# PROTECTED AREAS AND MUNICIPALITY FINANCES: EVIDENCE FROM FRANCE

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Protected areas are one of the major tools used to conserve biodiversity, but their effectiveness is regularly questioned. One key concern is that municipalities might refrain from enrolling land into protected areas because it might be detrimental to economic activity. As a consequence, protected areas may be located in places where economic activity is low rather than where biodiversity is most threatened. We study the allocation of protected areas in France using a rich set of data on biodiversity, economic activity, tax potential of municipalities and socio-demographics. We first show that biodiversity is highly positively associated with protection, even conditional on economic activity, thereby softening the concerns that protected areas are unrelated to conservation objectives. We also uncover a major gap in tax potential between protected and unprotected areas conditional on biodiversity. We show that most of this gap is explained by variables measuring the intensity of economic activity. Finally, we find that socio-demographic and political variables do not explain the remaining gap. There are two possible explanations for our results: either protection kills economic activity, or areas are protected only where economic activity is not developed.

*JEL Codes:* H7, Q5, R1.
*Keywords:* Biodiversity, Protected Area, Tax Wealth, Municipality.

## 1. INTRODUCTION

Increasing international efforts have been devoted to nature protection policies, aimed at limiting anthropogenic pressures on ecosystems, in order to reduce the erosion of biodiversity (IPBES (2019)). The Aichi targets were adopted by the 190 countries of the Convention on Biological Diversity in 2010 in order to achieve this goal. In France, these efforts have resulted in the establishment of various protections of land areas, which more or less severely restrict human activities. More recently, the biodiversity conservation policy has set as its objective placing 30% of the national territory under protection, including 10% under strong protection (Léonard et al. (2021)). This has led to an increase

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in the number of protected areas[1]. The analysis of the distribution of these areas reveals a significant gap between their location and that of natural areas with high biodiversity conservation stakes, many of which remain poorly protected or unprotected (Lévêque and Witté (2019)). Thus, 5% of the territory of Metropolitan France corresponds to areas that are unprotected even though they are subject to strong pressures and should be subject to a particular vigilance with regard to biodiversity conservation. This discrepancy suggests that disincentives, like economic concerns, may be at play, which deter stakeholders from supporting the adoption of biodiversity protections in these key areas. In this study, we use statistical methods to explore how local economic conditions influence the presence of protected areas in French municipalities, focusing particularly on the impact of tax potential and human activity on protection decisions.
While the presence of important ecosystems is one of the main criteria that determines whether an area should be protected (Ministry of Ecological Transition and Ministry of the Sea (2021)), the decision to protect may also depend on many factors, especially economic ones. Indeed, the process of designating the territories that will be part of the protected area network consists in negotiations between different stakeholders with different interests (Deverre (2006), Van Tilbeurgh (2015)). In France, this process often involves consultation with local stakeholders who may have variable capacity to favor or oppose the area designations proposed on their territory. These stakeholders include local associations, land users, but also municipalities. Participation of the latter in the negotiation process is important as protection may constrain their development opportunities, and they are often involved in the management of areas that are designated as protected.

In this study, we examine the links between local economic conditions and the presence of protected areas (whether these originate from local, regional or national protection regimes) in French municipalities. These links may help explain observed mismatches between territories considered important for biodiversity protection and territories that are actually protected. The presence of important economic potential and the risk of being prevented from developing such potential could deter local elected representatives from supporting the designation of protected areas on their territory. Our hypothesis is that, in order to understand the spatial distribution of protected areas on the French territory, it is crucial to uncover the gains or losses that may affect municipalities when these protected areas are established. Among the main obstacles to the protection of natural areas, the local economic repercussions are likely to play a key role (Fisher et al. (1972)). Indeed, creating biodiversity sanctuaries may be perceived by municipal decision-makers as a costly decision in terms of a possible loss in residential and economic-based tax revenues, and therefore in terms of their ability to develop and implement policies for their territory. In other words, in addition to the costs associated with managing the protected area (Dixon and Sherman (1991)), protection can also lead to opportunity costs associated with lost tax revenues derived from economic activities and residential developments.
These opportunity costs in terms of foregone tax revenues may result from two different but related phenomena. Firstly, protection prevents, at least in part, the establishment

[1]Between 2013 and 2023, ten regional nature parks were created in France with a total area of 14,551 km2 . The 11th National Nature Park in France was created in 2019 in Bourgogne Franche Comté and in the Grand-Est region with a core area of 56,000 hectares, increasing the total surface area of this type of protection in Metropolitan France by 15%. In addition, the total surface area of Natura 2000 areas at sea in France has been multiplied by more than 3 since 2016

of new economic activities and the densification of housing, thus constraining the development of the municipality and consequently its capacity to increase its tax revenues. Secondly, the presence of a protected area may imply constraints on economic activities within the municipality and on residents, which may take various forms. Recent examples include stricter regulation of property renovation in some regional natural parks (Claeys et al. (2021)) or restrictions on the use of pesticides (Grimonprez (2022)). These restrictions, in turn, may generate local pressures in order to avoid the establishment of protected areas in municipalities with important economic and residential stakes. In both cases, this should lead to the existence of a negative relation between the existence of protections and municipal tax revenues, either as a result of a causal effect of protections on tax revenues or of a municipal choice to be less supportive of protections when the economic or residential stakes are high (selection effect).

Numerous economic studies of the impacts of protected areas exist. These have looked, for example, at the effects of protected areas on tourism (Capacci et al. (2015)), on plant cover and economic activity measured by luminosity (Grupp et al. (2023)), on residential attractiveness (Chen et al. (2016)), on income (Mayer et al. (2010)) or on employment levels (Waltert et al. (2011)). Other studies have addressed the opportunity cost associated with income losses in the primary sector (Durán et al. (2013), Ruslandi et al. (2011)). The impacts of protection measures on local populations and economies have also been considered from the perspective of ecology (McCarthy et al. (2012)) or anthropology (West and Brockington (2006)). While protected areas are mainly seen as having a negative impact on local development, some studies show that they could also be seen to have positive impacts on the attractiveness of local areas (Gibbons et al. (2014)). The designation of a natural area as protected could for example increase touristic activities in municipalities (Weiler and Seidl (2004)), which would likely increase their tax revenues. Thus, from the existing studies, the expected link between the presence of protected areas in a municipality and its tax wealth seems uncertain. Some works have studied the effect of some local policies on local finances (Greenstone and Moretti (2003)) but, to our knowledge, such a link between local finances and the implementation of protected areas has not been systematically evaluated, in the French case or internationally. The aim of this study is therefore to assess if the presence of protected areas is statistically correlated with the municipal tax wealth derived from local economic and residential activities.

This study is innovative in three ways. Firstly, existing studies seeking to measure the correlation between biodiversity protection and local economic outcomes have tended to focus on specific aspects of economic activity, such as employment or the income of inhabitants (Duvivier, 2021). We evaluate the correlation between the presence of protected areas and economic stakes through the use of an indicator of municipal tax wealth calculated in a uniform manner for each French municipality, which aggregates across these different economic aspects, called the tax potential ("*potentiel fiscal*"). This indicator measures the tax revenue a municipality would collect if it adopted the average national rates for the main local taxes (property taxes and business taxes, in particular, see DGCL 2021[2]). Using this indicator neutralizes the effects of local taxation decisions, and

[2]These strictly municipal tax revenues are supplemented, among others, by the municipal share of the tax revenues collected by intermunicipal bodies. See DGCL (2021), Guide pratique de la Dotation Globale de Fonctionnement, Ministère de l'intérieur de la cohésion des territoires, page 8. https://www.oise.gouv.fr/Actions-de-l-Etat/Collectivites-territoriales/Concours-financiers-de-lEtat-

allows us to classify municipalities according to the degree of potential tax wealth induced by the tax bases of their territory. Originally created in 1979 as part of the fiscal equalization policy conducted by the central government (Guengant (1991)), this tax wealth indicator has since been identified as one of the key determinants of municipal decisions, for example in terms of expenditure (Gilbert and Guengant (2004)). In our analysis, the tax potential makes it possible to aggregate the multiple economic consequences and determinants of the presence of protected areas on a municipal territory, so that it is directly relevant to local decision-makers.

Secondly, we consider most terrestrial protected areas in metropolitan France[3], and we classify these areas into four categories according to the degree of constraints imposed on human activities in the protected areas. This allows us to include the diversity of protection regimes in metropolitan France, and this contrasts with most existing works that focus on specific protected areas (Jakus and Akhundjanov (2018)) or on protected areas of a particular legal form, such as land protections (Kalinin et al. (2023)), UNESCO sites (Ribaudo and Figini (2017)), Natura 2000 areas (Schirpke et al. (2018)) or national parks (D'Alberto et al. (2023), Romano et al. (2021)).

Thirdly, the originality of the proposed work stems from the fact that we reconcile data on these protection measures with the best available information on local biodiversity status, which enables assessing the importance of each metropolitan municipality's territory with respect to the status of terrestrial biodiversity in France. This allows us to study the correlation between protections and municipal tax wealth, controlling for the contribution of local biodiversity to the presence of protections. From a policy evaluation perspective, such a control seems crucial since it is one of the primary motivations for creating a protected area in a particular municipality (Ministry of Ecological Transition and Ministry of the Sea (2021)).

Reconciling the data on tax wealth, biodiversity and protections in municipalities, and controlling for various economic, demographic, political and land-use characteristics at the municipal level, we seek to understand the extent to which the various local economic and residential activities play a role in decisions to implement protected areas. Using a combination of statistical methods applied to the municipal characteristics observed in 2021, we compare protected and unprotected municipal territories with respect to their tax potential, as well as their biodiversity, economic, and socio-demographic and political characteristics. We use analysis of variance and linear probability models to understand which of these characteristics best explain the differences in protection status between territories, our aim is to assess the importance of biodiversity issues compared with economic issues in the process of designating protected areas. We then use the propensity score matching method (Rosenbaum and Rubin (1983)) to elicit the existence of systematic differences in municipal tax wealth between protected and unprotected territories, controlling for these characteristics.

