally occupied by agriculture, with significant areas of natural vegetation
	321	Natural pastures
	322	Moors and heathland
	324	Transitional woodland-shrub
	411	Inland marshes
	412	Peat bogs
	511	Water courses
	512	Water bodies

Annex 1: CLC used in the study for each land use category

Variables	Cons_P_Houses_HT	Cons_P_Houses_HT
Log_living_area	0.560***	0.554***
	(0.0271)	(0.0261)
Log_nbr_rooms	0.288***	0.290***
	(0.0181)	(0.0177)
Log_nbr_bathrooms	0.187***	0.185***
	(0.0157)	(0.0151)
Log_nbr_floors	-0.223***	-0.208***
	(0.0243)	(0.0221)
shareMeadows_500m		0.207*
		(0.124)
shareagri_500m		0.345**
		(0.152)
shareforest_500m		0.134
		(0.127)
shareothers_500m		0.119
		(0.205)
shareMeadows_500m_Impluvium		-0.370
		(0.473)
shareagri_500m_Impluvium		0.284
		(0.343)
shareforest_500m_Impluvium		0.122
		(0.219)
shareothers_500m_Impluvium		-0.585
		(0.382)
Sq_shareMeadows_500m		0.0395
		(0.155)
Sq_shareagri_500m		-0.0868
		(0.138)

Sq_shareforest_500m		-0.0460
		(0.128)
Sq_shareothers_500m		0.310
		(0.426)
Sq_shareMeadows_500m_Impluvium		0.329
		(1.005)
Sq_shareagri_500m_Impluvium		-0.842*
		(0.436)
Sq_shareforest_500m_Impluvium		0.0599
		(0.466)
Sq_shareothers_500m_Impluvium		2.401***
		(0.737)
Constant	8.658***	8.558***
	(0.123)	(0.110)
Observations	10,787	10,787

Annex 2: Poisson model with share variables (500m)

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Chapitre 4 : Data production on environmental preferences for agri-environmental measures in the Vittel impluvium

Data production on environmental preferences for agri-environmental measures in the Vittel impluvium

Written with Claire Montagné-Huck, Serge Garcia and Jens Abildtrup

1. Presentation of data from a survey of residents' recreational preferences in the Vittel region (France)

Implementing measures to preserve the quality of spring water (controlling agricultural uses, restricting the use of pesticides, planting hedgerows, etc.) generates benefits beyond the water resource. Indeed, residents can benefit from landscapes and recreational sites shaped by these measures. Economic valuation techniques make it possible to quantify these co-benefits in monetary terms.

To this end, a survey, proposing a choice experiment exercise, was conducted, face-to-face, between November 2019 and August 2020, among over 600 households living in the vicinity of the Vittel Impluvium area. A total of 588 complete and usable responses were obtained.

The questionnaire included 75 questions, covering 1/ the socio-economic characteristics of the individuals surveyed; 2/ their sensitivity to environmental issues; 3/ the characteristics of their recreational visits; 4/ a choice experiment exercise involving hypothetical site choices for their recreational activities.

The final database includes 167 variables (numeric, categorical or alphanumeric).The anonymized data are stored in https://entrepot.recherche.data.gouv.fr/ and available in the BETA collection https://entrepot.recherche.data.gouv.fr/dataverse.xhtml?alias=PHD-BETA .This includes the objectives and modalities of the survey, the explanation of variables, the raw data (excel file) and the econometric treatment on stata and the other metadata; The DOI associated with this data is https://doi.org/10.57745/DSGPPR.

The purpose of this document is to present the data obtained through this work.

Since the 1980s, Nestlé-Waters, which operates the Vittel and Contrexéville drinking water springs, has been concerned about the impact of human activities on the quality of water resources. Through partnerships with the French National Institute for Agricultural Research (INRA, now INRAE), specific measures have been implemented locally to protect water quality. These measures have repercussions that go beyond preserving the quality of water resources. Indeed, impacts have been noted in terms of biodiversity, landscape quality, etc. generating benefits for local populations and tourists alike. In 2018, a PhD thesis project in economics began, with the aim of contributing to the measurement of the economic values

generated by these "co-benefits". The purpose of this section is to present the initial data obtained as part of this thesis. A DCE has been proposed to assess the impacts of the water protection measures implemented, on the recreational values of residents in the Vittel-Contrex Impluvium area.

The Vittel-Contrex impluvium covers an area of over 11,400 hectares and includes 17 communes. It covers the entire watershed that supplies the springs used to bottle the various mineral waters produced in the region by Nestlé Waters (Vittel, Contrex, Hépar).

As the survey presented here was aimed at residents of the impluvium area, a perimeter with a radius of around 15 km was defined around the impluvium in order to select the communes for our sample. Within this perimeter, 13 communes were selected for the sample: we kept the 3 main communes (Vittel, Contrexéville and Mirecourt), and 10 other ones were selected randomly. The initial sample of around 600 households was constructed by selecting 5% of households living in the 3 largest communes and 10% of households living in the municipalities. Household selection was based on a random walk protocol. The household member authorized to answer the questionnaire was the last adult to have celebrated a birthday.

Figure 4.1 shows the communes included in the sample and the number of households surveyed.

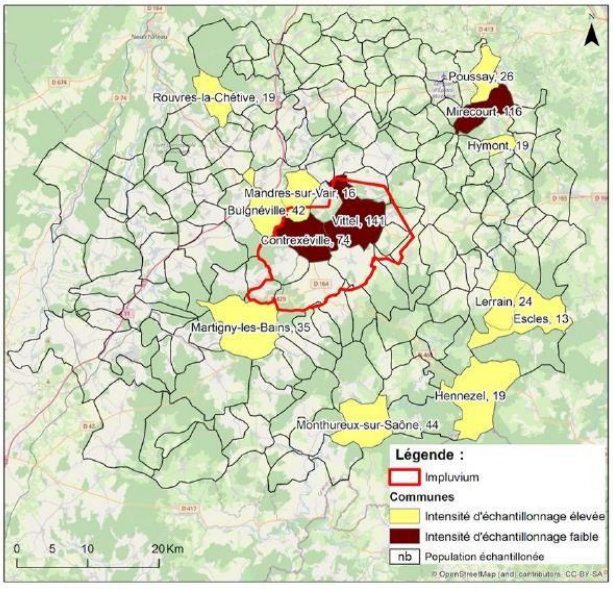


Figure 4-1: Municipalities selected in the Vittel impluvium

The survey questionnaire was constructed within BETA and administered face-to-face over the period from November 19, 2019 to August 28, 2020 (with an interruption linked to the

containment due to Covid-19, from spring 2020). Wood'Up (http://www.woodup-consulting.com/) was commissioned to carry out the survey in the field.

The questionnaire comprised 75 questions, divided into 4 themes:

1/ the socio-economic characteristics of the individuals surveyed ;

2/ their sensitivity to environmental issues and their attachment to the area;

3/ the characteristics of their recreational visits;

4/ a choice experiment exercise involving hypothetical site choices for their recreational activities.

Of the 624 interviews conducted, 588 were complete and usable for our analysis.

People who had declared that they had visited a forest or countryside site in the past year or in the past 5 years (N=380) were offered 8 sequences of choices between the last site they had visited and 2 alternatives, described synthetically on the basis of 8 attributes.

