Perceptions of ecosystem services and bonds with nature: the case of fish-farming ponds in France

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Abstract

Recent studies have shown the importance of relationships with nature, emotions felt, forms of attachment, and experience of nature on conservation motivations. They have proposed characterizing relational values based on these complex interactions with ecosystems. We analyzed these links for ecosystem services (ESs) associated with fish farming ponds. The analysis was based on an online survey conducted on mainland France. We identified the types of pro-environmental profiles and investigated the determinants of pro-environmental behaviors. We analyzed the types of services prioritized according to individual profiles and the factors determining sensitivity. We distinguish between individual ESs that are more hedonic in nature, and regulating or heritage cultural ESs that refer to collective motivations rather linked to eudaimonic well-being. The results highlight the importance of factors related to eudaimonic well-

being, which help integrate the role of ethical values and commitment to conservation. The modeling shows little influence of the usual sociodemographic variables and the strong significance of variables considering the knowledge and familiarity with these ecosystems and the pro-environment commitment, which refers to eudaimonic well-being. These results allow us to discuss the specificities of awareness-raising policies, which imply a rationale for active citizenship.

Keywords: Ecosystem services; Eudaimonic and hedonic well-being; Fish-farming ponds; Wetlands; Sense of place; Perceptions

1. Introduction

The concept of ecosystem services (ESs) provides an opportunity to revitalize research on the development and implementation of environmental conservation and protection policies (Mace et al., 2012; Beaumont et al., 2017; Gould et al., 2019). Following the research on the identification and mapping of ESs by region and ecosystem type, social science studies have relied largely on environmental economics approaches to estimate the value of these services (Nieto-Romero et al., 2014; Jacobs et al., 2016; Gould et al., 2019; Kadykalo et al., 2019). Thereafter, the scope and methods of evaluation diversified towards multi-criteria analysis with survey protocols combining individual and collective approaches in focus groups (Spash, 2007; Hattam et al., 2015; Rey-Valette et al., 2017; Sy et al., 2018). The initial focus of these studies on the provision of services has gradually shifted to the perceptions of and types of demand from citizens and stakeholders (Krause et al., 2017; Lau et al., 2019; Sy et al., 2021; Aryal et al., 2021). This sparked debate on the level of information, knowledge, and awareness of the contribution of these services to their

well-being, on their motivations to protect them, and, more generally, on their social appropriation as environmental assets (Smith et al., 2013; Spangenberg et al., 2014; Mathé and Rey-Valette, 2015; Caceres et al., 2015; Hicks et al., 2015). These issues call for an examination of the role of the cultural context of perceptions, using inputs from psychology and sociology to understand their determinants. The anthropocentric nature of ESs, although criticized by those supporting a broader approach to conservation issues, is often justified by their ability to mobilize people and policymakers more readily in favor of ecosystem conservation (MEA, 2005; Carpentier et al., 2009; Ring et al., 2010). In recent literature, we note both a questioning of the ES concept (Diaz et al., 2018; Muradian and Gomez-Baggethun, 2021) and a highlighting of its psychological dimensions through the notion of relational value (Martín-López and Gómez-Baggethun, 2017; Arias-Arévalo et al., 2017; 2018; Chan et al., 2018; Himes and Muraca, 2018; Ishihara, 2018).

However, the effectiveness of incentives for conservation implies several conditions. First, it assumes that people are aware of the contribution of ESs to their welfare, which is not always the case, depending on the individual and the type of service. Hence, Diaz et al. (2018) stressed the role of culture and local knowledge in the way people perceive the significance of ES and, therefore, the reasons for their preservation. This raises the question of the role of information and "proximity" to nature in shaping people's preferences and perceptions. The notion of proximity refers to two interactive dimensions: familiarity with the natural environment based on the frequency of use (information and awareness arising from experience) and, more generally, an individual's attitude towards nature (emotional, cultural, and ethical), which implies the ability to evaluate the significance of one's bond with nature. These studies emphasize the integration of local and layperson knowledge and the benefits of collective ranking within deliberative processes

(Paavola, 2007; Lundberg et al., 2019; Sy et al., 2018; 2021). It stresses the co-evolutionary process (Norgaard, 1994) as an analytical framework for the society-nature relationship, leading thereafter to the development of the notion of "novel ecosystem" (Kareiva and Marvier, 2012; Hobbs et al., 2006; 2014; Murcia et al., 2014).

Second, people must care for and value the preservation of ESs. Recent studies have emphasized the role of relationships with nature, felt emotions, and the experience of nature. (Cooper et al., 2016; Prévot et al., 2018; Bratman et al., 2019; Magda et al., 2022). Relational and experiential approaches highlight the importance of individuals' connections and attachments to nature. These works reflect a new approach centered on the relational value of nature, which extends the traditional partitioning between intrinsic and instrumental values (Gould et al., 2019; Jacobs et al., 2016; Martín-López and Gómez-Baggethun, 2017; Chan et al., 2018; Himes and Muraca, 2018; Ishihara, 2018; Arias-Arévalo et al., 2017; 2018). This new multidisciplinary approach makes it possible to define a new component of the value attributed to ecosystems based on more qualitative approaches that consider specific interactions, particularly emotional and experiential, with these ecosystems. This relational value makes it possible to integrate a greater diversity of behavioral drivers. In particular, it offers a new path for analyzing cultural ESs. Reviewing the history of these approaches, Chan et al. (2018) highlighted the role of these values in bringing about profound changes in behavior in favor of protecting these ecosystems. According to the authors, this approach offers significant potential for environmental education. Ishihara (2018) emphasizes Bourdieu's notion of *habitus* to explain the internalization of these relationships and underlines the role of symbolic factors. These ideas have sparked discussions on the notion of place attachment (Lewicka, 2011). Four nonexclusive place-related concepts were distinguished,

including emotional connections (place attachment) related to emotional ties with a particular place[1]. This concept was developed in the 2000s following research focusing on the relationship between humans and the environment. More generally, this evolution raises new research questions and new metrics to account for these forms of empathy that Callicott (1985) has called postmodern because of their "decentering" from Cartesian tradition and for the greater reciprocity with nature they suggest.

