Are protected areas effective in conserving human connection with nature and enhancing pro-environmental behaviours?

Victor Cazalis, Anne-Caroline Prévot

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Abstract:

Halting the on-going biodiversity crisis requires large individual behavioural changes through the implementation of more pro-environmental behaviours (PEBs) by every citizen. People's experiences of nature, such as outdoor activities, have been identified as great enhancers of such behaviours. Yet, these experiences of nature got scarcer in the last decades, due to an increased spatial segregation between human and nature, particularly in societies that follow a Western way of life. In this context, we wondered if protected areas (PAs), because they offer more opportunities for people to be in contact with natural landscapes and offer more ecological information and governance than other places, could enlarge the implementation of PEBs for people living in or close from them. We addressed this question by modelling the link between three types of PEBs in Metropolitan France (i.e., voting for Green party candidates, joining or donating to biodiversity conservation NGOs and participating in a biodiversity monitoring citizen science program) and the proximity to large PAs. Innovatively, we addressed this question at national level, with exhaustive data collected in more than 16,000 French municipalities with more than 500 inhabitants. All models controlled for difference in population size, average income and proportion of retired people between municipalities. We found that each of the studied PEBs decreased with distance of the municipality to PAs, even after having controlled by the naturalness of municipalities' surroundings. Our results suggest that, beyond their effect through exposure to natural landscapes, PAs affect PEBs by the institutional context they create. Additionally, PEBs were higher inside PAs than in close surroundings, suggesting that, besides restrictions brought by PAs on inhabitants, a fraction of the population responds positively to their implementation. Our results suggest that PAs can play a role in enhancing environmental friendly ways of life by conserving human's connection with nature.

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Introduction

We are currently facing the sixth mass extinction of biodiversity, with thousands of species vanishing and the decline of many species' populations, described as a time of biodiversity annihilation (Ceballos et al., 2017). This crisis is mainly due to the human domination of Earth's ecosystems (Balmford and Bond, 2005; Dirzo et al., 2014), and threatens ecosystem services and human well-being (Cardinale et al., 2012; Rockström et al., 2009).

Simultaneously with this decline in biodiversity, most societies are moving away from nature and biodiversity. Indeed, the proportion of people living in cities increased in the last centuries and decades, reaching 81.5% in high-income countries in 2018, a number that keeps increasing (United Nations, 2018). This spatial segregation of human and nature, together with a reduction of nature recreation activities (Soga and Gaston, 2016) dramatically reduced both desire and opportunities to directly experience nature (Turner et al., 2004; Clayton et al., 2017). Pyle (2003) characterised this on-going trend as the extinction of experience and defined it as an "inexorable cycle of disconnection, apathy, and progressive depletion".

Nonetheless, significant life experiences of nature are important to create sensitivity, concern and knowledge about environmental issues (Prévot et al., 2018; Chawla, 1998). Indeed, numerous studies have shown that they can increase concern about environmental issues and willingness to take action against them (Clayton and Myers, 2015a; Gifford and Nilsson, 2014; Prévot et al., 2018). Yet, changes in human behaviours and way of life are needed in order to reduce human impact on biodiversity (Martin et al., 2016). Consequently, pro-environmental behaviours (PEBs) have been of main interest in the field of conservation psychology, in order to understand which factors can enhance them and therefore reduce human's impact (Clayton and Myers, 2015b). This term of PEB includes a wide variety of environmental-friendly human behaviours, with different impact levels, from voting for Green party candidates or feeding birds in the winter, to environmental activism or adopting of environment-friendly consumption (Larson et al., 2015). Some of them have direct impacts on biodiversity, some have indirect impacts and some – considered sometimes as symbolic –, are seen by some authors as a "foot in the door" of environmental-friendly way of life, leading potentially to PEBs with bigger impact (Burger, 1999; Truelove et al., 2014).

One of the main tools used in conservation to halt biodiversity decline, is to define areas where human activities are restricted and controlled: that is protected areas (PAs), which can have very different protection levels. PAs currently represent about 15% of worldwide land area and should reach 17% by 2020 (UNEP-WCMC, IUCN and NGS, 2018). Even if increasing in importance, PAs alone cannot address the biodiversity crisis (Prévot-Julliard et al., 2011). However, aside from their direct conservation impact, we can expect PAs to have an effect on the environmental concern of nearby inhabitants. First, PAs are more natural than the average (Joppa and Pfaff, 2011), which allows nearby inhabitants to have more opportunities to experience nature than other people do. Second, as PAs' governance systems are particularly dedicated to biodiversity (UNEP-WCMC, IUCN and NGS, 2018), inhabitants can be in contact with ecological information through education initiatives of PAs (e.g., signs, activities, conferences, green tourism (Cetas and Yasué, 2017; Laurens, 1995)). Hence, PAs inhabitants and neighbours can be directly affected by PAs, for instance by being more

exposed to pro-biodiversity discourses in their daily lives than other people are; we refer to this effect in the manuscript by "PAs' institutional context". With these two processes, PAs may increase inhabitants opportunities to experience nature, knowledge and awareness of environmental problems, and therefore their motivations to implement some PEBs (Hinds and Sparks, 2008; Gifford and Nilsson, 2014). Conversely, PAs are often known to raise opposition preceding implementation (e.g., Stoll-Kleemann, 2001; Stern, 2008; Cadoret, 2017). Therefore, we could expect people living inside PAs to adopt fewer PEBs than people living outside but close to PAs, as this former group will benefit from greater opportunities to experience nature while they will not be subject to restrictions in their living location.

