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

Helene Rey-Valette, Thierry Blayac, Jean-Michel A Salles

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

Hélène Rey-Valette, Thierry Blayac, Jean-Michel Salles
CEE-M, Université de Montpellier, France

Abstract

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

Key words: Ecosystem services; Nature perceptions; Well-being, Fish-farming ponds.

Highlights:

Assessment of the contribution of ecosystem services to the well-being of residents

Influence of connection to nature on perceptions of ecosystem services

Link between life satisfaction and significance of ecosystem services on well-being

Commitment to nature and life satisfaction

The contribution of ecosystem services to well-being as a proxy for demand for services

1. Introduction

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

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

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

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

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

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

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

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

21. Well-being assessments: what the literature says

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

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

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

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

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

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

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

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

3.1. Questionnaire design

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

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

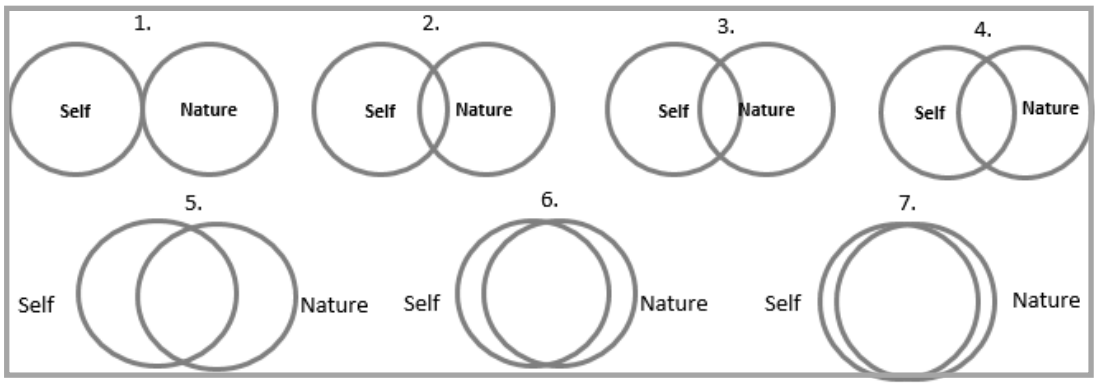

Figure 2: Measurement scale of the link to nature (Davis *et al*., 2009)

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 et *al.*, 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.

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

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

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

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

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

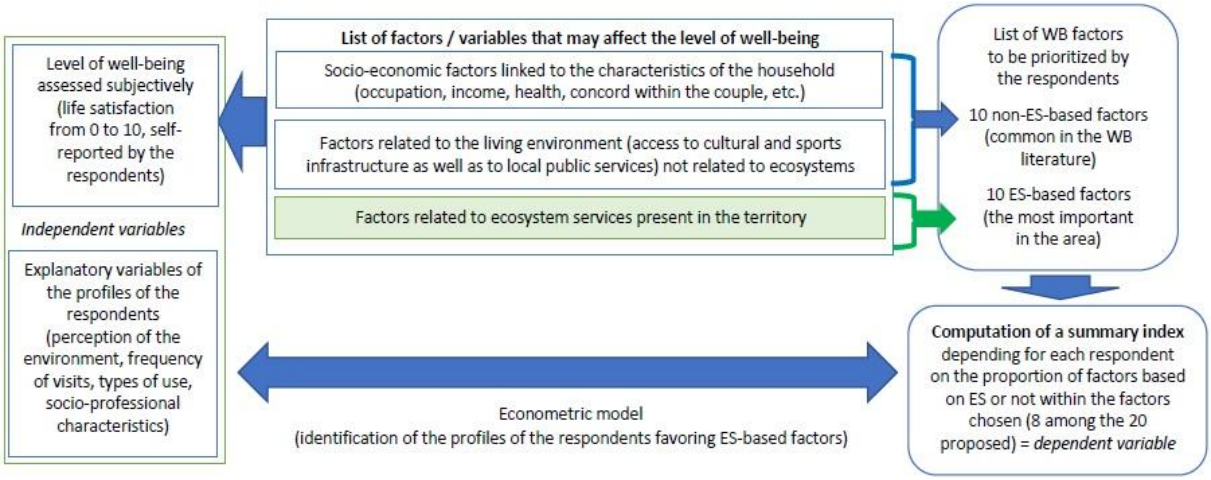

Figure 3: Selection of the WB factors and place in the research design

3.2. Survey implementation

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

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%

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

3.3. Statistical analysis

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

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

A latent variable Z_i is then defined which takes the following form for a given indidividual *i*:

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

Where X_{i1}, X_{i2}, X_{i3} and X_{i4} are the values taken by the explanatory variables for individual *i*, α_0 to α_4 are coefficients to be estimated and ε_i is a random term.

