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Convergences and divergences in understanding the word biodiversity among citizens: A French case study

Marine Levé[a,b,*], Agathe Colléony[a,c,1], Pauline Conversy[a,d,1], Ana-Cristina Torres[a,1], Minh-Xuan Truong[a,e,1], Carole Vuillot[a,1], Anne-Caroline Prévot[a,f]

[a] Centre d'Écologie et des Sciences de la Conservation (CESCO UMR7204), MNHN, CNRS, Sorbonne Université, BP 135, 57 rue Cuvier, 75005 Paris, France
[b] Écologie Systématique Évolution, Univ. Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, 362 rue du Doyen André Guinier, 91400 Orsay, France
[c] Faculty of Architecture and Town Planning, Technion, Israel Institute of Technology, Haifa 32000, Israel
[d] Réserve de biosphère de Fontainebleau et du Gâtinais, Centre d'écotourisme de Franchard, Route de l'Ermitage, 77300 Fontainebleau, France
[e] Albert Vieille SAS, 629 route de Grasse, BP 217, 06227 Vallauris Cedex, France
[f] Laboratoire Parisien de Psychologie Sociale (LAPPS, EA4386), Université Paris Ouest, Dpt psychologie, 200 avenue de la République, 92000 Nanterre, France

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ABSTRACT

Biodiversity is undergoing a major crisis. Institutions, while launching initiatives tackling the issue, are using and diffusing the term biodiversity and related expert knowledge. However, to collectively address the biodiversity crisis, it is important that actors are able to communicate with each other. This is particularly true in the three-part set including science, public institutions, and citizens. In this paper, we explored this mutual understanding with a focus on laypeople: we assessed the understanding of biodiversity in a sample of 1209 French adult citizens and explored the convergences and divergences with institutional and academic definitions. With a classical hypothetical-deductive approach, we first showed an overall congruence between laypeople and institutions: 80% of respondents provided a descriptive definition of plant and animal species as well as their diversity, which are main ideas diffused by institutions. However, based on the high diversity of the collected definitions, with 57% of provided words in definitions mentioned only once, we complemented this study with an inductive approach. We showed a discrepancy in the definitions from lay people and from conservation science (based on evolutionary and dynamic processes). We also highlighted that 18,5% of definitions are not descriptive and are referring to specific actions for biodiversity conservation. We discuss these results in the context of social-ecological transitions, and encourage conservation communities to acknowledge the range of biodiversity definitions used by laypeople, and to form closer relationships with laypeople to anchor conservation research and action with a bottom-up dynamic process of knowledge sharing.

1. Introduction

Biodiversity is currently experiencing a major crisis, which also affects humanity. The conservation science community has been mobilized for a long time in addressing this crisis, notably through conservation biology (Soulé, 1985; Bennett et al., 2017). > 15,000 scientists co-signed a call to humanity for protecting biodiversity in December 2017 (Ripple et al., 2017). Scientific or academic environmental bodies are producing information and definitions related to biodiversity (*e.g.* Sarrazin and Lecomte, 2016; Primack, 2014) (Table 1). Despite their diversity, these academic definitions consider biodiversity as a dynamic process, both at the long-term scale (through evolutionary processes) and short-term scale (ecological dynamics).

International initiatives have also been trying for a long time to address this crisis, from the Rio Earth Summit in 1992 to the current Strategic Plan for Biodiversity (2011 – 2020) designed by the United Nations' Convention for Biological Diversity (CBD). This strategic plan has been available at regional (*e.g.*, Europe) and national levels (*e.g.*, France). At more local levels, initiatives are also increasingly flourishing, such as the differential management programme adopted by several European cities (*e.g.*, Amsterdam, Hamburg, Brussels, Paris) to enhance biodiversity in green spaces. These institutional texts and declarations all refer to "biodiversity", although providing slightly different definitions. For instance, the CBD, European Commission and

* Corresponding author at: Écologie Systématique Évolution, Univ. Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, 362 rue du Doyen André Guinier, 91400 Orsay, France.
E-mail addresses: marine.leve@cri-paris.org (M. Levé), anne-caroline.prevot@mnhn.fr (A.-C. Prévot).
[1] These authors contributed equally to this work.

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Table 1
Four examples of definitions provided by institutional bodies. Regarding the academic sphere, we included an example of a definition from a very popular textbook (Primack, 2014).

Institutional/academic body	Definition	Source
CBD	"The variety of life on Earth. It includes all organisms, species and populations; the genetic variation among them; and their complex assemblages of communities and ecosystems"	https://www.cbd.int/2011-2020/about/biodiversity
European Commission	"The variety of life on Earth. It refers not just to species but also to ecosystems and differences in genes within a single species"	http://ec.europa.eu/environment/nature/biodiversity/intro/index_en.htm
French government	The "variability of living organisms from all origins, including terrestrial, marine and other aquatic ecosystems, as well as the ecological complexes they belong to. It encompasses diversity within species and between species, ecosystem diversity and interactions between living organisms"	JO, 2016
Conservation biologists	"a set of information, material and energy fluxes relying on dynamical processes at various spatial and temporal scales. […] Biodiversity arises from ecological, evolutionary and developmental processes"	Primack, 2014

French government institutional definitions (Table 1) include many similar terms (*i.e.*, diversity, species, animals and plants, ecosystem and life). These institutional definitions are grounded in the scientific and academic definitions but usually lack the dynamic aspects.

The term "biodiversity" has also spread to society. For instance, the number of articles referring to biodiversity in the French national mass media source "Le Monde" dramatically increased in 2010 and remained at a high level afterwards (unpublished data). At the European level, the number of people aware of this notion increased by 9% from 2007 to 2013 (European Commission, 2007; European Commission, 2013), and in 2015, at least eight out of ten Europeans were worried about biodiversity loss (European Commission, 2015).

