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# Evaluating the contribution of nature to well-being: The case of ecosystem services related to fish-farming ponds in France

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1                                   **Evaluating the contribution of nature to well-being:**  
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3  
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6

7  
8   **Abstract**

9   Ecosystem Services (ES) can contribute to several aspects of human well-being (WB) that we  
10 understand as the subjective perception that individuals have of their quality of life, depending on a  
11 set of factors. We compare the relative weights of the WB factors resulting from ES (ES-based) and  
12 those that do not depend on ES (non-ES-based), from an online survey (N = 1006) relating to ES  
13 linked to fish-farming ponds in France. A summary variable, the “WB profile”, allows to identify  
14 individuals (38% of respondents) whose WB is strongly linked to the presence of ES (the number of  
15 ES-based WB factors is greater than the number of non-ES-based WB factors). The WB profile of  
16 these individuals is analyzed with a binary logit model showing the preponderance of variable  
17 accounting for perceptions and interactions with ecosystems (attendance, relationship and  
18 attachment to nature, efforts to preserve the environment). We observe a lower level of training and  
19 the existence of a threshold effect on the relationship between life satisfaction and the ES-  
20 dependent profile: this contribution only concerns people with a high life satisfaction index. These  
21 results attest to the importance of pro-environmental perceptions, emotions and behaviors for  
22 conservation policies.

23  
24  
25   **Key words:** Ecosystem services; Nature perceptions; Well-being, Fish-farming ponds.  
26

27   **Highlights:**

- 28  
29   Assessment of the contribution of ecosystem services to the well-being of residents  
30   Influence of connection to nature on perceptions of ecosystem services  
31   Link between life satisfaction and significance of ecosystem services on well-being  
32   Commitment to nature and life satisfaction  
33   The contribution of ecosystem services to well-being as a proxy for demand for services

## 37 **1. Introduction**

38 Environmental policies promoting ecosystem protection and biodiversity conservation increasingly  
39 focus on the evaluation of ecosystem services (ES). ES are defined as the benefits people derive,  
40 directly or indirectly, from functioning ecosystems (Costanza *et al.*, 2017). Several categories of ES  
41 are distinguished, provision, regulation and cultural (Plieninger *et al.*, 2013), the latter one being  
42 defined as “the non-material benefits that people obtain from nature, including spiritual, aesthetical,  
43 educational and recreational values” (Kosanic and Petzold, 2020, p. 2).

44  
45 When ES were institutionalized by the MA (2005), their contribution to well-being (WB) was  
46 examined using several dimensions: security, basic material for good life, health, good social  
47 relations and the strengthening of freedom of choice and action, relating to Sen’s concept of  
48 capability (1979). WB is the subjective perception that individuals have of their quality of life based  
49 on a set of internal (directly related to the psychological condition of the individuals) and external  
50 (related to the availability of services in the living environment) factors. In order to assess the  
51 contribution of ES, we aim to measure the relative importance of those related to ES (ES-based) or  
52 not (non-ES-based). For this reason, we develop an approach in line with the logic of “regional well-  
53 being” of the OECD (2014) that refers to the resources and amenities provided by their living  
54 environment. This leads to question the presence of various economic, social and cultural services  
55 and facilities, traditionally addressed in studies on the regional WB (OECD, 2014). In this study, we  
56 focus on the role of ecosystems and more generally of nature in the WB. However, the relationship  
57 between ES and WB was, until recently, less studied in detail, compared to the characterization and  
58 mapping of the supply of ES and their interaction within ES bundles (Raudsepp-Hearne *et al.*, 2010;  
59 Martin-Lopez *et al.*, 2012; Plieninger *et al.*, 2013; Turner *et al.*, 2014; Queiroz *et al.*, 2015; Renard *et al.*,  
60 2015). In particular, there is a lack of empirical measures to characterize the types of WB factors  
61 or the most significant ES. Indeed, studies on ES tend to focus on the supply and types of use and do  
62 not explicitly evaluate this contribution, except when it is linked with health (Kele, 2012; Smith *et al.*,  
63 2013; Sandifer *et al.*, 2015; Prévot and Geijzendorffer, 2016; Delgado and Marin, 2016; Bryce *et al.*,  
64 2016).

65  
66 More precisely, research on the links between ES and WB (Blythe *et al.*, 2020) has mostly been  
67 carried out during the last decade and mainly in developed countries (the EU in particular). Most  
68 often, these are holistic approaches that do not address the interactions between ES and WB and in  
69 almost half of the cases (44%) it does not provide an explicit framework for defining WB (Blythe *et al.*  
70 2020). Depending on the context, the literature focuses primarily on three aspects: human health  
71 (physical health, such as heart problems, or mental health, with the effects of the environment on  
72 stress) and landscape or recreational amenities, which are part of cultural services (Kosanic *et al.*  
73 Petzold, 2020), mostly in developed countries, and provisioning services that can be essential for  
74 livelihoods in developing countries (Polishchuk and Rauschmayer, 2012). The WB factors most often  
75 identified are: (i) a physical dimension, in particular the impact on health (Cox *et al.*, 2017; Shanahan  
76 *et al.*, 2016; Barton and Pretty, 2010), (ii) a subjective perception, and (iii) a third dimension which,  
77 according to the authors, relates to relational or mental factors (Marschke and Berkes, 2006;  
78 Coulthard *et al.*, 2011; Kamitsis and Francis, 2013; Tsunetsugu *et al.*, 2013; Chan, *et al.*, 2019).  
79 According to Blythe *et al.* (2020), the main dimensions studied are: employment, health, food  
80 security, social capital, place attachment, security, culture, and spirituality (in descending order from  
81 24% to 6%); while Chan *et al.* (2019) point out that non-material benefits are less studied. These non-  
82 material aspects, often linked to cultural ESs (CES) (Kosanic and Petzold, 2020), frequently relate to  
83 heritage and inspiration dimensions which partly come under the concept of sense of place (Lewika,  
84 2011; Raymond *et al.*, 2013; Klain *et al.*, 2014) and its influence on personal identity (Omolo and  
85 Mafongoya, 2019). These non-material aspects are also perceived as a positive factor for  
86 psychological health, for example in the case of the spiritual link with the sea (Willis, 2018). These  
87 aspects are often mentioned in studies on indigenous populations (Bark *et al.*, 2016). In developing  
88 countries, the issues relate to the impact of ES on the capacity for action and then on the WB, such as

89 their role for the availability of fish shown by Abunge *et al.* (2013) for fishermen in Kenya. In every  
90 case, emphasis is placed on the fact that interactions between ES and WB are context-dependent,  
91 with much work on the proximity of green spaces in urban areas and natural ecosystems in rural  
92 areas. It is also necessary to take into account the way in which individuals interact with these ES, in  
93 particular according to perceptions, proximity, but also the frequency and duration of visits of natural  
94 areas (Korpela *et al.*, 2014; De Vreese *et al.*, 2016; Jacobs *et al.*, 2016; Rey-Valette *et al.*, 2017; Sy *et*  
95 *al.*, 2018; Fagerholm *et al.*, 2020) and more generally the types of connection to nature (Lewicka,  
96 2011; Raymond *et al.*, 2013; Klain *et al.*, 2014). Finally, we note the need to take into account the  
97 capacity of individuals to benefit or even appropriate these processes, which raises equity and  
98 governance issues (Daw *et al.*, 2016; Kosanic and Petzold, 2020).