Indeed, the type and intensity of bonds with nature are increasingly being examined in view of their numerous positive impacts on the quality of life (Luck et al., 2011; Flint et al., 2013; Sanguinetti, 2014; Prévot et al., 2018; Fretwell and Greig, 2019; Kaltenborn et al., 2020). These studies seek to identify the values, forms of commitment, and, more generally, the forms of relationship with nature that determine pro-environmental behaviors. Some authors, in the biophilia line of thought, stress the need for contact with nature and its positive effects on well-being, productivity, and social bonds (Baldwin et al., 2011) and more specifically on health (Sandifer et al., 2015). For example, Martinez-Juarez et al. (2015) defined three types of interactions depending on whether they concerned resource harvesting or consumption, voluntary interaction (recreational activities, for example), or passive benefits through amenities relating to regulating services or cultural services, while others (Smith et al., 2013; Bryce et al., 2016) defined a greater number of interactions. Therefore, all perceptions of the issues leading to nature protection should be addressed. More generally, Rosa (2018) proposes a "sociology of our relationship to the world*"* based on the concept of "resonance" to convey these proximities and

[1] The other dimensions concern the symbolic (place meaning) and functional (place dependence) importance of the place as well as its role in the construction of the individual's identity (place identity). All of these elements thus make it possible to apprehend the identity, emotional, symbolic, and functional dimensions relating to the role of the place.

highlight the importance of these links for individuals' well-being, in conjunction with how human beings relate to others and social interactions. Rosa (2018) differentiates between a horizontal axis of resonance between people and a vertical axis with respect to a "*transcendent*" entity, which applies to bonds with nature. In his view, being in resonance means being affected by, being active in the sense of being able to react, and being able to integrate transformations and changes that cannot be planned because they depend on context and interactions.

In this new epistemological context, two questions appear to have been poorly addressed. First, the impact of relational values seems implicitly (the literature is not always explicit on this point) to concern hedonic well-being, whereas the development of pro-conservation behaviors depends rather on eudaimonic well-being. To better understand the drivers of behavioral changes, it seems relevant to better specify the nature of well-being, whose pursuit can motivate these changes. Second, despite the growing literature on relational values, the issue of their quantification is scarcely addressed (with the notable exception of the paper by Hicks et al., 2015), although having quantitative indicators can be useful for clarifying choices, particularly for public policies.

These findings, both in this new scientific context and in these research gaps, led us to study the perceptions of ESs in relation to the type of well-being with which they could be associated and the type of relationship to nature that individuals express. ESs associated with fishponds, which are exploited ecosystems whose functioning remains closely dependent on ecological processes, appear to be a relevant research field. Thus, the aim of this article is to report an original investigation that sought to identify how ESs perception can be affected by the extent and type of

connection with nature and how this connection can foster the willingness of certain people to protect biodiversity.

This study consisted of two main questions. First, we used principal component analysis to study whether these new approaches to relational value (Chan et al., 2018; Himes and Muraca, 2018; Ishihara, 2018; Arias-Arévalo et al., 2017; 2018) make it possible to better identify the types of pro-environmental profiles. To do this, in connection with existing works on the relationship and proximity to nature, the emotions felt and their contribution to well-being (particularly psychological), and the types of relationship to place, many questions were proposed in the survey to clarify these interactions. This part of the analysis aims to characterize the relational value of ESs. We assume that crossing these variables with the level of involvement and effort in nature conservation makes it possible to characterize the profiles associated with perceptions and behaviors. We partly resume the factors highlighted by the theory of planned behavior (Ajzen, 1985; Ajzen and Fishbein, 1980) by specifying the motivations for the intentions. However, aspects related to norms and the ability to control, which are important for distinguishing intentions from behaviors, were not included in this survey, which focused on analyzing the diversity of determinants of relational values.

In addition, we used econometric modeling to measure the weight of relational factors compared to factors generally tested as determinants of pro-environmental behavior. This type of survey does not directly observe pro-environmental behavior. We hypothesize that the prioritization of regulating ESs that do not directly contribute to well-being is representative of sensitivity to biospheric value and, therefore, to the conservation of ecosystems. Indeed, the work of Hicks et

al. (2015) on ESs related to coral reefs shows that individuals who prioritize regulating and supporting services are more sensitive to self-transcendent values and collaborative approaches. Similarly, the typology of ES perceptions associated with lagoons proposed by Sy et al. (2018) showed greater sensitivity to environmental concerns within the group that favored regulating ESs, while Arias-Arévalo et al. (2017) showed a positive relationship between relational values and altruistic motivations.

The remainder of this paper is organized as follows: After presenting the methodological protocol of the survey (Section 2) and the main results (Section 3), we discuss the originality and contribution of these results by showing how they can improve the acceptability and effectiveness of policies for the conservation of ecosystem services (Section 4).

2. Survey protocol and methodology

Our analysis focuses on ESs associated with fish farming ponds in France and is based on a national online survey of 1,006 people. This survey covered the intensity of use and user familiarity with ecosystems and their bonds with nature, considering the wide range of components of this bond. It is important to mention a specific feature of fish-farming ponds, which are an example of ecosystems exploited for productive purposes but in an extensive way, often contributing to the maintenance of neighboring wetlands that are generally not exploited. These ponds, which may be located on farmland or in nature reserves, possess some attributes, particularly in terms of scenery, that make them similar to nature reserves themselves.

2.1. Characteristics of fishponds in mainland France

Our study focused on ESs associated with a specific socio-ecosystem: fish farming ponds. These ponds were mostly created in the 10th century by monasteries (Bernard, 2008). The aim was to increase the fish supply in these dam-created ponds, which are generally replenished by runoff. Later, in the 15th century, others were created as part of a development scheme to address health issues in marshy areas (Billard, 2010). These ecosystems are now considered valuable heritage sites with high landscape value and significant biodiversity, given that they support certain well-known and appreciated fauna and flora whose existence is strongly dependent on the way the ponds are managed (Vanacker et al., 2015). They are used for fish production and restocking. In France, according to the professional association, fishpond farming involves about 100 people, for whom it is the principal occupation, and 112 000 ha of waterbodies, an output of 8 200 tons (i.e., 17% of total French aquaculture production (fish) and 20% of freshwater production), of which half comprises carps that are mainly destined for restocking (75%). France has three significant pond-based fish farming regions: Brenne, Dombes, and Lorraine. Photos were provided at the beginning of the questionnaire because this type of pond was not always known outside these regions (see Appendix).

2.2. Listing the services associated with fish-farming ponds

We selected a list of 21 services drawn from the 2013 CICES classification (Liquete et al., 2013) with stakeholders and specialists in these environments (Willot et al., 2019) and tested them with 15 fish farmers and stakeholders in the Dombes region (pilot survey). As the concept of ecosystem services was not necessarily known to the respondents, we opted for the more generic term "role of ponds." We referred to the CICES nomenclature to distinguish between the three ES categories. However, we distinguished two types of cultural ecosystem services (CESs) that are heterogeneous

(Kosanic and Petzold, 2020). To characterize the motivations for conservation according to the types of use, we distinguished the CESs that we qualified as individual, that is, corresponding to personal leisure or recreational uses, from all of the other CESs that relate to more collective uses and that we consider heritage ES. We often find this type of partitioning concerning methods that allow the quantification or spatialization of CESs (Izakovičová et al., 2020). In our case, this partition corresponds to different concepts of well-being (hedonic and eudaimonic) and answers the need to be able to distinguish not only the reasons for interest and attachment but also the attendance of these areas to define more suitable conservation measures (Kaltenborn et al., 2020). In total, we distinguished four types of ESs.