In addition to this general increase in knowledge about biodiversity and awareness of related issues, individual variations on these topics remain high (see, for instance Buijs et al., 2008 or Moss et al., 2016). For instance, at the European level in 2013, the declarative level of knowledge of biodiversity varied according to gender and education level: men and more educated Europeans were more likely to say that they know about biodiversity (European Commission, 2013). More precisely, in a Swiss study, Lindemann-Matthies and Bose (2008) found that the probability to never come across the term biodiversity significantly decreases with age (from 10 to 70 years old). Children's discourses about biodiversity are different according to their gender, with girls mentioning more ornamental plants and boys mentioning more wild plants in a study conducted in Argentina (Campos et al., 2012). Also in Argentina, students' understanding of biodiversity was largely centred on species diversity, underestimating other ecologically meaningful characteristics such as functional traits or species evenness (Bermundez and Lindemann-Mathies, 2018). In addition to socio-demographic influences, individual life experience towards nature has also been shown to impact people's knowledge of biodiversity: in England, Cox and Gaston (2015) showed that knowledge on birds was related to connectedness with nature. Pilgrim et al. (2007) showed that British people who walk in nature more often know more local species than people who do so less often. Awareness of conservation issues is also highly variable, depending on individual and social factors. Prévot et al. (2018) recently showed that French adults who are involved in local activities in relation to biodiversity in their daily life know more about biodiversity than people who are not. An understanding of biodiversity thus appears to vary according to gender, age, education, and connectedness to nature and experiences of nature.

Despite these variations in understanding, the concept of biodiversity is a prominent point of discussion between political spheres (at international and national levels), scientific communities and the rest of society (see also Bermundez and Lindemann-Mathies, 2018). Recent works addressed potential problems regarding information sharing between these communities: Moore et al. (2019) showed that American citizens progressively lower their perception of temperature abnormalities, which could explain the lack of support of public policies regarding climate change. Meinard and Quétier (2014) showed that the term "biodiversity" remains vague and is anchored on differing implicit knowledge between communities, notably scientists and conservation practitioners. To collectively address the biodiversity crisis, it is important that all these spheres understand each other. Citizens understanding of up-to-date biodiversity concepts should favour their empowerment to make decisions on socioscientific issues, such as biodiversity management, conservation or sustainable development (Bermundez and Lindemann-Mathies, 2018).

Mutual understanding among different individuals or social groups is encouraged when these persons or groups share mental models or social representations (Buijs, 2009). Mental models are cognitive frameworks that people use to understand and interpret the world (Biggs et al., 2011); social representations are socially elaborated and shared knowledge that participates in the construction of social groups (Moscovici, 1961). To address the issue of a mutual understanding regarding biodiversity, it is therefore important to assess the convergences and divergences in the definitions of biodiversity between the different spheres. In other words, do citizens understand biodiversity the same way that institutions do? What about the scientific definitions? And if citizens do not understand biodiversity in the way that scientists or institutions describe biodiversity, then how do they describe it?

A recent work by Moss et al. (2015) focused on assessing the understanding of one definition of biodiversity for people visiting at zoos. In their study, they provided a definition of biodiversity that includes diversity, animal and plant species (see Table 2). Then, they ranked the level of understanding of biodiversity for each person asked and compared it to the reference definition. Overall, 75% of the 5661 definitions collected in this survey were somehow close to this reference definition (Moss et al., 2015).

In this study, we focused on the understanding of biodiversity by citizens and on how this concept was shared between citizens, institutions and academia. Using the proposed definition framed by Moss et al. (2015), we explored French citizens' definitions of biodiversity. We hypothesized that people provide definitions of biodiversity that are closer to institutional definitions than to scientific definitions for several combined reasons: knowledge transfer towards the public is mainly based on media communication; scientists have difficulties transferring their knowledge both to practitioners (*e.g.*, Francis and Goodman, 2010) and to journalists (Nisbet and Scheufele, 2009; Besley and Tanner, 2011); public institutions are more directly involved than scientists in diffusing conservation messages to the public. We therefore assessed the convergence between definitions given by the citizens and institutional definitions, *i.e.*, referring to diversity, animal and plant species. Based on the literature (see above), we hypothesized that people who have experienced nature regularly defined biodiversity in a more detailed manner than people who have not. To test this hypothesis, we compared the definitions of biodiversity of people who grew up in the countryside or sub-urban areas, to those of people who grew up as city-dwellers. Moreover, based on the published results on the effects

Table 2
Description of questionnaire surveys.

Sampling period	Targeted public	Method	Number of provided definitions of biodiversity	Total length of the questionnaire (location of the question)	Subset
2010 & 2015	Parisian zoo visitors	Face-to-face	135 & 32	20 questions (#4) & 21 questions (#8)	B Zoo
2015	French citizens	Self-administered (online or paper survey)	393	25 questions (#16)	C French 1
2016	Inhabitants of the south of Paris	Self-administered online survey	152	23 questions (#6)	D South Parisian1
	French citizens		310	36 questions (#6)	E French 2
	Inhabitants of the south of Paris, near the Fontainebleau Forest	Face-to-face	79	30 questions (#7)	F South Parisian 2
	Visitors of 3 Parisian parks		108	15 questions (#10)	A Parks

of gender, age and educational path on biodiversity knowledge, we hypothesized that women, young people and students were more likely to provide definitions closer to institutional ones than other people.

Our quantitative assessment of the alignment of citizens' definitions with institutional ones allowed us to test these hypotheses. However, a reductive approach was used regarding the actual variety of definitions given by citizens and it thus did not allow us to address this variety for all of the existing understandings of biodiversity. Thus, we paired this hypothetical-deductive approach with an inductive approach, using an analysis of the content of the definitions. This approach revealed high potential for sharing and co-constructing knowledge of biodiversity conservation among scientists, institutions and citizens.

2. Method

2.1. Survey design

We collected biodiversity definitions from 1260 French citizens across 6 years, by pooling data from ten different questionnaire surveys. These surveys were all conducted by the same research team working at the French National Museum of Natural History and explored components of the human relationship to nature from different perspectives. They all included the same specific questions regarding the respondent's definition of biodiversity, the respondents' age, gender, current and childhood living places as well as their individual life experience with nature. Details of each survey can be found in Table 2. Because 51 out of 1260 respondents did not give any definition of biodiversity, we based our analysis on 1209 different definitions. All surveys were administered in France to French-speaking respondents. Participants remained anonymous, and no personal information allowing for identification was recorded. Participants were informed that the data were collected only for research purposes. Respondents did not receive any compensation for their participation. The process followed the ethical standards required by the French National Commission of Computing and Liberties (CNIL, 2018). Questionnaires corresponding to the subsets detailed in Table 2 are available as supplementary files.