The attributes used to describe the proposed sites have been discussed during a focus group with residents of the study area. Attributes included the presence of tourist facilities, the presence of hiking trails, the presence of water features (lakes, rivers, etc.), the use of pesticides, different agricultural land uses, the presence of hedges and biodiversity, the variety of tree species present and the distance to the site (Table 4.1).

Attributes	**Levels**	**Information**
Equipments (picnic tables, bins, information signs)	- Presence of equipments (picnic tables, bins, information signs) - Absence of equipments (picnic tables, bins, information signs)	
Marked hiking and biking trails	- Presence of marked hiking and biking trails - Absence marked hiking and biking trails	
Water stream	- Presence water stream - Absence of water stream	
Pesticides	- Use of pesticides - Absence of pesticides	
Agricultural land use	- Livestock (Visible animals)	Attribute specific to the countryside

	- Crops (wheat or maize) - Grasslands - mixed agricultural land use (grasslands, crops and livestock)	
Tree species	- Forest composed exclusively of conifers - Forest composed exclusively of deciduous trees - Mixed forest (confiners and decidious trees)	Attribute specific to the forest
Hedgerows and biodiversity	- Absence of hedgerows - Low level of hedgerows and biodiversity - High level of hedgerows and biodiversity	Attribute specific to the countryside
Distance	Round trip distance from residence to site	

Table 4-1 : Description of the attributes used in the choice experiment

The resulting database represents an original source of information, unavailable elsewhere. These data were used to estimate residents' willingness to pay for the attributes of recreational sites in the forest or countryside. The results of this work are available in Amiri et *al.* (2021) and Amiri et *al.* (2022a).

These results can be used to support resource managers and public decision-makers when implementing recreational developments or measures to preserve natural areas. The availability of anonymized data will enable them to be reused in the scientific field to replicate the results of Amiri et *al.* (2021) and Amiri et *al.* (2022a) or to be integrated into comparisons of similar case studies or meta-analyses.

The anonymized data are stored in https://entrepot.recherche.data.gouv.fr/ and available in the BETA collection https://entrepot.recherche.data.gouv.fr/dataverse.xhtml?alias=PHD-BETA .This includes the objectives and modalities of the survey, the explanation of variables, the raw data (excel file) and the econometric treatment on stata and the other metadata; The DOI associated with this data is https://doi.org/10.57745/DSGPPR.

Tables 4.2, 4.3, 4.4 and 4.5 below present the descriptive statistics of our sample.

- Figure 4.2: commune of residence of respondents ;

- Figure 4.3: socio-economic characteristics of respondents;

- Figure 4.4: respondents' sensitivity to environmental issues and attachment to the territory;

- Figure 4.5: characteristics of recreational visits to the natural environment.

Municipality	Number of inhabitants	Number of households	Sampling objective	Final sample (complete questionnaires)
Mirecourt	5 285	2 561	(5%) 128	116
Vittel	5 192	2 702	(5%) 135	141
Contrexéville	3 232	1 577	(5%) 79	74
Monthureux-sur-Saône	862	383	(10%) 38	44
Mandres-sur-Vair	464	162	(10%) 16	16
Poussay	698	311	(10%) 31	26
Rouvres-la-Chétive	452	192	(10%) 19	19
Hymont	477	219	(10%) 22	19
Bulgnéville	1 525	624	(10%) 62	42
Lerrain	476	206	(10%) 21	24
Hennezel	404	188	(10%) 19	19
Escles	435	179	(10%) 18	13
Martigny-les-Bains	799	363	(10%) 36	35
Total	20 201	9 667	624	588

Table 4-2 : Respondents municipalities of residence

Variable	N	Mean (standard deviation)	Min	Max
Gender (Man=1)	588	0,568 (0,496)	0	1
Age	587	49,53 (17,89)	18	97
Degree **None or below** **High school diploma** **High school diploma + 2 years** **High school diploma + 3 years**	588	1,947 (1,211)	1	7
High school diploma + 4 years **High school diploma + 5 years** **High school diploma + 8 years**				
Socio-professional category **Farmer** **Independent worker** **Executive** **Intermediate profession** **Employee** **Worker** **Retired** **No professional activity** **Others**	588	 0,0068 (0,082) 0,0799 (0,271) 0,0884 (0,284) 0,0391 (0,194) 0,289 (0,454) 0,0510 (0,220) 0,262 (0,440) 0,138 (0,345) 0,0459 (0,209)	 0 0 0 0 0 0 0 0 0	 1 1 1 1 1 1 1 1 1
Number of people of the households	588	2,639 (1,338)	1	8
Number of children in the household	588	0,820 (1,122)	0	6
Residence = appartement	588	0,316 (0,465)	0	1
Residence with garden (1=yes)	588	0,699 (0,459)	0	1
Net income of the household1= **Less than 1 500€** **2= [1 500€ - 1 999€]** **3= [2 000€ - 2 499€]** **4= [2 500€ - 3 499€]** **5= [3 500€ - 4 999€]** **6= [5 000€ - 6 999€]** **7= More than 7 000€**	501	3,116 (1,605)	1	7

Table 4-3 : Socio-economic characteristics of respondents

Variable	N	Mean (standard deviation)	Min	Max
Childhood on the territory (1=yes)	588	0,716 (0,451)	0	1
Work on the territory (1=yes)	588	0,653 (0,476)	0	1
Degree of attachment to the area1= Very weak 2= Weak 3= Mean 4= Strong 5= Very strong	588	3,781 (0,820)	1	5
Degree of sensitivity to environmentalissues 1= Very weak 2= Weak 3= Medium 4= Strong 5= Very strong	588	3,466 (0,938)	1	5

Table 4-4 : Sensibility of respondents to environmental issues and attachement to the territory

Variable	N	Frequence or mean (standard deviation)	Min	Max
Visit in the forest or in the countryside during the last 12 months (1=yes)	588	61,22%	0	1
Several visits in the forest or in thecountryside during the last 12 months (1=yes)	588	28,06%	0	1
Several visits in the during the last12 months (1=yes)	588	18,20%	0	1
One visit in the forest during thelast 12 months (1=yes)	588	5,10%	0	1
Several visits in the countryside during the last 12 months (1=yes)	588	7,82%	0	1
One visit in the countryside duringthe last 12 months (1=yes)	588	2,04%	0	1

Visits in the forest or in the countryside in the impluvium during the last 12 months (1=yes)	360	30%	0	1
Number of visits in the forest or in the countryside during the last 12 months (total sample)	579	19,42 (54,18)	0	350
Number of visits in the forest or in the countryside during the last 12 months (0 excluded)	351	32,04 (66,66)	1	350
Number of visits in the forest or in the countryside during the last 12 months for the residents of the impluvium	140	6,76 (6,55)	1	52
Number of visits in the forest or in the countryside during the last 12 months for the non-residents of the impluvium	211	48,82 (81,66)	1	350
Number of visits in the forest or in the countryside during the last 12 months in the impluvium	106	18,54 (47,15)	1	350
Distance round-trip to the last visited site	360	49,96 (131,62)	0	1600
Visit in the forest or in the countryside during the last 5 years (1=yes)	588	64,62%	0	1

Table 4-5 : Descriptive statistics about the visits in the forest or in the countryside

2. Presentation of data from a survey on the estimation of non-use values associated with the implementation of water quality and biodiversity protection measures in the Rupt de Mad watershed (France).

This section describes a survey carried out as part of a partnership project between INRAE and Nestlé Waters. The overall aim of the project was to have a better understanding of people's preferences and willingness to pay for the implementation of water quality protection measures and for the co-benefits generated by these measures (protection of biodiversity, agricultural and forest landscapes, etc.).