To our knowledge, few studies investigated the relationships between PAs and PEBs. Halpenny (2010) conducted a survey study in Canada and showed that the place-attachment expressed by PAs visitors enhanced their PEBs intentions. Ramkissoon et al. (2012) developed a conceptual framework providing rationale for this relationship, splitting place-attachment in four items: place dependence, place identity, place affect and place social bonding. Cetas and Yasué (2017) reviewed cases where policy instruments were used in PAs to promote conservation behaviours in local people. They found numerous papers studying such policies and found they were more efficient when they targeted intrinsic motivations of PAs' inhabitants (i.e., arisen directly from an individual because of spontaneous interest in a particular activity) rather than extrinsic motivations such as rewards or punishment. However, to our knowledge, no study has compared PEBs between protected and unprotected areas, which is a way to address PAs impact on PEBs.

Here, we investigated the relationship between PEBs of French inhabitants and the distance between their living location and PAs. To do so, we considered three types of behaviours, as follows. First, we considered people's implication in a biodiversity monitoring citizen science program, which reflects a local interest in biodiversity and can be linked to concern about biodiversity issues and the implementation of PEB (Cosquer et al., 2012; Prévot et al., 2018). Second, we considered donations or membership to wildlife NGOs, which shows a specific concern about biodiversity issues at national or global scales, and constitute a tangible contribution to its conservation (Larson et al., 2015). Finally, we considered voting for Green parties in elections, which reflects people's willingness to act on environmental problems by a broader, transversal, societal transformation (Gill et al., 1986; Larson et al., 2015). We gathered exhaustive data for these three types of PEBs in each municipality in metropolitan France, and modelled how they varied with distance to large French PAs (national parks and regional parks). As PEB levels are known to differ between rural and urban populations (Gifford and Nilsson, 2014), to vary with people age and to depend on social variables such as income (Hines et al., 1987; Gifford and Nilsson, 2014), we controlled in the models for municipalities' average income, proportion of retired people and population size (in first approximation, we assumed a direct negative link between population sizes and rurality level of the municipalities, but see Hart et al. 2005). In order to discriminate the effect PAs have by increasing opportunities to experience nature from the effect of the institutional context, we have run all models with and without controlling for exposure to nature. Indeed, as PAs surroundings are on average more natural, when we added a control for exposure to nature in our models, the measured effect of PAs only included institutional context, allowing us to

discriminate both parts of the effect. In a second time, we compared the difference in PEBs between municipalities located inside PAs and the ones close to PAs, expecting lower levels of PEBs inside PAs because of restrictions applied on inhabitants.

Methods

We collected data of pro-environmental behaviours (PEBs) and control variables in all metropolitan France (*i.e.*, excluding overseas departments and territories), for each of the 36,528 municipalities. In France, a municipality (*'Municipalité'*) consists in an administrative division, often including a village or a city and territories around the urban area, that extend to an invisible border with adjacent municipalities (*i.e.*, every place in France belongs to a municipality).

Pro-environmental behaviour data

Vote data

We downloaded public vote data from a French government official website (République Française, 2018). We included in this study, only elections that have a unique clearly identified Green party candidate in each municipality. This was not the case in local elections, nor in the 2017 presidential election, as ecology was incorporated in several candidates' manifestos, while none presented ecology as the first focus. We used the 2012 presidential election data where Eva Joly was candidate for the Green party (*'Europe Ecologie Les Verts'*), and the 2014 European election data where there was a Green candidate in each of the seven constituency under the list *'Europe Ecologie Les Verts'*. For both elections, we considered as PEB score the percentage of vote cast in favour of the Green party candidate, excluding blank and invalid votes.

NGO data

We used the number of supporters per municipality for the two main French wildlife protection NGOs, both doing tangible actions in favour of biodiversity: the WWF France and the LPO. These data are not public and were provided directly by the organisations. The WWF France gets money through either donations or purchases (*e.g.*, books, textiles, goodies). Since its creation, 871,052 individuals have donated or purchased at least once to the organisation. We used as PEB score the number of inhabitants per municipality that made at least one donation or purchase to the WWF since its creation in 1973. The LPO (*'Ligue pour la protection des oiseaux'*) is a NGO recognized as being of public utility, defending and promoting nature (all fauna and plant species), and is the official representative of BirdLife International in France. This association can count on a network of 44,986 members (who outnumber the 20,000 donators). We used as PEB score the number of members per municipality in 2016.

Citizen science data

We wanted to include data from a biodiversity monitoring citizen science program that was widespread in France, did not require any naturalist background and that encourages people to monitor biodiversity where they live. Among programs matching these criteria, the program '*Oiseaux des jardins'*, managed together by the *'Museum National d'Histoire Naturelle'* and the LPO, is the most popular. It is the French equivalent of the UK Garden Birdwatch program, and monitors birds seen in gardens with a checklist system: each observer registers its garden and reports, opportunistically, a list of birds. No particular background in

ornithology is required to participate in this program. Between the creation in March 2012 and the 28th of February 2018, 30,233 gardens have been registered. We used as PEB score the number of gardens per municipality.

