Measuring Impartial Preference for Biodiversity

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ABSTRACT

Biodiversity undergoes unprecedented rates of erosion despite the important services it provides. This is considered evidence that biodiversity is undervalued. Biodiversity valuation is accordingly a prominent issue in the literature. Economic valuations are, however, largely criticized. Numerous alternatives have been introduced. Most of them involve participatory protocols aimed at producing high-quality results. Being time-consuming and expensive, it is difficult to implement and reproduce them at a large scale. We produce an easily reproducible, inexpensive survey methodology to measure impartial preference for biodiversity. We implement it in Switzerland through a mail-based survey. Our result is that biodiversity should be ranked after retirement schemes and public transportation, but before relations with foreign countries, order and security, and culture and leisure in the expanses of the State. Current expenses therefore substantially underestimate the value that Swiss people grant to biodiversity. Our new method is a viable alternative to standard economic valuation. Given the impartiality achieved, at least in the Swiss political context our estimate can be used by decision makers to assess the legitimacy of conservation programs or to gauge public support. At a philosophical level, our measure is relevant for public policies because it captures the stances that people take when they participate in public decisions.

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1. Introduction

Biodiversity is "the variety of living organisms; the biological complexes in which they occur, and the ways in which they interact with each other and the physical environment" (Groves et al., 2002). Over the past ten years, biodiversity valuation has become a prominent issue in the economic (Bartkowski et al., 2015), ecological (Laurila-Pant et al., 2015) and philosophical (Maclaurin and Sterelny, 2008) literature.

This prominence stems from two observations. On the one hand, measures of biodiversity are correlated with measures of ecosystem functioning (Schmid et al., 2009), many of which provide "ecosystem services" (Quijas et al., 2012; Mace et al., 2012). On the other hand, biodiversity is under increasing pressure and undergoes unprecedented rates of erosion (Butchart et al., 2010).

The fact that biodiversity is being eroded despite the services it provides is considered evidence that biodiversity is undervalued (TEEB, 2010). Economic valuations are often presented as tools that can help to overcome this problem by informing environmental policies through:

- environmental accounting (Cobb and Cobb, 1994);
- rationalization of investments for the protection of species and/or habitats under:
  o national legislations such as the Swiss law on the protection of nature and natural landscapes (admin.ch/opc/fr/classified-compilation/19660144/index.html),
  o supranational legislation such as Natura 2000 in Europe (CEC 1992),
  o international agreements such as the Convention on Biological Diversity (Nijkamp et al., 2008),
- more generally, improvements of the allocation of conservation funds (Scharks and Masuda, 2016).

The economic methods at issue are predominantly based on individual willingness to pay (iWTP), and are classically divided in two types (Bartkowski et al., 2015):

- stated preference methods are survey-based inquiries encompassing contingent valuation, where respondents state their iWTP for an environmental entity or project, and choice experiments, where iWTP is inferred from choices between scenarios;
- revealed preference methods, which use observation of behavior, mainly on markets, to infer iWTP.

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The notion that these iWTP-based methods can inform environmental policies is debated (Ives and Kendal, 2014; Jax et al., 2014; Spash, 2012) with respect to two issues: (1) informational basis and (2) aggregation procedure.

(1) In terms of informational basis, the relevance of iWTP is questioned on four counts.

(1.1) iWTP is sensitive to knowledge, and individuals are often poorly knowledgeable about scientific issues such as biodiversity (Munro and Hanley, 2001).

(1.2) iWTP is sensitive to income and socio-economic status (Meinard et al., 2016), implying that the richer one is, the more influential one can be on iWTP-based decisions.

(1.3) Despite evidence that respondents can act as committed citizens by modulating their stated iWTP (Ami et al., 2014; Martínez-Espiñeira, 2006), iWTP elicitation arguably confines people to their role as consumers rather than citizens (Anderson, 1993; Sagoff, 2008; Sarkar, 2005).

(1.4) iWTP measurements ignore the motives (including social norms and ethical motivations) behind actions and statements, which impairs their usefulness for public policies (Spash et al., 2009; Liebe et al., 2011).

(2) In terms of the aggregation procedure, the relevance of iWTP is questioned on two counts.

(2.1) Many methods aggregate iWTP through summations and therefore endorse utilitarianism (Lo and Spash, 2012), an ethical doctrine whose relevance has long been debated (Rawls, 1971; Kymlicka, 2002).

(2.2) According to the theory of deliberative democracy (Chappell, 2012), by confining aggregation to a mathematical exercise, these methods bypass the crux of legitimate collective decision-making: the public discussions through which people form their positions about public policy.

In the wake of these debates, the main methodological tool introduced is deliberative monetary valuation (DMV) (Kenter et al., 2015; Randhir and Shriver, 2009; Spash, 2007). Various approaches to DMV tackle different deficiencies of standard iWTP-based methods (Bunse et al., 2015). Empirical studies mainly aim at improving the estimates produced by "facilitating the construction of well-informed and rational preferences" (Bunse et al., 2015, p. 91), and therefore mainly tackle deficiency (1.1) and to some extent (2.2). Theoretical studies tackle all the deficiencies by questioning the standard economic theoretical framework, using various interpretations of the deliberative democracy literature (in particular, Bunse et al., 2015 single out Spash and Lo, 2012 as defending a distinctively pluralist interpretation).

The present study aims to contribute to the development of alternatives to iWTP-based methods, not by developing a new DMV approach, but by assessing whether a measure of reasonably impartial preference for biodiversity can be reached through an easily reproducible, inexpensive survey methodology.

This aim has two aspects. The first aspect is that we aim at capturing "impartial preferences"—that is, preference of people focusing on biodiversity per se rather than on their personal situation. Indeed, most conservation actions result in different costs and benefits for various people. Therefore, if they take their personal situation into account, some agents strongly favoring biodiversity might downplay this attitude because they think that conservation policies might have detrimental consequences on their personal situation. Conversely, some agents not concerned with biodiversity might express a positive attitude because they expect positive impacts on themselves. Here we want to focus on preference for biodiversity per se.

The second aspect of our aim is to produce an easily reproducible, reasonably inexpensive survey method. Indeed, the current alternatives to standard iWTP-based methods such as DMV involve dense protocols, where participants are asked to work together for several hours or days.

For example, Hattam et al. (2015) organized a citizen's workshop to assess the ecosystem services provided by a sandbank. To set up their jury with 19 members, they implemented a recruitment procedure, invited experts to explain the stakes of the exercise, and orchestrated deliberations. Such protocols produce high-quality results, but because they are time-consuming and expensive, it is difficult to reproduce them at a large scale. Accordingly, Bunse et al. (2015) highlight the development of larger-scale investigations as a pivotal challenge for the future of DMV. That is why we aim at developing a more quantitative method.