Our results show that the average tax potential per hectare of protected municipalities is 1,049 euros lower than that of unprotected municipalities. This highlights a possible causal or selection effect linked to economic issues. We show that ecological variables,

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subventions-et-dotations/Dotation-globale-de-fonctionnement-DGF

[3]With the exception of sensitive natural areas , which are a form of land protection under the responsibility of the departmental councils, but whose zoning is not centralized by any national body, hence no central data set is available to describe these.

especially biodiversity stakes, are the strongest predictors of the presence of protected areas in a municipality, softening the concerns that the location of protected areas may be unrelated to conservation objectives. Variables showing anthropogenic pressures resulting from economic issues also play a significant, but less important, role: the proportion of arable land in a municipality has a negative effect on its probability of hosting a protected area, and it appears to be the second most important variable, out of the 24 used, in explaining the variance of the explanatory model for the presence of protected areas in the municipalities.

On average, after controlling for ecological, economic and socio-demographic characteristics, protected municipalities have 1,398 euros of tax wealth per hectare less than similar unprotected ones. We find that the difference in tax potential is much larger when conditioning on ecological variables than when considering the raw difference alone. This indicates that protected and unprotected areas of similar observed ecological importance have very different economic potential. This may result either from an economic impact of the protections implemented, which would kill the economic activity (and consequently generate a disincentive to protect), or from the presence of major economic stakes, which lead to political pressures that result in protected areas being established only where economic activity is not developed, hence a selection effect. In both cases, this suggests that there is an economic barrier to the establishment of protected areas in certain municipalities. Our result leads to consider the possible need for compensatory measures through which the Central Government could mitigate potential tax losses, and the associated tax disincentives to protect biodiversity.

The article is structured as follows. Section 2. presents the statistical approach, as well as the control variables and data used. Section 3. presents the results and Section 4. discusses them and concludes.

## 2. METHOD AND DATA

### 2.1. *Method*

The effects of protection measures can be evaluated using different approaches such as matching methods (Mammides, 2020), linear regressions (Silva and Mosimane, 2013) or double-difference regressions (Jagger et al., 2018), depending on the data available.

Due to the lack of availability of data at different dates for the biodiversity indicators we use, and to the fact that the calculation of the tax potential was regularly modified as a result of tax reforms led by the Central Government, it is not possible to use a dynamic model over a sufficiently long period to assess a causal effect at the national scale. We thus focus on correlations measured with cross-sectional data, and try to explain them.

The approach is in three steps. Firstly, we carry out descriptive analyses to characterize protected and unprotected municipalities. Secondly, we analyze how different variables influence the presence of protected areas using a linear probability model, and examine the importance of each predictor variable in explaining the observed variance. Finally, we carry out a propensity score matching analysis to measure the differences in tax potential between municipalities otherwise similar in terms of the variables we are controlling for.

#### 2.1.1. *Step 1: descriptive analysis of protected versus unprotected territories*

First, we carry out a descriptive analysis of the existence of protected and unprotected territories in 2021. We represent the distribution of French municipalities under protection according to their tax potential, and compare this with the distribution for unprotected municipalities, using kernel density estimation[4]. This comparison is carried out for a set of protection scenarios reflecting different ways of distinguishing protected from unprotected territories (see section 2.2).

We then focus on unprotected municipalities that hold major biodiversity stakes at the scale of metropolitan France. Within the 10% of municipalities representing the greatest biodiversity challenges in terms of irreplaceable biodiversity assets at a national scale, we select the 951 municipalities that are protected by none of the protection systems studied in our different scenarios (see section 2.2 ). This represents almost 2.7% of the municipalities in mainland France. We then compare this sub-group of municipalities with the other protected municipalities in order to identify any characteristics that might explain the under-protection of these areas.

#### 2.1.2. *Step 2: Predicting the presence of biodiversity protections in a territory*

We then utilize a linear probability model to analyze the presence or absence of protected areas across our study area. The model is expressed as follows.

(1) $$P_i = \beta_0 + X_i\beta_1 + \epsilon$$

Where $P_i$ is equal to one if municipality $i$ is protected and 0 if not. $X_i$ includes three categories of variables relating to ecological characteristics of the territory, anthropogenic pressures (which are related to economic stakes) and other socio-demographic and political controls (see subsection 2.3.2) and $\epsilon$ is the vector of error terms. We use information available for year 2021 to estimate this model.

We also employ dominance analysis to assess the relative importance of the same independent variables in a linear model explaining the presence or absence of protected areas (Budescu (1993), Grömping (2007))[5]. This approach allows us to determine which variables contribute most significantly to the model's predictive power. Dominance analysis involves comparing the contribution of each variable to the overall predictive accuracy of the model by decomposing the total variance explained into individual contributions. In this work, we calculate general dominance statistics, which represent the average marginal contribution of each explaining variable across all possible sub-models.

To carry out such an analysis, we should run all the $2^p$ possible models predicting the dependent variable using combinations of the $p$ independent variables, and then compute a general dominance statistic by averaging the marginal contribution of the independent variable in all the possible models in which it is included. In our case, this would imply running more than 33 million models. To reduce computation requirements, we run a Relative Weights Analysis (Johnson (2000))[6], which allows estimating only a subset of models thanks to an orthogonalisation process.

[4]This is carried out using a normal kernel and a smoothing window generated automatically by the "k-density" command in the software *Stata*.

[5]This analysis is carried out using the "domin" command in the software *Stata*

[6]This is carried out using the "epsilon" option in the "Domin" command of the software *Stata*.

#### 2.1.3. *Step 3: Propensity score matching to estimate tax potential differences between otherwise similar municipalities*

Finally, we use the propensity score matching method to compare the tax wealth of protected and unprotected municipalities by controlling for potentially confounding variables that could be correlated with the tax wealth of municipalities and/or with their probability to be protected. Propensity score matching has been developed to evaluate the effects of a treatment *P* in the case that this treatment is not randomly distributed. It allows computing the average treatment effect on the treated (ATT) of *P* on a variable *R*, which can be written as follows:

$$E[R_{1i} - R_{0i} | P_i = 1] \tag{2}$$

The value of the ATT on a sample of treated individuals is therefore given by the following formula:

$$ATT = \frac{1}{N_t} \sum_{i=0}^{N_t} (R_{i1} - R_{i0}) \tag{3}$$

where $N_t$ represents the number of treated individuals.

As it is impossible to have access to information on the status of individual *i* in both treated and untreated situations, the value of $R_{i0}$ is not known for each individual. To evaluate the effect of treatment *P* on *R*, a propensity score matching method can be used (Rosenbaum and Rubin (1983)). This approach aims to approximate the unknown term for each individual *i* by finding the best possible counterfactual to that individual (i.e. the untreated individual with the closest characteristics to individual *i*) in the set of observations, and to replace the unknown term with the *R* value of that counterfactual (Cochran and Rubin (1973)). In this approach, the counterfactual of each treated individual is the untreated individual which has the nearest estimated probability of being treated (i.e. the nearest propensity score estimated with a logit (in this work) or a probit model, including all confounding variables).

In our case, it is not possible to estimate a causal effect of protections on tax wealth as we only have access to cross sectional data. We use the propensity score matching method to compare the tax wealth of unprotected and protected municipalities by controlling for some characteristics which could have impacted the choice to protect or which could have been affected by the establishment of the protection measure. We estimate different models by successively adding the different variable sets described in the next section. This allows us to better understand the role that these variables play in the interactions between protected areas and municipal tax wealth. The standard errors of these models are estimated using the method developed by A. Abadie and G.W. Imbens (Abadie and Imbens (2012)). This adjustment takes into account the variance of the estimator as well as the variability introduced when estimating the propensity score with the logistic model.

### 2.2. *Definition of the control and treatment municipalities*

The report by Léonard et al. (2021) provides a complete diagnosis of the different types of protected areas. These different types of protected areas do not have the same legal basis, are not managed in the same way and do not have the same objectives. Thus, we use the classification of the (Léonard et al. (2021) report based on the degree of constraints that a protected area imposes on the territory. This classification is the one used in the French national strategy for protected areas (Stratégie Nationale des Aires Protégées, Ministry of Ecological Transition and Ministry of the Sea (2021)) and it is also used in many analyses of the French protected area network (Suarez et al. (2023)). This classification is composed of four levels. Protections are aggregated in groups from one, with the strongest protections in terms of constraints imposed on the territory, to four, with the weakest protections. The first group includes land acquisitions (an association, a community or a public institution buys the land to protect it, and can thus fully restrict the development on the protected territory), and regulatory protections (legal texts regulate practices on a territory in order to protect it). The second and third groups are made up of contractual protections based on local agreements between the different actors of a territory. This includes Natura 2000 areas (group 2, for which the European Union sets conservation objectives) and contractual protections such as regional natural parks, as well as municipalities that have become part of the perimeter surrounding a national park (group 3, areas in which the conservation objectives are set by the actors involved in the creation and management of the park). Finally, the fourth level is composed of areas created by international conventions such as the Ramsar Convention.

We use the GIS data available on the National Inventory of Natural Heritage (INPN - Inventaire National du Patrimoine Naturel) website[7]. By superimposing the different protection layers with the delimitations of French municipalities (borders of 2021), we calculate indicators concerning the level of protection of each municipality in metropolitan France. In the context of this work, we only use the presence variables which provide information on the existence or not of each type of protected area in a municipality. Table I summarizes the types of protected areas for which centralized data is available in this database.