2.3. Questionnaire

We drew from the literature to introduce several modules to reflect the relationship with the place of residence, visit rates of the studied ecosystems, psychological profiles, and various forms of the bond with nature, and to develop summary measures using the scale of Davis et al. *(*2009). Two pictures were used to illustrate the types of fish-farming ponds (see Appendix). A pilot survey was carried out in the Dombes region, which is one of the three main French regions with numerous fishponds with 320 residents between May and June 2018. The experiment was conducted face-to-face (30 minutes on average). In September 2019, a workshop was held in which 20 surveyed stakeholders discussed the survey results.

The questionnaire was organized into six modules (see Table 1; the questionnaire is provided in the appendix).

Table 1: Questionnaire structure and number of questions per theme

A) Relationship with place of residence	9
B) Relationship with and use of the ponds	14
C) Selection and ranking of services provided by the ponds	1
D) Perception of the environment,	11
E) Attitude and behavior	10
F) Socio-demographic profile	13

We used the method proposed by Rey-Valette et al. *(*2017) for Module C (selection and ranking of ESs). Respondents were asked to first identify (i) all services that were important to them (ESs Selected), and then (ii) rank within this selection the relative significance of the six main services (scored from 1 to 6 (ESs Ranked)). This dual assessment allows, on the one hand, to list all ESs considered important in absolute terms and, on the other hand, to select the main ESs (a maximum of six ESs) by considering the relative place granted to them in relation to the other services (Rey-Valette et al., 2017). It is based on the work of Dewey (1939), who emphasized that the assessment of value must integrate hierarchies relative to other items. This approach makes it possible to calculate the selection frequency of services and establish the average score of their importance.

For module D, we apprehended the perceptions of ponds as natural spaces by detailing the emotions felt when visiting these ecosystems, as well as their connection to nature. Several questions aimed to understand these links by taking items developed in the literature (Sandifer et al., 2015; Lopez-Mosquera and Sanchez, 2011) and globally evaluating the importance of this connectedness using the analysis grid proposed by Davis et al. (2009). Numerous evaluation scales

have been proposed in environmental psychology to convey attitudes towards nature (Dunlap et al., 2000; Milfont and Duckitt, 2010). The aim is to define profiles that are more or less pro-environmental using a set of questions evaluated on a decimal or Likert scale (Likert, 1932). While most approaches involve significant lists, Davis et al. (2009) suggested a synthetic approach wherein respondents choose a level of interaction between themselves and nature, represented by two circles, the overlap of which represents the degree of connectedness with nature (Figure 1). This framework offers a synthetic approach to reduce the size of the questionnaire. During the face-to-face test, we were able to verify that the questionnaire was well understood by the respondents, who answered easily. Finally, in this module, two questions made it possible to assess the level of effort made in relation to the environment to account for behavior.

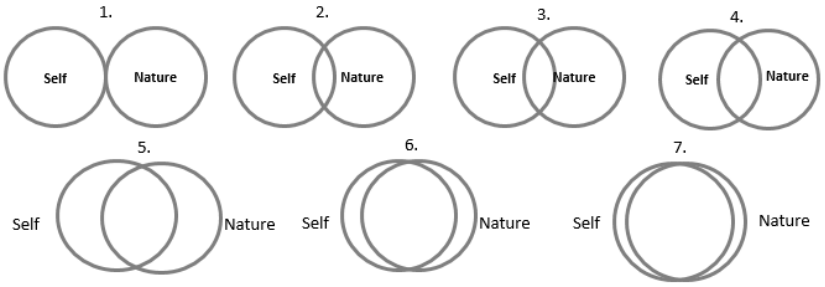


Figure 1: Measurement scale of connectedness to nature (Davis et al., 2009)

2.4. Survey method

The survey was conducted online in January 2018 with 1,006 people from all over mainland France using a list of addresses provided by a specialist survey organization. The questionnaire took 10–40 minutes to complete (an average of 20 minutes). The exclusion of questionnaires that were incomplete or conducted in too short a time reduced the sample (from 1,422 to 1,006 respondents). Survey participants resided in 636 municipalities (see Table 2). The survey was based on a

stratified sample, depending on the size of the municipality, in order to test the results as a function of the urban or rural nature of the area.

Table 2: Sampling according to municipalities' size

	<5000	5 000 to 15 000	15 000 to 100 000	>100 000	Total
Number of *communes*	193	120	173	150	636
Number of respondents	200	122	223	461	1006
% of respondents	20%	12%	22%	46%	100%

2.5. Statistical analysis

Statistical and econometric analyses were undertaken to improve the understanding of the bond with nature and its determining factors in the case of the ponds under study, as well as the effect of these factors on preferences for regulating services. These regulating services were used in the analyses as a *proxy* for pro-conservation attitudes towards functional ecosystems. Principal component analysis (PCA) (§ 2.5.1) was used to examine the relationship between the variables that reflect links between ponds and nature (relational variables). A partition based on the types of ranked services (Section 2.5.2) then enabled a nested dichotomy approach to identify the variables that determine sensitivity to different service types, especially regulating services.

2.5.1. Using a PCA to examine the relationships between variables reflecting connection with nature

The survey provided detailed information on the variables reflecting bonds with nature, emotions experienced in the case of fish-farming ponds, and perceptions of ponds. Within the framework of the questionnaire, 21 items were evaluated by the interviewees by assigning a score ranging from 0 to 10 for each item. To relate the different variables and constitute homogeneous groups of respondents, we used principal component analysis on the matrix of centered and reduced data (Individuals × Variables). These variables aim to qualify the types of bonds with nature and ponds, drawing on examples from the literature (Sandifer et al., 2015; López-Mosquera and Sánchez 2011). PCA allows the identification of several principal components that are linear combinations of the initial variables. The projection of individuals in the new axis system constituted by the principal components allowed us to identify homogeneous groups of individuals.

2.5.2. Definition of classes of ranked services and the nested dichotomies approach

Since regulating services is used as a *proxy* for pro-conservation attitudes, it is important to (i) characterize the respondents according to the categories of preferred services among the four under consideration in the study and (ii) identify the factors explaining the probability that an individual will rank one category of services over another.