This article is organized as follows. The core theoretical elements structuring the protocol are developed in the "Methods" section. The "Results" section presents empirical findings. Additional theoretical elements useful to interpret them are presented in the "Discussion".

2. Methods

2.1. Theoretical Framework

2.1.1. The Literature on Preference for Redistribution as Role-model

We developed a survey-based approach, inspired by the economic literature on preferences for redistribution. One can distinguish two approaches in this literature. The first uses data from international survey programs such as the World Values Survey to identify the determinants of people's attitudes towards redistributive policies (e.g. Alesina and La Ferrara, 2005; Fong, 2001). The second approach, largely inspired by the work of Rawls (1971), encompasses theories of "extended" (Harsanyi, 1977), "laundered" (Goodin, 1986), "fundamental" (Kolm, 2005) or "abstract" (Meinard and Grill, 2011) preferences. These theories claim that, in order to express their preferences for redistribution, people have to abstract from their personal situation. Indeed, if they take their personal situation into account, rich people are incited to oppose redistribution while poorer ones are incited to favor it. Empirical studies aiming to capture preferences for redistribution therefore have to embed an "impartialization" (Kolm, 2005) protocol, leading respondents to abstract from their personal situation (Clément and Serra, 2001). An illustrative classic impartialization protocol was implemented by Frohlich and Oppenheimer (1992). Working in small groups, they asked participants to choose one among four principles of redistribution (maximization of minimal income, maximization of mean income, maximization of mean income within limits in income disparity, maximization of mean income subject to a lower limit for the minimal income), in view of the distribution of income that each principle would produce among eight classes of income. Each individual was randomly assigned to one class, but did not know which one until the principle was chosen. At the end, each player received a payoff determined by the principle chosen and the class to which s/he was assigned. In this protocol, the players cannot take their personal situations as players into account to decide their move, because when playing they don't know the class to which they have been assigned. Numerous other examples are presented by Gaertner and Schokkaert (2012).

If the logic behind impartialization is thought through to the end, it can be criticized for reducing agents to "unemcumbered selves", deprived from personal attachments and shared meanings, and therefore incapable to have preference (this criticism was originally raised against Rawls's theory: see Kymlicka, 2002). Unemcumbered selves are rhetorical specters, but in concrete terms this criticism means that the personal situation and history of real-life respondents can have a deep effect on their values, from which even the best imaginable impartialization protocol is powerless to abstract. Impartialization is hence better conceived as what Sen (2009) terms a "comparative", as opposed to a "transcendental" notion: thorough impartialization is elusive, but certain preferences can be more impartialized than others.

2.1.2. Application to Biodiversity in a Large-scale Approach

Beyond redistribution, the above-explained logic applies to any issue having redistributive implications, and in particular to biodiversity. Since conservation actions can have effects on personal situations, assuming that people can anticipate (imperfectly) that such effects can exist, identifying their preferences for biodiversity per se requires them to abstract from these anticipations. Our survey therefore had to embed an impartialization protocol.

Most impartialization protocols are, however, small-scale role-playings that produce high-quality data but are expensive, time-consuming and limited in scale (Clement et al., 2008). In contrast, here we introduce a new type of impartialization protocol which is simple and easily reproducible. It is based on the "democracy/contractualism analogy". This refers to philosophical theories claiming that democratic procedures can be seen as models of impartialization protocols (Howard, 2013). This philosophical notion is to some extent corroborated by empirical findings: although predicting political choices on the basis of social classes has long been central to political science, recent studies argue that political choices are increasingly independent of socio-demographic determinants (Ogien and Laugier, 2014).

Taking advantage of this "democracy/contractualism analogy" to design a new type of impartialization protocol is intrinsically worth testing. But it is all the more relevant in a study of biodiversity. Indeed, it is arguably built into the very notion of biodiversity that decision-making on it is unavoidably political (Meinard and Mestrallet, 2014; Sagoff, 2008). Being deprived of this political dimension, standard economic valuations "of biodiversity" are in fact valuations of biodiversity proxies. By contrast, by implementing a protocol fleshing out the democracy/contractualism analogy, one captures this political dimension. In a somewhat similar vein, Schläpfer (2016) advocated a new economic valuation method ("democratic valuation"—DV) based on democratic principles, stressing important strengths as compared to iWTP. In particular, the emblematic democratic aggregation rule—the simple majority rule—proves more robust to strategic answers, more acceptable for respondents and more credible than welfare economic aggregations. Schläpfer (2016), however, does not explore impartialization, his empirical implementations are embedded in standard iWTP surveys, and they focus on concrete projects rather than on biodiversity per se. He therefore turns a blind eye towards important features of protocols based on democratic principles.

By contrast, here we design a large-scale survey formatted to model a democratic political choice and we assess its credential to capture preferences for biodiversity per se.

2.1.3. Empirical Assessment

We empirically assess whether this protocol works as an impartialization device. Our assessment has two dimensions—impartiality and impartialization—each involving important methodological choices.

2.1.3.1. Impartiality Assessment.
Impartiality can be defined in so-called "internalist" terms: preferences are internalist impartial when agents do not take into account their personal situation when identifying and expressing them. But it can also be understood in an "externalist" approach: preferences are externalist impartial when they are independent from socio-economic status.

Externalist impartiality is harder to achieve than internalist impartiality. Indeed, even if respondents do not take their personal status into account (and preferences are therefore internalist impartial), answers can remain correlated with socio-economic status (and are therefore not externalist impartial). This can happen, for example, because socio-economic status had a deep effect in their psychological history and the formation of their values. But externalist impartiality is easier to measure than internalist impartiality, because it can be assessed by studying correlations between responses and socio-economic status. By contrast, assessing internalist impartiality is a complex psychological task.

Because it is easier to measure and harder to achieve, externalist impartiality can be used as criterion to assess internalist impartiality. This is our approach here.

Another methodological issue is whether impartiality should be assessed question by question or at the scale of the whole questionnaire. A global assessment is theoretically difficult because it is unclear how impartiality of responses to a given question can outweigh partiality of responses to another. However, a question-by-question assessment is also questionable. Indeed, one might argue that it is psychologically implausible that, within a single questionnaire, respondents switch from impartial to partial stances and back again. In this article, we do not take a rigid stance on these issues. We implement statistical models on a question-by-question basis and discuss in more informal terms the picture at the scale of the whole questionnaire.