Given the heterogeneity of constraints exerted across protections on any given territory, we consider several alternatives in determining what a treated municipality is. Indeed, it is likely that the weakest protections, which correspond to level 4 of the typology used by Léonard et al. (2021), do not imply enough constraints to really affect the activities in a territory, and therefore the tax wealth of municipalities. The use of different scenarios in the analysis makes it possible to account for the existence of significant or non-significant correlations for different groups of protection measures, which we call scenarios.
We considered six scenarios as summarized in Table II. Scenarios 1, 2 and 3 respectively oppose P1-3 (municipalities with protected areas of levels 1, 2 or 3), P1-2 (municipalities with protected areas of levels 1 or 2) and P1 (municipalities with protected areas of level 1) as treated groups, to the municipalities without any protections as a control group (all municipalities with protections not included in those of the treated group being excluded from the analysis). Scenarios 4, 5 and 6 respectively oppose P1-3, P1-2, P1 as treated groups, to the rest of municipalities as the control group (all the municipalities with other protections than those of the treated group or without any protection, without excluding any municipalities)[8].

[7]https://inpn.mnhn.fr/accueil/donnees-referentiels, data downloaded in November 2021

[8]Scenarios S4, S5 and S6 allow the model to be estimated at the scale of 34,827 municipalities, 9 of which are excluded from the analysis due to a lack of data in the complete INSEE file (some of these municipalities have no inhabitants) or due to changes in the delimitations of municipalities between 2018 and 2021, which prevented the use of land use data. Scenarios S1, S2 and S3 relate to a smaller number of

TABLE I

CATEGORIES OF PROTECTED AREAS (BASED ON LEONARD ET AL. 2021).

| Level | Subdivision | Protected area type |
|---|---|---|
| 1 | Regulatory protections | Biotope protection orders<br>National Natural Reserves<br>National park core areas<br>Managed biological reserves<br>Biological reserves<br>Regional natural reserves<br>Protection orders for natural habitats<br>National park wilderness areas<br>Corsica Natural Reserve<br>National hunting and Wildlife Reserves<br>National natural reserve protection perimeters |
| 1 | Land protection | Conservatory of natural areas<br>Coastal Conservatory |
| 2 | Contractual protections (Natura 2000) | Sites of Community importance (Natura 2000)<br>Special Protection Areas (Natura 2000) |
| 3 | Contractual protections (membership areas) | National park membership areas<br>Regional natural parks |
| 4 | International agreements | Cartagena Convention<br>Ramsar Convention<br>Biosphere reserves (buffer zones)<br>Biosphere reserves (transition zones)<br>Biosphere reserves (core areas)<br>Specially protected areas of Mediterranean interest<br>UNESCO World Heritage<br>UNESCO Global Geoparks<br>Areas protected by the OSPAR Convention |

The interest of using these six scenarios is that their comparison allows understanding how the different protection tools interact with economic and ecological stakes. Stronger protection tools may be more impacted by economic and ecological stakes when they are implemented. They also should impact local economies (and consequently tax wealth) in a different way than weaker ones do. Moreover, it is possible to compare scenarios with different control groups in order to test whether the interactions between local economies and weaker protections tools are so weak that the correlations can not be assessed: finding significant results with S3 while finding non-significant results with S6 would suggest that protections of level 2 and 3 have interactions with local economies close to those of protections of level 1.

## 2.3. *Key variables and data*

### 2.3.1. *Tax potential as a proxy of the municipal tax wealth*

We use the tax potential as the variable of interest of our propensity score matching method. This indicator (labelled *R* in the preceding sections) is considered to be a good proxy for municipal tax wealth (Guengant (1991)) and it is the sum of two components *R1* and *R2* (with *R* for revenues).

municipalities due to the exclusion from the analysis of those which have less stringent protections.

TABLE II
DESCRIPTION OF THE DIFFERENT SCENARIOS OF THE EVALUATION PROTOCOL

| Scenario | Treated group | Control group | Excluded municipalitie |
|---|---|---|---|
| S1 (P1-3/0) | Level 1, 2 and/or 3 protections<br>17 372 municipalities | No protection (0)<br>16 271 municipalities | Level 4 protections<br>1 184 municipalities |
| S2 (P1-2/0) | Level 1 and/or 2 protections<br>15 411 municipalities | No protection (0)<br>16 271 municipalities | Level 3 and 4 protections<br>3 145 municipalities |
| S3 (P1/0) | Level 1 protections<br>5 822 municipalities | No protection (0)<br>16 271 municipalities | Level 2, 3 and 4 protections<br>12 734 municipalities |
| S4 (P1-3/others) | Level 1, 2 and/or 3 protections<br>17 372 municipalities | No protection (0) or level 4 protections<br>17 455 municipalities | No protection<br>0 municipality |
| S5 (P1-2/others) | Level 1 and/or 2 protections<br>15 411 municipalities | No protection (0) or level 3 and/or 4 protections<br>19 416 municipalities | No protection<br>0 municipality |
| S6 (P1/others) | Level 1 protections<br>5 822 municipalities | No protection (0) or level 2, 3 and/or 4 protections<br>29 005 municipalities | No protection<br>0 municipality |

Its first component $R1$ refers to local taxes for which municipalities are able to vote the local tax rates. It is calculated as the amount of tax revenues that a municipality would receive if it taxed each of its tax bases at the average national rate. In France in 2021, its calculation takes into account the following three local taxes: the property tax on built properties ("*taxe foncière sur les propriétés bâties*") and the property tax on non-built properties ("*taxe foncière sur les propriétés non-bâties*"), paid by the owners of the properties, as well as the housing tax ("*taxe d'habitation*"[9]) paid by the household living in the dwelling on the first January of each year. Calculating *R1* leads to identify what we call a "residential" tax wealth since the housing tax is exclusively paid by households and 72% of the revenues coming in 2021 from the property tax on built properties are based on houses or apartments.

The second component *R2* of the tax wealth indicator is calculated by the central government on the basis of the receipts obtained from business taxes (mainly the business real estate contribution ("*cotisation foncière des entreprises*") and the value added contribution ("*contribution à la valeur ajoutée des entreprises*"), taking into account the fact that municipalities cooperate in different types of inter-municipal structures that differ in the nature of municipal responsibilities to be shared and in the extent of municipal taxes to be transferred at the intermunicipal level of government. Therefore, when needed, the

[9]The tax was deeply reformed in 2022 by the French central government, with local tax payers being fully exempted in 2023 except for second homes.

intermunicipal tax wealth is distributed between municipalities according to their shares in the intermunicipal population. To sum up, the tax potential variable takes into account the municipal income linked both to residents with the *R1* component and to local economic activities with *R2*.

The data on the total tax potential and its two components were extracted from the global operating grant ("Dotation Globale de Fonctionnement" or DGF) database for the year 2021, available on the website of the French Ministry of Territorial Cohesion and Relations with Local Authorities[10]. Rather than standardizing the municipal tax potential by the number of inhabitants of the municipality, which is the usual approach in local public economics to neutralize the significant heterogeneity in demographic sizes of municipalities in France (Levasseur (2016), L'Horty and Morin (2016)), we use tax wealth per hectare as a measure of *R*. This is because the main issue for a municipality with respect to protected areas is spatial, as protection implies spatial constraints.

Figure 1 shows the map of this tax potential per hectare for each municipality in metropolitan France and illustrates the great heterogeneity of the indicator: a large majority of municipalities located on what some geographers (Bouron and Georges (2015), Grésillon et al. (2016)) call 'the diagonal of low densities' (a sparsely populated strip running from the south-west to the north-east and cutting France in two halves) has a tax potential of less than 100 euros per hectare, whereas the tax potential of municipalities in large conurbations can exceed 100,000 euros per hectare[11].

[10]http://www.dotations-dgcl.interieur.gouv.fr/, download in October 2021

[11]For example, in Creuse (23), the average tax potential per hectare is 176 euros, whereas it is 213,984 euros in Hauts-de-Seine (92). In France, the richest department in terms of tax potential per hectare (Paris, 75) has a tax potential per hectare that is almost 4,000 times higher than that of the poorest departement (Lozère, 48), while if we look at tax potential per inhabitant, that of the richest department (Paris, 75) is 4.2 times higher than that of the poorest (Gers, 32).

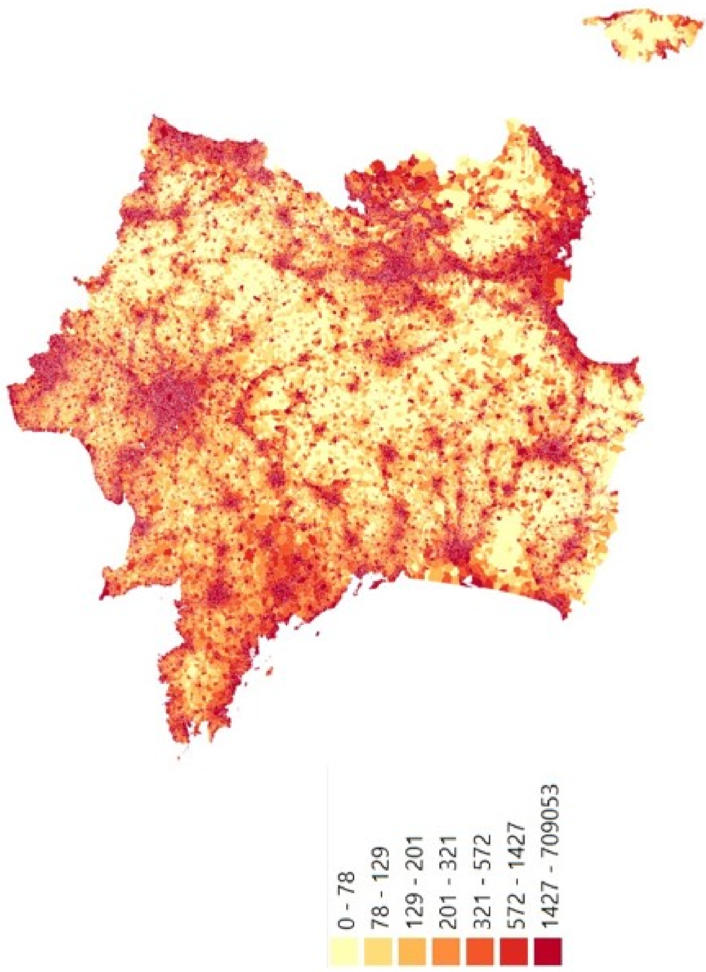



Figure 1: Map of tax potential of French metropolitan municipalities (in euros per hectare)

### 2.3.2. *Explanatory variables for the presence of protected areas*

We use 24 variables in the linear probability model and in the logit models which are used to estimate the propensity scores and to run our different analyses: the ecological variables, which we call the '$X_A$ block' or 'set A', the anthropic pressure variables, which we call the '$X_B$ block' or 'set B', and finally the sociodemographic and political variables, which we call the '$X_C$ block' or 'set C'. We use these control variables in order to match comparable municipalities according to characteristics such as biodiversity or land use. Obviously, the treatment can affect these variables in the long term (e.g., urbanization rates could be affected by the presence of protected areas). Here we control for the effects that protected areas could have had on the topography of municipalities (i.e. important changes in land uses).