2.2. Questionnaire design

2.2.1. Definition of biodiversity

All surveys asked respondents to give their definition of biodiversity with an open-ended question, using the formulation “How would you define biodiversity?”

2.2.2. Individual life experience with nature

We assessed individual life experience with nature by using two proxies as follows. First, we assessed the declared level of rurality of the childhood living place on a 5-point scale with the following categories labelled from 1 to 5: big city, medium city, small city, village, and hamlet, *i.e.*, a small settlement in a rural place usually set around a farm building. We used this information as a proxy for individual life experiences with nature, as we considered that people who grew up in rural places were more likely to be in contact with nature than people who grew up in urban environments.

Second, we used a derived version of the Inclusion of Nature in Self (INS, Schultz, 2001) on a 5-point scale. This scale provides a set of five overlapping circles labelled “nature” and “self”. People were asked to choose the assemblage that best defined their relationship to nature. Data were coded from 1 for the less overlapping circles to 5 for the completely overlapping circles (Supplementary Fig. A.1). The INS scale has been widely used in research (Liefländer et al., 2013) and phas rovided an easy and quick way to measure individual life experiences with nature in sometimes long questionnaires.

2.2.3. Socio-demographic variables

We also recorded age and gender (feminine/masculine). Depending on the surveys, age was assessed by year of birth or by age categories. We therefore homogenized the data using seven age categories (18–25; 26–30; 31–40; 41–50; 51–60; 61–70; over 70 years old). Because our surveys were biased towards students, we distinguished students from non-students when the information was available. We refer to this as the variable “student/non-student” hereafter.

2.3. Hypothetical-deductive analyses

2.3.1. Convergences of citizens' definitions with the institutional definition

We evaluated the extent to which people's definitions of biodiversity were close to the institutional definition by using the same reference and the same scoring system as Moss et al. (2015). As such, we assessed a score on a 5-point scale that we called the “Institutional proximity index” (IPI, see Table 3). To check the consistency of this categorization process, three of the authors coded the same random sample of 80 definitions. Inter-reliability was over 0.75 (0.89) and was considered excellent (Cicchetti, 1994). One author coded all of the remaining datasets.

2.3.2. Statistical analyses

We used ordinal models (package ordinal for R, Christensen, 2015) to test the relationship between the IPI and the following individual factors: INS, rurality of childhood living place, gender, age and student/non-student. We included the data subset as a fixed effect, with subset C (French citizens 1) being the reference factor. We also included an interaction term between age and the survey subset, as well as between the student variable and the survey subset. We accounted for this because of a partial knowledge of sampled respondents in each subset, one having been targeted more towards students than others and a great

Table 3
Characteristics associated with the IPI scoring of definitions.
(Adapted from Moss et al., 2015.)

Score	Definition characteristics	Number of definitions (this study)
1	Inaccurate, too vague to indicate accurate knowledge	154
2	Some accurate descriptions and some inaccurate ones	261
3	Positive evidence, mention of biological objects or concepts related to biodiversity (*e.g.*, species), no details	421
4	Accurate descriptions, mention of animals or plants but not both, vague but accurate descriptions (*e.g.*, variety of species on Earth)	243
5	No inaccurate elements, mention of both animals and plants	130

proportion of these students were ecology/biology students.

More specifically, we first checked for the influence of the student variable compared to the age variable, the student variable being not equally distributed across age groups (chi-square = 595.06, df = 6, $p < 0.001$). We first used the portion of the dataset in which the student variable was available to fit the model with both age and student variables, along with the other variables. If the student variable had no significant effect, we fitted the model without it and used the full dataset.

2.4. Inductive analyses

2.4.1. Content analyses of the definitions

We changed conjugated verbs to infinitives, and plural nouns to their singular forms. We identified articles, conjunctions and other grammatical operative words, and excluded them from our final set of words (see example in Fig. 1). We therefore obtained a set of nouns, proper nouns, infinitive verbs, adverbs and adjectives.

We then calculated the number of definitions in which each term of this set appeared. Among these terms, we highlighted those that also belonged to institutional definitions, as well as terms that specifically referred to academic definitions, i.e., biodiversity dynamics and evolution.

2.4.2. Inductive categorization of definitions and statistical modelling

Reading the citizens' definitions led us eventually to propose a categorization of three groups. Groups were assessed and discussed by all authors for relevance. They are defined as follows:

- Group 1: definitions that referred to the ecological description of biodiversity and to perceptions, with terms such as “habitat”, “territory”, “harmony”, “beauty”, e.g. “Diversity of living organisms, of habitats, genes”; “All nature”.
- Group 2: definitions that referred to actions related to biodiversity; actions could be general, with terms such as “conservation”, “preservation”, or specific, such as buying local and organic food, e.g. “Preserving species”; “To favour fauna and flora diversity in order to achieve natural equilibrium, without synthetic additions”.
- Group 3: definitions that did not refer to biodiversity, e.g. “no idea”.

To check for consistency within the categorization process, three authors coded the same random sample of 50 definitions. Inter-reliability was over 0.75 (0.83) and was considered excellent (Cicchetti, 1994). One author coded all of the remaining datasets.

We used generalized linear models (package lme4 for R, Bates et al., 2015) with logit link (binomial family) to test the relationship between the respective proportions of the first two groups of definitions and the following individual factors: INS, rurality of childhood living place, gender, age and student/non-student. We included the data subset as a fixed effect, with subset C (French citizens 1) being the reference factor.

All statistical analyses were performed using R 3.4.3 (R Core Team, 2017).

3. Results

3.1. Dataset description

The overall dataset included 1209 respondents. It included 61.4% of women and the most represented age class included 18–25 year old (34.0%). We did not find any significant difference between the different surveys for the declared rurality of the childhood living place or for gender (chi-squared = 25.25, df = 20, p-value = 0.19, and chi-squared = 7.684, df = 5, p-value = 0.17, respectively). However, age distributions differed between the surveys (chi-squared = 587.19, df = 30, p-value $<$ 0.001), as did as the student/non student distributions, when that information was available (chi-squared = 272.88, df = 3, p-value $<$ 0.001).