The survey presented here specifically aims at assessing the NUV associated with such measures. It therefore focuses on a public that does not derive any direct benefit from the protected resource through actual, immediate or future use.

The study site, the Rupt de Mad watershed, is located in eastern France. The targeted individuals for the survey (carried out online between June 28, 2021 and July 30, 2021) are spread across France, with a particular focus on inhabitants of the Rhine-Meuse basin.

The sample was built according to age, gender and socio-professional category quotas. A total of 977 usable responses were obtained.

The questionnaire included a set of 29 questions relating to: 1/ respondents' environmental sensitivity (in terms of product consumption habits or global environmental issues); 2/ the economic valuation of respondents' preferences for the implementation of programs aiming at the renaturation of watercourses, the promotion of forestry and agricultural management practices favorable to water quality and rural landscapes (through an increase in drinking water bills); 3/ respondents' socio-economic characteristics. The final database includes 110 variables (numeric, categorical or alphanumeric). The data are stored in https://entrepot.recherche.data.gouv.fr/, together with the questionnaires, the completed data and a summary report.

The data presented in this document are part of a partnership between Nestlé Waters and the French national research institute for agriculture, food and the environment INRAE (formerly INRA), represented by the bureau of theoretical and applied economics (BETA). The overall aim of the project was to shed an economic light on the environmental and social benefits co-produced by actions to improve water quality. In particular, the aim is to assess the well-being

that society derives from actions taken to improve water quality and preserve the natural environment. This work is based on three field surveys carried out with a variety of audiences.

The first one (see Amiri et *al.* 2022a) focused on assessing the values that residents derive from the preservation of water quality and landscapes in the Vittel impluvium. The second, which we present here, aims at analyzing the NUV associated with these measures.The third survey will examine the values generated by these measures for tourists and non- residents in the Vittel region.

NUV are economic values associated with the preservation or enhancement of a resource, without the person assigning the value being linked to the resource by any present or future possibility of using it. The notion of non-use value is therefore based on the idea that we can derive a well-being, a satisfaction, measurable in monetary terms, that is simply linked to the acceptability of a better use of the resource by others than ourselves, or simply for the improvement of the resource itself.

In order to estimate such non-use values in the context of setting up programs to preserve rural landscapes and water resources, a survey was carried out throughout mainland France.

The study focused on the Rupt de Mad watershed, a sparsely populated area of around 385 km² at the crossroads of the Meuse, Moselle and Meurthe et Moselle departments. This watershed supplies drinking water to nearly 200,000 inhabitants of the Metz metropolitan area.

The survey questionnaire was designed at BETA and administered online between June 28, 2021 and July 30, 2021, by the Kantar compagny (https://www.kantar.com/fr). The sample was designed to be representative in terms of respondents' age, gender and socio-professional category.

In terms of location, we included in the sample respondents living at different distances from the study area, to be able to test the effect of distance from the respondent's site on his willingness to pay and identify NUV. Indeed, people who live a long way from the study site do not, a priori, attribute any value linked to a possible use of the resource. The values elicited for them must therefore represent "pure" NUV.

A total of 1005 questionnaires were completed in 654 communes across France (see figure 4.2).

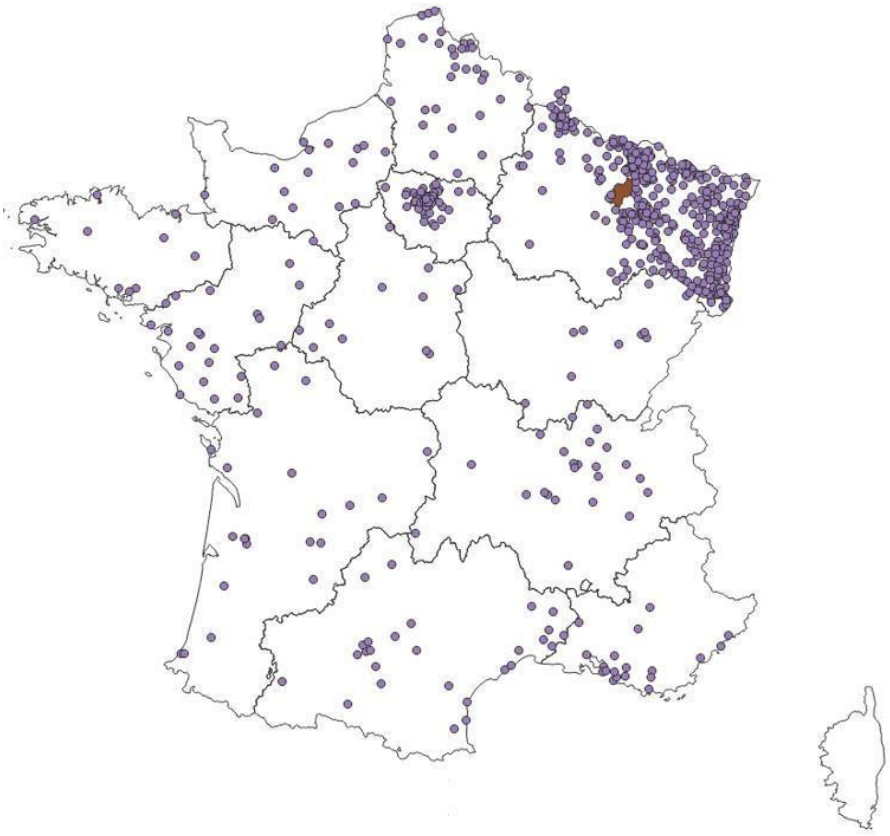


Figure 4-2: Distribution of respondents over the French territory

The survey questionnaire consisted of 3 parts, related to:

- the socio-economic characteristics of respondents;

- respondents' environmental awareness (consumption habits and sensitivity to global environmental issues)

- the economic valuation of values linked to the implementation of measures to preserve water quality and agricultural and forest landscapes. Implementation of a choice experiment technique to estimate willingness to pay for different attributes through an increase in household water bills.

Questions relating to the comprehension of this last part of the questionnaire enabled us to identify individuals who had not understood the approach, and to exclude them from the final sample. We therefore have 977 fully-completed and usable questionnaires for analysis.

The resulting database provides original information not available elsewhere. These data have enabled us to assess respondents' willingness to pay for the attributes proposed in the choice

experiment: pesticide use, renaturation of watercourses, type of fertilizer used, plantation of hedgerows, forest management methods (Amiri et *al.* 2022a; 2023a). This information can help resource managers and public decision-makers to better understand the incentive mechanisms needed to finance such actions. The data can be reused in the scientific field for replication of the results of this study, as well as for inclusion in comparisons with similar case studies or meta-analyses.

The anonymized data are stored in https://entrepot.recherche.data.gouv.fr/ and available in the BETA collection https://entrepot.recherche.data.gouv.fr/dataverse.xhtml?alias=PHD-BETA .This includes the objectives and modalities of the survey, the explanation of variables, the raw data (excel file) and the econometric treatment on stata and the other metadata; The DOI associated with this data is https://doi.org/10.57745/MXDUB2.

Tables 6 and 7, below, present the main descriptive statistics of this survey in terms of respondents' socio-economic characteristics (Table 4.6) and their sensitivity to environmental issues (Table 4.7).