Tables III, IV and V provide synthetic descriptions of these variables and of our hypothesis about their possible correlation with the probability for a municipality to be protected ((+) means that we assume that the variable has a positive impact on the propensity score, (-) means that we assume the variable has a negative impact on it and (?) means that we do not have a clear hypothesis on the sign of the associated coefficient). The explanation of these hypothesis as well as the sources of data are presented in appendices A, B and C.

TABLE III

DESCRIPTION OF THE SET A OF ECOLOGICAL CONTROL VARIABLES USED IN THE LOGISTIC MODEL

| Variable name | meaning | hypothesis |
|---|---|---|
| Irreplaceability | Biodiversity irreplaceabilty index of the municipality computed using the Marxan software (see appendix D) | + |
| Number of observations | Number of occurrences of the municipality in the inventory database of biodiversity sightings | ? |
| Richness of “with status” species | Number of endemic, subendemic or “on red lists” species reported in the municipality | + |
| Share of wetlands | Wetland surface area in the municipality / Total surface area of the municipality | + |
| Share of “bare” nature | Vegetation-free natural surface area in the municipality / Total surface area of the municipality | + |
| Share of forests | Forests surface area in the municipality / Total surface area of the municipality | + |
| Coastal dummy | Dummy equal to 1 if the municipality is on the coastline, 0 otherwise | + |

TABLE IV

DESCRIPTION OF THE SET C OF SOCIO-DEMOGRAPHIC AND POLITICAL CONTROL VARIABLES USED IN THE LOGISTIC MODEL

| Variable name | meaning | hypothesis |
|---|---|---|
| Share of 3 stars and more rooms | Number of rooms in hostels with 3 or more stars / Total number of hostel rooms in the municipality | ? |
| Unemployment rate | Total number of unemployed inhabitants of the municipality / Total population of the municipality | ? |
| Share of farmers | Total number of farmers in the municipality / Total population of the municipality | ? |
| Share of inactive population | Total number of inactive people (retired people excluded) / Total population of the municipality | ? |
| Share of executives and managers | Total number of executives and managers in the municipality / Total population of the municipality | ? |
| Share of green vote in % | (Total number of people who voted for the green party (EELV) during the 2019 European elections in the municipality / Total number of people who voted for a declared list during the 2019 European elections in the municipality) multiplied by 100 | + |
| Share of the population under 25 | Total number of people under 25 in the municipality / Total population of the municipality | ? |
| Share of non-leaving population | Total number of people who lived in the municipality one year before the census / Total population of the municipality | ? |
| Share of vacant dwellings | Total number of vacant dwellings in the municipality / Total number of dwellings in the municipality | ? |
| Share of 1 room dwellings | Total number of dwellings which have only one room in the municipality / Total number of dwellings in the municipality | ? |
| Share of houses | Total number of dwellings which are considered as houses in the municipality / Total number of dwellings in the municipality | ? |
| Share of dwellings built after 1970 | Total number of dwellings built after 1970 in the municipality / Total number of dwellings in the municipality | ? |

TABLE V
DESCRIPTION OF THE SET B OF CONTROL VARIABLES ABOUT PRESSURES USED IN THE LOGISTIC MODEL

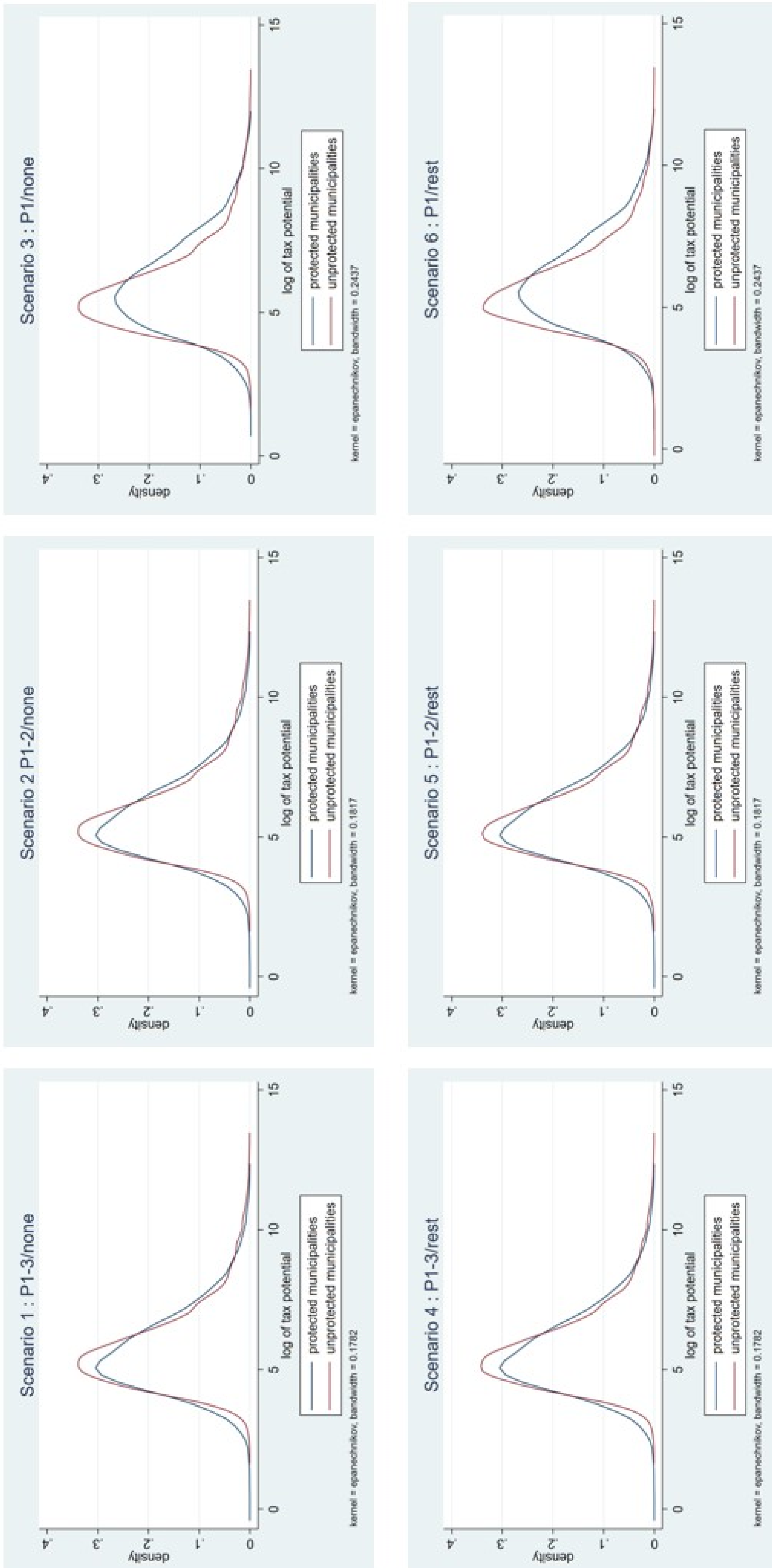
| Variable name | meaning | hypothesis |
|---|---|---|
| Tourism density | Estimated non-permanent residents based on the number of second homes and caravan pitches in the municipality / Total surface area of the municipality | - |
| Share of industrial areas | Surface area of the municipality which is occupied by industrial activities / Total surface area of the municipality | - |
| Share of transports infrastructures | Surface area of the municipality which is occupied by transport infrastructures / Total surface area of the municipality | - |
| Share of arable lands | Surface area of the municipality which is occupied by arable lands / Total surface area of the municipality | - |
| Population density | Total population of the municipality / Total surface area of the municipality | - |

## 3. RESULTS

### 3.1. *Density distributions of municipal tax potential*

Examination of the density distributions of the logarithm of the tax potential of protected municipalities compared with unprotected municipalities provides (figure 2) insights regarding correlation of environmental protection and economic wealth. In particular, the tails of the distributions indicate differences in the location of protection measures in both the richest and least wealthy municipalities.

Figure 2: K-density distributions of the log of tax potential in French municipalities



In all the scenarios, we observe a flatter distribution for the protected municipalities than for the unprotected municipalities, with a systematic over-representation of protected areas in the poorest municipalities, suggesting that either the least tax wealthy municipalities are preferred to those with intermediate tax wealth for receiving protection, or that these poorer municipalities have not been able to develop economic and residential activities because of the presence of protected areas. On the other hand, protected areas are under-represented among municipalities with intermediate tax potential. Finally, when we look at the tails on the right of the distributions, we see that the protected municipalities are over-represented among the relatively wealthy municipalities but under-represented among the wealthiest municipalities for scenarios 1, 2, 4 and 5. For scenarios 3 and 6, the distributions merge at the extreme right.