We did not pool PEBs by type in order to facilitate interpretation and enable comparisons between PEBs. Therefore, our dataset included five PEBs, of three types: voting for Eva Joly in the 2012 national presidential election, voting for EELV in 2014 European elections, donating or purchasing items to WWF France, being member of the LPO in 2016, participating in the French garden birdwatch program.

Protected area data

Our main explanatory variable was the distance to a PA. We integrated two types of PA into this study, national parks (*'Parcs nationaux'*) and regional parks (*'Parcs naturels régionaux'*). Both of them cover fairly large areas and are well known to local people who are aware that they live in or near such PAs, unlike some of the smaller PAs in France. These two types of PA are nevertheless very different in terms of their objectives and means of nature conservation (Laurens, 1995; Lepart and Marty, 2006). The primary objective of national parks is to protect biodiversity, often concerning the presence of emblematic species. To achieve this objective, they are spatially organized with two different zones: a "core area" where human activities are highly restricted and regulated, i.e. PA category II in the IUCN classification, (UNEP-WCMC, IUCN and NGS, 2018)), and a peripheral "adhesion area" that allows for more human activities (category V). Because of their national status, their governance system includes nominated representatives from the state (France), representatives from local authorities in an administrative council with local stakeholders and experts (each park has a scientific commission). The *'Parc national des Cévennes'* is an exception as the core area includes habitations and human activities such as hunting, the whole park is therefore considered as being a type V class by the IUCN. Regional parks allow for human activities, often they contain several villages or small towns, and they do not have a core area with regulatory control. Their primary aim is to protect both natural and cultural heritages (often categorised V by the IUCN, sometimes IV). Their governance system is composed of an administrative council with elected representatives of the local communities and stakeholders; they also have a scientific commission. National and regional parks are therefore different in their objectives, means and governances. However, peripheral adhesion areas in national parks are similar to regional parks in terms of objectives and restrictions (i.e., same IUCN category) and both follow a charter signed by all the local municipalities that adhere to the National Park, or which are within the boundaries of the regional park. Local governance is thus an important element of both types of PA, indeed local municipalities actually choose whether they want to be included in the peripheral adhesion area of a national park or within a regional park or not. As there are no inhabitants and villages inside core areas in all national parks, except in the *'Parc national des Cévennes'*, both types of parks might have similar effects on inhabitants.

There are 7 national parks and 51 regional parks in metropolitan France. We included all national parks except (1) the *'Parc national de Port-Cros',* which is located on a small island

and (2) the most recently created, the *'Parc national des Calanques'*, created in 2012, because we considered that its young age prevented any impact on most of the studied PEBs. In addition, the latter has the city of Marseille that fringes the core zone of the park making any study of distance from the PA difficult. We included all regional parks other than the *'Parc naturel régional de la Sainte-Baume'* and the *'Parc naturel regional de l'Aubrac',* because they were created very recently, respectively in 2017 and 2018. Selected parks are shown in Fig.1.

Among the 36,528 municipalities located in metropolitan France, we only considered the 16,825 municipalities with more than 500 inhabitants (Fig.1), in order to remove extreme values (*e.g.*, vote score can be very high in small villages, as a single individual will affect strongly the municipality score). Among these selected municipalities, respectively 79 and 1,828 were located inside national and regional parks.

We calculated the distance of each French municipality to the closest national or regional park, as follows: we first calculated the coordinates of the barycentre of each municipality using the shapefile from OpenStreetMap (2015). We then used the parks shapefile provided by MNHN-INPN (2017) to determine the closest edge of the closest park for each municipality, considering peripheral areas of national parks as parts of the park. Finally, we calculated the distance between the municipality barycentre and the closest edge of this park; this distance was negative for municipalities located inside a park.

Control variables

In order to control for social differences, we controlled in our analyses for municipality population size, using municipality population size from 2014, available in a French official website (République Française, 2018). We also controlled for income declared to the tax office by households (*'Revenu fiscal de reference'*). We extracted from the same website the summed *'Revenu fiscal de reference'* and the number of fiscal households of each municipality and calculated an income index as the quotient of these two variables (*i.e.*, the average *'Revenu fiscal de reference'* of a tax household in the municipality). We extracted from the same dataset, the number of retired inhabitants *('Retraites et pensions, nombre'*) and calculated the retirement proportion of municipalities as the number of retired inhabitants divided by the total number of inhabitants.

In order to discriminate the effect of exposure to nature from the effect of the institutional context, we have run models controlling for exposure to nature. Hence, in the first set of models (without exposure to nature), the measured effect of PAs includes both a greater exposure to nature and institutional context, while in the second set of models (with exposure to nature), the measured effect of PAs only includes institutional context. We estimated exposure to nature using the 2012 Corine Land Cover raster (CLC, 2012), calculating the proportion of pixels overlapping with the municipality limits that represent natural land uses. We considered as natural land use: pastures (CLC code = 231), forests (244-313), open natural habitats (321-324, 333), sandy areas (331), bare rocks (332), burnt areas (334), glaciers and perpetual snow (335), and wetlands (411-523).

Statistical analysis

All five PEBs were independently modelled against distance to PAs using General Additive Models (GAMs) with the *'mgcv'* R package (Wood, 2011). Vote data were modelled assuming a Gaussian distribution, after being log transformed (log(Vote)+1) in order to fit to this distribution. NGOs and citizen science data correspond to count data but were overdispersed compared to a Poisson distribution and were therefore modelled assuming negative binomial distributions.