Variable	**Modality**	**Mean or frequency**
Residence in the Rhin-Meuse basin	1=yes, 0=no	68,9%
Gender	Men / Women	46,88% / 53,12%
Age	[18-24 years old]	10,64%
	[25-29 years old]	6,55%
	[30-34 years old]	8,50%
	[35-39 years old]	7,27%
	[40-44 years old]	9,01%
	[45-49 years old]	10,24%
	[50-54 years old]	8,29%
	[55-59 years old]	9,21%
	[60-64 years old]	10,13%
	[65-69 years old]	12,18%
	[70-74 years old]	6,65%

	[+75 years old]	1,33%
Degree	None or below high school diploma	22,31%
	High school diploma	28,86%
	High school diploma + 2 years	23,23%
	High school diploma + 3 years	10,34%
	High school diploma + 4 years	5,83%
	High school diploma + 5 years	8,19%
	High school diploma + 8 years	1,23%
Socio-professional category	Farmer	0,20%
	Independent	2,35%
	Manager	9,01%
	Employee	28,05%
	Worker	6,14%
	Intermediary	12,08%
	Retired	25,90%
	No activity	16,27%
Household composition	Mean number of people	2,57
	Mean number of children	0,71
Housing type	Apartment	39,61%
	House	59,77%
	Other	0,61%
Monthly household income	Less than 1500€	18,53%
	1500-1999€	16,07%
	2000-2499€	15,56%
	2500-3499€	20,57%
	3500-4999€	17,81%
	5000-6999€	4,20%
	More than 7000€	1,02%
	No answer	6,24%

Table 4-6 : Socio-economic characteristics of respondents

Variable	Modality	Mean or frequency
Bottle water drinkers	Never	18,01%
	Occasionlly	44,22%
	Mostly	22,82%
	Always	14,94%
Pro-environmental behaviour (% yes)	Purchase of organic products	45,24%
	Purchase of recycled products	57,42%
	Belonging to pro-environmental association	9,83%
	Participation to pro-environmental events	7,47%
	None	25,28%
Sensitivity to environmental issues	Not sensitive at all	1,94%
	Not very sensitive	7,37%
	Neutral	14,84%
	Rather sensitive	58,75%
	Very sensitive	17,09%
Sensitivity to the local water ressources preservation issue	Not sensitive at all	2,76%
	Not very sensitive	4,30%
	Neutral	16,07%
	Rather sensitive	57,42%
	Very sensitive	19,45%
Sensitivity to the local biodiversity preservation issue	Not sensitive at all	2,15%
	Not very sensitive	4,81%
	Neutral	20,27%
	Rather sensitive	51,89%
	Very sensitive	20,88%
Sensitivity to the water ressources preservation issue outside your living area	Not sensitive at all	2,97%
	Not very sensitive	4,71%
	Neutral	22,11%
	Rather sensitive	52,00%

	Very sensitive	18,22%
Sensitivity to the biodiversity preservation issue outside your living area	Not sensitive at all Not very sensitive Neutral Rather sensitive Very sensitive	2,76% 5,32% 23,64% 51,69% 16,58%

Table 4-7 : Respondents sensitivity to environmental issues

Table 4.8 shows the main characteristics of the alternatives offered in the choice experiment section of the survey:

Attribute	**Level**
Pesticides use	- The project does not plan to ban the use of pesticides. - The project plans to ban the use of pesticides.
Watercourse renaturation	- The project does not involve the restoration of a watercourse. - The project involves the renaturation of a watercourse (narrowing the stream to allow water to flow more quickly, planting trees, etc.). This will encourage the development of aquatic and terrestrial biodiversity.
Type of fertilizer(s)	- Organic fertilizer is applied at low rates to all agricultural land (100%). No negative impacts on biodiversity and water quality are observed. - Significant application of organic fertilizer to part of agricultural land. Local negative impacts on water quality andbiodiversity. - Maximum amount of organic and chemical fertilizer allowedby the law. Overall negative impact on water quality.
Hedgerows	- Without the project, hedgerow clearance will continue.Negative impact on landscape, carbon sequestration, biodiversity (birds, insects, etc.) and water quality. - Maintaining hedgerows to avoid negative impacts on water quality, carbon sequestration and biodiversity (birds, insects, etc.) and plant species. - Planting hedges. Significant positive impact on landscape, water quality, carbon sequestration and biodiversity (birds, insects, etc.) and plant species.
Forest management	- Forest management for timber production and protection of water resources. - Forest management aiming at producing timber and protecting water resources, as well as preserving biodiversity.
Increase in annual water bill	1€, 5€, 10€ 15€ 20€ 25€ 30€ 35€ 40€ 45€ 55€ 0€ if no project is implemented

Table 4-8 : Attributes and levels proposed in the DCE

3. Presentation of survey data on tourist preferences for forest and agricultural landscape management and impact on the local economy in the Vittel region (France)

This section provides the description of a survey targeting tourists in the Vittel impluvium in the Vosges department (France) carried out among people present in the communes of Vittel and Contrexéville during the 2023 summer (from July 17 to September 12, 2023).

The survey was based on a structured questionnaire, administered face-to-face to 479 individuals, mainly in the Vittel thermal park and the Contrexéville tourist office.

The information gathered covered people who visited the area alone, as a couple, as a family or in a group. They included data on the motivations for the visit (price, duration of transport, thalasso, nature, reputation) and its characteristics (duration, expenditure), and on the characteristics of the respondents (region of origin, gender, qualifications, jobs, income, consumption of bottled water).

The data also contain results on whether or not tourists would accept the implementation of an environmental tax to help finance actions to improve water quality and biodiversity (absence of pesticides, planting of hedges, renaturation of watercourses, etc.). We first measure the acceptance of an additional tax per person on the bill for a restaurant lunch (for a one-day visit) or on the bill for a hotel night (for a longer visit), and then, their maximum willingness to pay. Data were collected using LimeSurvey software.

The data set contains a total of 223 numeric, categorical and non-numeric variables. The data are stored in https://entrepot.recherche.data.gouv.fr/ along with the questionnaires, completed data and a summary report.

In addition to preserving water quality, the actions undertaken by Agrivair to maintain and even improve environmental conditions favorable to a good quality of raw water resources, particularly at Nestlé Waters' water production sites, also have other beneficial environmental, social and economic effects. In particular, the practices implemented protect biodiversity, modify landscapes and can even have an impact on economic areas such as tourism and the local economy in general. Doing so, they affect the well-being of populations.

We present here data from a survey conducted in summer 2023 (July 17 to September 12, 2023), among tourists identified as being present for leisure activities on the Vittel impluvium, more specifically the communes of Vittel and Contrexéville, in the Vosges department (France). This survey was designed to study the effect of the measures on the number of tourists visiting the hotels, vacation clubs, campsites and thermal baths in Vittel and Contrexéville because of the quality of their water. In particular, this survey seeks to identify spending in local shops and crafts, but also to assess their willingness to pay (WTP) for a stay in an improved local environment as a result of these actions to protect water quality.

The questionnaire was implemented using the LimeSurvey software. A copy of the questionnaire is available in the appendix, showing the structure of the questionnaire, the questions and proposed answers, and the logic for administering the questions and sub-questions.

To encourage tourists to complete the questionnaire, it was mentioned that a bottle of Château Couhins wine (Pessac Léognan appellation - operated by INRAE) and a meal for two in a gourmet restaurant would be drawn at the end of the survey period.