The construction and composition of these ESs classes were determined according to the ESs types selected and prioritized. For each respondent and each of the distinguished categories of services, we established the number of hierarchized services belonging to one of the following four categories: provision, individual cultural, heritage cultural, and regulating services. This categorization into four ESs classes was made with reference to the three CICES categories, but by dividing the cultural services into two to distinguish those giving rise to direct use and those

relating to collective uses and heritage values (Izakovičová et al., 2020; Kosanic and Petzold, 2020). Because individuals had to rank or prioritize only six ESs among those selected, the dominant profile of each individual was determined by the class of ESs with the largest number of prioritized services. When individuals ranked the same number of ESs in both categories (e.g., two in provisioning services and two in regulating services), the profile of the individuals was determined using as additional information the number of ESs selected (among the 21) belonging to each category. At the end of the procedure, each subject was assigned to an ESs category.

To do so, we used a nested dichotomy model (Friendly and Meyer, 2015; Fox, 2016). The model used includes four disjoint and nested categories of services, which amounts to estimating a three-level nested dichotomy model with three choice nodes, for which the aim is to identify the factors explaining the probability that an individual will rank one category of services over another. Figure 2 shows the selected nested structure.

Each respondent had an ESs profile summarized by three values, one for each level (Figure 2). Thus, an individual who has chosen to prioritize a large number of ESs in the Provisioning services category will have a profile characterized by values (1, -, -). At Level 1 of the nested dichotomies, the econometric model determines the factors involved in the probability of ranking a large number of ESs in the provisioning services category. At Level 2, individuals classified in the individual cultural services category are coded (0, 1, -). Finally, at Level 3, the individuals are either profiled (0,0,0) for those having classified many ESs in the Heritage cultural services category or profiled (0,0,1) for those having classified many ESs in the Regulating services category. Consequently, at each level, the variable to be explained takes the form of a dichotomous variable (0.1), which

legitimizes the use of a binary logit model. The explanatory variables used accounted for the relationship with and use of ponds (module B), perceptions of the environment (module D), attitudes and behaviors (module E), and sociodemographic profile variables (module F). Two variables from Module A were also integrated: the size of the commune and the influence of the proximity of natural spaces on the choice of residential location. A total of 49 variables were included.

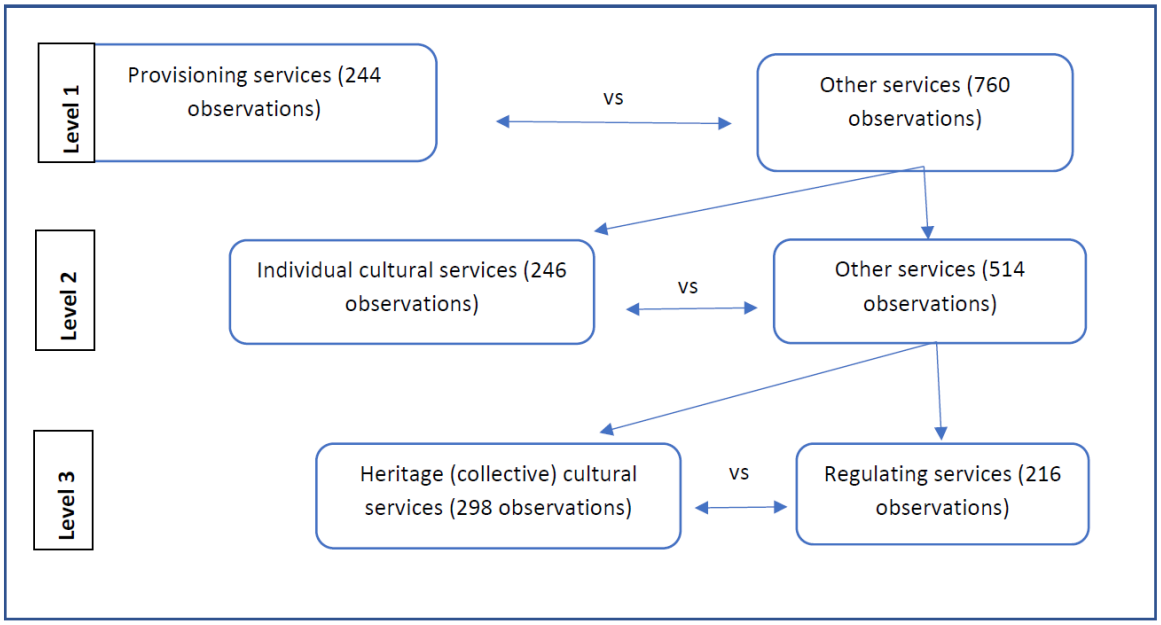


Figure 2: Characterization of the service classes

Finally, it can be shown that in nested dichotomy models, the choice probabilities at each level are independent (Friendly and Meyer 2015; Fox 2016), and it is possible to find the probability of choosing one type of service as the product of the associated probabilities at each level where the service appears. Therefore, we have:

$$Prob(Regulating\ services) = Prob\ (Regulating\ services - Level\ 3) \times Prob\ (Others - Level\ 2) \times Prob(Others - Level\ 1). \quad (1)$$

2.6. Surveyed samples

Table 3 presents the sample's main sociodemographic characteristics.

Table 3: Characteristics of the surveyed sample

Women	50%
Cohabiting couples	60%
Average age	50 years
Detached house with garden	38%
Pets	50%
Regular consumption of organic goods	28%
Retired	27%
Higher education diploma	56%
Technicians and associate professionals, employees, workers	37%
Senior managers, tradesmen, retailers, company directors	16%
Donations to environmental associations	15%
Average monthly income of the household	€ 2 900

3. Results 3.1. Visit rates and perceptions of the ponds

Concerning the frequency of ponds, 25% of the respondents had never visited this type of ecosystem. Most of the time (65%), the average visit rate ranged from several times a year to once

or twice a month, with 10% of respondents visiting the ponds more than once a month. The main activities were walking (61%), observing nature (28%), cycling (15%), photography (11%), and picnics (11%). Traditional activities such as fishing (7%) and hunting (2%) were seldom undertaken. Table 4 shows the scores (from 0 to 10) for the set of variables representing types of perception, intensity of connection, and feelings experienced with respect to the ponds and highlights the significant social and psychological contributions that they make. Furthermore, the bond with nature, using Davis et al.'s (2009) scale, scored an average of 4.7 (on a scale of seven) and was significantly correlated (p-value < 0.001) with all other perception items (Table 4).