All models assumed the link between PEBs and distance to PAs to be linear and included all control variables as smoothed terms, allowing non-linear relations. A first set of models (one per studied PEB) included as control variables logarithm of population size, logarithm of the income index, retirement proportion, together with longitude and latitude of the municipality barycentre in order to control for spatial autocorrelation in the country. Each PEB was then modelled with similar models but including also exposure to nature as smoothed term, in order to discriminate the effect of exposure to nature from the effect of the institutional context.

Because of national parks' scarcity and agglomeration in mountains (see Fig. 1), comparing the impact of national and regional parks was not statistically straightforward. Rather than a general quantitative comparison, we therefore decided to check that the effect of national and regional parks were qualitatively similar. To do so, we ran the same 10 models (5 PEBs with and without considering exposure to nature) but considering distance to regional parks only (see Supporting Information Table S1). Then, we compared the percentage of deviance explained by models considering distance to regional parks only with those considering distance to all types of park (both regional and national). A higher percentage of deviance explained by the model when all parks are considered would highlight that national and regional parks' effect are qualitatively similar (i.e., they affect PEBs in the same direction; see Supporting Information Table S2).

In order to test for the effect of living inside a PA rather than close to a PA, we made a subset of our dataset, keeping only municipalities inside a PA or close to a PA (< 20 km). This represents about half of our dataset with 1,907 municipalities inside a PA and 7,002 municipalities close to a PA. We ran GAMs modelling the five PEBs against a binary variable (inside or outside PA) and controlling for population size, income, retirement proportion, longitude and latitude as in previous models. We also ran the analyses controlling for exposure to nature.

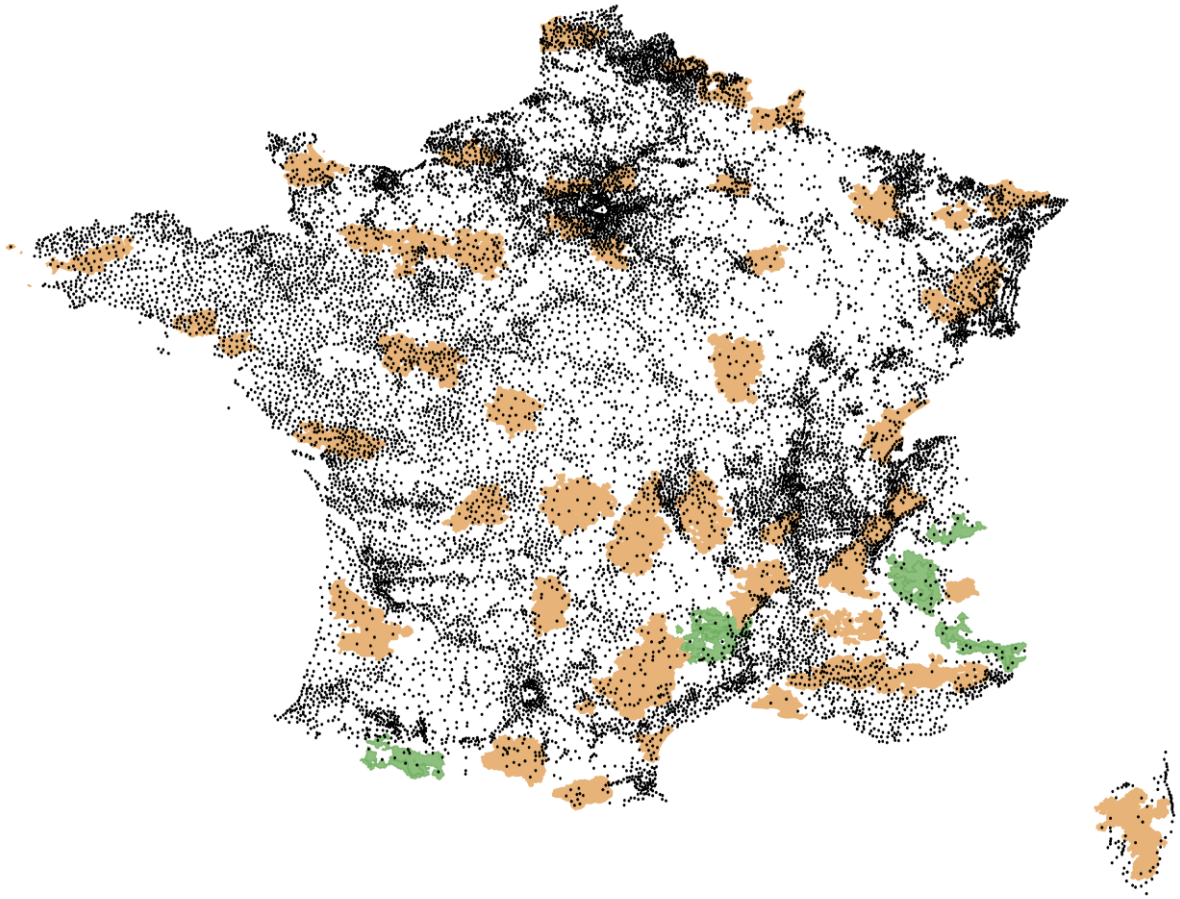

Figure 1: Map of the studied area (Metropolitan France). Protected areas considered include national parks, or *'Parcs nationaux'* (in green), and regional parks, or *'Parcs naturels régionaux'* (in orange). Each dot represents the barycentre of a municipality with more than 500 inhabitants, which corresponds to the municipalities included in the analyses.