A total of 506 people were interviewed, mainly face-to-face (479)[36], to find out their preferences in terms of management of agricultural and forest landscapes, and to estimate their CAP for implementing measures to preserve biodiversity and water quality. Of the 506 interviews carried out, 19 were not completed and were excluded from the sample, as they could not be used. We also withdrew the responses of 12 residents and professionals who did not fit into the target audience of our survey. Our final sample therefore includes 475 usable responses.

In addition to standard questions relating to respondents' socio-economic characteristics, we asked people about the characteristics of their visit to the region, their bottled water consumption practices and their knowledge of water quality and biodiversity preservation measures That take place in the region. A contingent valuation was also proposed to estimate the WTP for implementing additional measures to preserve biodiversity and water quality. The proposed means of payment was a tax designed to help finance actions to protect water quality and biodiversity. The amounts proposed ranged from 0.5€ to 10€ for a tax deducted

[36] The survey was conducted face-to-face with a single interviewer on a tablet. Number of interviewers, locations mainly in the Vittel spa park and the Contrexéville tourist office. Some paper questionnaires were also made available to passers-by at the Vittel and Contrexéville tourist offices.

from the bill for a restaurant lunch (for an all-day visit) and from 0.5€ to 5€/night/person for an increase in the tourist tax (if visits lasted several days).

Our database provides original information not available elsewhere. These data will enable us to assess the preferences and estimate the WTP of tourists in the Vittel and Contrexéville region for the implementation of measures to preserve water quality and biodiversity. This information can help resource managers and public decision-makers to better understand the incentive mechanisms to be put in place to finance such actions. The data can be reused in the scientific field to replicate the results of this study, as well as to be integrated into comparisons with similar case studies or meta-analyses.

The anonymized data are stored in https://entrepot.recherche.data.gouv.fr/ and available in the BETA collection https://entrepot.recherche.data.gouv.fr/dataverse.xhtml?alias=PHD-BETA .This includes the objectives and modalities of the survey, the explanation of variables, the raw data (excel file) and the econometric treatment on stata and the other metadata; The DOI associated with this data is https://doi.org/10.57745/SMMQXT.

Tables 4.9 to 4.12 give some characteristics of the sample, respondents, their visits and knowledge of environmental protection measures in place.

Variable	**Detail**	
Characteristics of the survey		
Number of answers		506
Number of complete answers		475
Interview place (N= 487)		Frequency
	Contrexéville camping	0,2%
	Seasonova Vittel Camping	0,2%
	Contrexéville casino Vittel	0,2%
	club med	0,4%
	Vittel thermal park	75,2%
	Contrexéville tourism office	21,1%
	Vittel tourism office	1,0%
	Others (internet, paper)	1,6%

Table 4-9 : Sample characteristics

Respondents characteristics		
Reason of the visit (N=487)	Leisure Resident Professional motive	Number: 475[37] 9 3
Home country (N=475)	Algeria Germany England Belgium France Marocco Monaco New-Zealand No answer	Number: 1 1 1 11 453 1 1 1 5
Home region (France) (N= 453)	Auvergne Rhône Alpes Britanny Bourgogne Franche Comté Centre Val de Loire Grand Est Hauts de FranceIle de France Normandie Nouvelle Aquitaine Occitanie Provence Alpes Côte d'Azur Pays de la Loire	Frequency: 6,2% 1,5% 7,3% 2,4% 52,3% 7,7% 12,1% 2,6% 2,0% 0,4% 2,9% 2,4%
Bottled water consumption yes/no (N=475)	Yes (N=328)	Frequency : 69,1%

[37] As the survey was designed to analyze tourist preferences, residents and professionals did not continue with the questionnaire.

	No (N=147)	30,9%
Bottled water consumption(N=475)	I mostly drink bottled water I occasionally drink bottled water I only drink bottled water I occasionally drink bottled water	Frequency : 19,6% 24,4% 25,1% 30,9%
Bottled water consumption brand (N=328) **Several answers possible**	Contrex Cristaline Evian Hepar MDD Vittel Volvic Other	Frequency : 38,7% 41,2% 21,3% 28,0% 8,2% 51,8% 24,4% 37,5%
Gender (N=475)	Woman Man Other	Frequency : 60,4% 39,2% 0,4%
Degree (N=475)	None Below high school diploma High school diploma High school diploma + 2 years High school diploma + 3 years High school diploma + 4 and High school diploma +5 years High school diploma +8 years	1,9% 26,7% 18,1% 16,0% 9,9% 6,1% 18,1% 3,2%
Socio professional category (N=475)	Farmer Independent No activity Manager	Frequency: 0,6% 4,4% 4,0% 16,6%

	Employee	10,9%
	Worker	1,3%
	Intermediary	10,5%
	Retired	51,6%
Net monthly income (N=475)		Frequency :
	Less than 1500€	7,8%
	1500-1999€	14,3%
	2000-2499€	21,3%
	2500-3499€	21,5%
	3500-4999€	21,3%
	5000-6999€	10,5%
	More than 7000€	3,4%

Table 4-10 : Respondents characteristics (standard deviations between brackets)

Visits characteristics		
Accompaniment (N=475)	Alone With your partner With your family With a group	Frequency: 37,9% 49,1% 9,9% 3,2%
Mean number of people (N=475)		1.77 (0,97)
Reasons for visiting : Price (N=475)	Extremely important Very important Important Rather important Not very important Not important	Frequency : 0,6% 3,2% 11,6% 9,1% 12,6% 62,9%
Reasons for visiting: Transportation time (N=475)	Extremely important Very important Important Rather important Not very important Not important	Frequency : 2,3% 35,6% 23,4% 9,3% 12,2% 17,3%

Reasons for visiting: Nature (N=475)	Extremely important Very important Important Rather important Not very important Not important	Frequency : 12,4% 45,5% 19,8% 4,2% 5,9% 12,2%
Reasons for visiting : Thalasso (N=475)	Extremely important Very important Important Rather important Not very important Not important	Frequency : 6,7% 40,2% 32,4% 3,8% 5,9% 10,9%
Reasons for visiting: Fame (N=475)	Extremely important Very important Important Rather important Not very important Not important	Frequency : 1,1% 8,4% 19,6% 13,9% 13,9% 43,2%
Duration of the stay (N=475)	Less than a day (round trip in a day)	Frequency : 20%

	More than a day	80%
Mean duration of the stay (N=475)	(Less than a day = 1 day)	12,68 (10,3)
Accommodation expenditure (N=475)	Average expenditure on accommodation during your stay in Vittel and surrounding area (if family or group, average per person)	387,25 (821,13)
Expenditure excluding accommodation (N=475)	Average expenditure per day and per person (excluding accommodation) for your various activities during your stay in and around Vittel.	38,09 (61,80)

Table 4-11 : Visits characteristics (standard deviation between brackets)

Local context knowledge		
Prior knowledge of protection measures in place (N=475)	Yes No	Frequency 46,32% 53,68%
Importance of protective measures in the decision to visit (N=220)	Yes No	Frequency 10% 90%

Table 4-12 : Local context knowledge (Standard deviation between brackets)

In Table 4.13 we present the main statistics corresponding to the answers yes (= 1) or no (= 0) to a random draw of an amount per person and for a bill between 0.50€ and 10€. Table 14 concerns people staying more than one day on site for yes (= 1) or no (= 0) answers to a random draw of an amount per person and for a night between 0.50€ and 5€.