This first graphical analysis therefore shows that the richest municipalities rarely host protected areas, probably because of the constraints that protected areas impose on economic development or because of the impossibility of creating protections in areas that have already been too severely degraded by human activities. The over-representation of protected municipalities in relatively wealthy municipalities could be explained by the attractiveness of municipalities with the presence of environments of high ecological interest. The coast and mountains in particular illustrate this since they often host species-rich areas (Lévêque and Witté (2019)), with species endemic to these regions, while also being attractive for tourism, commerce and industry (Ayyam et al. (2019)).

These differences in distribution could also be explained by the possible causal effects of protected areas on the economic development capacity of municipalities. It is indeed possible that municipalities with very low tax wealth may have seen their economic development capacity constrained by the presence of protected areas on their territory.

### 3.2. *Differences between protected and unprotected high-biodiversity stakes municipalities*

Next we examine the differences between protected and unprotected municipalities which are in the 10% of the metropolitan municipalities with the most important stakes in term of biodiversity irreplaceability. The results of Student's t tests are presented in Table VI, providing a comparison between municipalities that are protected and those that are not.

Although the large number of municipalities makes it possible to obtain significant differences for almost all the variables, some stand out with very marked differences. The results indicate that among this subset of municipalities with the highest biodiversity stakes, unprotected municipalities have a significantly ($p < 0.0001$) almost 7 times higher tax potential per hectare (16,794 euros) than protected municipalities (2,501 euros), the mean tax potential per hectare being equal to 1,731 euros in metropolitan France. This result suggests that biodiversity in unprotected municipalities is under greater economic pressure, probably due to more intensive development, as reflected in the 2.4 times higher presence of industrial activities (0.031 vs. 0.013) and the 3.3 times higher presence of transport infrastructures (0.001 vs. 0.003) in unprotected municipalities.

This first analysis shows that the 2.7% of municipalities in mainland France that are both very important for national biodiversity and unprotected are subject to significant economic pressures reflected in both land use and tax wealth. This significant difference can either be linked to the constraints generated by the establishment of protected areas or to the reluctance of public decision-makers to establish protection in areas with high eco-

TABLE VI

T-TEST RESULTS BETWEEN PROTECTED AND UNPROTECTED MUNICIPALITIES WITH A HIGH IRREPLACEABILITY INDEX.

| Variable | unprotected | protected | pr$(T < t)$ | pr$(T > t)$ |
|---|---|---|---|---|
| Number of municipalities | 951 | 2 589 | | |
| Tax potential per ha | 16 794 | 2 501 | $< 0.0001$ | $> 0.9999$ |
| Set A variables : | | | | |
| Nb. of observations | 98 | 618 | $> 0.9999$ | $< 0.0001$ |
| Richness of "with status" species | 11.4 | 33.6 | $> 0.9999$ | $< 0.0001$ |
| Share of wetlands | 0.001 | 0.01 | $> 0.9999$ | $< 0.0001$ |
| Share of bare nature | 0.003 | 0.019 | $> 0.9999$ | $< 0.0001$ |
| Share of forest | 0.2 | 0.31 | $> 0.9999$ | $< 0.0001$ |
| Coastal dummy | 0.01 | 0.11 | $> 0.9999$ | $< 0.0001$ |
| Set B variables : | | | | |
| Density of tourism | 0.17 | 0.21 | 0.8864 | 0.1136 |
| Share of industrial areas | 0.031 | 0.013 | $< 0.0001$ | $> 0.9999$ |
| Share of transport infrastructures | 0.01 | 0.003 | $< 0.0001$ | $> 0.9999$ |
| Share of arable lands | 0.3 | 0.18 | $< 0.0001$ | $> 0.9999$ |
| Population density | 11.4 | 2.2 | $< 0.0001$ | $> 0.9999$ |
| Set C variables : | | | | |
| Share of 3 stars and more rooms | 0.13 | 0.14 | 0.7705 | 0.2296 |
| Unemployment rate | 0.047 | 0.05 | 0.9998 | 0.0002 |
| Share of the population under 25 | 0.32 | 0.29 | $< 0.0001$ | $> 0.9999$ |
| Share of non-leaving population | 0.9 | 0.89 | 0.0254 | 0.9746 |
| Share of farmers | 0.014 | 0.19 | 0.9999 | 0.0001 |
| Share of inactive population | 0.109 | 0.104 | 0.0113 | 0.9887 |
| Share of executives and managers | 0.067 | 0.054 | $< 0.0001$ | $> 0.9999$ |
| Share of vacant dwellings | 0.071 | 0.074 | 0.9543 | 0.0457 |
| Share of 1 room dwellings | 0.018 | 0.011 | $< 0.0001$ | $> 0.9999$ |
| Share of houses | 0.8 | 0.83 | 0.9953 | 0.0047 |
| Share of dwellings built after 1970 | 0.85 | 0.86 | 0.9998 | 0.0002 |
| Share of green vote | 12.6 | 13.14 | 0.9997 | 0.0003 |

nomic stakes, even though these areas also represent high ecological stakes.

This conclusion should be qualified, however, by the existence of significant differences between the two groups of municipalities with respect to ecological variables. Unprotected municipalities with a high irreplaceability index also have a significant ($p < 0.0001$) and 3 times lower 'with status' species richness (11.4) than protected municipalities (33.6). In addition, the higher proportions of the municipal surface with wetlands, bare nature and forests in the protected municipalities (respectively 0.01, 0.019, and 0.31 against 0.001, 0.003, and 0.2 in the unprotected municipalities) highlights the fact that protection policies in France also focus on protecting natural habitats.

Although these ecological differences between protected and unprotected municipalities with a high irreplaceability index may partly explain the protection status of these municipalities, all the municipalities in these two groups have a high irreplaceability index. These differences therefore also show that the 2.7% of unprotected but biodiveristy rich municipalities probably contain fragile ecosystems (fewer natural environments) with species that are probably rarer than in the protected municipalities, underlining the potential importance of protection measures in these municipalities.

### 3.3. *Explaining the presence of protected areas*

Tables VII and VIII provide additional information on the links between our different variable sets on the presence of protected areas, for the different protection scenarios. The results of the linear probability model[12] and the dominance analysis make it possible to identify the key factors influencing the decision to protect territories.

[12] Since the propensity scores used for matching are estimated using a logistic model. We also estimated this type of model for each of the scenarios. The results are broadly similar and are presented in Appendix E.