99

100 This overview of the types of research highlights, except for the health dimension, a recent interest  
101 in studying these interactions, including a few econometric analyses aimed at characterizing the  
102 profiles of beneficiaries globally or according to the types of ES (Blythe *et al.*, 2020; Fagerholm *et al.*,  
103 2020; Kosanic and Petzold, 2020). Thus, Fagerholm *et al.* (2020) study the contribution of landscapes  
104 and ESs to WB in 13 European rural and peri-urban regions. They characterize clusters according to  
105 the types of WB contribution freely expressed and structured by distinguishing a wide variety of WB  
106 factors (40 items). This type of analysis of perceptions and impacts on the WB helps to inform the  
107 design of conservation policies which increasingly focus on the needs (i) for knowledge and  
108 awareness of individuals regarding the roles of ES, and their direct or indirect impacts on their WB  
109 (Martín-López *et al.*, 2012; Costanza *et al.*, 2017), but also (ii) for indicators easily appropriable.  
110 Indeed, taking WB into account explicitly (Kele, 2012; Smith *et al.*, 2013; Delgado and Marin, 2016;  
111 Bryce *et al.*, 2016) is, in our view, an original way to address more precisely the demand for ES of this  
112 type and its determinants.

113 In this context, the aim of this article is to explicitly measure the weight of the contribution of ES to  
114 people's WB using surveys to rank the importance of such ES as a WB factor. The core of our analysis  
115 consists in defining a summary variable named "WB profile" based on the comparison of the number  
116 of reported ES-based WB factors versus that of the non-ES-based WB factors. Profiles with a higher  
117 ES-based factor score than that for non-ES-based factors are considered "ESs-dependent WB." From  
118 an econometric analysis (binary logit model), we can then identify which variables affect the  
119 probability of belonging to the "ESs-dependent WB" profile, with a large share of variables reflecting  
120 perceptions among the possible explanatory variables. This type of analysis associates a subjective  
121 hierarchy of the factors perceived as the most important within a set of objective factors selected  
122 according to the factors of regional WB (OECD, 2014) and the contribution of ESs. In addition, we  
123 evaluate the relationships of this variable "WB profile" with an evaluation of the respondents' life  
124 satisfaction (Frey and Stutzer, 2002; Frey *et al.*, 2009). The objective was to rank ES according to their  
125 contribution to people's WB and to identify the determining factors of this contribution, especially  
126 the types of use, people's proximity to and familiarity with ecosystems, given that sociologists and  
127 psychologists stress the role of attachment to place (Lewicka, 2011; Raymond *et al.*, 2013; Klain *et*  
128 *al.*, 2014) and familiarity with nature (Moser, 2009; Antunez *et al.*, 2016). This analysis is carried out  
129 from an online survey across France and for a particular type of ecosystem, namely the fish-farming  
130 ponds, which represent 112,000 ha in France (mainland). These are shallow stagnant water bodies,  
131 of natural origin or man-made, which are maintained by the activity of fish farming. These are  
132 extensive forms of exploitation, mainly for the purpose of restocking. They offer an original example  
133 of ES, and they contribute to wetlands, and thereby biodiversity, maintenance (Vanacker *et al.*,  
134 2015). They also make a very positive landscape contribution as they are effectively natural areas. In  
135 France, they were mostly created between the 10<sup>th</sup> and 16<sup>th</sup> centuries by monasteries in order to  
136 develop fish consumption (Bernard, 2008) or to improve health in marshy areas (Billard, 2010).  
137 Consequently, fish-farming ponds constitute an important heritage resource for the territories.

138

139 Section 2 reviews the bibliography underlying our analysis and section 3 presents the survey  
140 protocol. The results are presented in section 4 which is followed by a discussion of the interest of  
141 this approach.

142

## 143 **2. Well-being assessment and impact of ecosystem services on well-being**

### 144 **21. Well-being assessments: what the literature says**

145 The issue of and methods for WB evaluation have both developed substantially during the last two  
146 decades and several approaches co-exist (Dolan *et al.*, 2011). Objective WB evaluations aim to  
147 complement standard approaches primarily based on income by displaying the diversity across  
148 external WB factors. These multidimensional analyses are based on a wide range of indicators of  
149 living conditions considered to be determining factors in WB. Initially undertaken at national level  
150 (Bigot *et al.*, 2012), they are now carried out at a local level, making it possible to define the concept  
151 of regional WB (OECD, 2014), also used to study regional inequalities. However, it appears that  
152 environmental dimensions have only been integrated marginally, if at all, into the concept of regional  
153 WB, which mainly emphasizes access to infrastructure and public goods, and mobility conditions. In  
154 France, environmental issues are only addressed through the extent of man-made development in  
155 the analysis of the quality of life (Reynard, 2016) whereas the OECD proposes four indicators: air  
156 quality, satisfaction with environmental quality, access to green spaces and a final indicator of  
157 environmental morbidity based on noise, air, water and soil pollution.

158

159 Concurrently, subjective WB evaluations have been widely accepted as a relevant measure of WB  
160 (Frey and Stutzer, 2002; Frey *et al.*, 2009). The diversity of approaches is such that a new field of  
161 research on the economics of happiness has emerged (Clark and Oswald, 2002; Clark *et al.*, 2005).  
162 According to Diener *et al.* (1999), subjective WB is related to the set of individual evaluations –  
163 negative and positive, cognitive and emotional – that we make about our life. Kahneman *et al.* (1999)  
164 showed that cognitive and emotional factors co-exist and in the same way several approaches co-  
165 exist. As a rule, evaluations promote the cognitive component. The aim is to converge broadly on an  
166 index of life satisfaction. In France, life satisfaction was rated 7.2 on a 10-point scale using a  
167 standardized protocol (Godefroy, 2011), a score which is consistent with those obtained across OECD  
168 countries (2014). At the same time, the integration of the emotional dimensions of WB gives a  
169 measure of the general sense of WB based on a range of emotions over a given period of time (Dolan  
170 *et al.*, 2011; Antoine *et al.*, 2007). The “Positive and Negative Affect Scales” of Watson *et al.* (1988) or  
171 the “Day Reconstruction Method” of the OECD (2014) may also be noted here. These approaches  
172 should be combined rather than opposed (Moser, 2009) in order to identify correlations (Antoine *et al.*  
173 *et al.*, 2007) and inconsistencies. Whilst cognitive approaches might be biased, for instance, depending  
174 on the time of the survey or the mood of the respondent (Kahneman and Krueger, 2006), studying  
175 the net result of emotions might be more accurate but is more difficult and may be biased by  
176 memory problems. These “non-welfarist” approaches emphasize the relative nature of WB  
177 perception (Frey and Stutzer, 2002) and therefore the need to include declared emotions and not  
178 only observed behaviors (Dolan *et al.*, 2011).