Tax amount	Obs.	Mean.	min	max
0,5	5	0,60	0	1
1	9	0,5556	0	1
2	11	0,4545	0	1
3	10	0,50	0	1
4	5	0,40	0	1
5	12	0,25	0	1
6	15	0,0667	0	1
7	6	0,3333	0	1
8	6	0	0	1
9	11	0,2727	0	1
10	6	0,3333	0	1
Total	98	0,3163	0	1

Table 4-13 : Willingness to pay [random amount/person between €0.50 and €10] an additional amount on the restaurant bill?

Tax amount	Obs.	Mean.	min	max
0,5	38	0,8158	0	1
1	49	0,6735	0	1
1,5	31	0,4516	0	1
2	35	0,3714	0	1
2,5	32	0,25	0	1
3	30	0,1333	0	1
3,5	38	0,2632	0	1
4	41	0,2195	0	1
4,5	34	0,1176	0	1
5	27	0,1481	0	1
Total	382	0,3403	0	1

Table 4-14 : willingness to pay [random amount/night/person between €0.5 and €5] an additional amount on the price of a hotel night

Tables 4.15 and 4.16 show the descriptive statistics for maximum WTP for day visitors and longer-term visitors respectively.

WTP	Freq.	Relative freq.
0	48	48,98
0,2	1	1,02
0,5	3	3,06
1	8	8,16
2	8	8,16
3	7	7,14
4	3	3,06
5	5	5,10
6	1	1,02
7	3	3,06
9	2	2,04
10	8	8,16
50	1	1,02
Total	98	100

Table 4-15 : Maximum willingness to pay - tax per person on restaurant bill

WTP	Freq.	Relative Freq.
0	130	34,03
0,2	1	0,26
0,4	2	0,52
0,5	65	17,02
0,6	1	0,26
1	79	20,68
1,2	1	0,26
1,5	22	5,76
2	32	8,38
2,5	10	2,62
3	10	2,62
3,5	5	1,31
4	9	2,36
4,5	3	0,79
5	8	2,09
6	2	0,52
8	1	0,26
10	1	0,26
Total	382	100

Table 4-16 : Maximum willingness to pay - tax per person on the price of a hotel night

Acknowledgements

We would like to thank all the respondents who agreed to take part in our survey. We would like to thank the municipalities, hotels, campsites and tourist offices of Vittel and Contrexéville for hosting our questionnaire and allowing us to conduct the interviews. We would also like to thank Nestlé Waters for their help in constructing the questionnaire and for their financial support.

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4. Annex

Questionnaire quatrième chapitre

Bonjour,

Nous vous remercions d'avoir accepté de répondre à ce questionnaire, qui a pour cadre un projet de recherche INRAE (Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement), dans lequel nous travaillons sur la région de Vittel pour étudier les préférences en termes de gestion des paysages forestiers et agricoles. Il n'y a pas de bonne ou de mauvaise réponse, mais il est important que vous répondiez à toutes les questions.
Vos réponses seront strictement anonymes[2]. Une bouteille de vin Château Couhins (appellation : Pessac-Léognan), exploité par INRAE est à gagner ! Le gagnant sera désigné par tirage au sort sous réserve de nous communiquer vos coordonnées email ou postales à la fin du questionnaire.

1) **Ce questionnaire vous a-t-il été distribué à ?**

a) La station thermale de Vittel

b) Vit tel ta nature

c) l'hôtel Cosmos

2) **Vous venez dans la région :**

Veuillez sélectionner une réponse ci-dessous:

a) A des fins de loisirs

b) Pour des raisons professionnelles

c) Je suis résident

Si réponse a) à la question 2

3) **Où habitez-vous ?** (Indiquez le nom de la commune et le code postal si vous vivez en France, et le pays si vous vivez ailleurs).

Commune : ☐

Code postal : ☐

Hors France, pays : ☐

[2] Les informations recueillies serviront uniquement à ce projet de recherche et respectent les principes du règlement général sur la protection des données (RGPD). Si vous ne souhaitez pas que vos réponses soient utilisées par la suite, faites-le savoir à l'adresse suivante : tristan.amiri@inrae.fr

4) **Vous êtes venu(e) :**

Veuillez sélectionner une réponse ci-dessous:

a) seul(e)

b) en couple

c) en famille

d) en groupe

préciser le nombre de personnes : ☐

5) **Indiquez, selon vous, l'importance de chacun des critères suivants dans le choix de Vittel et de sa région comme destination touristique.**

	Pas important	Peu important	Assez important	Important	Très important	Extrêmement important
Le prix du séjour						
Le temps de trajet						
L'environnement naturel (paysage, contact avec la nature etc.)						
Les activités à effectuer						
La notoriété du site						

6) **Quelle est la durée de votre séjour à Vittel ou dans les environs ?**

Veuillez sélectionner une réponse ci-dessous :

a) Moins d'une journée (je fais l'aller-retour dans la journée)

b) Plus d'une journée (indiquer le nombre de jours dans le cadre suivant) : ☐

7) **Consommez-vous de l'eau en bouteille ?**

Veuillez sélectionner une réponse ci-dessous

a) Je ne consomme jamais d'eau en bouteille

b) Je consomme occasionnellement de l'eau en bouteille

c) Je consomme majoritairement de l'eau en bouteille

d) Je consomme uniquement de l'eau en bouteille

Si réponse b), c) ou d) à la question 7

8) **Vous avez répondu que vous consommiez de l'eau en bouteille. Consommez-vous l'eau d'une ou plusieurs des marques suivantes ?**

Cochez-la ou les réponses

a) Marque de distributeur
b) Vittel
c) Contrex
d) Cristaline
e) Evian
f) Hépar
g) Volvic
h) Aucune de ces marques

9) **Le groupe Nestlé, propriétaire de la marque Vittel© exploite les sources d'eau situées sur le bassin versant de Vittel. Pour faire face aux risques de pollution de l'eau, le groupe a décidé de mettre en place des partenariats avec les agriculteurs locaux afin de préserver la qualité de l'eau (arrêt d'utilisation de pesticides sur le site, arrêt de la culture du maïs, etc.). En parallèle, le groupe mène des actions en faveur de la biodiversité (plantations de haies, renaturation de cours d'eau, etc.). Indirectement, ces mesures, qui sont financées par Nestlé, profitent aux habitants et aux touristes (à travers la diversification du paysage, par exemple). Aviez-vous connaissance de telles actions ?**

Veuillez sélectionner une réponse ci-dessous

a) Je n'avais pas connaissance de ces actions
b) J'avais connaissance des actions menées pour améliorer et préserver de la qualité de l'eau
c) J'avais connaissance des actions menées en faveur de la biodiversité
d) J'avais connaissance des actions menées pour la qualité de l'eau et la biodiversité

Si réponse b), c) ou d) à la question précédente

10) Ces actions de préservation de l'environnement ont-elles joué un rôle sur votre décision de vous rendre dans la région ?