TABLE VII

LINEAR PROBABILITY MODEL RESULTS

| | Scenario 1 P1-3/None | Scenario 2 P1-2/None | Scenario 3 P1/None | Scenario 4 P1-3/rest | Scenario 5 P1-2/rest | Scenario 6 P1/rest |
|---|---|---|---|---|---|---|
| **Set A variables** : | | | | | | |
| Irrepleceability | 0.00186*** | 0.00194*** | 0.00138*** | 0.00195*** | 0.00192*** | 0.000691*** |
| | (0.000112) | (0.000116) | (0.000124) | (0.000112) | (0.000114) | (0.0000901) |
| Nb. of observations | -0.0000135*** | -0.0000140*** | -0.0000143*** | -0.0000138*** | -0.0000145*** | -0.00000468*** |
| | (0.00000266) | (0.00000275) | (0.00000262) | (0.00000271) | (0.00000277) | (0.000000936) |
| Richness of “with status” species | 0.00615*** | 0.00658*** | 0.00776*** | 0.00638*** | 0.00706*** | 0.00499*** |
| | (0.000145) | (0.000151) | (0.000189) | (0.000146) | (0.000152) | (0.000150) |
| Share of wetlands | 0.395*** | 0.402*** | 0.627*** | 0.436*** | 0.459*** | 0.836*** |
| | (0.116) | (0.120) | (0.155) | (0.117) | (0.123) | (0.168) |
| Share of bare nature | -0.0176 | -0.0230 | 0.158* | 0.0191 | 0.0219 | 0.270*** |
| | (0.0458) | (0.0483) | (0.0628) | (0.0487) | (0.0540) | (0.0644) |
| Share of forest | 0.281*** | 0.278*** | 0.298*** | 0.266*** | 0.204*** | 0.116*** |
| | (0.0141) | (0.0147) | (0.0174) | (0.0140) | (0.0144) | (0.0119) |
| Coastal dummy | 0.223*** | 0.240*** | 0.315*** | 0.224*** | 0.269*** | 0.294*** |
| | (0.0126) | (0.0130) | (0.0174) | (0.0131) | (0.0133) | (0.0176) |
| **Set B variables** : | | | | | | |
| Density of tourism | 0.000555 | -0.0000639 | 0.00632 | 0.00136 | -0.000741 | 0.0162** |
| | (0.00509) | (0.00516) | (0.00584) | (0.00516) | (0.00527) | (0.00607) |
| Share of industrial areas | -0.629*** | -0.628*** | -0.420*** | -0.594*** | -0.550*** | -0.211*** |
| | (0.0817) | (0.0806) | (0.0768) | (0.0803) | (0.0769) | (0.0639) |
| Share of transport infrastructures | -0.379** | -0.382** | -0.416*** | -0.359** | -0.352** | -0.257** |
| | (0.125) | (0.122) | (0.0970) | (0.121) | (0.117) | (0.0828) |
| Share of arable lands | -0.333*** | -0.331*** | -0.204*** | -0.287*** | -0.265*** | -0.0836*** |
| | (0.0107) | (0.0108) | (0.0104) | (0.0105) | (0.0103) | (0.00728) |
| Population density | -0.00432*** | -0.00381*** | -0.00321*** | -0.00431*** | -0.00342*** | -0.00265*** |
| | (0.000403) | (0.000395) | (0.000376) | (0.000399) | (0.000382) | (0.000298) |
| **Set C variables** : | | | | | | |
| Share of 3 stars and more rooms | 0.0261* | 0.0340** | 0.0385** | 0.0201 | 0.0371** | 0.0244* |
| | (0.0114) | (0.0117) | (0.0139) | (0.0115) | (0.0117) | (0.0108) |
| Unemployment rate | 0.255* | 0.217 | -0.0616 | 0.343** | 0.0725 | -0.274** |
| | (0.123) | (0.128) | (0.130) | (0.123) | (0.125) | (0.0914) |
| Share of the population under 25 | -0.420*** | -0.430*** | -0.128** | -0.376*** | -0.269*** | 0.127*** |
| | (0.0441) | (0.0454) | (0.0455) | (0.0438) | (0.0441) | (0.0329) |
| Share of non-leaving population | -0.0760 | -0.117 | 0.0300 | -0.0767 | -0.0865 | 0.144** |
| | (0.0695) | (0.0714) | (0.0701) | (0.0688) | (0.0690) | (0.0501) |
| Share of farmers | 0.0632 | -0.0126 | -0.185** | 0.0943 | -0.0749 | -0.176*** |
| | (0.0581) | (0.0601) | (0.0609) | (0.0578) | (0.0589) | (0.0423) |
| Share of inactive population | -0.0784 | -0.129** | -0.187*** | -0.0672 | -0.149** | -0.180*** |
| | (0.0486) | (0.0498) | (0.0471) | (0.0483) | (0.0483) | (0.0338) |
| Share of executives and managers | -0.211** | -0.344*** | -0.176** | -0.227*** | -0.387*** | -0.0447 |
| | (0.0665) | (0.0676) | (0.0647) | (0.0658) | (0.0646) | (0.0479) |
| Share of vacant dwellings | 0.163** | 0.241*** | 0.0554 | 0.145** | 0.297*** | 0.0505 |
| | (0.0562) | (0.0581) | (0.0596) | (0.0559) | (0.0564) | (0.0418) |
| Share of 1 room dwellings | -0.238 | -0.419 | -0.720** | -0.285 | -0.560** | -0.547** |
| | (0.212) | (0.216) | (0.229) | (0.201) | (0.201) | (0.172) |
| Share of houses | 0.00196 | 0.0185 | -0.104*** | -0.0298 | 0.00372 | -0.154*** |
| | (0.0256) | (0.0266) | (0.0305) | (0.0256) | (0.0264) | (0.0242) |
| Share of dwellings built after 1970 | -0.220*** | -0.225*** | -0.282*** | -0.200*** | -0.185*** | -0.165*** |
| | (0.0370) | (0.0379) | (0.0384) | (0.0366) | (0.0366) | (0.0281) |
| Share of green vote | 0.00143** | 0.00138** | 0.00200*** | 0.00193*** | 0.000580 | 0.000557 |
| | (0.000452) | (0.000486) | (0.000515) | (0.000451) | (0.000472) | (0.000351) |
| Constant | 0.779*** | 0.782*** | 0.502*** | 0.732*** | 0.642*** | 0.216*** |
| | (0.0761) | (0.0785) | (0.0796) | (0.0754) | (0.0762) | (0.0567) |
| R2 | 0.2282 | 0.2441 | 0.3197 | 0.2105 | 0.2023 | 0.1631 |
| N of observations | 33 643 | 31 682 | 22 093 | 34 827 | 34 827 | 34 827 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Lines: variables included in the linear model, grouped by variable set (A, B and C). Columns: model results per protection scenario. Coefficients measure the marginal effect of the variable on the probability of being protected. The number below the coefficients indicate the standard error. Bottom lines provide the R2 and number of observations included for each model.

Six of the seven ecological variables (both the two biodiversity variables and the five habitats variables) significantly contribute to explaining the presence of protected areas in

TABLE VIII

DOMINANCE ANALYSIS RESULTS

| | Scenario 1 P1-3/no protec (rank) | Scenario 2 P1-2/no protec (rank) | Scenario 3 P1/no protec (rank) | Scenario 4 P1-3/others (rank) | Scenario 5 P1-2/others (rank) | Scenario 6 P1/others (rank) |
|---|---|---|---|---|---|---|
| **Set A variables** : | | | | | | |
| Irreplaceability | 0.0159 (4) | 0.0179 (4) | 0.0205 (5) | 0.0164 (4) | 0.0168 (4) | 0.0087 (4) |
| Nb. of observations | 0.0016 (14) | 0.0019 (14) | 0.0039 (12) | 0.0017 (14) | 0.0020 (12) | 0.0029 (11) |
| Richness of "with status" species | 0.0590 (1) | 0.068 (1) | 0.1142 (1) | 0.0606 (1) | 0.0709 (1) | 0.0667 (1) |
| Share of wetlands | 0.0028 (11) | 0.0033 (11) | 0.0088 (8) | 0.0028 (11) | 0.0035 (9) | 0.0073 (7) |
| Share of bare nature | 0.0042 (7) | 0.0047 (7) | 0.0115 (6) | 0.0044 (7) | 0.0045 (7) | 0.0070 (8) |
| Share of forests | 0.0393 (3) | 0.0386 (3) | 0.0386 (3) | 0.0336 (3) | 0.0236 (3) | 0.0085 (5) |
| Coastal dummy | 0.0106 (6) | 0.0128 (6) | 0.0317 (4) | 0.0106 (6) | 0.0141 (5) | 0.0248 (2) |
| **Set B variables** : | | | | | | |
| Density of tourism | 0.0012 (15) | 0.0014 (15) | 0.0035 (15) | 0.0012 (15) | 0.0014 (15) | 0.0036 (10) |
| Share of industrial areas | 0.0022 (13) | 0.0022 (13) | 0.0016 (17) | 0.0019 (13) | 0.0016 (14) | 0.0006 (18) |
| Share of transport infrastructures | 0.0004 (21) | 0.0004 (21) | 0.0004 (21) | 0.0004 (21) | 0.0003 (21) | 0.0001 (23) |
| Share of arable lands | 0.0576 (2) | 0.0579 (2) | 0.0434 (2) | 0.0465 (2) | 0.0383 (2) | 0.0118 (3) |
| Population density | 0.004 (9) | 0.0038 (9) | 0.0037 (13) | 0.0037 (9) | 0.0029 (11) | 0.0018 (13) |
| **Set C variables** : | | | | | | |
| Share of 3 stars and more rooms | 0.0027 (12) | 0.0034 (10) | 0.0072 (10) | 0.0025 (12) | 0.0033 (10) | 0.0041 (9) |
| Unemployment rate | 0.0008 (19) | 0.0008 (20) | 0.0006 (19) | 0.0010 (17) | 0.0005 (20) | 0.0002 (21) |
| Share of the population under 25 | 0.0141 (5) | 0.0143 (5) | 0.0077 (9) | 0.0117 (5) | 0.0087 (6) | 0.0009 (17) |
| Share of non-leaving population | 0.0002 (23) | 0.0003 (23) | 0.0001 (24) | 0.0002 (23) | 0.0002 (23) | 0.0001 (24) |
| Share of farmers | 0.0003 (22) | 0.0003 (22) | 0.0011 (18) | 0.003 (22) | 0.0003 (22) | 0.0012 (15) |
| Share of inactive population | 0.0001 (24) | 0.0002 (24) | 0.0004 (23) | 0.0001 (24) | 0.0002 (24) | 0.0003 (19) |
| Share of executives and managers | 0.0008 (18) | 0.0013 (16) | 0.0005 (20) | 0.0007 (19) | 0.0014 (16) | 0.0001 (22) |
| Share of vacant dwellings | 0.0007 (20) | 0.0011 (18) | 0.0004 (22) | 0.0005 (20) | 0.0011 (17) | 0.0002 (20) |
| Share of 1 room dwellings | 0.0009 (17) | 0.0009 (19) | 0.0017 (16) | 0.0009 (18) | 0.0009 (19) | 0.0010 (16) |
| Share of houses | 0.0041 (8) | 0.0042 (8) | 0.0098 (7) | 0.0041 (8) | 0.0037 (8) | 0.0075 (6) |
| Share of dwellings built after 1970 | 0.0011 (16) | 0.0012 (17) | 0.0036 (14) | 0.0010 (16) | 0.0011 (18) | 0.0024 (12) |
| Share of green vote | 0.0035 (10) | 0.0032 (12) | 0.0048 (11) | 0.0036 (10) | 0.0018 (13) | 0.0014 (14) |
| R2 | 0.2282 | 0.2241 | 0.3197 | 0.2105 | 0.2030 | 0.1631 |
| N of observations | 33 643 | 31 682 | 22 093 | 34 827 | 34 827 | 34 827 |

*Notes:* Lines: variables included in the linear model, grouped by variable set (A, B and C). Columns: model results per protection scenario. Coefficients or dominance scores measure the contribution of the variable to explaining the total variance of the predicted variable. The rank (in brackets) indicates the variable's relative contribution to the model's explained variance, calculated by dividing the dominance score by the model's R2. Bottom lines provide the R2 and number of observations included for each model.

a municipality, their effect being positive, as expected (see the first seven lines in Table VII). In particular, irreplaceability and species richness have a positive effect on the probability of a municipality having a protected area on its territory, in line with the fact that the French biodiversity protection policy (Ministry of Ecological Transition and Ministry of the Sea (2021)) sets as a priority that municipalities with the highest biodiversity stakes also be the best protected. These ecological variables are also among those that play an important role in the models' ability to explain variance (see Table VIII): for all the scenarios, richness (of with status species) is the variable that explains the most variance, with dominance scores ranging from 0.059 to 0.1142, representing between 27 and 36% of the variance explained for the different models. This finding is coherent with two hypotheses: either the selection of municipalities where protected areas are implemented is mainly driven by biodiversity stakes or the richness in species is increased by protection areas in the targeted municipalities.