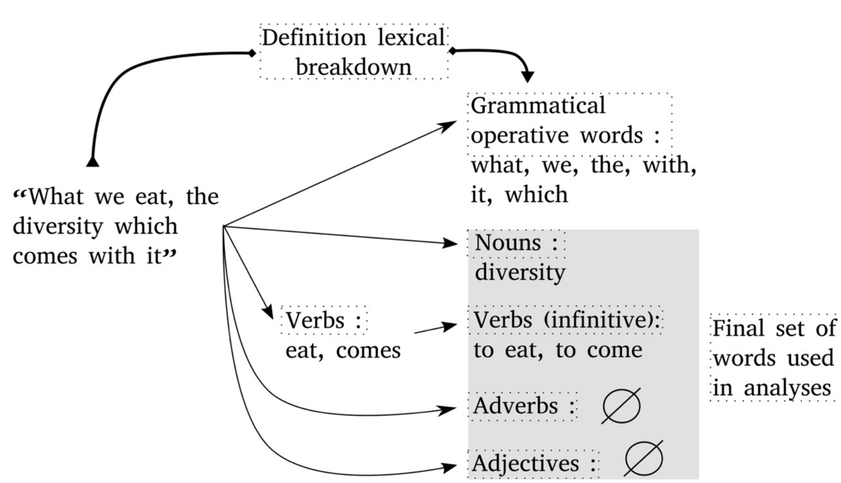

Fig. 1. Description of the content analysis of the definitions.

Table 4
Estimates and *p*-values for the IPI ordinal model ($N = 1190$). Interaction terms were not significant and are not shown; feminine gender and C survey are references factors for categorical data.

Dependent variable	Estimate ± SD	p-Value[a]
Age	−0.23 ± 0.068	0.0006***
INS	–	0.53
Childhood living place	–	0.26
Gender (masculine)	–	0.83
Subset A	–	0.53
Subset B	−1.32 ± 0.41	0.0011**
Subset D	−0.93 ± 0.35	0.009**
Subset E	–	0.59
Subset F	−2.2 ± 0.69	0.0012**

[a] Significance codes: *: < 0.05; **: < 0.01; ***: < 0.001.

3.2. Degree of convergence of citizens' definitions with the institutional definition

The institutional proximity index (IPI) mostly commonly obtained was 3 (34.8% of the dataset definitions, see also Table 3). The IPI was significantly related to the age of respondents, with older respondents providing definitions that were less convergent with the institutional definition (Table 4). The IPI was not significantly related to gender or individual history of experiences with nature (INS, rurality of childhood living places).

3.3. Core definition, diversity of definitions and appearance of academic biological terms

Definitions given by respondents included 13.5 words on average. The full set of definitions provided 1065 different words, i.e., nouns, proper nouns, adjectives, adverbs or infinitive verbs. Out of this total, 57% were only mentioned by a single respondent, and 1% (i.e., 11 terms) were used by > 100 respondents. Most of these 11 terms echoed the institutional definition with terms such as "species", "living", "diversity" or "ecosystem". Others belong to the scientific vocabulary, such as "fauna" and "flora". The term "species" was the most reported, with > 50% of the respondents using it in their definition (Table 5).

Among the 1209 definitions, only 7 included the term "dynamics" and only 19 included the terms "evolution" or "evolutionary". More specifically, 4 out of the 7 definitions with "dynamics" referred to both dynamics and evolution. Only 1 referred to selective processes, and it was one of the 7 abovementioned definitions (see Supplementary material Table A.2). We noticed that definitions sometimes referred to terms linked to ecological processes: 24 definitions mentioned the term "balance" and 85 mentioned "interactions". We found six definitions referring to ecosystem services: 4 explicitly mentioned "services", and 2 mentioned the "beauty" of biodiversity (which could refer to a cultural service).

3.4. Definitions categorization and relationship to individual factors

We found that 965 (80%) of the definitions provided were descriptive (846 definitions) or related to perceptions about biodiversity (119 definitions) (group 1), e.g., "Diversity of living organisms, of habitats, genes"; "All nature". Action-related definitions (group 2) accounted for 224 definitions (18.5%), e.g., "Preserving species"; "To favour fauna and flora diversity in order to achieve a natural equilibrium, without synthetic additions". Overall, 29 out of these 224 action-related definitions mentioned precise actions: 14 referred to agricultural changes, 6 referred to individual connection with nature and 9 mentioned a behaviour of consumption. The other 1.5% of the definitions (n = 20) were categorized in the third group, e.g., "no idea".

We found that non-students were significantly more prone to giving definitions related to conservation actions (Table 6). We did not find any other correlations between the respective proportions of descriptive/action-related definitions and the following individual factors: gender, age, INS, rurality of childhood living places.

4. Discussion

In this study, we explored the convergence between definitions of biodiversity provided by institutions, academics and the rest of society. We combined two approaches: through the IPI, we assessed the diffusion of expert institutional knowledge towards society; through inductive categorization, we assessed local knowledge of lay people. Indeed, expert institutional knowledge and local knowledge coexist

Table 5
List of the 11 words appearing in at least 100 definitions (French translation of words in brackets) and example of definitions given by respondents. French translations of examples are given in supplementary Table A.1.

Word (French word)	Number of definitions with this word (%)	Examples
Species (Espèce)	522 (43.1)	"All **species**, living beings in their environment, their interactions" "Preserving **species**"
Living[a] (Vivant)	356 (29.4)	"Several **living** systems which coexist, by natural link" "Diversity of **living** organisms, of habitats, genes"
Diversity (Diversité)	304 (25.1)	"**Diversity** of animal, plant and mineral species" "What we eat, the **diversity** which comes with it"
All (Ensemble)	214 (17.7)	"**All** animals, nature and humans; what lives on Earth" "**All** nature"
Ecosystem (Écosystème)	170 (14.0)	"It is an **ecosystem** with relationships among species" "An **ecosystem** to protect"
Animal (Animal)	169 (14.0)	"Cohabitation of high number of species (**animal**, plant, fungi, etc.) in a place, with equilibrium in resources sharing" "The quantity of **animal** and plant species"
Plant (Végétal)	159 (13.1)	"A mix of several species (animal or **plants**) which manage to live together!" "Quantity but also, and firstly, quality of species (animal, **plant**, etc.) constituting an ecosystem"
Nature (Nature)	150 (12.4)	"Numerous plant and **nature** essences" "Equilibrium between man-**nature**; to have a right place"
Being (Être)	148 (12.2)	"All **beings** who live in nature" "Diversity of landscapes, number of different living **beings** (qualitatively and quantitatively) in a given area"
Fauna (Faune)	102 (8.4)	"To preserve the multiplicity of species (**fauna** and flora) in their natural habitat" "Diversity **fauna** flora"
Flora (Flore)	102 (8.4)	"Fauna, **flora** as well as the environment they live in" "To favour fauna and **flora** diversity in order to achieve natural equilibrium, without synthetic additions"

[a] The word "living" has been separated from the expression "living being".