2.1.3.2. Impartialization Assessment.
Impartialization assessment aims to determine whether the protocol has a causal effect in rendering preferences more impartial than iWTP. Five approaches can be envisaged.

(1) *Embed a iWTP elicitation procedure within the questionnaire*. This would allow comparing how a given respondent answers differently to a iWTP-based question and to a question integrated in the impartialization protocol. However, iWTP-based questions arouse numerous protest non-responses (Milanesi, 2010). Integrating a iWTP-based question in our questionnaire would therefore probably lower the response rate, and the resulting sample would be biased towards people accepting iWTP-based approaches. This would therefore impose very high costs in terms of quantity and quality of data. Besides, given that iWTP-based approaches encompass numerous methods (Alberini and Kahn, 2009), a comparative approach within a questionnaire would open endless debates about whether it sheds light on iWTP in general or on the specific method implemented.

(2) *Implement two parallel questionnaires: one embodying the impartialization protocol and the other a iWTP elicitation procedure*. This approach is immune from the risk of biasing responses. But the subpopulation answering the two questionnaires would likely be different, rendering it impossible to disentangle this effect from the impartialization effect. And like approach (1), the comparison would arouse inconclusive debates.

(3) *Implement an experimental approach precisely monitoring whether and how respondents modify their answers as a response to the impartialization protocol*. This would involve setting the questionnaire in a small-scale experimental format, incompatible with our ambition to produce a large-scale, relatively inexpensive methodology.

(4) *Compare the results of our questionnaire with the ones of iWTP-based valuations*. In the current state of the literature, this is hardly feasible, as illustrated by Bartkowski et al. (2015)'s comprehensive review. They identified only 7 studies (among 123) focused on biodiversity in general rather than on a specific proxy. One of them is embedded in a deliberative protocol and the other six are focused on specific ecosystems. None can be used as benchmark for our purposes.

(5) *Use a theoretical, incentive-based benchmark*. A more modest approach is to use, more informally, a coarse incentive-based theoretical benchmark delineating what a partial response would look like, and compare actual responses with this benchmark.

Approaches (1) and (2) appear unpromising. Ultimately, a perfectly satisfactory assessment would involve parallel implementations of approaches (3), (4) and (5). Given the data limitations to which we are subject, we limit ourselves to a modest implementation of approach (5).

Table 1
Descriptive statistics. The variables are labeled by the number corresponding to the question in the survey.

Dependent variable (answers to questions in the questionnaire)	Number	Percentage (%)
I. Opinion concerning the arguments to preserve biodiversity	434	100
1. Perfectly convincing	124	28.6
2. Rather convincing	175	40.3
3. Interesting, but insufficient	92	21.2
4. Rather weak	6	1.4
5. Not convincing at all	4	0.9
o No response	33	7.6
II. Rank of biodiversity in the state budget	434	100
1. 1st position, before all the others	48	11.1
2. 2nd position, after retirement schemes	77	17.7
3. 3rd position, after public transportation	105	24.2
4. 4th position, after relations with foreign countries	63	14.5
5. 5th position, after order and security	94	21.7
6. Last position, after culture and leisure	32	7.4
o No response	15	3.4
III. Opinion on the formulation of question II	434	100
1. Perfectly	129	29.7
2. Rather well, but I would have more to say	178	41.0
3. Don't know	65	15.0
4. Rather badly	45	10.4
5. Not at all	12	2.8
o No response	5	1.1
IV. Modalities of financing	434	100
1. Rise taxes	4	0.9
2. Diminish state interventions in other domains	278	64.1
3. Both	136	31.3
o No answer	16	3.7
V. Opinion on the formulation of question IV	434	100
1. Perfectly	137	31.6
2. Rather well, but I would have more to say	171	39.4
3. Don't know	50	11.5
4. Rather badly	49	11.3
5. Not at all	15	3.4
o No response	12	2.8
Socio-demographic variables		
VI. Age	434	100
o 18–25	5	1.2
o 26–35	16	3.7
o 36–45	39	9.0
o 46–55	46	10.6
o 56–65	46	10.6
o 66–75	51	11.7
o 76 or more	37	8.5
o No response	194	44.7
VII. Civil status	434	100
1. Married	265	61.1
2. Single	82	18.9
3. Divorcee	66	15.2
4. Widowed	18	4.1
o No response	3	0.7
VIII. Number of children	434	100
1. None	117	27.0
2. One	58	13.4
3. Two	163	37.6
4. Three or more	95	21.8
o No response	1	0.2
IX. Education	434	100
1. Apprenticeship	222	51.2
2. "Maturité gymnasiale" (qualification to enter university)	46	10.6
3. Two years of university studies	31	7.1
4. Three years or more	122	28.1
5. No education	2	0.5
o No responses	11	2.5
X. Amount of taxes paid last year	434	100
1. Less than 2000 CHF	25	5.8
2. Between 2000 and 6000 CHF	72	16.6
3. Between 6000 and 10,000 CHF	91	21.0
4. Between 10,000 and 14,000 CHF	80	18.4
5. Between 14,000 and 18,000 CHF	40	9.2
6. Between 18,000 and 25,000 CHF	33	7.6

Table 1 (*continued*)

Dependent variable (answers to questions in the questionnaire)	Number	Percentage (%)
7. More than 25,000 CHF	80	18.4
o No response	13	3.0
XI. Employment status	434	100
1. Employee	193	44.5
2. Self-employed	50	11.5
3. Jobless	12	2.8
4. Undergoing training	2	0.5
5. Retired	169	38.9
o No answer	8	1.8
XII. Canton	434	100
1. Zürich	211	48.6
2. Neuchâtel	223	51.4

2.2. Technical Implementation

We carried out a questionnaire study in Switzerland. The Swiss political context (Cormon, 2015) is particularly convenient for the implementation of our approach. Indeed, this political system is very close to a direct democracy, in the sense that referenda are very often used, both for Constitutional changes and for more day-to-day changes in law. "Popular initiatives" and "votations" are widely used instruments of direct democracy through which citizens can make bottom-up decisions about governance and policies. This system applies at three nested levels (federal state, cantons and municipalities). Democracy, understood in a sense that gives prominent importance to voting and to the simple majority rule, is therefore especially well-entrenched in Switzerland.

In October 2011, we sent 1000 questionnaires, in a French version, to a random sample of households in the canton of Neuchâtel and another 1000 questionnaires, in German, to a random sample in the canton of Zürich. The samples were drawn from the Directories Phonebook (www.local.ch). Our documents (supplemental data S1) follow a recommended format (Kanninen, 2007; Alberini and Kahn, 2009).