Out of the whole set of variables, irreplaceability is generally the fourth most important variable explaining the variance in the presence of protected areas. For equal levels of species richness, irreplaceability plays a role in this probability of being protected. Irreplaceability in fact appears complementary to species richness, accounting for the overall scarcity of certain species found in a specific territory. These results suggest that, despite Lévêque and Witté (2019) pointing to the fact that some territories with high biodiversity stakes are not protected enough, on average, and for an important part of the metropolitan territory, the existing network of protected areas in metropolitan France succeeds in covering territories that are a priority. This result, taken in conjunction with those of the previous sub-section, may suggest that irreplaceability is taken into account in the choice of areas to be protected. However, this may vary from one territory to another. In some cases, and particularly where there may be high economic stakes, the irreplaceability of biodiversity in a municipality may be given less consideration in the choice of areas to be protected.

In addition to the variables associated with biodiversity, the four ecological variables characterizing habitats (shares of the municipality's surface area covered by wetlands, bare nature, forests or the fact of being a coastal municipality) also have a significant and positive effect on the probability that a municipality is protected. Some of these variables are also ranked among the first variables to explain the variance, in particular forest cover and being a coastal municipality. These results are in line with our intuitions described in Appendix A and confirm that the protection of habitats is also a key determinant in the establishment of protected areas.

Secondly, as expected, four variables reflecting anthropogenic pressures on biodiversity and habitats of a municipality are systematically negatively correlated with the probability that it will host a protected area on its territory: the share of industrial zones, the share of arable lands, the population density and the share of transport infrastructures. Since we are studying the situation of municipalities in 2021 and most of the protections were established several years before this date, we cannot conclude on any causal effect. It may be that the presence of pressures discourages local and national actors from protecting, as it may be that the protections have led to a reduction of these pressures after the moment they were implemented. The dominance analysis shows that the pressure variables play very different roles in the models' ability to explain the variance in protection status. The share of arable land plays a dominant role in the explanatory capacity of the models, with a dominance score of between 0.0118 and 0.0579 depending on the scenarios, representing between 7 and 26% of the variance explained. This result shows the role that agricultural issues can play in public decisions to protect biodiversity.

The only surprising result (as we supposed that pressures would have a negative effect on the probability of being protected) is the one concerning tourism pressure, approached by the indicator of the number of beds dedicated for tourists per hectare, which never has a significant effect on the probability of protection. This is probably because we also control for the fact that the municipality is on the coast, this variable having a positive effect.

Finally, we note that six socio-economic and political variables out of the twelve are (for at least 4 of the 6 scenarios) significantly correlated with the probability for a municipality of being protected. It would seem that this probability decreases with the share of inhabitants under 25 years of age in the municipality (except for scenario 6 where the effect is positive), the share of managers and professionals, the share of houses and the share of dwellings built after 1970. The share of green vote in the 2019 European elections has a significant (positive) effect on the probability of the presence of protected areas at the 1% level in the first four scenarios. In addition, it is interesting to note that when the treated group is only composed of municipalities protected by level 1 areas (scenarios 3 and 6), the variables "share of farmers" and "share of inactive people" exert their strongest effects, suggesting a specific resistance of these two components of the municipality's population to the establishment of highly protected areas. Finally, it can be noted that although the significance of certain indicators varies from one scenario to another, the signs of the effects are stable except for two indicators (the unemployment rate and the share of under 25s in the population), which suggests that the explanatory model is robust.

Although these variables are significantly correlated with the presence of protected areas in French municipalities, only the proportion of people aged under 25 and the proportion

of houses, to a lesser extent, play a relatively important role in the variance explained.
Overall, the models of scenarios S4, S5 and S6 present weaker performances (R2 of around 0.2 for scenarios 4 and 5 and close to 0.16 for scenario 6) than the models of scenarios S1, S2 and S3 (R2 of 0.23, 0.24 and 0.32 respectively). The weakness of the explanatory power of S6 seems to stem from a lesser capacity of the ecological variables (in particular the share of bare nature and the share of wetlands) to distinguish the municipalities affected by protections of level 1 from the other municipalities. This weakness is likely due to the fact that the territories affected by lower level protections are in the control group, which includes the 9,595 municipalities where there are Natura 2000 protections but no level 1 protections. The Natura 2000 municipalities have ecological characteristics close to those of the municipalities with level 1 protections, so their presence in the control group reduces the ability of ecological variables to distinguish the two groups. The differences in explanatory capacity between the models of scenarios S1, S2 and S3 suggest that the stronger a protection system is, the more its implementation is targeted towards municipalities whose ecological characteristics are of high concern.

### 3.4. *Propensity score matching*

In each scenario, matching allows us to obtain two groups that are similar in terms of the variables used. Indeed, after matching, there is no variable for which the standardized difference between the control group and the treated group is less than 0.2. Matching therefore allows us to be below the 0.25 criterion put forward by Imbens and Wooldridge (2009): it significantly reduces the standardized mean differences between the two groups, in particular for the ecological variables, whether they concern biodiversity or ecological habitats. For some variables, the matching does not succeed in reducing the standardized mean difference between the two groups, but for these variables this standardized mean difference was below the 0.25 criteria even before the matching process. Tables showing the standardized mean differences before and after matching, when all the variable sets are included, are presented in Appendix F.
The graphs showing the distributions of propensity scores according to membership of the treated and untreated groups are presented in Appendix G. They make it possible to ascertain the existence of an important common support (*i.e.* each municipality of a given protection status can be matched with a municipality of the other status).
Analysis of the links between the presence of protected areas and the municipal tax potential per hectare through the propensity score matching process for the three first scenarios (Table IX) provides relevant insights into the interactions between environmental, economic and socio-demographic variables[13]. The results of these analyses for the other combinations of sets of variables included as the explanatory variables of the logit model are presented in appendix H.
For each scenario presented and including ecological variables as confounding variables, the ATTs estimated by propensity score matching are greater than the raw differences. This indicates that, whether there is a causal effect or a selection effect, the difference in economic potential between protected and unprotected areas with similar ecological

[13] We conducted similar analyses by measuring the 'average treatment effect' (ATE), and found similar results in terms of sign and significance. The results of these analyses showed weaker differences but also weaker standard errors (Appendix XIX).

importance is greater than the raw difference between protected and unprotected municipalities.

In Scenario 1, which includes all protections from P1 to P3, the estimated link between being protected and the municipal tax potential per hectare is significantly negative, confirming that protected municipalities have a lower tax potential compared to unprotected municipalities. When only the ecological variables (Set A) are included, the difference in municipal tax wealth is marked (-6,956 euros with a confidence interval ranging from -12,994 to -919). The inclusion of economic pressure variables (Set B, in addition to set A) considerably reduces the magnitude of this difference (down to -1,409 euros). With the addition of socio-demographic variables (Sets A + B + C) the difference becomes similar to when only the two first sets of variables were included in the model (-1,398 euros).

Overall, municipalities with equivalent ecological characteristics are largely poorer in terms of tax wealth when they are protected. This result still holds true, even when we compare similar municipalities in terms of economic stakes and socio-demographic characteristics.

TABLE IX

PROPENSITY SCORE MATCHING RESULTS

| Scenario | Logit Independant variables | ATT | AI Robust Standard error | Z | p-value | 95% Conf. Interval |
|---|---|---|---|---|---|---|
| Scenario 1 (P1-3/no protec) | Raw difference | -1049 | | | | |
| | set A | -6956 | 3080 | -2.26 | 0.024 | (-12994) - (-919) |
| | sets A + B | -1409 | 180 | -7.84 | $< 0.001$ | (-1761) - (-1057) |
| | sets A + B + C | -1398 | 234 | -5.97 | $< 0.001$ | (-1857) - (-939) |
| Scenario 2 (P1-2/no protec) | Raw difference | -1033 | | | | |
| | set A | -7734 | 4199 | -1.84 | 0.065 | (-15963) - (496) |
| | sets A + B | -1354 | 249 | -5.43 | $< 0.001$ | (-1843) - (-865) |
| | sets A + B + C | -1523 | 190 | -8.03 | $< 0.001$ | (-1895) - (-1151) |
| Scenario 3 (P1/no protec) | Raw difference | -558 | | | | |
| | set A | -12248 | 8431 | -1.45 | 0.146 | (-28773) - (4277) |
| | sets A + B | -2863 | 603 | -4.74 | $< 0.001$ | (-4045) - (-1680) |
| | sets A + B + C | -3077 | 532 | -5.79 | $< 0.001$ | (-4119) - (-2035) |

*Notes:* Set A includes ecological variables, set B includes pressure variables and set C includes socio-demographic and political variables.

For the three scenarios presented, the existence of a significant difference when the comparison involves municipalities with similar economic and socio-demographic characteristics raises questions about the factors behind this difference. It appears that the presence of a protected area is linked to a lower tax potential, even when the presence of certain economic and residential activities is controlled for. The determinants of this difference would need to be analyzed further.

These differences in estimated average tax wealth can be considered quite strong when compared with the average tax potential in France, which is 1,731 euros per hectare. However, this average masks major disparities: the standard deviation of this difference being 11,935, and half of French municipalities having a tax potential of under 250 euros per hectare. It therefore seems that the large differences estimated on average result mainly of very large differences in tax potential between protected and unprotected municipalities that are among the richest in France[14].

[14]We attempted to assess the heterogeneity of the differences in municipal tax potential by repeating

## 4. DISCUSSION

We examined the extent to which the existence of protected areas may be correlated with the tax wealth of municipalities in metropolitan France as measured in 2021. We find that a negative correlation exists between the presence of protected areas and the tax wealth of municipalities, and that the difference in tax potential is much larger when conditioning on ecological variables than when considering the raw difference alone. This indicates that protected and unprotected areas of similar observed ecological importance have very different economic potential.