Table 6
Estimates and p-values for the proportions of definitions related to an action (categorization group 2), according to the tested dependent variables ($N = 902$). Only significant interaction terms are shown; feminine gender, non-student category and C survey are reference factors for categorical data.

Dependent variable	Estimate ± SD	p-Value[a]
Age	–	0.50
Student (student)	−1.9 ± 0.99	0.049*
INS	–	0.11
Childhood living place	–	0.74
Gender (Masculine)	–	0.51
Subset E	−1.6 ± 0.78	0.037*
Subset E:age class	0.50 ± 0.19	0.007**

[a] Significance codes: *: < 0.05; **: < 0.01; ***: < 0.001.

within society, interact with each other and take part in conceptual definitions.

4.1. Citizens collectively define biodiversity similarly to institutions

Our study revealed that 11 words were employed by > 100 respondents each, for a total of 1065 different words. This points towards a common basis for the representation of biodiversity among respondents. Concepts such as species, ecosystems, and diversity are part of this common representation. The notion of interactions between elements of biodiversity is also present (even if less abundant), with 85 definitions including words referring to these interactions. These commonly shared terms indicated that the collected definitions were quite close to the definitions used by institutions (e.g., the CBD, European Union regulations and the French government, see Table 1). They indeed underlined the diversity of individuals, species, and ecosystems, together with interactions and ecological networks. Diversity was also the most important component of biodiversity understanding in the Bermundez and Lindemann-Mathies (2018) study in Argentina with students, as well as in the Fiebelkorn and Menzel (2012) study in Costa-Rica and Germany with student biology teachers and in the Kilinc et al. (2013) study in Turkey with students. Buijs and Elands (2013) explored the social representations of nature in a group of 364 Dutch lay people, whom they asked to associate up to 5 words to the term “nature”. Similar to our results, some of the terms most often associated with the concept of nature for people interviewed were general terms such as “animals” (50% of their respondents), plants (22%) and everything living (10%). Most often mentioned terms were also tree/forest (37%) and meadows (10%). In Chile, Cerda and Bidegai (2018) explored the representations of biodiversity by 45 people from different social groups in a Biosphere Reserve; they found that “all the groups of respondents thought that biodiversity had something to do with the diversity of animals and plants” (p. 206), which corresponds to the general finding of our study. Similarly, in a study with focus-groups in Scotland, Fischer and Young (2007) found that both experts and non-experts in natural history “perceived and appreciated the diversity in their surrounding” (p.274).

Eighty percent of the collected definitions corresponded to a description or a perception of biodiversity (Group 1 in the results section). This high proportion is encouraging, regarding the fulfilment of the current Strategic Plan for Biodiversity of the CBD and the associated Aichi targets. In particular, the first target states that “by 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably”, values here being “interpreted in the broadest sense, including environmental, cultural, economic and intrinsic values” (https://www.cbd.int/doc/strategic-plan/targets/T1-quick-guide-en.pdf). However, gathered definitions seldom mentioned these values specifically, and when they did, the mentioned values were mostly environmental and intrinsic values of biodiversity. While the first Aichi target also encompasses ecosystem services, economic or social values, those were mentioned by a negligible proportion of respondents. The big picture of biodiversity does not seem to be fully recognized by citizens so far.

We found that young people defined biodiversity according to the institutional definitions more often than older ones, and that students gave relatively more descriptive definitions than non-students. We did not find any other correlation, notably regarding gender and individual life experience with nature. The fact that students gave more descriptive definitions than other people was expected in our study because the students surveyed were predominantly studying ecology. However, the absence of correlations with the other individual factors was first surprising, because the knowledge and awareness of biodiversity do vary between individuals (e.g., European Commission, 2015), notably according to one's individual life experience with nature (e.g., Chawla, 1998). However, the apparent discrepancy of our results with the literature can be explained by at least two reasons: first, our index of institutional proximity did not embrace biodiversity knowledge as a whole. Indeed, following Frick et al. (2004), environmental knowledge is composed of at least three components: declarative or factual knowledge (what is it), action-related knowledge (what can I do) and effectiveness knowledge (how are my actions efficient?). Our index only partly encompassed the first level of knowledge. Second, the way we assessed individual life experience with nature was also very restrictive: the declared rurality of childhood living place may not have reflected the varying lifestyles among respondents. Furthermore, although the Inclusion of Nature in Self (INS) is one of the existing scales to assess the individual level of connection with nature, it is mostly dedicated to the cognitive relationship and does not embrace wider connections (Tam, 2013).

4.2. Contrary to conservation scientists, citizens do not embrace any dynamic component in their understanding of biodiversity

The collected definitions seldom mention the dynamics or evolution of biodiversity, even if they are of importance in ecological and conservation biology science (Sarrazin and Lecomte, 2016). Thus, the biodiversity they refer to is not fully consistent with the current academic definition usually used in ecology.

The fact that the definitions of biodiversity used by most people converge with the static definition provided by institutions rather than with a dynamic one shared by the scientific community (which relies on the dynamics and evolution of biodiversity) indirectly reveals a side issue for conservation scientists: the concepts of equilibrium or balance of nature are still present in institutional visions, even if they are no longer the single vision within the scientific community (e.g., Couix and Hazard, 2013; Robert et al., 2017; Mace, 2014). These links with dynamic and evolutionary processes are now essential in biodiversity conservation (Sarrazin and Lecomte, 2016) and seemed to be lacking in this study dataset. However, some published elements suggest that the dynamic vision of biodiversity is present in professionals such as foresters (Buijs et al., 2008) and that farmers recognize the complexity of biodiversity (Kelemen et al., 2013). We therefore encourage the ecological scientific community to communicate more widely what is relevant now in this current and very fast changing period, i.e., on the dynamic processes underlying biodiversity functioning and interactions with humans (see also Mace, 2013).