The Z_i function incorporates factors or variables that are likely to explain the probability that an individual *i* will have a ESs_dependent WB profile. These explanatory factors can be grouped into 4

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

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

The following figure summarizes the different statistical steps.

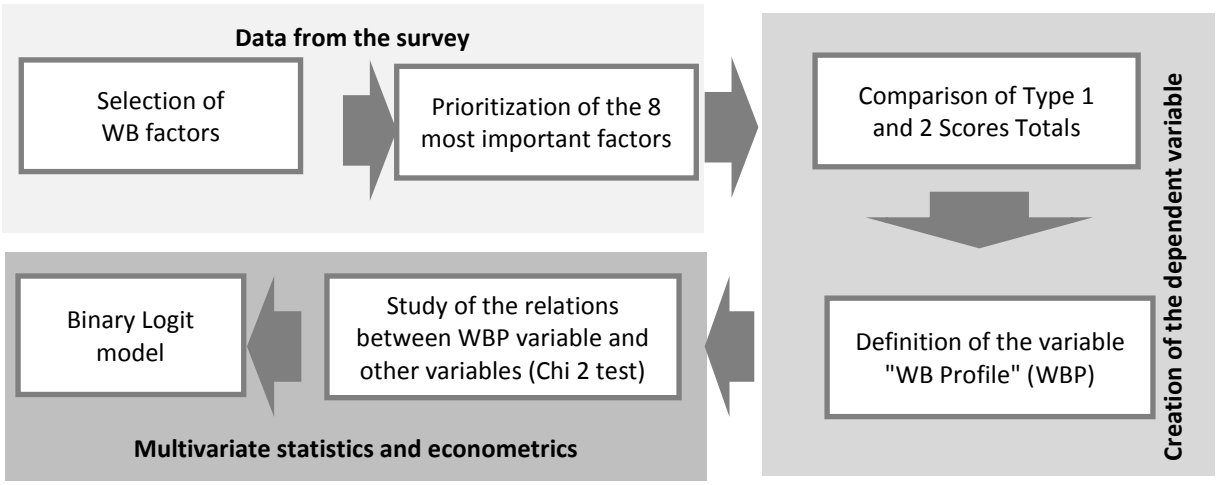

Figure 4: Steps of the econometric modeling

3.4. Surveyed sample

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

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

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

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

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
These spaces have value for nature independently of humans	**7.6**
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
Visiting these sites gives a feeling of freedom	**6.9**
Visiting these sites helps communicate with nature	6.7
Visiting these sites enables learning from nature	6.6
Visiting these sites improves your physical well-being	**6.5**
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	
I dedicate a lot of time, energy and effort to maintain the quality of the environment	**5.9**
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)	**4.7**

Source: Online survey by CEE-M, 2018

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

4.2. Analysis of life satisfaction and ranking of WB factors

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

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	
No noise	**68%**	**4.5**	**5**	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	
Micro climate related to the proximity of the ponds	**13%**	**4.9**	**7**	Type 2 ES-based (Regulating Services)
Air quality	**74%**	**5.1**	**8**	
Proximity of healthy natural spaces	**52%**			
Flood reduction effect of ponds	**15%**			
Revitalizing nature of pond proximity	**57%**	**5.3**	**9**	Type 2 ES-based (Cultural Services)
Feeling of freedom related to the proximity of the ponds	**50%**	**5.4**	**10**	
Proximity of recreational sites	**61%**	**5.5**	**11**	
Cultural and sporting activities	43%	5.7	12	Type 1 Non-ES-based
Beauty of landscapes near the ponds	**62%**	**5.8**	**13**	Type 2 ES-based (Cultural Services)
Easy transport	45%	5.8	13	Type 1 Non-ES-based
Social bonds related to nature	**18%**	**6.0**	**14**	Type 2 ES-based (Cultural Services)
Quality of democracy	22%	6.1	15	Type 1 Non-ES-based