Table 4: Evaluation of feelings experienced towards the ponds (average score out of 10)

	Mean	SD
Mankind must respect nature	8.41	2.08
Mankind must show solidarity with other species	7.87	2.33
Nature is a source of inspiration	7.26	2.10
These spaces are valuable as they are a source of well-being for mankind	7.18	2.19
Visiting these sites helps connect with nature	7.06	2.32
The beauty of these sites creates emotions in me	7.01	2.31
Visiting these sites is relaxing and reduces stress	6.96	2.54
Visiting these sites gives a feeling of freedom	6.87	2.46
Nature can come to town if the number of green spaces is increased	6.81	2.37
Visiting these sites helps communing with nature	6.68	2.63
Visiting these sites enables learning from nature	6.55	2.33

Visiting these sites improves your physical well-being	6.46	2.32
Visiting these sites gives pleasure	6.37	2.32
Visiting these sites makes you feel in better health	5.98	2.60
Visiting these sites gives a sense of fulfillment	5.87	2.45
In these sites, I feel that I am part of something bigger than myself	5.91	2.70
Visiting these sites strengthens family relationships	5.69	2.49
Nature requires the exclusion of mankind	4.62	2.92

3.2. Selection and ranking of services

As shown in Table 5, the results per category were similar in terms of the number of selected (36% to 50%) and ranked (28% to 40%) services, except for the higher scores for regulating services, which can be explained by the greater number of proposed services (Table 5).

Table 5: Number and proportion of selected and ranked services by category

Categories	Total proposed	Selected (as many as they wish)		Ranked (6 max)	
		Average number	% of the total proposed	Average number	% of the total proposed
Provisioning	4	2	50%	1.6	40%
Regulating	7	2.5	36%	2	29%
Cultural-Individual	4	1.7	43%	1.2	30%
Cultural-Heritage	4	1.7	43%	1.1	28%

3.3. Typology of perceptions and attitudes towards nature

The PCA implemented allows to build synthetic components (i.e. factorial axes)) which are linear combinations of original variables. Positioning individuals on this new axis system reveals four homogeneous groups of respondents according to their perceptions and attitudes towards nature.

Indeed, several dimensions were considered in terms of perception, emotional experience, commitment, and efforts made to protect the environment. The first four factorial axes explained over 64% of the information contained in the scatter plot or initial data table (Table 6).

Table 6: Statistical criteria of the PCA

Axes	Eigen value	% of inertia explained	% of inertia explained (cumulative)
1	8.35	39.76	39.76
2	1.96	9.37	49.13
3	1.66	7.93	57.07
4	1.50	7.18	64.24

The PCA results (Table 7) showed that the relationships between the variables could be construed around the four axes. Interestingly, these partitions involve different types of variables. Axis 1 represents a combination of variables that convey experienced feelings and individual contributions in terms of pleasure, well-being, health, and knowledge (relational variables). It reflects relational values and can therefore be named as such (Table 7). Axis 2 represents variables

that make a significant contribution, conveying perceptions that are favorable to the intrinsic value of nature (also found in axis 3, which is associated with a contribution in terms of sociability). Axes 2 and 3 were not retained because the quality of the statistical representation of significant variables is lower than that of axis 4 (cf. supplementary material). Finally, Axis 4 helps to distinguish the two variables in the questionnaire that enable the measurement of the importance (compared to others) of individual commitment to environmental protection. It accounts for pro-environmental commitment and is named as such.

Table 7: Variables' contribution to PCA axes

Module	Variables	Axis 1 Relational values		Axis 4 Pro-environmental commitment	
		Contribution to the axis	Squared cosine	Contribution to the axis	Squared cosine
Relationship with the ponds (B)	Visiting these sites helps connect with nature	7.5	62.8		
	Visiting these sites gives a feeling of freedom	7.5	62.6		
	The beauty of these sites creates emotions in me	7.2	59.9		
	Visiting these sites enables learning from nature	6.9	57.3		
	Visiting these sites makes you feel in better health	6.6	55.1		
	Ponds contribute to well-being	5.4	44.7		
Emotions felt when visiting the ponds (D)	Visiting these sites gives pleasure	6.3	52.6		
	Visiting these sites improves your physical well-being	6.2	51.5		
	Visiting these sites gives a feeling of self-fulfillment	5.9	49.6		

	Visiting these sites helps communing with nature	5.9	49.1		
	In these sites, I feel that I am part of something bigger than myself	5.4	44.9		
	Visiting these sites is relaxing and reduces stress	5.1	42.4		
	Visiting these sites strengthens family ties				
Perception of the environment (D)	Mankind must respect nature				
	Mankind must show solidarity with other species				
	I dedicate a lot of time, energy, and effort to maintaining the the environment			29.1	43.9
	Compared with other people I know, I invest a lot in the environment			27.5	41.5
	Nature requires total human exclusion				
	If we multiply the green spaces, we can recreate nature in the city				
	Advances in medicine and agriculture can reduce human dependence on nature				
	Nature is a source of inspiration not only for artists, but also for engineers, urban planners, and doctors				

The projection of individuals in the new frame comprising axes 1 and 4 allowed us to obtain the coordinates of the individuals on each of the axes. Each quadrant of the frame allowed us to identify four homogeneous groups of individuals. Table 8 presents the distribution of respondents according to the importance given to their emotions and commitment. We note a balanced score, with nearly half of the individuals having a strong commitment to the protection of nature (52%), and a quarter (27%) for whom this strong commitment is coupled with the strong role of emotions felt during attendance at natural sites.

Table 8: Distribution of respondents according to the axes of the PCA

		Pro-environmental commitment (Axis 4)	
		Weak	Strong
Relational Values (Axis 1)	Weak	24%	25%
	Strong	24%	27%

3.4. Econometric modelling

We provide the estimation results of the nested dichotomies (See Figure 2). As we assume that the final category related to regulating services (Level 3) could be used as a proxy for preferences focused on functional ecosystem conservation, it is useful to identify the cumulative set of variables involved at each stage (Levels 1, 2 and 3) of the choice process. The variables involved at each level affect as a last resort the probability that a respondent will choose regulating services (see eq. 1); that is, they have a profile that is more sensitive to the conservation of pond ecosystems.

At Level 1, the modeled probability is the probability of choosing another ESs category compared to the provisioning services category. This probability is negatively related to the score assigned by respondents to the statement "mankind must show solidarity with other species" and positively related to the score assigned to the statement "I dedicate a lot of time, energy, and effort to maintaining the quality of the environment." At Level 2, the modeled probability is the probability of choosing an ESs category other than the individual cultural services category. This probability is negatively related to the scores attributed by respondents to the following statements: "visiting these sites improves my physical well-being," "visiting these sites is relaxing and reduces stress," "nature requires total human exclusion" and not giving to environmental associations; and positively related to scores given by respondents to the following statements: "Visiting these sites enables learning from nature" and "nature is a source of inspiration...". At Level 3, the probability model is the probability of choosing the regulating services category rather than the heritage cultural services category. This probability is positively related to the fact that it is not influenced by the proximity to natural spaces when choosing residential locations. At the mean point of our sample, the probability of opting for the Regulating Services category was 0.214.