179

### 180 **22. Impact of ES on the WB: A few recent studies**

181 As pointed out in the introduction, the question of how to measure the impact on or contribution of  
182 ES to WB has received little attention. Beyond the systematic reviews already mentioned (Blythe *et al.*  
183 *et al.*, 2020; Kosanic and Petzold, 2020), some illustrations of published works can be noted. Nisbet *et al.*  
184 (2009) propose the “Nature Relatedness”, which evaluates individual levels of connectedness  
185 through cognitive, affective and experience dimensions, and shows the significance of time spent in  
186 natural areas. Bryce *et al.* (2016) emphasize the plurality of ES values and adopt a deliberative  
187 approach in focus groups to identify differences in representation. The feelings of participants  
188 visiting natural areas are evaluated on a Likert scale. They found six types of positive correlation  
189 between WB and ES: engagement and interaction with nature, place identity, therapeutic value,  
190 social ties, spiritual value and memory. Martinez-Suarez *et al.* (2015) recommend drawing a

191 distinction between three cases of interaction, depending on whether they are willingly sought, for  
192 example recreational activities, or they relate to consumption or to resource extraction (not limited  
193 to provisioning services) or they are a passive benefit arising from a set of amenities (aesthetic,  
194 regulating, and even cultural services).

195  
196 Regarding the WB factors studied, in addition to the health impact which is the most frequently  
197 analyzed, especially the impact on anxiety, depression, respiratory problems, asthma and infections  
198 (Browning and Lee, 2017), these analyses reveal the impact of nature relatedness: on the  
199 development of pro-social behavior (Smith *et al.*, 2013), on people's physical and mental health  
200 (Smith *et al.*, 2013; Sandifer *et al.*, 2015), on educational opportunities (Smith *et al.*, 2013), on  
201 productivity (Bryce *et al.*, 2016), on social ties (Baldwin *et al.*, 2011), and on school performance  
202 (Sandifer *et al.*, 2015). Some studies show the importance of urban or rural context, with the  
203 relationship between ES and WB strongly impacted by the urban or rural nature of the dwelling  
204 (Prévot and Geijzendorffer, 2016). Furthermore, some subjective approaches of WB point out the  
205 impact of psychological profiles on the evaluation and the perception of WB and the impact of  
206 positive emotions, of engagement in activities that are meaningful for the individual and their  
207 capacity to find a purpose in life (Seligman *et al.*, 2004). Therefore, it is important to address  
208 personality traits such as optimism, bias towards happiness, and gratitude, which promotes positive  
209 emotions and is, according to Shankland and Martin-Krumm (2012), "*one of the personality traits*  
210 *most strongly correlated with subjective WB*". Moreover, perceptions of the contribution of ES to WB  
211 depend on the familiarity, and frequency of contact, with natural areas as well as on the relationship  
212 and engagement with nature, for which different assessment metrics are proposed by different  
213 authors (Dunlap *et al.*, 2000; Davis *et al.*, 2009; Milfont and Duckitt, 2010).

214  
215 **3. Survey protocol** We undertook an online national survey with 1,006 people nationwide  
216 (mainland France). The type of ecosystem being studied related to pond-based fish farming, with  
217 supporting photos (Figure 1), but without reference to a particular pond or area.

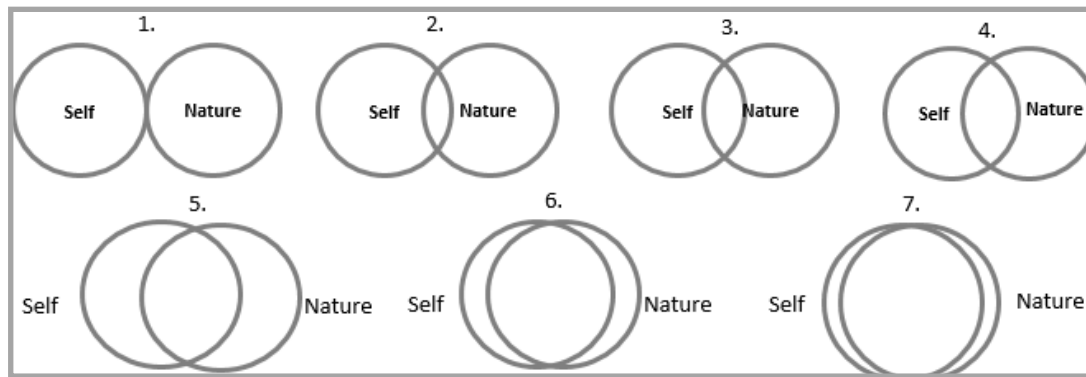


218 Figure 1: Examples of French fish-farming ponds (Dombes and Brenne regions)  
219

### 220 3.1. Questionnaire design

221 The questionnaire was designed by a multidisciplinary team of researchers specializing in ES and  
222 ponds (biologists, ecologists, economists, statisticians, zootechnicians) with the support of  
223 representatives of the profession at the national level, to convey the relative importance of the  
224 contribution of ES to the WB ecosystem of respondents. Drawing on the literature review, the  
225 questionnaire was built around several blocks to assess the importance of the contribution of ES to  
226 people's WB (Table 2), such as the impact of the relationship with the place of residence, the  
227 frequency of visits to the studied ecosystems, the psychological profiles and the relationship with  
228 nature. In order to measure the relationship with nature, we used the rating scale of Davis *et al.*  
229 (2009) which provides a set of diagrams summarizing the types of link to nature that are easily  
230 understood by respondents (Figure 2). This figure was presented to each respondent (block B) who  
231 had to choose the type of diagram that best corresponded to her/his own link to nature.  
232 Furthermore, drawing on research relating to emotions felt in contact with nature, we integrated

233 several suggestions from Bryce *et al.* (2016) into the questionnaire in order to better understand the  
 234 emotions sparked by ponds. The questionnaire consisted of a total of six blocks (Table 1).  
 235