Results

Models not controlling for exposure to nature showed a significant decrease in all five PEBs with distance to PAs (Fig.2A, Table 1 first column). Thus, a municipality within or close to a PA showed greater PEBs than a municipality far from PAs, the effects of population size, income, retirement proportion and spatial autocorrelation being taken into account. In models controlling for exposure to nature, all PEBs were positively correlated with exposure to nature (Fig.3D), leading to a decrease in regression coefficients between PEBs and distance to PAs (Fig.2B, Table 1, second column) emphasizing that part of PAs effect on PEBs is due to their more natural landscapes than average. Yet, the negative effect of distance to PAs was still significant for all PEBs, meaning that municipalities with equal population sizes, incomes, retirement proportion and exposure to nature, still showed different PEB levels depending on their distance to a PA. This highlights that PAs have a direct effect, aside from providing higher exposure to nature.

Population size of the municipality was strongly and inconsistently correlated with PEBs (Fig.3A). Both, voting scores for Green party candidates and WWF donation were higher in municipalities with larger population sizes. Conversely, participation in the French garden birdwatch program was higher in municipalities with small populations. LPO membership declined with population size - until ca. 10,000 inhabitants - before increasing for large cities. Income level was also strongly, and mainly positively, correlated with PEBs (Fig.3B). The proportion of retired inhabitants of municipalities was positively correlated with NGOs and citizen science participation, but negatively with voting for Green parties (Fig. 3C). Longitude and latitude plots in Fig.S2 and Fig.S3 (Supplementary Information) show that spatial autocorrelation was rather high, especially for PEBs with limited data (*i.e.*, LPO membership and French garden birdwatch), highlighting that these PEBs have not homogeneously spread across the country.

The covariates effects for models not including exposure to nature are similar to the effects for models including exposure to nature and are given in Supplementary Information (Fig.S1), together with all covariate effects on PEBs with confidence intervals (Fig.S2 and Fig.S3) .

All effects but one hold when we considered regional parks only (Table S1). However, these models had a smaller percentage of deviance explained, except for membership to the LPO (Table S2), than models considering distance to all parks (both national and regional). This suggests that the effects of national and regional parks were qualitatively similar.

All PEBs were significantly higher in municipalities inside PAs than in municipalities close to PAs (Fig.4), refuting the hypothesis that PEBs decrease inside PAs because of restrictions applied on populations.

Table 1: Estimated effects of the distance to PAs for the five studied PEBs measured in French metropolitan municipalities with at least 500 inhabitants. The estimates were obtained using GAM models with smoothed terms controlling for log(population size), log(income), latitude and longitude. Regression coefficients for distance to PAs are given in the c_{Tot} column (for models not including exposure to nature) and c_{Red} (for models including exposure to nature as a smoothed term). c_{Red} / c_{Tot} is a measure of the relative importance of exposure to nature in the relationship between PEBs and distance to PAs. Deviance explained columns correspond to the percentage of deviance explained by the whole model. *P-values* are given following: 0.05 > * > 0.01 > ** > 0.001 > ***

	Without exposure to nature			**With exposure to nature**			
PEB	c_{Tot}	*P*	Deviance explained (%)	c_{Red}	*P*	Deviance explained (%)	c_{Red} / c_{Tot}
Vote (E. Joly, 2012)	-0.0015	***	28.7	-0.0010	***	30.1	0.69
Vote (EELV European elections, 2014)	-0.0017	***	34.7	-0.0014	***	35.1	0.83
NGO (donation or purchase to WWF)	-0.00093	***	94.6	-0.00052	**	94.7	0.56
NGO (membership to LPO in 2016)	-0.0068	***	50.0	-0.0064	***	50.1	0.94
Citizen science (garden birdwatch)	-0.0036	***	49.7	-0.0029	***	49.9	0.81