Veuillez sélectionner une réponse ci-dessous :

a) Oui
b) Non

Si réponse a) à la question 6)

11). **Imaginons maintenant que Nestlé arrête de financer ces actions pour la qualité de l'eau et la biodiversité. Accepteriez-vous de payer [montant aléatoire/personne entre 0,50€ et 10€] supplémentaires sur votre addition au restaurant (ou, si ce n'est pas le cas, auriez-vous accepté le cas échéant), pour que les mesures décrites précédemment (absence de pesticides, plantation de haies, renaturation de cours d'eau, etc.) continuent d'être appliquées ? (Ce montant sera prélevé via une taxe environnementale et servira uniquement au financement des actions évoquées).**

a) Oui
b) Non
Si réponse a) à la question 6)

11 bis**) Quel est le montant maximum/personne que vous seriez prêt à payer pour que les mesures décrites précédemment (absence de pesticides, plantation de haies, renaturation de cours d'eau, etc.) continuent d'être appliquées ? Inscrivez votre réponse dans le cadre ci-dessous :**

Si réponse b) à la question 6)

11ter) **Vous avez répondu "oui" à la question précédente. Accepteriez-vous de payer [montant aléatoire/nuit/personne entre 0,5€ et 5€] pour que les mesures décrites précédemment (absence de pesticides, plantation de haies, renaturation de cours d'eau etc.) continuent d'être appliquées ? le montant sélectionné viendra s'ajouter à votre la taxe de séjour et servira uniquement au financement des actions évoquées).**

a) Oui

b) Non

Si réponse b) à la question 6)

11quater) **Quel est le montant maximum que vous seriez prêt à payer pour que les mesures décrites précédemment (absence de pesticides, plantation de haies, renaturation de cours d'eau, etc.) continuent d'être appliquées ? Inscrivez votre réponse dans le cadre ci-dessous:**

12) **Vous ne souhaitez pas payer pour que les mesures décrites précédemment (absence de pesticides, plantation de haies, renaturation de cours d'eau, etc.) continuent d'être mises en place. Pourquoi ?**

Cochez-la ou les réponses

b) La qualité de l'eau et la protection de la biodiversité ne sont pas importantes pour moi

c) C'est à Nestlé de payer pour de telles mesures

d) Ce sont les résidents qui doivent financer ces mesures

e) C'est aux responsables de la pollution de financer ces mesures

f) Etant un(e) touriste, je ne me sens pas concerné par ce qui se passe ici

g) Autre :

Si réponse b) à la question 6

13) **Combien avez-vous dépensé (environ) pour l'hébergement lors de votre séjour à Vittel et dans les environs ? Veuillez inscrire le montant dans le cadre suivant (si vous êtes en famille ou dans un groupe, donner une moyenne par personne) :**

14) **Combien avez-vous dépensé (environ) par jour et par personne (hors hébergement) pour vos différentes activités lors de votre séjour à Vittel et dans les environs ? Veuillez inscrire le montant dans le cadre suivant :**

15) **Etes-vous :**

Veuillez sélectionner une réponse ci-dessous :

a) Un homme
b) Une femme
c) Autre

16) **Quel âge avez-vous ?**

Veuillez sélectionner une réponse ci-dessous :

a) 18-24 ans
b) 25-29 ans
c) 30-34 ans
d) 35-39 ans
e) 40-44 ans
f) 45-49 ans
g) 50-54 ans
h) 55-59 ans
i) 60-64 ans
j) 65-69 ans
k) 70-75 ans
l) Plus de 75 ans

17) **Quel est votre diplôme le plus élevé ?**

Veuillez sélectionner une réponse ci-dessous

a) Aucun ou inférieur au bac
b) Bac
c) BTS, DUT ou équivalent bac +2
d) Licence ou équivalent bac +3
e) Master ou équivalent bac +4
f) Master 2 ou équivalent bac +5
g) Doctorat ou équivalent bac +8

18) **Quelle est votre Profession et Catégorie Socioprofessionnelle (PCS) ?**

Veuillez sélectionner une réponse ci-dessous :

a) Agriculteur exploitant
b) Artisan, commerçant, chef d'entreprise
c) Cadre et profession intellectuelle supérieure
d) Profession intermédiaire
e) Employé
f) Ouvrier
g) Retraité
h) Autre personne sans activité professionnelle

19) **Quel est le revenu mensuel net de votre foyer ?**

Veuillez sélectionner une réponse ci-dessous :

a) Moins de 1500€
b) 1500-1999€
c) 2000-2499€
d) 2500-3499€
e) 3500-4999€
f) 5000-6999€
g) Plus de 7000€

Nous avons conscience du caractère très personnel de la question. Pour autant, pour l'analyse des résultats de l'enquête, il est très important que vous répondiez à cette question (et le traitement des données recueillies est totalement anonyme). Merci de votre compréhension.
Si vous souhaitez participer au tirage au sort permettant de gagner une bouteille de vin Château Couhins (appellation : Pessac-Léognan), merci de laisser votre adresse postale ou adresse email.

Adresse postale : ☐
Adresse email : ☐

Merci de votre participation !

5. References

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General conclusion

1. Additional work on PES schemes is nedeed

Over the years, PES schemes became an important tool for natural ressources' conservation. In Europe, PES are discussed in the context of the of the post-2020 Common Agricultural Policy (CAP) reform[38]. In France, PES development is discussed at the political level : in a recent amendment studied by the french senate[39], PES are presented as « a tool that can combine economic necessity with societal expectations ». In the academic literature, analyses of PES schemes seem to heavily rely on emblematic cases such as the schemes implemented in New-York, in Costa Rica and on the Vittel watershed. The vittel case is particularly interesting, as it can be labelled as a Cosean PES *i.e.* « [PES] that emmerge from contractual transactions between private actors (i.e., providers and users of a service) in the absence of overt government intervention » (Bingham, 2021). These programs are also called "user-financed" or "privately-funded" PES (Bingham, 2021 ; Ezzine-de-Blas et *al.* 2016). In France, it represents almost one-third of the PES schemes (32%) (Duval et *al.* 2019). The Vittel case study is probably the most emblematic french private case study (Claise et *al.* 2022), even if references to other schemes exist (Chevrier et *al.* 2017). Indeed Bingham (2021) reported 72 peer-reviewed journal articles in english over the period 2010-2020, that mentionned the Vittel case. However, he stated that these references « are often more didacticthan analytic: because it is often cited as a famous, easy-to-understand illustration of a Coasean PES solution, detailed, in-depth assessments are uncommon ». Some initiatives are nevertheless noticable: an interesting study by Grémillet and Fosse (2020) assess different agri-environmental « cahiers des charges » using the scoring method upon various criterias relatives to biodiversity, ressources preservation, fertilizers use etc. Nevertheless, additional work is still needed for decision-makers interrested in developping a PES program, in order to have in mind how large and diversify total benefits from such schemes can be. This thesis participates to fill this gap.

[38] See : https://www.agriculture-strategies.eu/en/2018/09/will-the-payment-for-environmental-services-concept-cause-further-damage-to-the-environmental-side-of-the-cap/

[39] See: https://www.senat.fr/amendements/2020-2021/667/Amdt_1668.html

2. Objective of the thesis

The aim of this thesis project was to investigate the co-benefits of the Vittel PES *i.e.* benefits that are additional to water quality. This work is in line with recent publications investigating secondary benefits of nature-based solution schemes (Le Coent et *al.* 2023 ; Hérivaux and Le Coent, 2021; Hérivaux et Grémont, 2019) and in particular Hérivaux and Le Coent (2021) who implemented a DCE that evaluates to assess preferences for various types of NBS relative to flood risks. As the authors suggested, this kind of analysis is applicable to others topics than flood risks, such as the protection of water ressources. In this thesis, I applied NMV methods (DCE and HPM) to value the different co-benefits associated with the Vittel PSE program.