236  
 237 Figure 2: Measurement scale of the link to nature (Davis *et al.*, 2009)  
 238

239 Table 1: Questionnaire structure (number and domain of the questions)

Blocks	Number of questions in the block	Domain of the questions
A) Relationship with place of residence	9	Qualifications of the living environment, Duration of residence, Size of the municipality, Type of accommodation, Distance to natural areas, Factors associated with the area of residence.
B) Relationship with and use of the ponds	22	Frequency of visits of pond areas (current and in childhood), Reasons for visiting, Type of activities practiced, Vacation spot, Various questions on emotions and perceptions (beauty, tranquility, health, feeling of freedom, pleasure, conviviality, fullness, knowledge of nature...).
C) Ranking of WB factors	2	Selection of the factors considered important (without restriction), Prioritization of the 8 most important factors within the list.
D) Evaluation of life satisfaction	2	Rating (on a scale from 0 to 10), current situation, Rating (on a scale from 0 to 10), if moving away from natural spaces.
E) Perception of the environment, attitude and behavior	11	Scale of the link to nature (Figure 2), Importance of various protective actions (from 0 to 10), Importance of environmental protection practices (from 0 to 10), Using 4 items of the NEP (Dunlap <i>et al.</i> , 2000), Types of behavior and attitude in general (socio-psychology).
F) Sociodemographic profile	15	General profile: gender, age, education, marital status, socio-professional category, income category. Proxy for the environmental profile: presence of animals in the household, frequency of consumption of organic products, donations to environmental associations.

240  
 241 In order to rank the impact of ES on WB, people were asked to identify first (i) the WB factors they  
 242 thought important and then (ii) to rank within this selection the relative significance of eight main  
 243 WB factors (scored 1, the most important, to 8, the least important). This approach, previously used  
 244 in the past to assess ES perceptions (Blayac *et al.*, 2014; Rey-Valette *et al.*, 2017), enables the  
 245 calculation of a citation index (number of selections) and of an average score corresponding to the  
 246 sum of the scores obtained during ranking. This selection and ranking procedure was based on a  
 247 balanced list of ten non-ES-based WB factors and ten ES-based factors. The non-ES-based factors  
 248 were chosen among the regional WB indicators selected by OECD (2014). The ten ES-based factors  
 249 were chosen according to the main ES derived from this type of ecosystem from documented  
 250 typologies (Liquete *et al.*, 2013; Haines-Young and Potschin-Young, 2018). Table 2 lists the 20  
 251 selected WB factors. In accordance with the recommendations of Smith *et al.* (2013), the elaboration

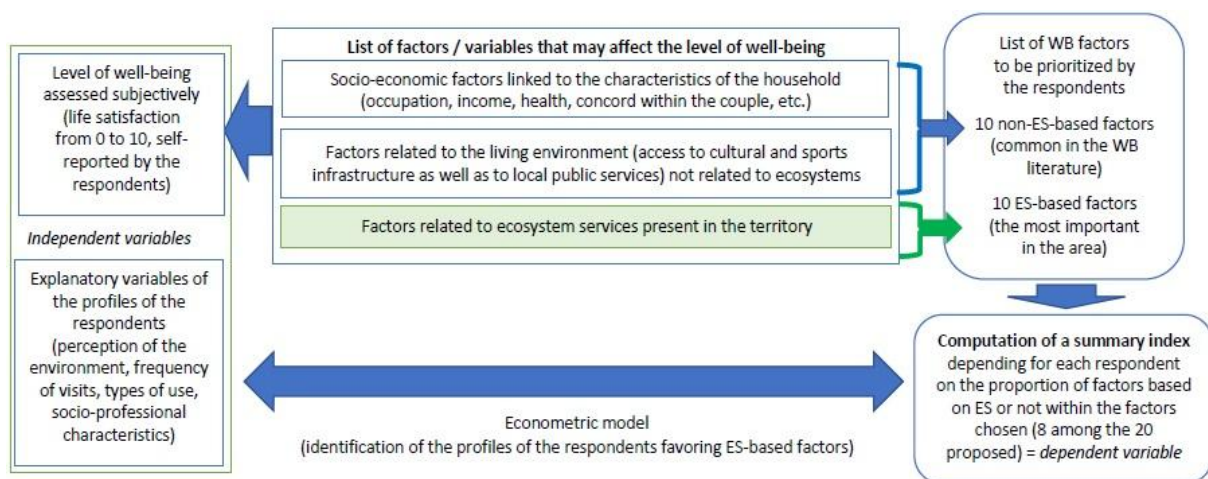
252 of these ES factors was designed to facilitate people’s interpretation of the contribution to their WB.  
 253 Thus, some regulating services were presented through their direct impact on people’s living  
 254 conditions. Of course, the types of factors were presented randomly and without referring to any  
 255 category to avoid anchoring bias.

256  
 257 Table 2: List of WB factors

Type 1 Non-ES-Based WB factors (OECD, 2014)	Type 2 ES-based WB factors		
	Wording proposed in the survey	Type of ES (Liquette et al., 2013) CICES, V5.1; (CES = cultural ES, RES = regulating ES)	
Health	Beauty of landscapes near the ponds	CES	Enable esthetic experience
Relationships with friends	No noise	RES	Noise attenuation
Cultural and sporting activities	Proximity of places for walks	CES	Physical interactions
Work/leisure balance	Feeling of freedom related to nature	CES	Spiritual or symbolic
Size and quality of dwelling	Air quality	RES	Regulation of contaminants
Harmony within the household	Proximity of healthy natural spaces	RES	Experiential interactions
Easy transport	Revitalizing aspect of nature	CES	Experiential interactions
Quality of local democracy	Microclimate related to pond proximity	RES	Micro climate regulation
Income	Fewer floods due to the presence of the ponds	RES	Flood regulation
Employment and professional relationship	Social bonds related to nature	CES	Recreational

258 Life satisfaction measurement was implemented by using the norms recommended in Europe since  
 259 2003 (European quality of life survey - EQLS) and in France since 2010 (INSEE, Godefroy, 2011), for  
 260 measuring subjective WB. The following question was asked: “On a scale of 0 (not at all satisfied) to  
 261 10 (totally satisfied), rate your satisfaction with regard to the life you are currently experiencing”.