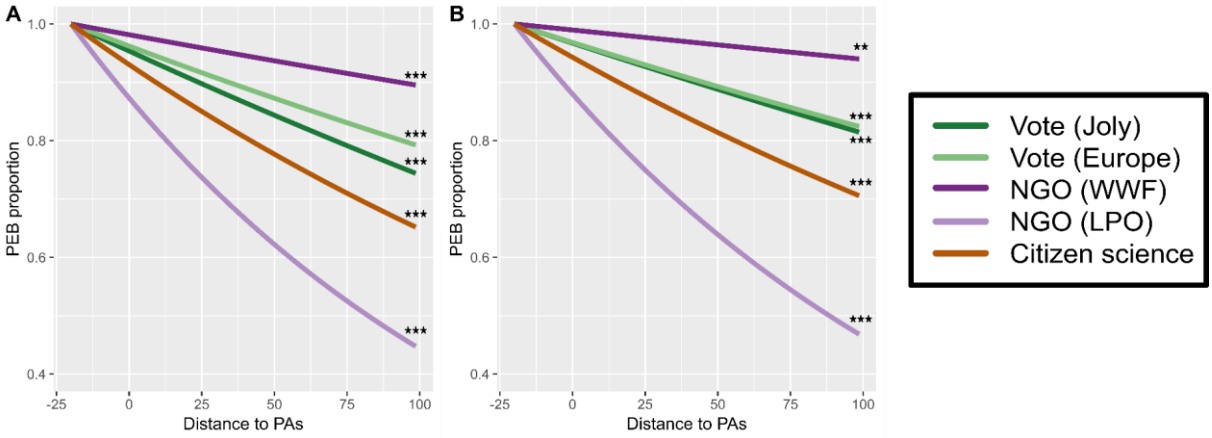

Figure 2: Effect of distance to PAs on Pro-Environmental Behaviours in models without accounting for exposure to nature (A) and accounting for exposure to nature (B). All covariates are fixed to their median values. In order to obtain comparable scales, we divided PEB predictions by their predicted level for the minimal value of distance to PAs (making the plot start at 1). Confidence intervals of each curve are presented in Fig. S2 and S3.

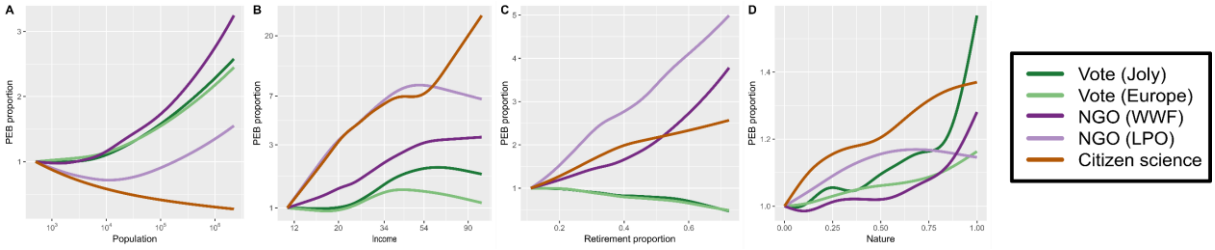

Figure 3: Covariates effects on Pro-Environmental Behaviours in models including exposure to nature. We predicted PEB values against one covariate, fixing all other covariates to their median values. In order to obtain comparable scales, we divided PEB predictions by their predicted level with the minimal value of the studied covariate (making the plot start at 1). NGO and citizen science PEB variables consisted in counts (of respectively people and gardens), but for the population plot (A), we divided the predicted level of PEBs by the population in order to obtain the proportion of the population adopting the given PEB (for interpretation purposes). Longitude and latitude effects and confidence intervals of each curve are presented in Supplementary Information (Fig.S2).

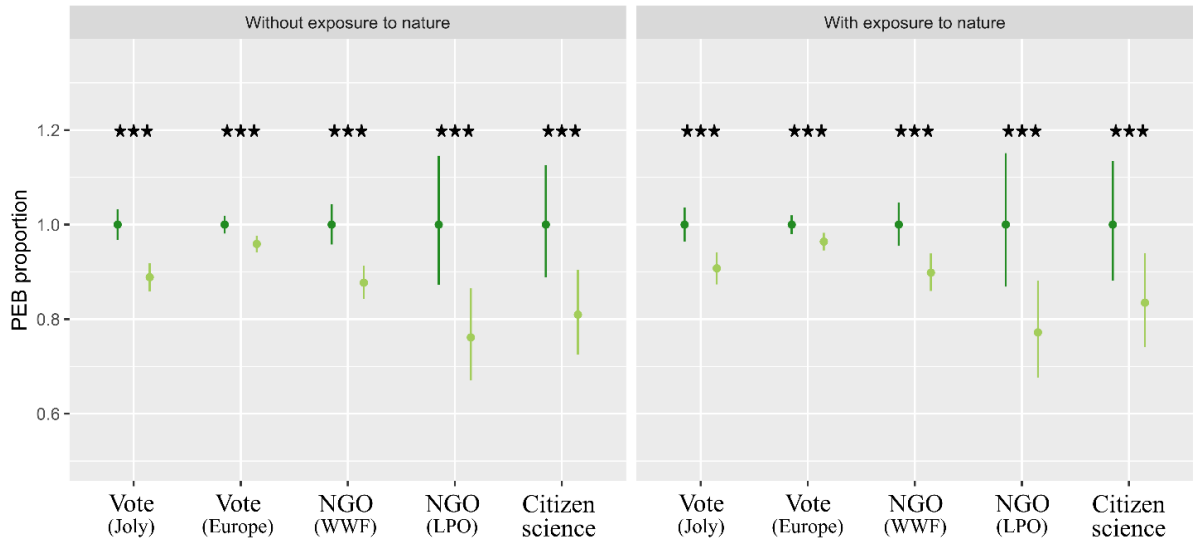

Figure 4: PEBs' levels differences between municipalities located inside a PA (dark green) and municipalities located outside but close to a PA (< 20 km; light green) in models without accounting for exposure to nature (left) and accounting for exposure to nature (right). The effect shown are predictions extracted from the model, with all covariates fixed to their median values. Bars represent 95% confidence intervals predicted from the models. In order to obtain comparable scales, we divided PEB predictions by their predicted value inside PAs, fixing all dark green dots to 1. The three stars illustrate *p-value* below 0.001.

Discussion

In this study, we have found a significant decrease in pro-environmental behaviours (PEBs) with distance to large French PAs (national and regional parks), consistently in all five studied PEBs (voting for Green party candidates in two elections, joining or donating to two biodiversity conservation NGOs, and participating in a bird monitoring citizen science program).