3. Main results

In chapter one, I conducted a DCE to investigate the preferences of the local population around the Vittel impluvium: the idea was to test different scenarios of recreational activities. Each scenario (or alternative) was composed of attributes representing common features of recreational sites (picnic tables ect.) and more specific attributes related to agri-environmental measures implemented on the Vittel watershed (nonuse of pesticides, for instance). I gave respondents the choice between three alternatives: two hypothetical sites (forest or countryside because they are common areas for recreation) and one alternative representing the last forest or countryside visited by the respondent. Some attributes were common to each area (water course, for example) and others were specific to the forest (the type of forest) or to the countryside (such as the agricultural land use). Each individual faced eight different *choice sets* (combinaison of three alternatives). It allowed me to analyse the trade-offs made by respondents between the characteristics of the recreational sites. I have found that respondents expressed preferences for some environmental characteristics, like the presence of a water courses or the nonuse of pesticides, which is an important measure in the Vittel impluvium. The marginal willignesses to pay (MWTP) for environmental characteristics reflected this trend: people were ready to pay significant amounts to go to sites were pesticides were not used, but overall, preferences for environmental attributes were quite heterogenous.

In chapter two, I implemented an other DCE that aimed, this time, to target nonusers of water ressources. NUV can be substantial for some environmental assets (Marre et *al.* 2015). To make the DCE exercice more realistic, we informed respondents that environmental preservation projects (including measures for banning pesticides, restoring water courses etc.)

were about to be implemented in the Rupt de Mad watershed located in the Rhin-Meuse Basin. I identified residents consuming drinking water from this watershed in order to exclude them from the final sample. Individuals who answered the DCE were located on the french territory, sometimes really far from the watershed. It allowed me to investigate the existence of a distance-decay effect *i.e.* the idea that the further individuals were from the Rupt de Mad watershed, the less concerned they felt about environmental improvements. To do so, i used the centroids of the respondent's municipality of residence to calculate distances to the watershed.

Results from the econometric analysis have shown that preferences for environmental attributes were quite heterogeneous. I estimated a LCM with four classes. The objective was to identify different profiles of respondents classes: individuals in class one are willing to pay a significant amount per year (€10.69) on the water bill to ban pesticides. Respondents from the second class had high WTP for some environmental measures (banning pesticides, restoring watercourses, planting hedges and managing forests). Nevertheless, these WTP were estimated with a large confidence interval, due to weakly significant coefficient on the monetary attribue. The third class gathered individuals that were the closest to the site of interest. In particular, they were willing to pay a very high amount (€133.72) for pesticide ban. Finally, people in class 4 had only positive preferences for pesticide ban and watercourse restoration. In opposition to class two, their WTP were quite low (€3.48 and €4.60, respectively for pesticides ban and watercourse restoration).

Identification of a potential distance-decay effect was not conclusive: I found that distance to environmental projects matters only for a small proportion of respondents (16%) who were allocated in the third class.

In comparison to chapter one, pesticide ban seems to be an important environmental measure for nonusers, as it was the case for individuals located around the Vittel watershed and going recreational areas. These results tend to indicate that French water authorities should prioritise pesticide bans as a measure to protect water and biodiversity, in order to be in line with public preferences. This is also consistent with the biodiversity plan presented in 2018 (MTES, 2018).

In the third chapter, i conducted an hedonic analysis on the Vosges department. I used data from the french notarial society Perval, that proved to be useful in such analyses (Osseni et *al.* 2021): housing characteristics (selling price without taxes, number of rooms, number of

bathrooms etc.) and geographic coordinates were used in the hedonic analysis for the 1998-2021 period. After cleaning, 10 801 observations remained in the sample. Besides house characteristics, the objective of the paper was to assess the influence of different land uses over house prices. I defined five broad categories: agriculture, forest, meadows, urban zones and others (that gathered all the remaining land uses). Two different specifications were defined (Osland et *al.* 2022): first, I looked at the influence of distance from houses to amenities. Secondly, I investigated the influence of the land use shares on house prices, using different buffer areas. (Liljenstolpe, 2011; Ready and Abdalla, 2005) Hedonic regressions were estimated using the *ppmlhdfe* Stata command (Correia et *al.* 2020). Econometric results that grasslands significantly inluence house prices for all the buffers considered. This is in line with what I found with the distance specification : the shorter the distance is, the higher the house price is. Overall, results were less significant for houses located inside the Vittel impluvium. Nevertheless, a positive effect of agriculture is observed in the area with the 1km buffer. It tends to indicate that within the 1km radius, positive effects of agriculture in the impluvium (absence of pesticides, landscape diversification etc.) overtake potential disamenities.

These results complete the findings of the first paper where preferences for mixed agricultural plots were found. In complement with the hedonic analysis, it seems that landscape diversification is appreciated.

Finally, the last chapter provides a data production relative to the different surveys implemented for the thesis : the two DCE (chapters 1 and 2) and a third survey relative to tourists' preferences for forest and agricultural landscape management and the impact on the local economy in the Vittel region. This last survey complements what has been done in chapter one and chapter two for the local and non-local pupulations This data provide a description and various descriptive statistics for each survey. Data coming from these surveys are stored in the are stored in https://entrepot.recherche.data.gouv.fr/ and available in the BETA collection https://entrepot.recherche.data.gouv.fr/dataverse.xhtml?alias=PHD-BETA. It participates to the open science dynamic (Dedieu, 2022).

4. Limitations and perspectives

Even if the results from the four chapters appear to be quite complementary, It's important to emphasize on several limitations.

First, the objective of this thesis was to assess the co-benefits induced by a PES implementation in the Vittel watershed. If monetary valuation exercises are useful, they need to be combined with other types of valuation (O'Hara, 2001; Odum and Odum, 2000). In particular, Hérivaux and Le Coent (2021) advice to combine monetary valuation approaches with socio-cultural valuation ones. They even propose to include a specific socio-cultural section in stated preference surveys, such as DCE. That was not the case in this study. Moreover, the method used in the different chapters are subject to various criticisms: for example, stated preference surveys can display hypothetical biais, and revealed preference methods can only capture use values. Acknowledging that, it is even more important to combine different techniques, like in this manuscript, but going even further is necessary.

Secondly, If assessing co-benefits of NBS solutions is important, reserchears should also have a look at potential negative effects of such schemes (Hérivaux and Le Coent, 2021). As I tried to assess the co-benefits of the Vittel scheme, the negative impacts are not the focus of this study. As the Vittel case study is sometimes seen as exemplary, a critical perspective is even more important.

In the same idea, the thesis does not provide a CBA of the Vittel PES. Some studies (Depres et *al.* 2008; Perrot-Maître, 2006) provided a cost estimation of the Vittel programm: the total cost was estimated at 24.25 million euros for Nestlé Waters for the first seven years, *i.e.* 980€/ha/year. It corresponds to 1.52€/m³ of bottled water produced and includes land acquisition or investments in farm equipement, for instance. But the costs linked to the creation of Agrivair are not included in that estimation (Depres et *al.* 2008; Perrot-Maitre, 2006). They need to be taken into account, as well as indirect costs (such as potential negative effects of the scheme) (Capodaglio and Callegari, 2018) to provide a complete CBA analysis.

Because the PES started to be implemented in the 1980's, this thesis provides a kind of ex-post valuation process of a particular PES program. Valuation of *potential* benefits and costs should nevertheless be conducted ex-ante in order to take more informed decisions (Banque des territoires, 2022). That's why we can see this work as a first step to more systematic NMV of PES schemes, in order to provide decision-makers tools to decide if they constitute the best instrument for environmental preservation.

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