Source: Online survey CEE-M, 2018

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

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

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

4.4. Econometric modelling

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

Table 8: Estimated coefficients of the logit regression

Variable		**Estimated Coefficient (*p-value*)**	**Type and Measure**
Intercept		0.3650 (*0.7505*)	/
Category A: Relatedness to nature			
Intensity of the link to nature (Davis *et al.,* 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*)	
Category B: Pond perception and number of visits to the ponds			
Therapeutic value of the ponds (sum of health contribution and feeling of freedom according to Bryce *et al.,* 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*)	
Category C: Socio-demographic characteristics			
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*)	
Category D: Life satisfaction			

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*)	

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

5. Discussion

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

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

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

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

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

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

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

Conclusion

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

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

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

Acknowledgements

This work was supported by the *Observatoire Homme Milieu* (OHM) program of the French Institute for Ecology and Environment (INEE/CNRS) and by the Metaprogram EcoServ (INRA). The authors thank Nicole Lautrédou-Audouy for organizing the online survey and the database and Fériel Adjeroud for preliminary statistical analysis. They express their gratitude to the anonymous referees whose criticisms and comments have significantly improved the paper.

References

Abunge, C., Coulthard, S., Daw, T.M., 2013. Connecting Marine Ecosystem Services to Human Well-being: Insights from Participatory Well-being Assessment in Kenya, *Ambio*, 42, 1010-1021.

Antoine, P., Poinsot, R., Congard, A., 2007. Evaluer le bien-être subjectif : la place des émotions dans les psychothérapies positives. *Journal de Thérapie Comportementale et Cognitive*, *17* (4), 170-180.

Antunez, K., Haran, L., Roussez, V., 2016. Diagnostics de qualité de vie : prendre en compte les préférences des populations. *Revue de l'OFCE*, 145, 49-62.

Baldwin, R.F., Powell, R.B., Kellert, S.R., 2011. Habitat as Architecture: Integrating Conservation Planning and Human Health. *Ambio*, 40, 322-327.

Bark, R.H., Robinson, C.J., Flessa, K.W., 2016. Tracking cultural ecosystem services: Water chasing the Colorado River restoration pulse flow. *Ecological Economics*, 127, 165–172.

Barton, J., Pretty, J., 2010. What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environ. Sci. Technol*. 44 (10), 3947-3955.

Benabou, R., Tirole, J., 2006. Intrinsic and extrinsic motivations. *Review of Economics Studies*, *70* (3), 489-520.