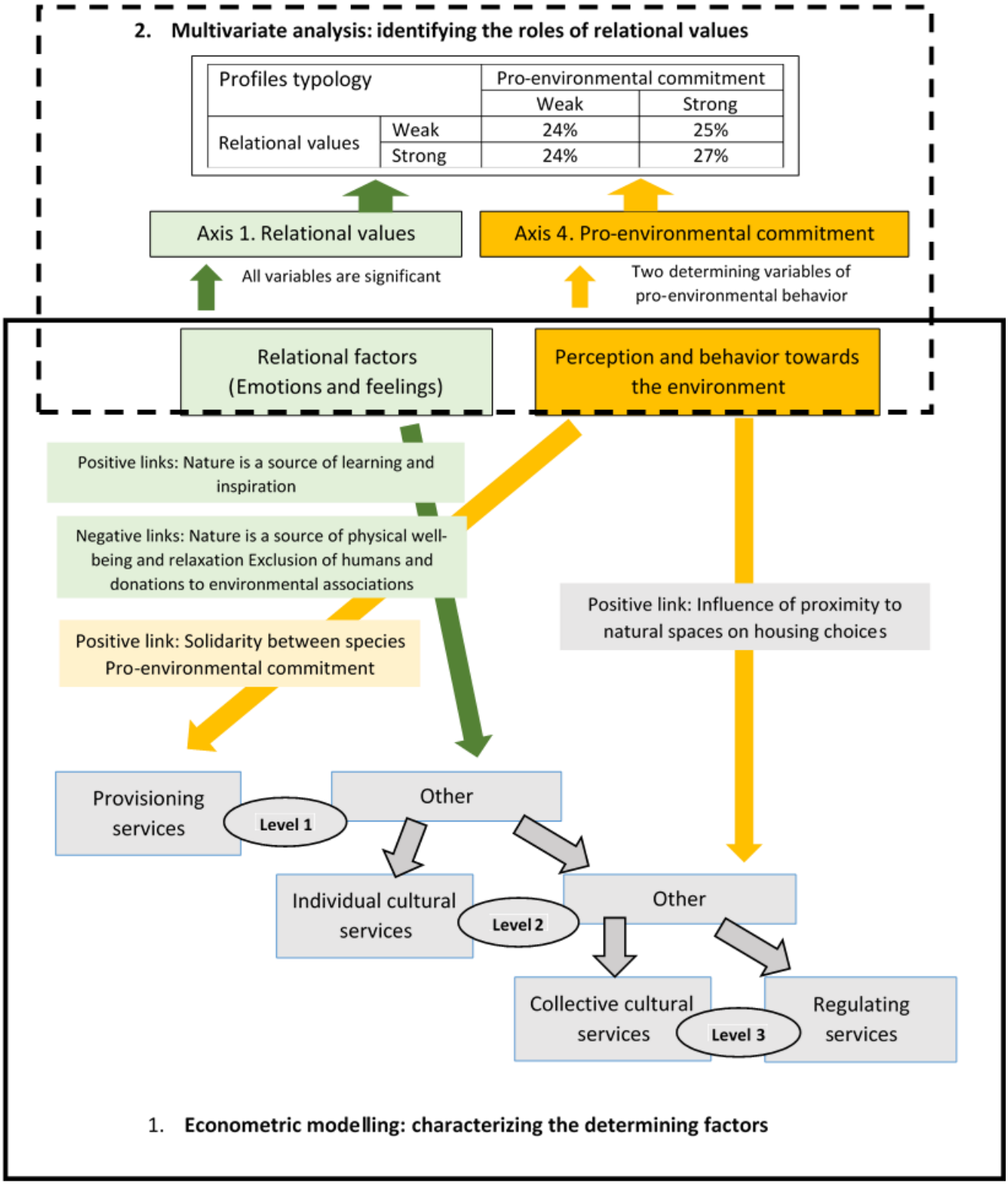
Table 9: Model results

		Explanatory variables	Estimated coefficiens	p-value
Level 1 – Provisioning services vs other services				
Modelled probability	**Individual and heritage cultural**	***Intercept***	***1.1327***	***0.0002***
		Mankind must show solidarity with other species	-0.0915	0.0096

	services and regulating services	I dedicate a lot of time, energy, and effort to maintaining the quality of the environment	0.1272	0.0002
Level 2 – Individual cultural services vs other services				
Modelled probability	**Heritage cultural services and regulating services**	***Intercept***	***0.5770***	***0.1165***
		Visiting these sites makes you learn from nature	0.1380	0.0005
		Visiting these sites improves your physical well-being	-0.1160	0.0003
		Visiting these sites is relaxing and reduces stress	-0.0986	0.0073
		Nature requires the exclusion of mankind	-0.0668	0.0419
		Nature is a source of inspiration	0.1501	0.0005
		Donations to environmental associations		
		Yes	Ref.	Ref.
		No	-0.2441	0.0367
Level 3 – Heritage-based services vs regulating services				
Modelled probability	**Regulating services**	***Intercept***	***-0.3889***	***<.0001***
		Impact of the proximity of natural spaces on housing choice		
		Yes	Ref.	Ref.
		No	0.2143	0.0244

4. Discussion The following figure compares the results of the multivariate analysis (PCA) and econometric modelling, i.e. the typology derived from relational values and pro-environmental behaviors, and the factors determining choices in favor of heritage or regulating services that come under eudaimonic well-being. Firstly, it shows that all the dimensions relating to relational values are correlated with each other and contribute to identifying the services that fall within the scope of eudaimonic well-being (level 2 of the nested dichotomies, the econometric model). Factors related to pro-environmental behavior are also involved in both analyses, but to a lesser extent than relational values since only one appears significant.

Figure 3: Summary of results


2. Multivariate analysis: identifying the roles of relational values
Profiles typology
Pro-environmental commitment
Weak
Strong
Relational values
Weak
24%
25%
Strong
24%
27%
Axis 1. Relational values
Axis 4. Pro-environmental commitment
All variables are significant
Two determining variables of pro-environmental behavior
Relational factors (Emotions and feelings)
Perception and behavior towards the environment
Positive links: Nature is a source of learning and inspiration
Negative links: Nature is a source of physical well-being and relaxation Exclusion of humans and donations to environmental associations
Positive link: Solidarity between species Pro-environmental commitment
Positive link: Influence of proximity to natural spaces on housing choices
Provisioning services
Level 1
Other
Individual cultural services
Level 2
Other
Collective cultural services
Level 3
Regulating services
1. Econometric modelling: characterizing the determining factors

4.1. Role of experience and relational interactions with nature

The typology resulting from relational interactions and commitment to the environment showed a balanced partition characterizing the four profiles (Table 8). A distinction is made between indifferent citizens who are not very sensitive (low relational value and low commitment), citizens committed with conviction who are rather sensitive to factors of eudaimonic well-being (low relational value and strong commitment), epicurean citizens who are sensitive to factors of hedonic well-being (high relational value and low commitment), and attached and pro-environmental citizens (high relational value and strong commitment). The factors differentiating these profiles partly cross the types of attitudes identified by Magda et al. (2022) by associating, on the one hand, relational attitudes with those of experience-based approaches and, on the other hand, protectionism with functionalist attitudes.