As expected, all PEBs were positively correlated with income. This is probably due to the well-known positive correlation between PEBs and both knowledge and education level (Hines et al., 1987; Gifford and Nilsson, 2014), which correlate with income (Autor, 2014; van Winden et al., 2007). Conversely, the relationship between PEBs and municipalities' population size (considering municipalities above 500 inhabitants only) differed between PEBs. Both WWF donation and votes for Green party candidates, which can be considered as the large-scale PEBs in our dataset, were higher in municipalities with high population sizes, consistently with French literature (Bussi and Ravenel, 2001). Conversely, the proportion of the population participating in the French garden birdwatch program decreased with municipalities' population size. LPO membership decreased with municipalities' population size before increasing for large cities; this increase is combined with a very large confidence interval, making this small increase hypothetical (see Fig. S2). To participate in the French garden birdwatch program, people are asked to count regularly birds in a garden, making people living in large cities less likely to participate in this program, as they may not have easy access to a garden and a biodiversity rich area (Turner et al., 2004). The same is probably true for LPO membership, which could be associated with ordering bird-feeding equipment to the organisation. These differences in municipalities' population size relationship with PEBs are consistent with literature, which suggests that PEB differences between rural and urban areas are inconsistent across places and PEBs measured (Gifford and Nilsson, 2014). Similarly, the correlation between retirement proportion and PEBs is different according to PEBs, being positive for NGOs donation and citizen science participation and negative for vote behaviours. In their review, Gifford and Nilsson (2014) found that PEBs were generally higher in elders, while younger people showed a greater concern about environmental issues. This could explain why active behaviours were positively correlated with retirement proportion, while votes – which appear as weekly related to active participation but more related to global environmental concerns – are more represented in municipalities with lower proportions of retired people. Moreover, LPO membership and participation to citizen science could be enhanced by the fact that elders live more in rural areas and have greater access to private gardens (Stockdale and MacLeod, 2013).

For all PEBs, models including exposure to nature emphasized a positive correlation between nature exposure and PEBs, and consequently decreased the coefficient between PEBs and distance to PAs. This result is consistent with Joppa and Pfaff (2011)'s study, who showed that PAs presented more natural land uses than unprotected areas. In our case, we propose that living close to a PA offers more opportunities to be in contact with nature, which in turn encourages individuals to implement more PEBs. However, distance to PAs effect was still strongly significant after exposure to nature was taken into account. This suggests that

exposure to nature was not the only factor explaining the negative correlation between PEBs and distance to PAs and, hence, that protection itself has a direct effect on PEBs. This effect could include for instance environmental education, institutional communication implemented in the parks, as well as governance systems or even social contexts and relationships. However, our control for exposure to nature could be improved. Indeed, this control considers only municipalities' landscape; landscapes from nearby towns are not included in this control while they may also affect people. Moreover, our exposure to nature index is based on a binary vision of land use (natural versus non-natural), which is a simplification from reality and does not consider the diversity of natural landscapes people can experience (Clayton et al., 2017). Therefore, we cannot entirely exclude the fact that our correlation between PEBs and PAs is only due to a higher exposure to nature near PAs. Moreover, we cannot specify how protection affects PEBs through what we call "institutional context", as no data on environmental education or access to ecological information are available at the scale considered.

The strong negative correlation between PEBs and distance to PAs arisen from our models could be explained by several processes, that we cannot discriminate from our quantitative and correlative study. First, this correlation could have arisen if PAs have been implemented in areas where people already had a strong environmental concern. However, based on the strength of our results, their consistency between PEBs and across all the distance gradient, and the fact that most of the PAs included in the analyses were implemented decades ago (1963-1979 for national parks and from 1969 for regional parks), we can reasonably assume that the correlation between PEBs and distance to PAs is posterior to PAs' implementation.

Second, PAs might have attracted and concentrated people with high level of PEBs. Several geographic studies showed that some people, particularly among elders, move toward rural areas, searching a higher quality of life through more natural and rural lifestyles (Cadieux and Hurley, 2011; Stockdale, 2006; Stockdale and MacLeod, 2013). It is possible that people with high environmental concern were more likely to move toward more natural areas, and that they were attracted by the protection status of PAs. To our knowledge, no study investigated the link between environmental concern and life movements, and this hypothesis would be very interesting to explore.

Thirdly, this correlation result could reflect behavioural changes in people leaving in or close to PAs. This interpretation is strongly supported by literature. First, there are increasing evidences that people disconnection with nature is related to reduced direct experiences of nature (Clayton et al., 2017; Turner et al., 2004; Soga and Gaston, 2016). This disconnection is supposed to lead to an increased psychological distance with biodiversity and environmental issues, which can further lead to a decrease in willingness to actively address these issues (Clayton and Myers, 2015b; Gifford and Nilsson, 2014; Spence et al., 2012). For instance, Prévot et al. (2018) showed with a survey study in an urban area that five out of the six studied PEBs (including buying organic and seasonal food, enhancing biodiversity in private garden or voting for candidates with conservation concerns) were more implemented