566 Bernard, C., 2008. *L'étang, l'homme et l'oiseau. Incidences des modes de gestion des étangs piscicoles*
567 *sur les ceintures de végétation et l'avifaune nicheuse en en Sologne, Brenne, Bresse, Territoire de*
568 *Belfort et Champagne humide*. Thèse de Géographie, ENS Lettres et Sciences Humaines, Univ. Lyon,
569 632 p.
570
571 Bigot, R., Croutte, P., Daudey, E., Hoibian, S., Müller J., 2012. *L'évolution du bien-être en France*
572 *depuis 30 ans*. Credoc Cahier de Recherche N° 298, 158 p.
573
574 Billard, R., 2010. *Derrière chez moi, il y a un étang. Les étangs, textes d'hier, regards d'aujourd'hui et*
575 *de demain*, Quae, Paris.
576
577 Blayac T., Mathé S., Rey-Valette H., Fontaine P., 2014. Perceptions of the services provided by pond
578 fish farming in Lorraine (France), Ecological Economics, 108, 115-123
579
580 Blythe, J., Armitage, D., Alonso, G., Campbell, D., Esteves Dias, A.C., Epstein, G., Marschke, M., Nayak,
581 P., 2020. Frontiers in coastal well-being and ecosystem services research: A systematic review. *Ocean*
582 *and Coastal Management* 185, 105028, 10 p.
583
584 Browning, M., Lee, K., 2017. Within what distance does "greenness" best predict physical health? A
585 systematic review of articles with GIS buffer analyses across the lifespan. *International journal of*
586 *environmental research and public health*, *14* (7), 675.
587
588 Bryce, R., Irvine, K.N., Church, A., Fish, R., Ranger, S., Kenter, J.O., 2016. Subjective well-being
589 indicators for large-scale assessment of cultural ecosystem services. *Ecosystem Services*, 21, 258-269.
590
591 Chan, C., Armitage, D., Alexander, S. M., Campbell, D., 2019. Examining linkages between ecosystem
592 services and social wellbeing to improve governance for coastal conservation in Jamaica. *Ecosystem*
593 *Services*, *39*, 100997.
594
595 Clark, A. E., Etilé, F., Postel-Vinay, F., Senik, C., Van Der Straeten, K., 2005. Heterogeneity in reported
596 well-being: evidence from twelve european countries. *Economic Journal,* 115, 118-132.
597
598 Clark, A. E., Oswald, A. J., 2002. A simple statistical method for measuring how life events affect
599 happiness. *International Journal of Epidemiology,* 31, 1139-1144.
600
601 Commissariat Général à l'Egalité des Territoires (CGET), 2017. Perception des conditions de vie : des
602 contrastes selon les territoires de résidence. *Rubrique en Bref* n°40, juin, 4 p.
603
604 Costanza, R., De Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., Grasso, M.,
605 2017. Twenty years of ecosystem services: how far have we come and how far do we still need to
606 go?. *Ecosystem services*, *28*, 1-16.
607
608 Coulthard, S., Johnson, D., McGregor, J.A., 2011. Poverty, sustainability and human well-being: a
609 social well-being approach to the global fisheries crisis. *Global Environnemental Change* 21 (2), 453-
610 463.
611
612 Croson, R., Treich, N., 2014. Behavioral environmental economics: promises and challenges.
613 *Environmental and Resource Economics*, 58, 335-351.
614
615 Cox, D.T.C., Shanahan, D.F., Hudson, H.L., Plummer, K.E., Siriwardena, G.M., Fuller, R.A., Anderson, K.,
616 Hancock, S., Gaston, K.J., 2017. Doses of neighborhood nature: The benefits for mental health of
617 living with nature. *Bioscience*, 67 (2), 147-155.

618
619 Davis, J.L., Le, B., Coy, A.E., 2011. Building a model of commitment to the natural environment to
620 predict ecological behavior and willingness to sacrifice. *Journal of Environmental Psychology*, *31* (3),
621 257-265.
622
623 Davis, L. A. Jeffrey, D. Green, A, Reed, A., 2009. Interdependence with the environment:
624 Commitment, interconnectedness, and environmental behavior *Journal of Environmental Psychology*,
625 29, 173-180.
626
627 Daw, T.M., Hicks, C.C., Brown, K., Chaigneau, T., Januchowski-Hartley, F.A., Cheung, W.W.L.,
628 Rosendo, S., Crona, B., Coulthard, S., Sandbrook, C., Perry, C., Bandeira, S., Muthiga, N.A., Schulte-
629 Herbrüggen, B., Bosire, J., McClanahan, T.R., 2016. Elasticity in ecosystem services: Exploring the
630 variable relationship between ecosystems and human well-being. *Ecology and Society*, 21(2), 11-24.
631
632 De Vreese, J.R., Leys, M., Fontaine, C.M., Dendonker, N., 2016. Social mapping of perceived
633 ecosystem services supply. The role of social landscape metrics and social hotspots for integrated
634 ecosystem services assessment landscape planning and management. *Ecological Indicators*, 66, 517-
635 533.
636
637 Delgado, L.E., Marin, V.H., 2016. Well-being and the use of ecosystem services by rural households of
638 the Rio Cruces watershed, southern Chile. *Ecosystem Services*, 21, 81-91.
639
640 Diener, E., Suh, E.M., Lucas, R.E., Smith, H.L., 1999. Subjective well-being: Three decades of progress,
641 *Psychological Bulletin,* 125, 276-302.
642
643 Dolan, P., Layard, R., Metcalfe, R., 2011. *Measuring Subjective Well-being for Public Policy*. Office for
644 National Statistics, Newport, 19 p.
645
646 Douglas, I., 2012. Urban ecology and urban ecosystems: understanding the links to human health and
647 well-being. *Current Opinion in Environmental Sustainability*, *4*(4), 385-392, 4 (4), 385-392.
648
649 Dunlap, R. E., Van Liere, K. D., Mertig, A., Jones, R.E., 2000. Measuring endorsement of the new
650 ecological paradigm: a revised NEP scale. *Journal of Social Issues*, 56, 425-442.
651
652 Fagerholm, N., Martín-López, B., Torralba, M., Oteros-Rozas, E., Lechner, A.M., Bieling, C., Stahl
653 Olafsson, A., Albert, C., Raymond, C.M., Garcia-Martin, M., Gulsrud, N., Plieninger, T., 2020.
654 Perceived contributions of multifunctional landscapes to human well-being: Evidence from 13
655 European sites, *People and Nature.,* 2, 217-234
656
657 Farrow, K., Grolleau, G., Ibanez, L., 2017. Social norms and pro-environmental behavior: A review of
658 the evidence. *Ecological Economics*, *140*, 1-13
659
660 Frey, B., Stutzer, A., 2002. *Happiness and Economics: How the Economy and Institutions Affect*
661 *Human Well-Being*. Princeton University Press, Princeton.
662
663 Frey, B.S., Luechinger, S., Stutzer, A., 2009. *The Life Satisfaction approach (LSA) to environmental*
664 *valuation*. IZA Discussion paper N° 4478, 29 p.
665
666 Godefroy, P., 2011. Satisfaction dans la vie : les personnes se donnent 7 sur 10 en moyenne. *INSEE,*
667 *France, Portrait Social. Insee Références*, *105*, 118 p
668