The envelope contained an introduction, the questionnaire and a stamped envelope. The introduction gave the opportunity to send it back without answering the questionnaire.

The introduction specified that the questionnaire was part of scientific research aiming to assess how the Swiss society valued biodiversity. It stressed that, although independent from political parties, its results should provide information for policy-makers to better understand the importance granted by Swiss people to biodiversity. This was meant to focus respondents' attention on the value of biodiversity per se and its political dimension.

The questionnaire contained three parts. Part 1 summarized knowledge about biodiversity and clarified that it did not advocate any environmental position. It emphasized that protecting biodiversity requires costly, organized, cooperative efforts, so as to point out the potential political implications of responses.

Part 2 contained the valuation questions. The central question (II in Table 1: "In your opinion, how important is biodiversity when compared with these various sectors?") asked respondents to express the importance they granted to biodiversity. We presented the Swiss budgetary allocation to five tasks (retirement schemes, public transportation, relations with foreign countries, order and security, culture and leisure), listed in this order according to the percentage of federal budget allocated to them (according to administrative databases: www.efd.admin.ch), and asked where biodiversity should be ranked in importance in relation to these sectors.

The formulation in terms of budgetary allocation conveys that concrete, costly collective actions are at stake. The question had to take into account political and economic constraints, in particular the fact that political decision-making cannot change budgetary repartitions overnight. This is why respondents were not asked to rank the

sectors as they see fit, but rather to rank biodiversity conservation relative to these fixed items.

Notice that, by expressing importance in terms of relative budgetary ranking, we take the term "importance" in a specific sense. One can take some costless things to be more important than all the things to which a State allots its budget. Our questionnaire does not take "importance" in this sense. In yet another understanding, one could argue that, given that the various sectors have different operating costs, a more meaningful measure of relative importance is in terms of the quantity of service that citizens want for the various sectors. The relative budgetary ranking is in that case derived from applying sector-specific budget requirements to chosen quantities. The specific understanding of "importance" used in our valuation question is therefore only one possible understanding (which should be kept in mind when interpreting the results).

Our choice of sectors is largely arbitrary. They are not the most important ones in the budget. For example, health insurance accounted for more than foreign relations in expenses in the original data. Using the five most important sectors would have biased the responses by suggesting that biodiversity must be ranked among the six most important sectors. We have therefore chosen five sectors that span across the spectrum of the orders of magnitude of expenses by sector. This approach, however, leaves many options available. We chose five sectors intuitively epitomizing emblematic issues of political debates. Framing the question in these terms was therefore likely to lead respondents to associate their answers with realistic collective choices. Notice also that this list contains both sectors corresponding to benefits accruing in a diffuse way to everyone (e.g. relations with foreign countries) and sectors with clear beneficiaries (e.g. retirement schemes). This is because the point is not to interrogate respondents about issues on which they do not have a personal stake, but rather to lead them to take an impersonal stance on issues on which they can have personal stakes.

Notice also that some of the current expenses of the State could be interpreted as falling within the category "biodiversity": there is a sector "protection of the environment" in databases, and part of the State expenses devoted to "research" finance research on biodiversity. Furthermore, in Switzerland farmers benefit from direct payments if they protect biodiversity. Therefore, one might object that the current position of the sector "biodiversity" should have been mentioned. This was not our approach because the current ranking would have been a salient point attracting responses.

We also emphasized that responses would be aggregated according to the majority rule like in a democratic vote (first-past-the-post), which recalled the link between answers and political choices in a democratic setting. Given that the aggregation mode is one to which respondents are accustomed (especially in Switzerland), one can assume that pointing it helped respondents to understand how their voice could be translated into collective political choices.

Following question II, question IV strengthened the link between biodiversity valuation and its potential consequences by asking how respondents would contribute to the costs of conservation. Placing this question after the valuation question was crucial, because if placed the opposite sequence, respondents would have been incited to focus on anticipations of redistributive effects.

Further questions in part 2 allowed respondents to assess whether the formulation of the questions about valuation and financing allowed them to express their opinion in a convenient way (Questions III and V). Despite the admitted importance of understanding motives behind responses to questionnaires (Spash et al., 2009; Liebe et al., 2011), we purportedly did not include more precise questions concerning motivations. This is because our primary aim in this pilot implementation was to assess the feasibility of our protocol and its credential as an impartializing device. Adding questions to capture motivations would have lengthened the questionnaire, and hence could have lowered the response rate, thereby affecting our primary empirical aim. And the payoff would have been uncertain, because our format is

very different form deliberative settings such as discussions groups, which are admitted to be the most convenient to capture such information (Bunse et al., 2015). In the discussion, we come back to the importance of integrating such questions in further implementation.

Part 3 contained questions about socio-demographic attributes of respondents.

3. Results

The proportion of complete responses was 21.7% (433 out of 1994), which is relatively high (Whitehead, 2009) and sufficient for a meaningful quantitative analysis. The global rate of responses, including short responses containing only the first page, was 29.7%. Among the short responses, 20% stated that they were not interested in biodiversity and 31% that they were against the use of questionnaires. These purportedly short questions do not provide easily interpretable results. But at least they testify that numerous respondents had a protest attitude towards our survey that future implementations could strive to characterize.

A great majority of respondents were rather or perfectly convinced by the arguments for the preservation of biodiversity (68.9%; Question I: "In your opinion, how convincing are the arguments [for the preservation of biodiversity] mentioned above?"). Regarding Questions III and V, most individuals felt that Questions II and IV enabled them to rather well or perfectly express their opinion (70.7% and 71.0%, respectively).

The main result, which is the aggregate response to the valuation question according to the majority rule, indicates that biodiversity should be ranked third in budget allocation among the six presented tasks (Table 1; Question II). Almost two thirds of respondents stated that conservation should be financed through reallocating money from the existing budget (64%) rather than through an increase in taxes or a combination of the two (Question IV). This suggests that respondents took seriously the monetary implications of their responses.
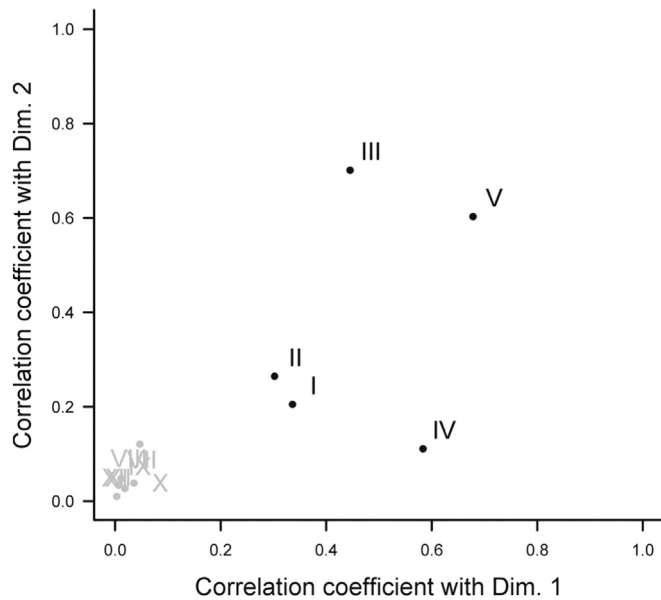
We first studied the dependent variables graphically with a multiple correspondence analysis (MCA; Fig. 1), and statistically with an ordered probit regression (Table 2).