4.3. In addition, what else?

The third main result of our study is that it revealed great diversity in the understanding of biodiversity by lay people around the common representation. Indeed, in addition to the 11 most cited words, the collected definitions included > 1000 other words, with 57% of the total number of words being mentioned only once and thus giving an idea of the variety of citizen interpretations of biodiversity. Similarly, in their study asking for association with the term “nature”, Buijs and

Elands (2013) collected 670 different terms, of which only 22 were mentioned by > 4 people. A very large proportion of the terms appeared thus to be mentioned by < 4 people, revealing a very high diversity in the perception of nature by those interviewed. This result confirms that citizens commonly link biodiversity to other concepts: in Fischer and Young (2007) study, Scottish people who were interviewed rooted biodiversity in specific places, biodiversity contributing to specific spatial patterns, as well as to concepts such as natural flows (e.g. food chains). Buijs et al. (2008) found that people interviewed in the Netherlands, Scotland and Germany "used broad definitions, often including diversity of landscapes and cultural diversity in, for example, land use or even cuisine" (p.70). This last example echoes the definitions in our sample that defined biodiversity as a whole assemblage of interacting elements, including humans. Notably, some respondents mentioned the need for more appropriate interactions between humans and other species, using terms such as "live together". These definitions may reflect a diversity of worldviews about nature or relationships to biodiversity (e.g. Van den Born, 2008), notably the proposed "relational value" for human-nature relationships (Chan et al., 2016).

This diversity also appeared when considering a small group of definitions, which were related to actions. The existence of this group may be partly due to the national context when the study was conducted. First, all but one survey took place in 2015 or early 2016, and France hosted COP21 at the end of 2015. Thus, 2015 was a year of preparation and popularization of the associated issues, with biodiversity being among them: on this occasion, environmental issues were very present in media communications (e.g., a public book gathered "30 questions to understand the Paris conference", Canfin and Staime, 2015) as well as in citizen mobilizations (e.g., Coalition Climat 21, http://coalitionclimat21.org/en). Second, biodiversity was highlighted by French national policy-makers in 2016, with the combination of a new important law for biodiversity (JO, 2016) and the launching of the French Agency for Biodiversity. However, most of the 224 action-based definitions referred to very general attitudes or behaviours, such as respect or a general need to protect or conserve nature. This could be due to the history of the dissemination of the term biodiversity in society since 1992, which has always been accompanied by associated threats (Maris, 2016). However, surprisingly, no action mentioned related to activism or social involvement towards biodiversity, such as social environmentalism (sensus Larson et al., 2015). This was surprising because a significant proportion of students were part of the data set and since young people are more prone to activism (Stern, 1999), we could have expected for it to have been mentioned in such a political context.

Considering this variety of definitions, we should also considerwhat could be gained or lost by adopting one universal definition of biodiversity. The adoption of a universal unequivocal definition of biodiversity with a precise meaning may be seen as a great help to design and implement policies and programmes for biodiversity conservation now and in the future (Swingland, 2013). Erwin (1991) argued that science allows transcultural policies. Basing the biodiversity definition on science might thus help the related worldwide, transcultural conservations. However, the extensive work of Takacs (1996) showed that scientific statements about biodiversity are informed by culture and that biologists have only a part of the solution regarding biodiversity issues (pp. 332–336). A diversity of biodiversity definitions, encompassing scientific and citizen definitions, could then be helpful in understanding related local and global challenges, such as environmental justice.

Finally, interesting results would likely come from studying occurrences of biodiversity and its definition in school and high school programmes. French school and high school programs regularly change (every ten years roughly) and have incorporated biodiversity per se quite recently: oldest respondents might not have come across the term at school. However, it may have appeared indirectly, and a whole study would be necessary to understand the impact of French school learning experiences on the understanding of biodiversity.

4.4. Study limitations

Our study faced limitations that are frequently encountered when gathering data from several different studies. While allowing for larger datasets, the various sample sets were not collected with exactly the same designs. However, all surveys were designed collaboratively within the same research team using similar methods, and many questions were very similar. In addition, we included the questionnaire subsets in our analyses to take this possible source of variability into account. In all of the surveys, we obtained an over-representation of high socio-professional categories, making our sample not statistically representative of French society. However, the high sample size makes us confident in saying that this part of French society is aware of the institutionally-defined biodiversity concept.

5. Conclusion and perspectives

Our results suggest several possible routes for conservation. First, the high proportion of people that accurately defined biodiversity should make conservation scientists confident in the existence of a general common understanding of biodiversity. The next issue for conservation scientists could be therefore to increase the understanding of the components of biodiversity, such as the dynamic properties, for instance through closer collaborations with the media. The gap between this static definition and the dynamic one of conservation science is likely to close progressively thanks to communication and education on the definition of biodiversity.

However, the general understanding of biodiversity should not disguise the high diversity of individual appropriations and interpretations of this term in society. In particular, some definitions include interconnections between humans and nature. Because biodiversity serves the common goods, this range of definitions should be considered as an advantage; we encourage conservation scientists to encourage and take part in a co-construction of the meaning of biodiversity through bottom-up approaches. This could address the issue of the separation of modern societies from nature (Moscovici, 1976), or of the disconnection from nature and the 'extinction of experience' (Pyle, 2003; Soga et al., 2016).

Furthermore, the existence of action-based definitions of biodiversity suggests the personal involvement of laypeople in biodiversity issues. However, most cited actions rely on general injunctions to implement so-called "better" practices. One final conservation route could be to encourage individuals to enrich their definition of biodiversity based on their own experiences of nature and associated emotions and affects.

All these complementary routes would be a fertile ground to engage people and society in a social-ecological transition. We strongly encourage the conservationist community to disseminate more of their results, but also to encourage, explore and highlight relationships between citizens and nature that are likely to generate emotions and practices and to anchor their future research and communication strategies in this richness.

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Appendix A. Supplementary data

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References

Bates, D., Maechler, M., Bolker, B., Walker, S., 2015. Fitting linear mixed-effects models using lme4. J. Stat. Softw. 67 (1), 1–48. https://doi.org/10.18637/jss.v067.i01.