669 Haines-Young, R., Potschin-Young, M., 2018. Revision of the common international classification for
670 ecosystem services (CICES V5. 1): a policy brief. *One Ecosystem*, *3*, e27108.
671
672 Jacobs, S., Dendoncker, N., Martín-López, B., Barton, D.N., Gomez-Baggethun, E., Boeraeve, F.,
673 McGrath, F.L., Vierikko, K., Geneletti, D., Sevecke, K.J., Pipart, N., Primmer, E., Mederly, P., Schmidt,
674 S., Aragão, A., Baral, H., Bark, R.H., Briceno, T., Brogna, D., Cabral, P., De Vreese, R., Liquete, C.,
675 Mueller, H., Peh, K.S.H., Phelan, A., Rincón, A.R., Rogers, S.H., Turkelboom, F., Van Reeth, W., van
676 Zanten, B.T., Wam, H.K., Washbourn, C.L., 2016. A new valuation school: Integrating diverse values of
677 nature in resource and land use decisions. Ecosystem Services, 22, 213–220.
678
679 Kahneman, D., Krueger, A.B., 2006. Developments in the Measurement of Subjective Well-Being.
680 *Journal of Economic Perspectives*, 20 (1), 3-24.
681
682 Kahneman, D., Diener, E., Schwartz, N., 1999. *Well-being: The Foundations of Hedonic Psychology*
683 Russel Sage Foundation, New York.
684
685 Kamitsis, I., Francis, A.J.P., 2013. Spirituality mediates the relationship between engagement with
686 nature and psychological wellbeing. *Journal of Environnemental Psychology*, 36, 136–143.
687
688 Kele, R., 2012. The quality of life and the environment. *Social and Behavioral Sciences*, 35, 23-32.
689
690 Klain, S. C., Satterfield, T. A., Chan, K. M. A., 2014. What matters and why? Ecosystem services and
691 their bundled qualities. *Ecological Economics*, *107*, 310-320.
692
693 Korpela K., Borodulin K., Neuvonen M., Paronen O., TyrväinenL., 2014, Analyzing the mediators
694 between nature-based outdoor recreation and emotional well-being, *Journal of Environmental*
695 *Psychology* 37, 1-7
696
697 Kosanic A., Petzold J., 2020. A systematic review of cultural ecosystem services and human wellbeing,
698 *Ecosystem Services*, 45, 101168
699
700 Lewicka M., 2011. Place attachment: How far have we come in the last 40 years? *Journal of*
701 *Environmental Psychology* 31 (3), 207-230.
702
703 Liquete, C., Piroddi, C., Drakou, E.G., Gurney, L., Katsanevakis, S., Charef, A., Egoh, B., 2013. Current
704 Status and Future Prospects for the Assessment of Marine and Coastal Ecosystem Services: A
705 Systematic Review. *PLoS One* 8, e67737.
706
707 López-Mosquera, N., Sánchez, M., 2011. The influence of personal values in the economic-use
708 valuation of peri-urban green spaces: An application of the means-end chain theory. *Tourism*
709 *Management* 32(4), 875-889.
710
711 MA, 2005. *Ecosystem and Human Well-being: A framework for Assessment*. Island Press, Washington
712 DC, 563 p.
713
714 MacKerron, G., Mourato, S., 2013. Happiness is greater in natural environments. *Global*
715 *Environmental Change*, *23*(5), 992-1000.
716
717 Marschke, M., Berkes, F., 2006. Exploring strategies that build livelihood resilience: a casefrom
718 Cambodia. *Ecological Society*, 11 (1).
719