The MCA showed that socio-demographic variables did not explain much of the two principal dimensions (Fig. 1). The first principal dimension (Dim 1) accounted for ca. 9.8% of total variance, while the second one (Dim 2) accounted for ca. 7.9%. To check whether non-responses distorted correlation coefficients, we replaced missing answers with simulated answers according to the participant's profile regarding the answers to the other questions. This gives a similar pattern with strong correlations between the principal dimensions' values and the answers to Questions I—V, but weak correlations with the socio-demographic variables.

The percentage of total variance explained by the first two dimensions in the MCA is low but not unusual for MCA. To reach more conclusive results we therefore tested whether the socio-demographic variables had an influence on individual responses with the ordered probit regression. The results of the comprehensive models are presented in Table 2. Age was not considered due to the high proportion of non-respondents (Table 1). For each dependent variable, we selected the most parsimonious model by a forward selection of significant terms in the corresponding analysis of variance (a backward elimination of non-significant terms gives similar results but is inapplicable at step 1 for question IV due to insufficiently numerous answers for some modalities).

None of the socio-demographic variables had a significant effect for Questions:

- I ("In your opinion, how convincing are the arguments (for the preservation of biodiversity) mentioned above?") (Likelihood Ratio tests: the variable "Canton" tended to have an effect: LR = 3.38, df = 1, $P = 0.066$; for the other variables: all $P > 0.1$),

Fig. 1. Representation of the absolute correlation coefficients between the first two principal dimensions (Dim 1 and Dim 2) and the dependent variables (in black) or the socio-demographic variables (in grey). The variables are labeled by the number corresponding to the question in the survey (see Table 1): the points I to V represent Question I to Question V; the points VII to XII represent the socio-demographic variables (civic status, number of kids, education, taxes, job, and canton respectively).

- III ("Do you think that the former question enabled you to express your opinion on the importance of biodiversity?") (LR tests: all $P > 0.1$),

- IV ("If the State decided to spend more money to protect biodiversity, how do you think it should proceed?") (LR tests: the variable "Employment status" tended to have an effect: LR = 9.28, df = 4, $P = 0.054$; for the other variables: all $P > 0.1$),

- V (identical to question III but referring to question IV) (the variable "Marital status" tended to have an effect: LR = 7.50, df = 3, $P = 0.058$; for the other variables: all $P > 0.1$).

For all these questions the ordered probit regression therefore concurs with the MCA to show that responses are impartial.

For Question II the variables "Number of Children" (LR = 8.54, df = 3, $P = 0.036$) and "Taxes" (LR = 45.77, df = 6, $P = 3.3.10^{-8}$) had a significant influence. Unsurprisingly, impartiality appears more difficult to achieve for the valuation question. We therefore studied more precisely these effects.

Concerning the variable "Number of children", 40% of the people without children rank biodiversity 5th or lower. When compared with the group of people with 1 or more child, the ranking they state is significantly lower (LR = 6.78, df = 1, $P = 0.009$) (Fig. 2, Supplemental data S2). It is tempting to interpret this difference by saying that people with children gave a higher priority to biodiversity because they are more responsive to the widely held notion that preserving biodiversity is important to ensure the quality of life for future generations. However, cautiousness is in order to interpret these results. Indeed, pairwise comparisons in the comprehensive model (Table 2) only identify the category of people with one child as significantly different from the category of people without child. This is counterintuitive, because people with 2 children or more have even more reasons than people with one child to take into account the importance of biodiversity for future generations. However, in the selected model (Supplemental

Table 2

Ordered probit regression, using procedures available in R 2.8.0 (http://cran.r-project.org/). The modalities of the dependent variables are ordered and directly defined by the possible responses to questions I, II, III and V in the order in which they appear in the questionnaire (Supplemental data S1). Concerning question IV, the second and last possible responses as they appear in the questionnaire must be switched to define a meaningful order. The model selected with a forward selection appears in shaded cells. Confidence levels: * 0.05, ** 0.01, *** 0.001.