The structure of the model allows us to explain the determinants of the preferences between the ESs categories with an order of segmentation that distinguishes the first two categories of ESs (individual supply and culture), focused on individual uses, more of a hedonic nature, and regulating and heritage ESs, which are derived to more collective motivations that can be related to eudaimonic well-being, which is still rarely studied in the environmental field (Pritchard et al., 2020; Garcia Rodrigues et al., 2021). The distinction between these two perspectives on well-being corresponds to contrasting motivations and positions in terms of interest in the conservation of ecosystems. Indeed, since it reflects the value attributed to commitment, individuals whose well-being is eudaimonic are encouraged to develop pro-environmental behaviors that contribute to their life satisfaction. Thus, in a survey of the types of relationships with nature regarding the interests linked to a marine protected area, Garcia-Rodrigues et al. (2021) showed the importance

of commitment to nature, which constitutes the main explanatory factor for the variance. This approach is in line with research on the relational value of ESs (Pereira et al., 2020), which emphasizes the cultural dimension of relationships with nature. Thus, the distribution of the evaluations of the types of connection with nature (Table 4) shows that, although the average scores tend to be fairly similar, the high score for nature recognition independently of mankind and the low score for health contribution (score of 6) are noteworthy, especially as the latter is often mentioned in the literature (Sandifer *et al.*, 2015; López-Mosquera and Sánchez, 2011). Generally, these approaches link the logic of care and the need to care for nature to policies in favor of the environment (Muradian and Gomez-Baggethun, 2021).

4.2. The role of eudaimonic well-being requires appropriate awareness-raising measures

The structure of the segmentation results from the hypothesis that the respondents' choice of a greater number of heritage and regulating ESs reflects a more marked sensitivity to environmental protection (Hicks et al., 2015; Sy et al., 2018), regulating ESs, and the valuation of a local public good for heritage cultural ESs. Therefore, depending on the signs of the correlations, the proposed modeling makes it possible to define a reference profile that corresponds to a higher probability of selecting a larger share of regulating services. Regarding the results, we first note the lack of relationship with socio-demographic variables, thus confirming the role of factors relating to social psychology or behavioral economics (Croson and Treich, 2014), in particular the types of relationships with nature (Nisbet et al., 2009; Davis et al., 2009; Lewicka, 2011) and their positive role on well-being (Luck et al., 2011; Flint et al., 2013; Sanguinetti, 2014; Fretwell and Greig, 2019; Kaltenborn et al. 2020), as well as on the strengthening of pro-environmental motivations (Flint et al., 2013; Sanguinetti, 2014; Dedeurwaerdere et al., 2016; Fretwell and Greig, 2019).

There is a positive relationship with individuals' commitment in terms of efforts devoted to environmental quality. This observation points to a growing tendency to prioritize forms of civic commitment through action rather than membership in or contribution to associations (Lichterman, 2005). It can thus explain the negative relationship, a priori counter-intuitive, of the variable "donation to environmental associations," intended to identify a sensitivity in favor of the environment. Thus, the characterized profile corresponds to individuals who prefer an active commitment to financial participation. This notion of commitment, which refers to the components of eudaimonic well-being and, although less studied, constitutes a determining factor of pro-environmental attitudes (Larson et al. 2019), This notion of eudaimonic well-being can be compared to the category of self-transcendence values highlighted by Hicks et al. (2015) on ESs related to coral reefs. These authors showed interest in psychological dimensions to identify motivations with self-transcendent values that reinforce behaviors in favor of the protection of ecosystems and collaborative approaches.

Therefore, awareness-raising and communication measures must consider these different commitment profiles, knowing that the conservation of ecosystems can fall under the register of the common good or the familiarity regime for its heritage dimension, as well as engagement in individual plans if individuals are committed to maintaining the amenities from which they benefit. It is, therefore, necessary to analyze, through specific studies, the determinants of these motivations and to propose, according to learning, deliberation, and participation systems, to promote the development of motivations and commitments in favor of the protection of nature, knowing that psychologists also highlight positive iterations between hedonic and eudaimonic

well-being (Ryan and Deci, 2001; Peterson et al., 2013). Thus, to diversify and strengthen engagement, innovative forms of learning should be promoted by strengthening familiarity with and reasoned use of ecosystems and, more generally, by developing information related to ecosystems (Sy et al., 2021). According to Renault-Tinacci et al. (2016), the promotion of active citizenship presupposes transformative learning methods in which learning takes place through (and no longer on) processual and experiential devices that facilitate engagement. This experiential need was found in the results of the model, which showed a positive relationship with the wish to not exclude people from nature. However, we should be cautious about the role of commitment in light of work on empowerment, particularly in Anglo-Saxon countries where these practices, which are very frequent, are often denounced for the weakness of effective learning when they are irregular and for the acceptance they generate regarding situations and inequalities (Eliasoph and Lichterman, 2003; Talpin, 2011; Eliasoph, 2011). Regarding the links to nature, the two significant variables that relate positively concern "a better knowledge of the functioning of ecosystems" and the fact of "considering nature as a source of inspiration." They provide evidence of the importance of local knowledge built through familiarity with ecosystems and an interest in biomimicry (Benyus, 1997). The negative relationship observed for the variable "contribution to physical or mental well-being" confirms that the pro-environmental motivations of this individual profile do not stem from hedonic motives. Finally, there was an explicit desire to live close to natural ecosystems, which was the only variable that distinguished preferences between heritage and regulating services. It arises here independently of the rural or urban context (size of the municipality) often mentioned (Lapointe et al., 2020). This type of variable refers to the influence of lifestyle and attachment to place and, therefore, to the role of lifestyle and context in life satisfaction.

In part, we found results of research aimed at integrating psychological dimensions to study the types of connections individuals have with nature. Still little developed concerning ESs, Kaltenborn et al. (2020) study these aspects, particularly concerning CESs, highlighting the important role of attachment and contribution to the quality of life in the territory studied in northern Norway. This importance is confirmed by Elwell et al. (2020) in the particular case of communities in southern countries dependent on provisioning services, for which one might have thought that the relative importance of cultural or regulating ecosystem services such as the beauty of landscapes or biodiversity were lower, which is not the case. From the perspective of collective action, this potential for engagement could be strengthened by developing and popularizing knowledge and opportunities for local engagement to enable, in conjunction with the psychological theory of motivation, autonomous learning (Dedeurwaerdere et al., 2016). Here, we can quote the work of Pedersen et al. (2019), which shows the importance of interest in scientific knowledge related to ecosystems not only on the connection to nature of individuals but also on their attitude and desire to preserve ecosystems, as well as more generally on their psychological well-being. Moreover, the theory of planned behavior (Ajzen, 1985; Ajzen and Fishbein, 1980; De Leeuw et al., 2015) insists on the importance of the role of perceptions in the types of attitudes, emphasizing that these are also determined by the feeling of control over behavior within communities.