262  
 263  
 264 Figure 3 summarizes the rationale behind the selection of WB factors for the survey and displays  
 265 their integration in the general design of the research.  
 266



267  
 268 Figure 3: Selection of the WB factors and place in the research design  
 269



270 **3.2. Survey implementation**

271 Our study was carried out online using a list of addresses provided by a specialist survey  
 272 organization. The exclusion of questionnaires that were incomplete or conducted in too short a time  
 273 reduced the sample by a third (from 1,422 to 1,006 respondents). In all, 636 municipalities were  
 274 involved in the survey. On average, the questionnaire took 20 minutes to complete. About half the  
 275 respondents (46%) lived in towns of over 100,000 inhabitants whilst only 20% lived in smaller towns  
 276 or villages with fewer than 5,000 inhabitants (Table 3). Our sampling plan aims to balance the share  
 277 of municipalities with less than 100,000 inhab. and over 100,000 inhab. to take into account the  
 278 distribution of the population according to urban areas (grouping of nearby municipalities) rather  
 279 than the size of the municipalities. Indeed, given the differences observed depending on the urban or  
 280 rural context, it is important to take into account the overall urbanization rate of the area and not  
 281 only the size of the municipality of residence. In addition, we also defined a balanced proportion of  
 282 respondents according to gender and age which are determining variables for the perception of the  
 283 environment (Table 4).

284  
 285 Table 3: Sampling according to the size of “communes” in number of inhabitants

Size of towns	< 5,000	5,000 to 15,000	15,000 to 100,000	> 100,000	Total
Number of respondents	200	122	223	461	1,006
% of respondents	20%	12%	22%	46%	100%
% mainland population (*)	41%	20%	24%	15%	100%

286 Source: Online survey CEE-M, 2018 (\*) administrative distribution of the population according to the  
 287 municipality of residence (French Direction générale des collectivités territoriales, 2019)

288  
 289 **3.3. Statistical analysis**

290 A first descriptive phase made it possible to identify some relationships between structuring  
 291 variables, the results of which are presented in the text along with their significance level (p-value). A  
 292 logit model was used to study the extent to which ES contribute to people’s WB. The aim is to  
 293 determine which elements affect the probability of an individual selecting a higher proportion of ES-  
 294 based factors within the set of WB factors considered to be important. To do this, we first  
 295 constructed a summary variable to compare the total score of non-ES-based factors (Type 1) with  
 296 that of ES-based factors (Type 2). In order to include both the selection rate and the ranking level, for  
 297 each respondent the scores given for each factor were divided by the average selection rate of this  
 298 factor. Taking into account the selection rate amounts to reducing the importance given to the  
 299 factors chosen by a large proportion of the respondents and giving relatively more weight to the  
 300 factors that were selected less often and are therefore more specific. By comparing the total scores  
 301 of the two types of WB factors we defined a “WB profile” variable: if the total score of ES-based  
 302 factors (Type 2) is higher than the total score of the non-ES-based factors (Type 1), then the  
 303 individual belongs to the “ESs-dependent WB” profile. This WB profile is the variable to be explained  
 304 by the model. We seek therefore to identify which variables affect the probability of belonging to the  
 305 “ESs-dependent WB” profile. Therefore, the endogenous variable takes the following form:

306  
 307 
$$WBP_i = \begin{cases} 1 & \text{if individual } i \text{ belongs to ESs\_dependent WB profile} \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

308  
 309 A latent variable  $Z_i$  is then defined which takes the following form for a given individual  $i$ :

310 
$$Z_i = \alpha_0 + \alpha_1 X_{i1} + \alpha_2 X_{i2} + \alpha_3 X_{i3} + \alpha_4 X_{i4} + \varepsilon_i \quad (2)$$

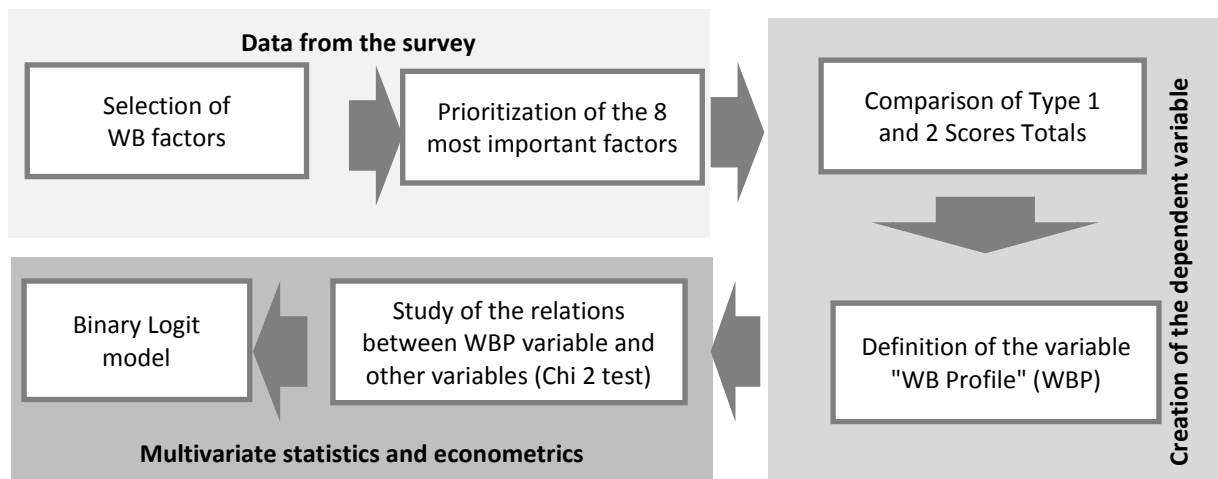
311 Where  $X_{i1}, X_{i2}, X_{i3}$  and  $X_{i4}$  are the values taken by the explanatory variables for individual  $i$ ,  $\alpha_0$  to  $\alpha_4$   
 312 are coefficients to be estimated and  $\varepsilon_i$  is a random term.

313  
 314 The  $Z_i$  function incorporates factors or variables that are likely to explain the probability that an  
 315 individual  $i$  will have a ESs\_dependent WB profile. These explanatory factors can be grouped into 4

316 main categories: (A)- those allowing to take into account the respondents' link to the nature ( $X_1$ ), (B)-  
 317 those reflecting the individuals' perceptions towards the ponds ( $X_2$ ), (C)- those expressing the socio-  
 318 demographic categories of the individuals ( $X_3$ ) and (D)- a variable measuring the subjective level of  
 319 WB ( $X_4$ ). A random term  $\varepsilon$  is also introduced in the expression of the  $Z_i$  function due to the  
 320 impossibility of observing all the explanatory factors. If the random term  $\varepsilon_i$  is assumed to be  
 321 distributed according to a Gumbel law, then a binary logit model can be used for modeling the  
 322 probability that an individual will have a ESs-dependent WB profile (i.e.  $WBP_i=1$ ). So we get:

$$323 \text{Prob}(WBP_i = 1) = \frac{\exp(Z_i)}{1 + \exp(Z_i)} \quad (3)$$

324  
 325 The following figure summarizes the different statistical steps.