Bennett, N.J., Roth, R., Klain, S.C., Chan, K., Christie, P., Clark, D.A., Cullman, G., Curran, D., Durbin, T.J., Epstein, G., Greenberg, A., Nelson, M.P., Sandlos, J., Stedman, R., Teel, T.L., Thomas, R., Verissimo, D., Wyborn, C., 2017. Conservation social science: understanding and integrating human dimensions to improve conservation. Biol. Conserv. 205, 93–108. https://doi.org/10.1080/00958969809599114.

Bermundez, G. M. A., Lindemann-Mathies, P., 2018. "What matters is species richness" - high school students' understanding of the components of biodiversity. Res. Sci. Educ., in press. doi.org/https://doi.org/10.1007/s11165-018-9767-y.

Besley, J.C., Tanner, A.H., 2011. What science communication scholars think about training scientists to communicate. Sci. Commun. 33, 239–263. https://doi.org/10.1177/1075547010386972.

Biggs, D., Abel, N., Knight, A.T., Leitch, A., Langston, A., Ban, N.C., 2011. The implementation crisis in conservation planning: could "mental models" help? Conserv. Lett. 4, 169–183. https://doi.org/10.1111/j.1755-263X.2011.00170.x.

Buijs, A., 2009. Lay people's images of nature: comprehensive frameworks of values, beliefs, and value orientations. Soc. Nat. Resour. 22, 417–432. https://doi.org/10.1080/08941920801901335.

Buijs, A.E., Elands, B.H., 2013. Does expertise matter? An in-depth understanding of people's structure of thoughts on nature and its management implications. Biol. Conserv. 168, 184–191. https://doi.org/10.1016/j.biocon.2013.08.020.

Buijs, A.E., Fischer, A., Rink, D., Young, J.C., 2008. Looking beyond superficial knowledge gaps: understanding public representations of biodiversity. Int. J. Biodivers. Sci. Manag. 4, 65–80. https://doi.org/10.3843/Biodiv.4.2.

Campos, C.M., Greco, S., Ciarlante, J.J., Balangione, M., Bender, L.B., Nates, J., Lindemann-Matthies, P., 2012. Students' familiarity and initial contact with species in the Monte desert (Mendoza, Argentina). J. Arid Environ. 82, 98–105. https://doi.org/10.1016/j.jaridenv.2012.02.013.

Canfin, P., Staime, P., 2015. Climat: 30 questions pour comprendre la conférence de Paris. Les petits matins, Paris.

Cerda, C., Bidegai, I., 2018. Spectrum of concepts associated with the term "biodiversity": a case study in a biodiversity hotspot in South America. Environ. Monit. Assess. 190, 207. https://doi.org/10.1007/s10661-018-6588-4.

Chan, K.M.A., Balvanera, P., Benessaiah, K., Chapman, M., Díaz, S., Gómez-Baggethun, E., Gould, R., Hannahs, N., Jax, K., Klain, S., Luck, G.W., Martín-López, B., Muraca, B., Norton, B., Ott, K., Pascual, U., Satterfield, T., Tadaki, M., Taggart, J., Turner, N., 2016. Opinion: why protect nature? Rethinking values and the environment. Proc. Natl. Acad. Sci. 113, 1462–1465. https://doi.org/10.1073/pnas.1525002113.

Chawla, L., 1998. Significant life experiences revisited: a review of research on sources of environmental sensitivity. Environ. Educ. Res. 4, 369–382. https://doi.org/10.1080/00958969809599114.

Christensen, R.H.B., 2015. Ordinal – regression models for ordinal data. R package version 2015.6-28. http://www.cran.r-project.org/package=ordinal/.

Cicchetti, D.V., 1994. Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. Psychol. Assess. 6, 284–290. https://doi.org/10.1037/1040-3590.6.4.284.

CNIL, 2018. https://www.cnil.fr/fr/respecter-les-droits-des-personnes, Accessed date: February 2018.

Couix, N., Hazard, L., 2013. When the futures of biodiversity depends on researchers's and stakeholders' thought-styles. Futures 53, 13–21. https://doi.org/10.1016/j.futures.2013.09.005.

Cox, D.T.C., Gaston, K.J., 2015. Likeability of garden birds: importance of species knowledge & richness in connecting people to nature. PLoS One 10, e0141505. https://doi.org/10.1371/journal.pone.0141505.

Erwin, T.L., 1991. An evolutionary basis for conservation strategies. Science 253, 750–752.

European Commission, 2007. Attitudes of Europeans Towards the Issue of Biodiversity. Flash Eurobarometer Survey.

European Commission, 2013. Attitudes Towards Biodiversity. Eurobarometer Survey.

European Commission, 2015. Attitudes of Europeans Towards Biodiversity. Eurobarometer Survey.

Fiebelkorn, F., Menzel, S., 2012. Student teachers' understanding of the terminology, distribution, and loss of biodiversity: perspectives from a biodiversity hotspot and an industrialized country. Res. Sci. Educ. 43, 1593–1615. https://doi.org/10.1007/s11165-012-9323-0.

Fischer, A., Young, J.C., 2007. Understanding mental constructs of biodiversity: implications for biodiversity management and conservation. Biol. Conserv. 136, 271–282. https://doi.org/10.1016/j.biocon.2006.11.024.

Francis, R.A., Goodman, M.K., 2010. Post-normal science and the art of nature conservation. J. Nat. Conserv. 18, 89–105. https://doi.org/10.1016/j.jnc.2009.04.002.

Frick, J., Kaiser, F.G., Wilson, M., 2004. Environmental knowledge and conservation behavior: exploring prevalence and structure in a representative sample. Pers Indiv Differ 37 (8), 1597–1613. https://doi.org/10.1016/j.paid.2004.02.015.

JO, 2016. LOI n° 2016-1087 du 8 août 2016 pour la reconquête de la biodiversité, de la nature et des paysages. https://www.legifrance.gouv.fr/eli/loi/2016/8/8/2016-1087/jo/texte, Accessed date: February 2018.