4.3. Implications for the governance of environmental policies

The combination of these results defines a coherent individual profile in which the importance of eudaimonic dimensions in well-being related to relationships with nature expresses the existence of pro-environmental motivations and commitment to environmental protection. Thus, these

profiles imply different sensitivities to incentives and forms of sensitization. Thus, it is possible to specify the acceptability of conservation measures according to the type of measures and implementation methods. Magda et al. (2022) insisted on the need for a constructivist approach to management measures, considering the differences in familiarity (the importance of frequenting natural areas) and attachment in the relationship of individuals to nature (Braito et al., 2017). A literature review on the interactions between scientific knowledge and decisions by Bitounet et al. (2022) on ESs mapping emphasizes the deficit and need for stakeholder participation and citizen awareness. Thus, considering the diversity of explanatory factors of behavior makes it possible to better understand motivations and anticipate behaviors in order to adapt incentive schemes (Hicks et al., 2015). This type of analysis allows identifying levers favorable to pro-environmental behavior, that is, ideally, by combining factors relating to eudaimonic or hedonic well-being to associate all determinants (Magda et al., 2022).

Therefore, the quality of governance arrangements also determines an individual's commitment to the environment (Lima and Bastos, 2020), considering that the concept of ecosystem services constitutes a reference framework that facilitates collective action (Langemeyer et al., 2018; Moreau et al., 2019). In particular, since learning and motivation involve regular visits to ecosystems (Lima and Bastos, 2020), especially from childhood (Prévot et al., 2018; Fretwell and Greig, 2019), these governance arrangements must allow for the adequate regulation of attendance. The organization of measures within governance arrangements implies taking into account two important levers or constraints. On the one hand, Cazalis and Prévost (2019) showed that the ability of citizens to adopt environmental behaviors is a function not only of their experiences of nature (in particular, outdoor activities) but also of the intensity of conservation policies carried out within

protected areas. These authors highlighted the correlation between changes in behavior and the proximity and attendance of frequented spaces. Nevertheless, incentives to develop experience, familiarity, and knowledge of ecosystems (Jacob et al., 2016) to reinforce protection motivations based on relational values must be strictly framed. Indeed, it is necessary to be vigilant of the fact that these relational factors must not induce over-frequentation of these ecosystems, which would be harmful to their conservation as denounced (Arif et al. 2022) concerning the impact of tourist activities on water resources and, more generally, on ecological indicators that the authors show are strongly impacted (72%) by these flows.

5. Conclusion

This article presents the lessons learned from a survey of ES perceptions. This survey was designed to include a large number of questions on the types of connections and feelings in relation to nature to test the influence of the factors increasingly identified as determinants of attitudes. The study was conducted using a large sample (1,006 respondents) across the entire French mainland. This study aims to understand the determinants of relational value by identifying the diversity of individual profiles and motivations. We must emphasize the absence of significant sociodemographic variables in the results of econometric modeling, which justifies the need to consider these psychological dimensions. This type of survey largely focused on closed questions based on a cardinal metric (a scale of 0 to 10 for the majority of questions) but did not allow for detailing the complexity and associations of psychological factors, values, and norms that explain behavior. Moreover, since the question is to understand better the aptitudes toward changes in behavior in the logic of transition, this type of survey does not make it possible to study the changes generally falling under more qualitative approaches in terms of the life course.

The analysis shows a partition of perceptions that distinguishes hedonistic motivations from more collective and heritage forms of commitment that fall under eudaimonic motives, which are conducive to pro-environmental behavior in favor of the protection of ecosystems. The analysis of the determinants confirms the specificity of the profiles favoring heritage or regulating ES, which assume that conservation motivations are not limited to hedonic motives focused on elements of individual well-being. Indeed, while the ES framework offers an anthropocentric approach, considering the components of well-being that are mobilized (hedonic and eudaimonic), as well as the determinants of commitment to nature, makes it possible to refine this anthropocentric dimension. The central point is to show that individuals favoring regulating and heritage ESs develop sensitivity more oriented towards the preservation of the common good than toward amenities or individual satisfaction. Even if the two perspectives, hedonic and eudaimonic, on well-being interact (Disabato et al., 2016), and if awareness and interest in conservation imply familiarity with these ecosystems, the consideration of these nuances aims to better understand the determinants of pro-environmental behavior to improve environmental conservation policies (Kollmuss and Ageyman, 2002; De Leeuw et al., 2015). Thus, our results argue for public policies to strengthen the commitment of users and citizens as well as the processes of local autonomous learning, information, and knowledge of the functioning of ecosystems by supporting local initiatives and recognizing local knowledge. It is also important to generalize the analysis of citizens' and stakeholders' perceptions and emotions to account for the evolution of the types of bonds to nature and strengthen pro-conservation development pathways.

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Supplementary material: Details of the contributions of all the PCA axes

Module	Variables	Axis 1		Axis 2		Axis 3		Axis 4	
		A	B	A	B	A	B	A	B
Relationship with the ponds (B)	Visiting these sites helps connect with nature	7.5	62.8						
	Visiting these sites gives a feeling of freedom	7.5	62.6						
	The beauty of these sites creates emotions in me	7.2	59.9						
	Visiting these sites enables learning from nature	6.9	57.3						
	Visiting these sites makes you feel in better health	6.6	55.1						
	Ponds contribute to well-being	5.4	44.7						
Emotions felt when visiting the ponds (D)	Visiting these sites gives pleasure	6.3	52.6						
	Visiting these sites improves your physical well-being	6.2	51.5						
	Visiting these sites gives a feeling of self-fulfillment	5.9	49.6						
	Visiting these sites helps communing with nature	5.9	49.1						
	In these sites, I feel that I am part of something bigger than myself	5.4	44.9			12.4	20.7		
	Visiting these sites is relaxing and reduces stress	5.1	42.4						
	Visiting these sites strengthens family ties					11.9	19.8		
Perception of the environment (D)	Mankind must respect nature			14.9	29.3	15.0	24.9		
	Mankind must show solidarity with other species			12.2	24.1	13.5	22.5		
	I dedicate a lot of time, energy, and effort to maintaining the quality of the environment							29.1	43.9
	Compared with other people I know, I invest a lot in the environment							27.5	41.5
	Nature requires total human exclusion								
	If we multiply the green spaces, we can recreate nature in the city								
	Advances in medicine and agriculture can reduce human dependence on nature								
	Nature is a source of inspiration not only for artists, but also for engineers, urban planners, and doctors								

A= contribution to the axis; B= squared cosine