by people involved in experiences of nature. Secondly, PAs offer specific institutional contexts that could make PEBs easier to appear, for instance by increasing knowledge, which has been shown to be important to promote PEBs. Hence, environmental education programs can increase ecological knowledge and further encourage PEB's (e.g., Kruse and Card, 2004). Yet, individuals anchor their behaviours in different forms of knowledge, including action-related knowledge (i.e. "which behaviours can be implemented and how") and effectiveness knowledge (i.e., "is this behaviour efficient", Frick et al., 2004). In addition, a diversity of media and contexts for knowledge acquisition permits individuals to learn freely and to informally increase their knowledge (Falk et al., 2007). Besides knowledge, PEBs have been shown to be encouraged by social norms regarding these behaviours (e.g., on energy consumption, Schultz et al. (2007); in private gardening: Uren et al. (2015)). These norms can be constructed and made salient by neighbourhood (Schultz et al., 2007), but also by personalities living in the places (Uren et al., 2015), or by discourses and actions of local authorities (e.g., Skandrani et al., 2015). Based on this literature support, our results therefore suggest that PAs, through the increase in opportunities to experience nature they provide and the effect of institutional context, can reduce the disconnection of their inhabitants with nature and their psychological distance with biodiversity and environmental issues. This can involve environmental education - exposing inhabitants to ecological information (*e.g.,* through popularisation activities or signs)-, and making people feel they live in a biodiversity rich area (Laurens, 1995; Hinds and Sparks, 2008; Halpenny, 2010). In addition, the concepts of biodiversity and sustainable development are more prone to be present in formal communication from the PAs' institutions; this could produce normative messages about environment, which may warrant individual implementation of PEBs. As our study is correlative, we cannot definitively conclude that these behavioural changes caused the described pattern. However, the statistical strength of our results, combined with pre-defined hypotheses regarding the causal relationships on abundant existing literature, together give high credit to this assumption. Only conducting survey experiments could allow to identify more clearly the underlying processes of these correlations.

This effect of PAs on PEBs held when we zoomed in around PAs and compared municipalities inside PAs with municipalities close to PAs. This result was not necessarily expected as PAs are well-known to provoke opposition about inhabitants before implementation (Stoll-Kleemann, 2001; Stern, 2008; Cadoret, 2017). Therefore, we could have expected PAs to have a negative impact on environmental concern of inhabitants, or at least to prevent people from being receptive to the PAs' institutional context. Yet, our analyses showed that PEBs were significantly higher for municipalities inside PAs than municipalities close to PAs. This does not imply that PAs are well received by all people, but rather that, beside restrictions, a part of the population is receptive to PAs environment quality and discourses.

In this study, we gathered two types of natural parks that present relatively different objectives (Lepart and Marty, 2006; Laurens, 1995). Indeed, national parks are mainly dedicated to biodiversity and landscape protection, excluding people from their core area. Regional parks' objectives rather include social aspects, promoting the coexistence of human and nature, and

are therefore less restrictive of human activities. However, national parks have a peripheral area, which is less restrictive in terms of human activities than the core area and are therefore classified by the IUCN in the same category as most regional parks (V). Moreover, municipalities decide whether they want to be part of this peripheral area and, if so, sign a charter established by the park. In all studied national parks but the *'Parc national des Cévennes'*, villages are only present in these peripheral areas. This implies that the municipalities that we considered inside national parks are only in this peripheral area, except for the *'Parc national des Cévennes'*, which includes municipalities in the core area (18 municipalities, including two with more than 500 inhabitants have their barycentre inside the core area). Although we could not compare their impact quantitatively, our analyses suggest that both national and regional parks enhance PEBs of nearby municipalities' inhabitants.

The studied PEBs have only indirect impacts on biodiversity and are implemented by only 0.05 % (French garden birdwatch) to 2.6 % (European elections) of the French population. Despite their high internal consistency, our results cannot thus pretend to be generalized without any caution. However, they open perspectives for further research at this national scale, which would concern behaviours with more direct or bigger impacts on biodiversity, such as designing private lands in order to favour biodiversity, changing consumption habits, or become an activist for biodiversity NGOs or Green parties.

The correlations between PEBs and covariates could have been more precise if we had access to individual data, which would have allow us to link geographical, social variables to PEBs directly. Here, we used data with resolution at the municipality level, which is the best scale available for the PEBs data we gathered, as well as income and retirement data. It is also important to remind that we excluded municipalities with less than 500 inhabitants in order to limit extreme values in PEBs, and therefore, we potentially excluded the most rural municipalities. The distribution of these small municipalities is slightly biased toward PAs as 13.4% of municipalities with population sizes below or equal to 500 are located inside PAs, against 11.3% for municipalities above 500 inhabitants.

Conclusion

With our study, we enlarged the potential roles of protected areas: besides the direct protection of biodiversity through reservation, PAs can provide opportunities to experience nature through different ways (*e.g.,* by living in there, by visiting, but also by being exposed to natural settings or ecological information). In addition, they provide local context where being involved in biodiversity conservation could be socially encouraged and accepted. Therefore, even if this is not the main objective of PAs, we suggest here that they can play a role in conserving human's connection with nature, and lead local inhabitants toward a higher care for nature and biodiversity. We encourage the local governance system of protected areas to enlarge their objectives by including social outcomes, notably by being aware of the social norms they support. In these conditions, implementing new PAs would not only cause inhabitants' opposition and frustration, but could be positively received by other, potentially more discrete, inhabitants.

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