Kelemen, E., Nguyen, G., Gomiero, T., Kovács, E., Choisis, J.P., Choisis, N., Paoletti, M.G., Podmaniczky, L., Ryschawy, J., Srthou, J.-P., Herzog, F., Dennis, P., Balázs, K., 2013. Farmers' perceptions of biodiversity: lessons from a discourse-based deliberative valuation study. Land Use Policy 35, 318–328. https://doi.org/10.1016/j.landusepol.2013.06.005.

Kilinc, A., Yeşiltaş, N.K., Kartal, T., Demiral, Ü., Eroğlu, B., 2013. School students' conceptions about biodiversity loss: definitions, reasons, results and solutions. Res. Sci. Educ. 43, 2277. https://doi.org/10.1007/s11165-013-9255-0.

Larson, L.R., Stedman, R.C., Cooper, C.B., Decker, D.J., 2015. Understanding the multi-dimensional structure of pro-environmental behavior. J. Environ. Psychol. 43, 112–124. https://doi.org/10.1016/j.jenvp.2015.06.004.

Liefländer, A.K., Fröhlich, G., Bogner, F.X., Schultz, P.W., 2013. Promoting connectedness with nature through environmental education. Environ. Educ. Res. 19 (3), 370–384. https://doi.org/10.1080/13504622.2012.697545.

Lindemann-Matthies, P., Bose, E., 2008. How many species are there? Public understanding and awareness of biodiversity in Switzerland. Hum. Ecol. 36, 731–742. https://doi.org/10.1007/s10745-008-9194-1.

Mace, G.M., 2013. Ecology must evolve. Nature 503, 191–192. https://doi.org/10.1038/503191a.

Mace, G.M., 2014. Whose conservation? Changes in the perception and goals of nature conservation requires a solid scientific basis. Science 345, 1558–1561. https://doi.org/10.1126/science.1254704.

Maris, V., 2016. Philosophie de la biodiversité. Buchet-Chastel.

Meinard, Y., Quétier, F., 2014. Experiencing biodiversity as a bridge over the science-society communication gap. Conserv. Biol. 28, 705–712. https://doi.org/10.1111/cobi.12222.

Moore, F.C., Obradovich, N., Lehner, F., Baylis, P., 2019. Rapidly declining remarkability of temperature anomalies may obscure public perception of climate change. PNAS 201816541. https://doi.org/10.1073/pnas.1816541116.

Moscovici, S., 1961. La psychanalyse, son image et son public. Presses Universitaire de France, Paris.

Moscovici, S., 1976. Society Against Nature: The Emergence of Human Societies. Branch Line.

Moss, A., Jensen, E., Gusset, M., 2015. Evaluating the contribution of zoos and aquariums to Aichi biodiversity target 1. Conserv. Biol. 29, 537–544. https://doi.org/10.1111/cobi.12383.

Moss, A., Jensen, E., Markus, G., 2016. Probing the link between biodiversity-related knowledge and self-reported proconservation behavior in a global survey of zoo visitors. Conserv. Lett. 10, 33–40. https://doi.org/10.1111/conl.12233.

Nisbet, M.C., Scheufele, D.A., 2009. What's next for science communication? Promising directions and lingering distractions. Am. J. Bot. 96, 1767–1778. https://doi.org/10.3732/ajb.0900041.

Pilgrim, S., Smith, D., Pretty, J., 2007. A cross-regional assessment of the factors affecting ecoliteracy: implications for policy and practice. Ecol. Appl. 17, 1742–1751. https://doi.org/10.1890/06-1358.1.

Prévot, A.C., Cheval, H., Raymond, R., Cosquer, A., 2018. Routine experiences of nature in cities can increase personal commitment toward biodiversity conservation. Biol. Conserv. 226, 1–8. https://doi.org/10.1016/j.biocon.2018.07.008.

Primack, R., 2014. Essentials of Conservation Biology, 6 edition. Oxford university Press, Oxford.

Pyle, R.M., 2003. Nature matrix: reconnecting people and nature. Oryx 37, 206–214. https://doi.org/10.1017/S0030605303000383.

R Core Team, 2017. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria URL. https://www.R-project.org/.

Ripple, W.J., Wolf, C., Newsome, T.M., Galetti, M., Alamgir, M., Crist, E., Mahmoud, M.I., Laurance, W.F., 2017. World scientists' warning to humanity: a second notice. Bioscience 67, 1028–1030. https://doi.org/10.1093/biosci/bix125.

Robert, A., Fontaine, C., Veron, S., Monnet, A.-C., Legrand, M., Clavel, J., Chantepie, S., Couvet, D., Ducarme, F., Fontaine, B., Jiguet, F., le Viol, I., Rolland, J., Sarrazin, F., Teplitsky, C., Mouchet, M.., 2017. Fixism and conservation science. Conserv. Biol. 31 (4), 781–788. https://doi.org/10.1111/cobi.12876.

Sarrazin, F., Lecomte, J., 2016. Evolution in the Anthropocene. Science 351, 922–923. https://doi.org/10.1126/science.aad6756.

Schultz, W., 2001. The structure of environmental concern: concern for self, other people, and the biosphere. J. Environ. Psychol. 21, 327–339. https://doi.org/10.1006/jevp.2001.0227.

Soga, M., Gaston, K., Yamaura, Y., Kurisu, K., Hanaki, K., 2016. Both direct and vicarious experiences of nature affect children's willingness to conserve biodiversity. Int. J. Environ. Res. Public Health 13, 529. https://doi.org/10.3390/ijerph13060529.

Soulé, M.E., 1985. What is conservation biology? BioScience 35 (11), 727–734.

Stern, P., 1999. A value-belief-norm theory of support for social movements: the case of environmentalism. Hum Ecol Rev 6, 81–97.

Swingland, I.R., 2013. Biodiversity, definition of. In: Levin, S.A. (Ed.), Encyclopedia of Biodiversity. vol. 1. Academic, San Diego, pp. 377–391.

Takacs, D., 1996. The Idea of Biodiversity. John Hopkins University Press, Baltimore and London.

Tam, K.-P., 2013. Concepts and measures related to connection to nature: similarities and differences. J. Environ. Psychol. 34, 64–78. https://doi.org/10.1016/j.jenvp.2013.01.004.

Van den Born, R.J.G., 2008. Rethinking nature: public visions in the Netherlands. Environ Value 17, 83–109. https://doi.org/10.3197/096327108X271969.