Dependant variables		I. Opinion Estimate	Standard error	II. Ranking Estimate		Standard error	III. Opinion ranking Estimate		Standard error	IV. Financing Estimate		Standard error	V. Opinion financing Estimate		Standard error
VII. Marital status															
1.	married	Ref		Ref			Ref			Ref			Ref		
2.	single	0.084	0.206	0.076		0.187	0.629	**	0.198	−0.402		0.225	0.249		0.198
3.	divorcee	0.055	0.170	−0.336	*	0.163	0.075		0.165	0.061		0.191	0.482	*	0.166
4.	widowed	−0.611	0.342	−0.094		0.299	0.188		0.299	−0.135		0.361	0.262		0.304
VIII. Number of children															
1.	none	Ref		Ref			Ref			Ref			Ref		
2.	one	0.132	0.220	−0.464	*	0.203	0.595	**	0.209	−0.071		0.237	0.270		0.210
3.	two	0.383	* 0.186	−0.208		0.171	0.492	**	0.182	−0.288		0.203	0.356	*	0.181
4.	three or more	0.270	0.205	−0.270		0.189	0.723	***	0.198	−0.207		0.224	0.535	**	0.198
IX. Education															
1.	apprenticeship	Ref		Ref			Ref			Ref			Ref		
2.	"maturité gym."	−0.189	0.199	−0.427	*	0.185	−0.142		0.188	−0.202		0.219	−0.103		0.191
3.	2 years at university	−0.322	0.244	0.127		0.222	0.209		0.227	0.217		0.256	0.186		0.232
4.	3 years or more	−0.095	0.146	−0.005		0.13	0.139		0.139	0.397	*	0.160	0.215		0.140
5.	no education	1.543	0.861	−0.062		0.799	1.018		0.805	0.701		0.975	0.881		0.805
X. Taxes															
1.	less than 2 000	Ref		Ref			Ref			Ref			Ref		
2.	2 000 and 6 000	−0.180	0.316	0.116		0.276	−0.100		0.286	0.250		0.328	−0.219		0.287
3.	6000 and 10 000	0.039	0.303	0.019		0.267	0.030		0.277	0.092		0.318	−0.045		0.277
4.	10 000 and 14 000	−0.197	0.308	0.250		0.272	0.074		0.282	−0.193		0.325	−0.093		0.282
5.	14 000 and 18 000	0.171	0.332	0.647	*	0.296	0.034		0.306	−0.046		0.353	−0.146		0.307
6.	18 000 and 25 000	0.081	0.351	0.472		0.312	0.208		0.324	0.128		0.374	0.046		0.324
7.	more than 25 000	0.216	0.319	0.950	***	0.285	0.270		0.293	−0.086		0.336	−0.030		0.294
XI. Employment status															
1.	employee	Ref		Ref			Ref			Ref			Ref		
2.	self−employed	0.187	0.191	0.185		0.180	0.172		0.182	0.280		0.212	0.240		0.186
3.	jobless	−0.564	0.417	−0.031		0.340	0.495		0.353	0.043		0.399	0.223		0.355
4.	undergoing training	−0.667	0.888	−0.559		0.783	0.285		0.811	5.861		126.3	1.043		0.800
5.	retired	−0.273	* 0.135	−0.040		0.122	−0.126		0.127	0.432	**	0.147	0.018		0.127
XII. Canton															
1.	Zürich														
2.	Neuchâtel	Ref		Ref			Ref			Ref			Ref		
		0.251	* 0.123	0.011		0.113	−0.145		0.117	−0.062		0.141	0.120		0.118

data S3, Table 3), the difference between the category of people without children and the categories of people with 2 children or with 3 or more children is significant ($P = 0.044$ and 0.04 respectively) but weaker than with the category of people having one child. The latter category therefore appears to account for an important part of the effect selected by the model selection procedure. In the light of these elements, the observed effect appears more hazardous to make sense of, and might well be largely amenable to sheer stochasticity. The plausibility of this interpretation is reinforced when one ponders on the fact that the ordered probit regression and the procedure used to select models involve performing very numerous tests, and therefore using the standard 0.05 significance level can lead to spurious rejections of null hypothesis. A classical approach to eschew this problem is the Bonferroni correction, but it is extremely conservative, and its relevance is debated (Moran, 2003). Delving into this technical debate however falls beyond our scope. In order to take account of the problems created by the numerous tests without turning a blind eye on the structure of the data, we indicate 3 significance levels (0.05, 0.01 and 0.001) in Table 2, and are very cautious when interpreting effects that, like the one concerning number of children in the comprehensive model, only reach the less stringent threshold (0.05).

The effect of the variable "Taxes" on responses to question II is more significant. As illustrated in Fig. 3 (Supplemental data S4), the higher the taxes respondents pay, the lower they tend to rank biodiversity. However, pairwise comparisons, using different modalities of "Taxes" as reference, suggest a more complex picture (Table 4, Supplemental data S5). People from the 4 lower categories in terms of taxes answer similarly, as do people from the 3 higher ones, and the two groups respond significantly differently (LR = 41.14, df = 1, $P = 1,4 \cdot 10^{-10}$) (this is clearly illustrated, in particular, when using the 5th category as reference). Within the subpopulation of people belonging to the three higher categories in terms of taxes, many of those who ranked biodiversity 6th also stated that question II did "not at all" allowed them to express their opinion about the importance of biodiversity ($P = 0.001$ for the test of correlation between modalities). Similarly, many of those who ranked biodiversity 5th stated that it did "not that much" allow them to express their opinion ($P = 0.04$). This suggests that many responses granting a low rank to biodiversity might be protest responses. However, even when focusing the analysis on people who did accept the valuation question as relevant, a significant difference remains between the two groups in terms of taxes ($P = 4 \cdot 10^{-7}$ in the comprehensive model).

Our results can hence be summed up as follows.

1) With 433 questionnaires analyzed, this study has a broader scale than typical DMV and competes with standard economic valuations.
2) The valuation exercise states that biodiversity should be ranked third in importance among six tasks of the Swiss state, after retirement schemes and public transportation, but before relations with foreign countries, order and security, and culture and leisure. This means between 4.6% and 8.4% of total expenses of the Swiss State. This figure can be compared with the actual amounts that the State devoted to the "Protection of the Environment" the corresponding year: 1.4% (www.efd.admin.ch). Our results therefore suggest that actual expenses substantially underestimate the value that Swiss people grant to biodiversity, or that policy-makers willing to increase these expanses can count on popular support. In the Swiss context, especially at the canton level, a candidate to local elections could use this figure to put forward budgetary adjustments.
3) For all the questions except the valuation question II, the statistical analysis shows that responses are independent of socio-demographic determinants and are, in that sense, impartial.
4) For the valuation question II, the statistical analysis unveils undisputable significant effects. The number of children has a demonstrable effect, but the detailed analysis shows that the data carry a blurred message. The most important effect concerns taxes paid. However,

answers do not smoothly track taxes paid; they rather draw two largely overlapping distributions (Fig. 3, Supplemental data S4). This suggests that the protocol has smoothed out partial differences to some extent, but did not reach profound differences between people from very different economic statuses.
5) With only one model selected, with only two explanatory variables (Table 2), the global image emerging (especially if one admits that it is psychologically incredible that respondents might switch from impartial to partial stances and back again within a short questionnaire) is that responses are globally impartial.
6) Given that our impartiality assessment is based on externalist impartiality, which is harder to achieve than internalist impartiality, our data suggest (but cannot demonstrate) that our protocol achieved a good degree of internalist impartiality.
7) Adjudicating impartialization is more delicate. However, for several questions, simple incentives benchmarks suggesting partial responses can be defined. In particular, being net beneficiaries of state expanses, retiaries are incited to favor higher taxes to finance biodiversity conservation; people in the highest categories in terms of taxes are incited to disfavor higher taxes; people with two or more children are more incited than people with one child to take account of the importance of biodiversity for future generations. When compared with these theoretical incentive-based benchmarks, responses to the corresponding questions appear impartialized.
8) All in all, this pilot implementation of our simple protocol manages to achieve a good degree of impartiality and impartialization, but differences remain between people with different economic statuses.