Martín-López, B., Iniesta-Arandia, I., García-Llorente, M., Palomo, I., Casado-Arzuaga, I., Del Amo, D. G., Gomez-Baggethun, E., Oteros-Rosaz, E., Palacios-Agundez, I., Willaarts, B., González, J. A., Santos-Marti, F., Onaindia, M., Lopez-Santiago, C., Montes, C., 2012. Uncovering ecosystem service bundles through social preferences. *PLoS one*, *7* (6), e3897.

Martinez-Suarez, P., Chiabai, A., Taylo,r T., Quiroga Gomez, S., 2015. The impact of ecosystems on human health and well-being: a critical review. *Journal of Outdoor Recreation and Tourism* 10, 63-69.

Meinard, Y. Quetier, F., 2014. Experiencing biodiversity as a bridge over the science–society communication gap. *Conservation Biology*, 28 (3), 705-712.

Milfont, T.L., Duckitt, J., 2010. The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology*, *30* (1), 80-94.

Moser, G., 2009. Quality of life and sustainability: Toward person–environment congruity. *Journal of Environmental Psychology,* 29, 351-357.

Nisbet, E.K., Zelenski, J.M., Murphy, S.A., 2009. The nature relatedness scale: Linking individual' connection with nature to environmental concern and behavior. *Environment and Behavior*, 41 (5), 715-740.

OECD, 2014. *How's Life in Your Region? Measuring Regional and Local Well-being for Policy Making*, OECD Publishing, Paris.

Omolo, N., Mafongoya, P.L., 2019. Gender, social capital and adaptive capacity to climate variability: A case of pastoralists in arid and semi-arid regions in Kenya. Int. J. Clim. Change Strategies Manage. 11 (5), 744–758.

Plieninger, T., Dijks, S., Oteros-Rozas, E., Bieling, C., 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land use Policy*, *33*, 118-129.

Polishchuk, Y., Rauschmayer, F. 2012. Beyond ''benefits''? Looking at ecosystem services through the capability approach. *Ecological Economics,* 81, 103–111.

Prévot, A.C., Geijzendorffer, L., 2016. Biodiversité, services écosystémiques et bien être. In Roche P., Geijzendorffer L., Levrel H., Maris V., *Valeurs de la biodiversité et services écosystémiques. Perspectives interdisciplinaires*. Quae, Paris, 89-101.

Queiroz, C., Meacham, M., Richter, K., Norström, A. V., Andersson, E., Norberg, J., Peterson, G., 2015. Mapping bundles of ecosystem services reveals distinct types of multifunctionality within a Swedish landscape. *Ambio*, *44* (1), 89-101.

Raudsepp-Hearne, C., Peterson, G. D., Bennett, E. M., 2010. Ecosystem service bundles for analyzing trade-offs in diverse landscapes. *Proceedings of the National Academy of Sciences*, *107* (11), 5242-5247.