340  
 341 Figure 4: Steps of the econometric modeling

### 342 3.4. Surveyed sample

343 Table 4 provides the main socio-demographic characteristics of the sample.

344  
 345 Table 4: Characteristics of the surveyed sample

	Sample	France Mainland Population (2017)
Women	50%	52%
Cohabiting couples	60%	72%
<45 year old	45%	36%
From 45 to 60 years old	24%	32%
>60 year old	31%	32%
Retired	27%	21%
Higher education diploma	56%	39%
Technicians, employees, workers	37%	54%
Managers, tradesmen, shopkeepers, company directors	16%	19%
Average monthly income of the household per consumption unit	€1,812	€1,734

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 348 Our sample is gender balanced. The average age of respondents is 50 years, which is fully  
 349 representative of the French population above the age of 18 (the average age of the French  
 350 population was 42 years in 2017, but this includes people under the age of 18 who are not in our  
 351 sample). The same is true of co-resident couples (60% in our sample compared with 72% in the  
 352 general population). Overall, these figures match with the French data on general population.

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**4. Results 4.1. Visit rates, pond perceptions and links to nature**

Only 10% of respondents declared that they “frequently” visit this type of ecosystem compared with 65% who do so “occasionally” (several times a year up to once or twice a month) and 25% who never go. The main activities are walking, and to a lesser extent, observing nature (Table 5). Figure 6 shows the average scores obtained for questions relating to perceptions and emotions linked to attendance of these sites and more generally representations and links to the environment (module B and E of the questionnaire).

Table 5: Distribution of activities related to the fish-farming ponds  
 (Respondents who frequently practice the activity)

	Frequency	Percent
Walking, hiking, jogging	610	46%
Bird watching and plant observation	282	21%
Cycling	151	11%
Photography; painting	113	9%
Picnics	108	8%
Recreational fishing	71	5%
Hunting	20	1%

Source: Online survey CEE-M, 2018

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Table 6: Evaluation of links to nature experience and perception toward the ponds  
 (Average score out of 10; in bold, the statistically significant variables of the logit model)

Concernment toward the environment	
Mankind must respect nature	8.4
Mankind must show solidarity with other species	7.9
<b>These spaces have value for nature independently of humans</b>	<b>7.6</b>
Nature is a source of inspiration	7.3
Emotions felt and impacts of frequenting pond areas	
Visiting these sites helps connect with nature	7.1
The beauty of these sites creates emotions in me	7.0
Visiting these sites is relaxing and reduces stress	7.0
<b>Visiting these sites gives a feeling of freedom</b>	<b>6.9</b>
Visiting these sites helps communicate with nature	6.7
Visiting these sites enables learning from nature	6.6
<b>Visiting these sites improves your physical well-being</b>	<b>6.5</b>
Visiting these sites gives pleasure	6.4
Visiting these sites gives a feeling of self-fulfilment	5.9
In these sites I feel that I am part of something bigger than myself	5.9
Visiting these sites strengthens family relationships	5.7
Commitment toward environmental conservation	
<b>I dedicate a lot of time, energy and effort to maintain the quality of the environment</b>	<b>5.9</b>
Compared with other people I know, I invest a lot in the environment	5.7
Framework for assessing the link to the nature of Davis et al., 2009	
Importance of the link to nature (scale out of 7 see Fig. 2)	<b>4.7</b>

Source: Online survey by CEE-M, 2018

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370 The assessments of perceptions and experiences show overall a significant concern with respect to  
 371 the protection of the environment with a rather high score for the link to nature (4.7 out of 7 or 6.77  
 372 out of 10), as well as rather positive emotions generated by frequenting pond sites, in particular for  
 373 physical or psychological WB factors.

374  
 375 **4.2. Analysis of life satisfaction and ranking of WB factors**

376 The life satisfaction of respondents (on a scale of 0 to 10) was rated at 6.7 which is lower than the  
 377 national average of 7.2 according to the INSEE (National Institute for Statistics and Economic Studies)  
 378 in 2013. As regards the contribution of pond-based ES to WB, we observe that 38% of respondents  
 379 have an ESs-dependent WBP. Most factors related to the presence of the ponds (in bold in Table 7)  
 380 were very often selected, but were less frequently ranked among the important factors.

381  
 382 Table 7: Selection and ranking of WB factors

	% selected	Score (*)		Type of factors
		Average	Rank	
Health	93%	1.6	1	Type 1 Non-ES-based
Harmony within the household	59%	2.7	2	
Income	58%	3.8	3	
Employment and quality of work relationships	47%	4.2	4	
<b>No noise</b>	<b>68%</b>	<b>4.5</b>	<b>5</b>	Type 2 ES-based (Regulating Services)
Relationships with friends	57%	4.8	6	Type 1 Non-ES-based
Balance between work and leisure time	52%	4.8	6	
Size and quality of dwelling	62%	4.9	7	
<b>Micro climate related to the proximity of the ponds</b>	<b>13%</b>	<b>4.9</b>	<b>7</b>	Type 2 ES-based (Regulating Services)
<b>Air quality</b>	<b>74%</b>	5.1	8	
<b>Proximity of healthy natural spaces</b>	<b>52%</b>			
<b>Flood reduction effect of ponds</b>	<b>15%</b>			
<b>Revitalizing nature of pond proximity</b>	<b>57%</b>	<b>5.3</b>	<b>9</b>	Type 2 ES-based (Cultural Services)
<b>Feeling of freedom related to the proximity of the ponds</b>	<b>50%</b>	<b>5.4</b>	<b>10</b>	
<b>Proximity of recreational sites</b>	<b>61%</b>	<b>5.5</b>	<b>11</b>	
Cultural and sporting activities	43%	5.7	12	Type 1 Non-ES-based
<b>Beauty of landscapes near the ponds</b>	<b>62%</b>	<b>5.8</b>	<b>13</b>	Type 2 ES-based (Cultural Services)
Easy transport	45%	5.8	13	Type 1 Non-ES-based
<b>Social bonds related to nature</b>	<b>18%</b>	<b>6.0</b>	<b>14</b>	Type 2 ES-based (Cultural Services)
Quality of democracy	22%	6.1	15	Type 1 Non-ES-based

383 Source: Online survey CEE-M, 2018

384 (\*) Ranking is in decreasing order so the lower the score the more important factor.

385  
 386 **4.3. Seeking correlations with the profile of individuals whose WB depends on ES**

387 The level of life satisfaction is not correlated with the WB profile but is correlated with the pond visit  
 388 rates; those people who rarely visit the ponds tend to have a lower level of life satisfaction (p-value  
 389 <0.01%). Likewise, people with a high level of life satisfaction (>8) typically have a rather strong  
 390 relationship with nature (p-value <0.03%) and a rather high level of engagement with nature (p-value  
 391 <0.01%). Finally, it is worth noting that people living in the towns or villages with fewer than 5,000  
 392 inhabitants visit the ponds quite regularly and often have a strong connection with nature.