4. Discussion

We first explore possible improvements of the protocol, and thereby identify three challenges for further implementations (Section 4.1). We then discuss at a more philosophical level the relevance of impartialization for public policy purposes (Sections 4.2–4.3), and thereby identify two additional challenges.

4.1. Possible Improvements of the Protocol

A complete sensitivity analysis of the effects of formulations of the valuation question was not carried out here because our point was to develop a first pilot implementation with one specific formulation. However, for further implementations, a sensitivity analysis to the formulation of the valuation question (comparing various representations of importance, tasks with which biodiversity is compared, figures to represent them, etc.) will be necessary to identify the best formulation. The sensitivity analysis is also needed to ensure that results are not biased by scoping and sequencing or embedding effects (Kahnemen and Knetsch, 1992). An interesting alternative in this respect would be to present the importance of sectors in the State budget as a fraction of the budget currently devoted to the protection of the environment. This would not change relative rankings, but would provide a reference point for respondents. The literature also recommends expanded introductory parts (Ami et al., 2011) containing more precisely calibrated information (Mathiews et al., 2007). The relatively small quantity of information given to respondents is justified by our aim to produce a simple protocol. But further implementations should test the effects of variations in quantity and quality of information. The marginal influence of all these modifications should be tested, through large-scale repeated implementations (challenge 1).

Besides, this pilot study used simple standards to adjudicate impartiality and impartialization. This reflects our choice not to attempt to identify the motives underlying responses. In further implementations, including questions on motivations would allow developing firmer and deeper interpretations (Spash et al., 2009; Liebe et al., 2011). It would allow sorting out various kinds of influences of socio-economic status and corresponding mechanisms of impartialization, and would allow

characterizing the role of psychosocial factors and ethical motives (challenge 2).

Since one of our aims was to develop a quantitative approach, a third pivotal issue is representativeness. Assessing representativeness is tricky in our current protocol, for two reasons. On the one hand, to keep the questionnaire short, we avoided asking too many socio-demographic questions; moreover, for some questions such as age, many respondents did not respond. Second, data are not available concerning the whole Swiss population for all the socio-demographic parameters that we used (http://www.bfs.admin.ch/bfs/portal/en/index/themen/01/02.html). Along the dimensions for which represen-tativeness assessment is possible (number of children and level of education), the sample of people who responded to our questionnaire appears representative of the Swiss population (respectively: $\times^2 =$ 2.95, df $= 3$, $P = 0.399$; $\times^2 = 1.30$, df $= 2$, $P = 0.523$).

However, the subsample of respondents who answered the age question appears to under-represents under-40s' and over-represent over 76 s' ($\times^2 = 24.97$, df $= 3$, $P = 1.564\text{e-}05$). One could conjecture that this might reflect a bias in the sampling procedure because younger people might be less likely to have telephone fixed-lines than older ones (2,361,433 persons, slightly less than a third of the Swiss population, are listed in the phonebook). Given that there might also be generational differences in stances towards biodiversity (which the high percentage of non-response to the age question did not allow to test), one could suspect that our study produces a distorted image of the importance that Swiss people grant to biodiversity due to a bias in the sampling procedure.

However, for both practical and theoretical reasons, in the current state of knowledge it is impossible to establish if these suspected biases really exist, and if so, to correct them.

At a theoretical level, the democracy/contractualism analogy creates unresolved problems for representativeness analysis. This analogy holds that the implementation of democratic procedures counts as an impartialization protocol. But in democratic procedures, the sample of people actually participating is typically not representative of the whole population. The absence of representativeness is in that sense already taken into account in the analogy. If one nevertheless wants to analyze representativeness, should one consider that the sample should be representative of the whole people, or of the sample of people typically partaking in democratic votes? If the latter, given that numerous democratic votes are implemented on different issues in various setting, what should count as "typical"? These unsettled issues show that this analogy is still in need of theoretical elaboration.

At a practical level, even if answers to these theoretical questions were available, they would not be feasible in our case. Indeed, the putative bias of the sample of respondents as compared to the whole population is actually the sum of two biases: the bias of the sample of people listed in the phonebook as compared with the whole population, and the bias of the respondents to our questionnaire as compared to the population listed. Neither the Swiss Statistics administration (www.bfs.admin.ch) nor the Official Swiss Phonebook (tel.local.ch) have statistics about the first bias. It is therefore impossible to sort out the two biases and correct them in the appropriate way. Elaborating a more controlla-ble sampling procedure, allowing for bias characterization and correc-tion, is therefore pivotal for further implementations of our method (challenge 3).

4.2. The Public Policy Relevance of Impartialization

So far, we have presented impartialization as a conceptual requirement not to conflate preferences for biodiversity per se with preferences for by-consequences on personal situations. But our approach has a richer philosophical significance for public policy.

Economic valuations are often presented as meaningful tools to support public policies because they claim to measure contributions to wellbeing (Barbier et al., 2009). This oft-cited argument is untenable because iWTP provides an unacceptably reductive picture of wellbeing (Nussbaum and Sen, 1983; Sen, 1970). Our measure of impartial preferences is more meaningful for public policy purposes. The reason is independent from wellbeing, which our methods do not capture. Our method however strives to capture deeper stances, which do not necessarily surface in everyday actions and reactions, but become decisive when people participate in public decisions. We term these deeper stances: "public opinion".

iWTP notoriously fails to capture public opinion. Indeed, Harvey's (1996) "[T]he rich are unlikely to give up an (environmental) amenity 'at any price' whereas the poor who are least able to sustain the loss are likely to sacrifice it for a trifling sum" is corroborated by quantitative studies: wealthy people are willing to pay more than poor people for a similar increase in environmental quality (Jacobsen and Hanley, 2009). By contrast, income does not influence stances towards environ-mental policy (Aklin et al., 2013). This contrast highlights that the variations of iWTP as a function of income include confounded effects of differing attitudes towards the environment, differing marginal utility of income and differing budget constraints. Due to these "income effects", iWTP draws a distorted image of public opinion. Some authors (e.g. Breffle et al., 2015) acknowledge that, beyond the technical debate on WTP versus willingness to accept (Hanemann, 1991), this impairs iWTP-based policy recommendations. But instead of accepting the policy irrelevance of iWTP, they prescribe to weight it with a measure of inequality. A more consequential approach is to carve out approaches digging deeper than iWTP to capture preferences that are closer to public opinion.

Impartialization, understood in a Rawls-inspired sense, is one such approach. Rawls' understanding of impartiality is encapsulated in the concepts of the "original position" and the "veil of ignorance", originally introduced to choose "principles of justice" (Rawls, 1971). Rawls (1993) however subsequently presented them as "device[s] of representation" that citizens can use to reason in an appropriate way when engaging in public discussion and justification. The achieved form of impartiality is constitutive of the "public reason" of citizens partaking in public decisions.