Raymond, C.M., Singh, G.G., Benessaiah, K., Bernhardt, J.R., Levine, J., Nelson, H., et al., 2013. Ecosystem services and beyond: using multiple metaphors to understand human–environment relationships. *Bioscience,* 63 (7), 536-546.

Renard, D., Rhemtulla, J. M., Bennett, E. M., 2015. Historical dynamics in ecosystem service bundles. *Proceedings of the National Academy of Sciences* PNAS, 112 (43), 13411-13416.

Rey-Valette, H., Salles, J.M., Mathé, S., 2017. An assessment method of ecosystem services based on stakeholders' perceptions: The Rapid Ecosystem Services Participatory Appraisal (RESPA). *Ecosystem Services,* 28, 311-319.

Reynard, R., 2016. La qualité de vie dans les territoires français. *Revue de l'OFCE*, 145, 63-90.

Sandifier, P.A, Sutton-Grier, A. E., Ward, B. P., 2015. Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. *Ecosystem Services*, 12, 1-15.

Seligman, M. E., Parks, A. C., Steen, T., 2004. A balanced psychology and a full life. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *359* (1449), 1379-1381

Sen, A., 1979. Equality of what?, *The Tanner Lectures on Human Value*, Salt Lake City, University of Utah Press.

Shanahan, D.F., Franco, L., Lin, B.B., Gaston, K.J., Fuller, R.A., 2016. The benefits of natural environments for physical activity. *Sports Med*., 46 (7), 989-995.

Shankland, R., Martin-Krumm, C., 2012. Evaluer le fonctionnement optimal : échelles de psychologie positive validées en langue française, *Pratiques Psychologiques,* 18, 171-187.

Smith, L.M., Case, J.L., Smith, H. M., Harwell, L.C., Summers J.K., 2013. Relating ecosystem services to domains of human well-being: Foundation for a U.S. index. *Ecological Indicators,* 28, 79-90.

Summers, K., Harwell, L.C., Smith, L.M., 2016. A model for change: An approach for forecasting well-being from service-based decisions, *Ecological Indicators*, 69, 295-309.

Sunstein, C.R., Reich, L.A., 2014. Automatically green: Behavioral economics and environmental protection. *Harvard Environmental Law Review*, 38, 127-158.

Sy, M., Rey-Valette, H., Figuières, C., Simier, M., De Wit, R., 2020. *The Impact of Academic Information Supply and Familiarity on Ecosystem Services Perceptions*. *Ecological Economic*, Forthcoming, 28 p.

Sy, M., Rey-Valette, H., Simier, M., Pasqualini, V., Figuières, C., De Wit, R., 2018. Identifying consensus on coastal lagoons ecosystem services and conservation priorities for an effective decision making: A Q approach. *Ecological Economic*, 154, 1-13.

Turner, K. G., Odgaard, M. V., Bøcher, P. K., Dalgaard, T., Svenning, J. C., 2014. Bundling ecosystem services in Denmark: trade-offs and synergies in a cultural landscape. *Landscape and Urban Planning*, *125*, 89-104.

Tsunetsugu, Y., Lee, J., Park, B.-J., Tyrväinen, L., Kagawa, T., Miyazaki, Y., 2013. Physiological and psychological effects of viewing urban forest landscapes assessed by multiple measurements. Landscape Urban Plann. 113, 90–93.

Vanacker, M., Wezel, A., Payet, V., Robin, J., 2015. Determining tipping points in aquatic ecosystems: The case of biodiversity and chlorophyll α relations in fish pond systems. Ecological Indicators. 52, 184-193.

824 Vemuri, A.W., Costanza, R., 2006. The role of human, social, built, and natural capital in explaining
825 life satisfaction at the country level: Toward a National Well-Being Index (NWI), *Ecological Economics*,
826 58, 119-133.
827
828 Watson, D., Clark, L.A., Tellegen, A., 1988. Development and validation of brief measures of positive
829 and negative affect: The PANAS scale. *Journal of Personality and Social Psychology*, 54, 1063-1070.
830
831 Willis, C., Papathanasopoulou, E., Russel, D., Artioli, Y., 2018. Harmful algal blooms: The impacts on
832 cultural ecosystem services and human well-being in a case study setting, Cornwall, UK. *Marine*
833 *Policy*, 97, 232-238.