393  
 394 **4.4. Econometric modelling**

395 The results of the estimation of the logit model pertaining to the variable “ESs-dependent WBP” are  
 396 presented in Table 8. The modelled probability is the probability of having such a profile. Not  
 397 surprisingly, the probability of having this profile is positively related to variables that convey (i) a  
 398 strong interest in or engagement with nature (relatedness to nature, time invested to protect the  
 399 quality of the environment, donations to environmental associations), (ii) a relatively frequent  
 400 number of visits to the ponds, (iii) a perception of these areas as having a therapeutic value as well as  
 401 to the fact of regularly consuming products from organic agriculture. On the other hand, this  
 402 probability is negatively related to the idea that ponds have some value for nature independently of  
 403 mankind (intrinsic value) and to having a higher educational level (postgraduate education). The fact  
 404 that, in the regression, the life satisfaction index and the square of its value are statistically  
 405 significant with opposite signs means that the probability of having a “ESs-dependent WB” profile is  
 406 non-monotonic, reflecting the existence of a threshold effect. Hence, the probability of having this  
 407 profile decreases with life satisfaction at a level of around 7.3 and increases thereafter, showing the  
 408 existence of a positive threshold effect with respect to the highest satisfaction levels which tend to  
 409 be more sensitive to the environment. Finally, it should be noted that the size of the town has no  
 410 impact.

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Table 8: Estimated coefficients of the logit regression

Variable		Estimated Coefficient (p-value)	Type and Measure
Intercept		0.3650 (0.7505)	/
<b>Category A: Relatedness to nature</b>			
Intensity of the link to nature (Davis <i>et al.</i> , 2009)		0.1931*** (0.0005)	Numeric / Scale: 1 to 7 (Mean: 4.74 - SD: 1.60)
Personal investment in preserving the environment		0.1280*** (0.0022)	Numeric / Scale: 0 to 10 (Mean: 5.88 - SD: 2.26)
Donations to associations	No	Ref.	Categorical / 3 categories No donation: 54.8%; Donations to non-environmental associations: 30.5%; Donations to environmental associations: 14.7%
	Yes, other associations	0.1557 (0.3660)	
	Yes, environmental associations	0.6578*** (0.0028)	
Consumption of organic goods	From time to time	Ref.	Categorical / 3 categories 55.5% eat organic food from time to time, 16.2% never and 28.3% regularly
	Never	0.1544 (0.4874)	
	Regularly	0.3311* (0.0567)	
<b>Category B: Pond perception and number of visits to the ponds</b>			
Therapeutic value of the ponds (sum of health contribution and feeling of freedom according to Bryce <i>et al.</i> , 2016)		0.0939*** (0.0016)	Numeric / Scale: 0 to 20 (Mean: 12.84 - SD: 4.72)
Intrinsic value of the ponds		-0.1229** (0.0125)	Numeric / Scale: 0 to 10 (Mean: 7.56 - SD: 2.19)
Number of visits to the ponds	Several times/year	Ref.	Categorical / 3 categories Once a week or more: 10.4%; Several times a year (a maximum of twice a month): 64.6%; Never: 25%
	Weekly	0.5737** (0.0213)	
	Never	-0.1640 (0.4168)	
<b>Category C: Socio-demographic characteristics</b>			
Educational level	≤ baccalaureate	Ref.	Categorical / 3 categories Secondary education: 44.3%; 2 to 4 years graduate education: 40.4%; Postgraduate: 15.4%
	2 to 4 years graduate studies	-0.2468 (0.1428)	
	Postgraduate	-0.6598*** (0.0092)	
<b>Category D: Life satisfaction</b>			

Life satisfaction index	-0.5128** (0.0162)	Numeric / Scale: 0 to 10 (Mean: 6.75 - SD: 1.69)
Square of life satisfaction index	0.0354** (0.0394)	

413 \*\*\* 1% significance level, \*\* 5% significance level, \* 10% significance level.

414

415 **5. Discussion**

416 Our survey aimed to explicitly measure the weight of contribution of ES to people’s WB. From the  
417 hierarchy of a list of factors contributing to the well-being of individuals, we defined a “WB profile”  
418 variable by distinguishing people whose total score of ES-based factors is higher than the total score,  
419 and those whose WB is more determined by non-ES-based WB factors. The analysis of the practices  
420 and perceptions of individuals and the use of econometric modeling make it possible to explain the  
421 specificities of people belonging to the “ESs-dependent WB” profile. Here we will discuss our results  
422 and the nature of these factors.

423

424 The first point to highlight is that, among the factors of WB (Table 7), several of the ES-based ones  
425 (Type 2) have high scores. This finding confirms the role of the factors contributing to regional WB  
426 (OECD, 2014; CGET, 2017), namely air quality, low noise, and access to green spaces, which attest to  
427 the importance of the environment to the quality of life and health as numerous authors have shown  
428 (Sandifer *et al.*, 2015; Blythe *et al.*, 2020). The regulation of local climate and of flooding are  
429 positively perceived by the residents who have a sound knowledge of the way these ecosystems  
430 function. It can be noted that regulating and maintenance ES are better ranked than cultural services  
431 among which the relational aspects are in last place. We find in part the factors most cited by  
432 Fagerholm *et al.* (2020), namely the tranquility, the social interactions, the quality of the air and the  
433 landscapes as well as the attachment to the place.

434

435 Econometric analysis (Table 8) indicates that the probability that ES contribute significantly to  
436 people’s WB is mostly related to variables (7 out of 9) accounting for perceptions and interactions  
437 with the environment. This finding is consistent with the literature (Kelé, 2012; Smith *et al.*, 2013;  
438 Martinez-Suarez *et al.*, 2015; Bryce *et al.*, 2016). First, we must point out the small number of socio-  
439 demographic variables in the determining factors of the WB profile. As is often the case, the  
440 “education” variable is important but it has the inverse relationship to that usually observed. Here,  
441 the relationship is negative, i.e. the most highly educated people have a greater probability that their  
442 WB is unaffected by the environment. However, here also, there may be a link with the context as  
443 the education level is lower in rural environments where there are more opportunities for  
444 interactions with ecosystems. We can also point out the existence of a threshold effect in regard to  
445 the relationship between life satisfaction and the ESs-dependent WBP. This relationship involves  
446 respondents with a life satisfaction index above 7.3. Given that this life satisfaction variable is linked  
447 to the level of income, age (>60) and the connection with nature, it is strongly related to all the  
448 variables conveying positive feelings towards the ponds. This echoes the results of several studies  
449 conducted on this issue. In Great Britain, MacKerron and Mourato (2013) analyzed the relationship  
450 between subjective WB at a given time and the type of surrounding environment based on a  
451 smartphone survey of 20,000 participants who used their GPS coordinates at the time of the survey.  
452 The people interviewed in a natural area tended to have a higher life satisfaction level than those in  
453 an urban environment. Vemuri and Costanza (2006) looked at 56 countries and found a strong link  
454 between Human Development Index (as a proxy of life satisfaction) and the density of ES per km<sup>2</sup>  
455 that explained 72% of the variation in life satisfaction.