Our impartialization protocol does not exactly mimics Rawls' device, since the latter is based on the unanimity rule, whereas our method in-volves the simple majority rule. Our approach is hence closer to other works in the Rawlsian tradition using as paradigmatic models for public reasoning the functioning of institutions involving the majority rule, such as constitutional courts (e.g. Brettschneider, 2007) or judicial juries (e.g. Estlund, 2008). These approaches do not take decision rules to be technical devices used to aggregate independent preferences of isolated individuals (as in aggregative models of democracy). Decision rules are rather considered an integral part of public reasoning, having a role in the formation of political stances and embodying a vision of how collective decisions can be made while respecting differing views. Our method endorses this vision. Despite this difference, it shares with Rawls' formulation and most theories in this tradition the idea that impartializing procedures allow coming closer to public opinion.

4.3. Towards Conjoint Usages of DMV and our Approach?

The latter idea is pivotal to Rawls' and many liberal theorists' understanding and endorsement of deliberative democratic theory (McCarthy, 1994; Cohen, 2003), an approach claiming that public opin-ion is the dynamic product of public discussions through which people form, express, criticize and make collective decisions on the basis of their respective ideas and positions—not only by taking an impartial stance, but also by exchanging reasons, being exposed to unexpected experiences and information, and exerting their critical and self-critical capabilities (Chappell, 2012, Chambers, 2003, Bunse et al., 2015). Given that DMV are explicitly anchored in deliberative democra-cy, it is important to clarify how our approach relates to DMV.

DMV concretize, in their various forms, different aspects of the deliberative democratic ideal that are not addressed by our Rawls-inspired approach: a delivery of information adjusted to the need of participants (e.g. Lienhoop and Macillan, 2007), a grasp of the possible psycho-social factors influencing respondents (e.g. Spash et al., 2009), an active implication in the formation of preferences (e.g. Macmillan et al., 2002), a confrontation with challenging alternative worldviews (e.g. Dietz et al., 2009, Lo and Spash, 2012), an understanding of the motivations underlying responses (e.g. Spash et al., 2009). This makes DMV closer to what Dryzek (2000) identified as the version of deliberative democratic theory anchored in critical theory in the wake of Habermas (1997), as opposed to a Rawlsian version anchored in liberal constitutionalism.

Following Freeman (2000, p.375), we claim that the main difference between the two approaches is that the Habermasian version of deliberative democracy is "dependant on argumentation actually being carried out… because real argument makes moral insight possible" (Habermas, 1990, p.5), whereas for Rawls deliberative democracy is a requirement that policies be justifiable by reasons that all can reasonably accept. Being closer to Habermas, DMV emphasise actual discussions and their concrete role in the collective identification of the common good. Being closer to Rawls, our approach emphasises impartiality as a legitimating force, and presupposes that a vivid democratic life has already played its formative role.

Our method therefore does not contradict the deliberative approach embodied in DMV. The two approaches rather tackle different stages in the policy process: DMV tackles the very formation of public opinion, whereas our method addresses its elicitation assuming its preexistence (which is admittedly a very substantial assumption, even in contexts such as the Swiss one, where democracy is vivid and deeply entrenched).

Seen through these lenses, the two approaches have complementary strengths and weaknesses:

- DMV closely approximates ideals of deliberative democracy through the quality of data it captures and its active engagement in the formation of public opinion, whereas our method is less precise and predicated on the assumption of an already formed public opinion;
- DMV faces a real challenge to develop itself quantitatively, whereas our method is inexpensive and simple enough to be implemented at a large scale.

It is therefore tempting to strive to capitalize on the strengths of both by using them conjointly. The general complementary strengths and weaknesses above are however too general to guarantee that the two methods can be used as complementary tools—that is, as tools that can be applied and support conjointly a common decision process. Ideally, such a conjoint usage is only permissible if the methods are compatible at an axiomatic level (Guba and Lincoln, 2005). But a complete axiomatic characterization of our method will not make sense until the sensitivity analyzes and broader scale tests and implementations mentioned above are performed. Similarly, there is currently no axiomatic characterization of DMV, which reflects that DMV encompasses a huge variety of approaches (Bunse et al., 2015). In the absence of axiomatic characterizations, as exemplified by Hattam et al. (2015), an analysis of the complementarities between work-stages, methods themselves and their results can be developed when several methods are applied to a common case-study, allowing to compare the approaches in concrete term.

This leads to identify two additional intertwined challenges for future implementations of our method.

- Challenge 4) Identify complementarities between our method and DMV at a general axiomatic level (including a precise characterization

of the conditions of applicability of the two approaches, especially in view of our assumption concerning the preexistence of public opinion) and at concrete levels in parallel implementations in common case-studies.
- Challenge 5) Use the results of the former steps to:
  - Determine the optimal design of the method.
  - Decide whether it should be used as stand-alone or as part of a mixed methods approach and, if the latter, establish how to aggregate the results of the methods involved.

5. Conclusions

Our aim here was to assess whether an empirical measure of reasonably impartial preference for biodiversity can be reached through a simple survey methodology. We identified theoretical resources for that purpose, and our pilot implementation illustrated the valuable degree of impartiality that can thereby be achieved.

Our results can be interpreted at two levels.

At a concrete level, we produced an estimate of the value that Swiss people grant to biodiversity. Many aspects of our method can be improved, and one should not underestimate the difficulties of translating such a result into directly implementable political recommendations. However, given the impartiality achieved and the specificities of the Swiss political context, in this very specific context our estimate can already be used by decision makers—perhaps not straightforwardly to reform the State budget but, keeping in mind the specific understanding of "importance" that our protocol embodies, at least to assess the legitimacy of conservation programs or to gauge public support. Our estimate is less precise than iWTP-derived monetary amounts. But biodiversity is not something about which people are accustomed to make decisions. Preferences for biodiversity are accordingly likely to be imprecise: the roughness of our measure reflects the roughness of the preferences it captures. In any case, the significance of our approach lies in the theoretical framework underlying this pilot application, and concrete applications in other contexts would require implementing the various improvements discussed.

At a deeper philosophical level, we argued that measures of impartial preferences such as the one we produced are proxies of the stances that people take when they participate in public decisions. Seen through these lenses, DMV and our method pursue similar aims but have symmetric strengths and weaknesses. Future studies should precisely identify the properties of both approaches and establish if and eventually how they could be used as complementary tools in a multi-criteria framework.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2016.10.007.

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