456

457 Finally, several significant variables are accounting for forms of interaction and of sensitivity to the  
458 environment. The number of pond visits, and thereby the use of ecosystems that creates a proximity  
459 in terms of familiarity and contributes to improving information, is, of course, a determining factor  
460 (Meinard and Quetier, 2014; Sy *et al.*, 2020). These results suggest a relationship between  
461 knowledge of these environments and an active behavior towards the environment, which shows

462 why the typology of Martinez-Suarez *et al.* (2015) is of interest. These authors distinguish between  
463 active, passive and consumption interactions, and show the positive impact of active interactions,  
464 which mainly concern leisure activities. These results also confirm the conditions underlying  
465 experience of nature discussed by Nisbet *et al.* (2009) and the intensity of the link to nature (Davis *et*  
466 *al.*, 2011). These factors are part of a recent research program that highlights the importance of the  
467 sense of place and of psychological factors in pro-environmental behavior (Lewicka, 2011). It is also  
468 worth noting the impact of pond perception which is negatively related with the fact of attributing an  
469 intrinsic value to nature independently of mankind. This relationship may be construed as revealing  
470 an anthropocentric bias with respect to the relationship with nature, in line with most studies  
471 showing the decisive role of the impact on health and the contribution to leisure and thereby to the  
472 quality of life (López-Mosquera and Sánchez, 2011; Sandifer *et al.*, 2015; Martinez-Suarez *et al.*,  
473 2015). These groups of factors are found in the ranking of ES based on their contribution to WB  
474 (Table 7). Likewise, the surveys undertaken by Bryce *et al.* (2016) demonstrate the importance of the  
475 therapeutic value of nature with differences related to the biophysical attributes of the sites. This  
476 aspect is accounted for here by the two dimensions proposed by Bryce *et al.* (2016), namely health  
477 contribution and feeling of freedom. More generally, the typology proposed by Fagerholm *et al.*  
478 (2020) displays the diversity of WB factors, depending in particular on urbanization. Thus, although  
479 some groups rather favor urban services, but with the presence of green spaces or cultural and  
480 heritage dimensions, two of the groups emphasize the contribution of ES (air, food, hiking, etc.), with  
481 a preponderant role of the contribution of landscapes of water bodies or proximity to the sea (48%  
482 of respondents) and, for one of the groups, a strong role of attachment to place and traditions.  
483 Although the econometric approach is different, their analysis confirms the importance of the  
484 natural dimensions of the living environment and of the visit of natural sites and therefore of the  
485 experience of nature through the role of the length of residence, ES perceptions and agricultural and  
486 non-agricultural trades.

487  
488 The highlighting of the important role of these forms of interaction and of sensitivity to the  
489 environment confirms the recent emphasis on the weight of individuals' intrinsic motivations on their  
490 behavior, in connection with the importance of sociological dimensions (standards) and psychological  
491 ones (behavioral economics) on behaviors. This sheds light on the development of regulatory  
492 measures aimed at acting on perceptions, information and values to encourage individual pro-  
493 environmental behavior and promote deliberative governance mechanisms. In this area, an  
494 interesting result of our model is that we take into account personal involvement in preserving the  
495 environment which should be stressed. In fact, many studies in environmental psychology and  
496 behavioral economics (Benabou and Tirole, 2006; Moser, 2009; Croson and Treich, 2014; Sunstein  
497 and Reich, 2014; Farrow *et al.*, 2017) show the significance of engagement in attitudes towards  
498 nature and not only perceptions and values (Nisbet *et al.*, 2009; Davis *et al.*, 2011). This attitude  
499 seems logically associated with the observed stronger tendency to consume organic food, a factor  
500 which makes a positive contribution to our model.

501 Finally, we can highlight that town size, and thereby the urban or rural context, did not affect our  
502 model, although the ESs-dependent WBP was correlated with size (somewhat higher in towns or  
503 villages with fewer than 5,000 inhabitants; Chi-squared test is significant at least at 1% level). It is  
504 thus difficult to adopt a stance on the paradox raised by Douglas (2012) according to which the  
505 relationship with nature is stronger in a rural environment, while the urban need is higher, indicating  
506 different motivations according to the type of context. Nonetheless, as these contextual differences  
507 also involve socio-demographic differences, in particular age, education and income level, it is  
508 difficult to isolate the role of the context.

## 509 510 **Conclusion**

511 The literature review carried out to situate the results of our survey indicates a growing interest in  
512 the analysis of the contribution of ES and nature to the WB of individuals (particularly in terms of  
513 health) with a very broad variety of approaches. Beyond the many approaches targeting a particular

514 factor and the differences depending on the context, it is most often a question of characterizing the  
515 factors of WB by producing typologies, which are difficult to compare or to generalize due to the lack  
516 of a common framework with regard to the elements of WB taken into account. In this context of  
517 rather descriptive approaches (Blythe *et al.*, 2020; Kosanic and Petzold, 2020), our survey aimed (i) to  
518 measure the relative share of WB factors linked to ES compared to non-ES-based factors  
519 independent of relationships with the environment and (ii) to characterize, through econometric  
520 modeling, the profile of people whose WB is strongly dependent on factors linked to the ES. We have  
521 shown that these people represent a significant part of the population (38%) and that they are  
522 distinguished above all by their perceptions and behavior vis-à-vis natural spaces, rather than by  
523 their socio-demographic profiles with a single significant variable, namely a lower level of education.  
524 Thus, in accordance with the literature, we note the importance of the variables of concern and links  
525 to nature, as well as the weight of the experience resulting from regular visits to the territories  
526 considered. Finally, the relationship with life satisfaction shows an interesting threshold effect with  
527 an influence of ES for the highest levels of satisfaction (>7.3 out of 10).

528  
529 Thus, our approach enables a fuller documentation and explanation of the nature's contribution to  
530 WB, using living conditions beyond the classical socio-demographic variables, the importance of  
531 contexts and attitudes. As noted by Summers *et al.* (2016), this type of result should be of interest to  
532 public decision-makers in guiding restoration policies and more generally in arbitrating between  
533 developments that affect living conditions, where environmental issues that were previously more or  
534 less ignored are increasingly coming to the fore.

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