In the absence of temporal data, two distinct and non-exclusive hypotheses may be considered to explain this correlation. Firstly, it is possible that a causal effect exists: the establishment of protected areas causes a reduction in municipal tax potential, by creating constraints on the territory, thereby reducing its economic and residential activities, confirming the fears of certain elected representatives. Of course, protecting biodiversity in some parts of a municipality's territory may lead to multiple benefits for local residents, some of which may be monetary and some others not. The bottom line of our first hypothesis is however that if they exist, such benefits will on average not translate into securing tax wealth to support local public policies.

Secondly, a selection effect may also exist, the areas selected for protection being those with the lowest economic and residential stakes, and therefore the poorest in terms of tax wealth. This could result from the fact that the constraints induced by protections are feared by local stakeholders, the problem being particularly acute in areas with high economic development potential. This could in fact be the preferred hypothesis, given the results of Grupp et al. (2023). Whether a causal or a selection effect, however, the negative correlation between protection and municipality finances implies the existence of disincentives to protect, which seem important to consider for several reasons.

First, such disincentives for municipalities to protect may help explain the observation by Léonard et al. (2021) of the insufficient level of protection of territories with high irreplaceable biodiversity in France. In other words, even in the presence of particularly remarkable biodiversity, municipalities may not support the creation of protected areas in order not to deprive themselves from the tax revenues needed to finance local public services.

In this respect, the legislator may want to include funding mechanisms to support its national biodiversity protection strategy, which would encourage municipalities to establish protected areas. The French central government grant to municipalities for the protection of biodiversity and rural amenities created in 2020 is an encouraging first step towards such compensation. However, its amount seems insufficient in view of the results of our work. Indeed, the total funding in support of this central government grant to municipalities was of only 24.3 million euros in 2022 for the entire country. Moreover, this "biodiversity grant" does not target all municipalities affected by protections: in fact, only municipalities with fewer than 10,000 inhabitants and of limited tax wealth can access the grant. Above all, the grant was not designed by the legislator to compensate for the loss of tax wealth linked to the protections, but rather to compensate for the management

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these analyses for sub-groups of municipalities and using scenario 1. We find significant differences in tax potential between protected and unprotected municipalities almost exclusively in the subgroups of the richest and most densely populated municipalities.

costs borne directly (in terms of municipal jobs to be created) or indirectly (with municipal subsidies to be allocated to the managing associations, for example) by municipalities. Second, if our first hypothesis holds true and municipalities that have accepted the establishment of protected areas find themselves financially penalized, while the benefits of protecting biodiversity on their territories are pursued and shared beyond their boundaries, as part of a national policy, the question may arise of whether a mechanism could be established which enables these municipalities to be compensated for this effort, and who should bear the costs of such compensation. One could argue that municipalities of comparable biodiversity, economic and socio-demographic characteristics that have not seen protected areas established on their territories are financially advantaged and could be asked to contribute to such compensation mechanisms.
The results presented in this article must be qualified by three main limitations . First, only two biodiversity measures (the irreplaceability index and the number of species) and four variables indicating habitat characteristics are taken into account in the analysis of ecological factors that can influence the decision to protect. These are key indicators mobilized by public actors to create protected areas, and this is the first time to our knowledge that their contribution to explaining the presence of a protected area in a municipality has been demonstrated in France. However, a certain number of other aspects of biodiversity should also be taken into account to better explain these decisions to protect areas, including interspecies interactions within ecosystems or the genetic diversity present in a territory. Moreover, the indicators used in this paper do not take into account the abundance of species but only their presence. Thus, our results do not include ecological dimensions that may strongly influence the decision to protect some municipalities more than others. In addition, in this work, the tax potential is the indicator used as a proxy of the tax wealth of a municipality. It is a useful indicator because it is the only one that makes it possible to grasp the diversity of the main forms of municipal development in relation to the demography and the economy of the territory and it is one of the key indicators of the planning decisions of municipalities. However, its method of calculation has had to be revised considerably since its creation in 1979 in order to integrate successive reforms of local taxation (in particular the abolition of the business tax (2009) and then the abolition of the housing tax (2019)) or the generalization of inter-municipal cooperation, which goes hand in hand with the transfer of some economic taxes to the intermunicipal level. The method for calculating the tax potential in 2021 is therefore not as good as it was in 1979 at capturing the reality of the tax bases located in a single municipality.
Moreover, given the nature of the protection data and our intent to include as many protection tools as possible in the analysis, we did not consider the effect of the size of protected areas in our analysis. This limitation will have to be overcome by more detailed works on specific protection tools.

The fact that we cannot conclude on a causal effect should encourage further research to understand the economic or political mechanisms behind the differences in tax wealth that we have found. Indeed, both hypotheses should lead public decision-makers to implement economic mechanisms that encourage the protection of areas with high ecological value currently not protected. The introduction of incentive mechanisms will not have the same impact in terms of social justice, depending on the reasons why these areas are under-protected. Where our first hypothesis holds true, this mechanism should make it possible to transfer money to compensate for the relative impoverishment of municipalities that results from protected areas. If it is the second hypothesis, this would be a question of

financing municipalities that already have strong economic assets in their territory, in order for them to agree to some level of protection.
Finally, it is important to emphasize the fact that this work does not aim to estimate the value of biodiversity and its protections. Moreover, it does not deal with the correlations between the presence of protected areas and the well-being of a local population. Our analyses come after many studies that show that biodiversity is valuable for populations (Díaz et al. (2015)) and that this value is not necessarily taken into account by market mechanisms (Schaeffer and Dissart (2018)). Moreover, one could argue that biodiversity is intrinsically valuable (Oksanen (1997)) and should be protected whatever the services it brings to human populations. Consequently, our findings do not show that protected areas are costly for local economies. They show that there could be tax disincentives to protect biodiversity for local decision-makers and that these disincentives should be removed in order to implement better protection policies.

## A. ECOLOGICAL CHARACTERISTICS OF MUNICIPALITIES ($X_A$)

The first four purposes of protected areas according to the OFB (French office for the biodiversity) are ecological conservation purposes. The first criterion for selecting an area to be protected in France therefore concerns its ecological characteristics. Consequently, we assume that the importance of biodiversity issues plays a crucial role in determining the territories where protected areas are established. The more an area represents important biodiversity issues, the greater the probability that it will be designated as a protected area. In order to characterise the biodiversity of municipal territories, we focus on the species for which the protection issue is important, based on observation data of all living species known as "with status". These are species that are on at least one red list or that are classified as endemic or sub-endemic in the TaxRef database[15].

The biodiversity data are obtained from the inventory file provided by the UMS Patrinat[16]. It is a database listing all observations made by various biodiversity stakeholders since 1758 of the presence of a species on a given territory. In order to avoid taking into account observations that no longer reflect the reality of the distribution of the species on the territory, we decided to exclude observations dating pre-1985.
In addition to the number of sigthings of species with status in municipal territories, we extract two indicators from this database:
-Richness, which corresponds to the number of species " with status " observed in a territory. -Irreplaceability, which is an indicator used by UMS Patrinat to assess the level of importance that a territory has in the biodiversity of France (Lévêque and Witté (2019)).
Irreplaceability aims to account for the vulnerability of taxa in measuring the importance of a territory with respect to biodiversity conservation. The indicator is used by UMS Patrinat to support public policies for the protection of biodiversity, in particular for the national strategy for protected areas (SNAP). The indicator therefore plays a direct role in decisions concerning the location of new protected areas. A description of how irreplaceability is calculated is provided in Appendix D.
The analysis of the geographical distribution of these indicators shows that some areas with a very high level of richness also appear to be highly irreplaceable, such as the

[15] https://inpn.mnhn.fr/telechargement/referentielEspece/taxref/16.0/menu# consulted in December 2021
[16] https://www.patrinat.fr/fr consulted in December 2021

Mediterranean coast, the Alps and the Pyrenees, other areas have a high irreplaceability index while the number of "with status" species on the territory is low such as Ardennes. The 10% of municipalities with the highest irreplaceability index have, on average, 24 species with status on their territory, whereas this average is 12 for the whole of Metropolitan France.

These two indicators are complementary in that irreplaceability integrates a dimension of species rareness that richness does not. They also make it possible to consider biodiversity and the way it is perceived by decision-makers at different scales: richness is a dimension that is directly visible at the local level since an inventory of the biodiversity of a municipality makes it possible for a local stakeholder to realise the number of threatened species found in its territory. Irreplaceability, on the other hand, is not directly visible at the local level since it depends heavily on the distribution of species across the national territory.

The objective of some protection tools in France is not only to protect biodiversity but also to preserve landscapes and habitats (Galy (2018)). Thus, the existence of a landscape of interest on a territory can justify the establishment of a protected area on it. Wetlands, for example, are particularly important in environmental preservation strategies, particularly in coastal areas. They are particularly sensitive to human pollution and global change, and the water resources in these areas are also the subject of many economic and health issues. It is for these reasons that they are the subject of specific provisions in the legal texts governing the management of various protection instruments (*e.g.* Natura 2000) and that their characteristics are defined in the French Environmental Code. These wetlands are often home to significant biodiversity, as the 1,659 municipalities with a wetland on their territory are home to an average of 34 species with status on their territory. The national average is 12. To account for the landscape and habitat dimensions of biodiversity protection strategies, we use the following data entries from the Corine Land Cover (CLC) database for the year 2018[17]:

- The share of wetlands in the municipality
- The share of 'bare nature' in the municipality, which is the share of open spaces with little or no vegetation.
- The share of forest in the municipality.
- An dummy indicating whether the municipality is located on the coastline.

### B. ANTHROPIC PRESSURES VARIABLES ($X_B$)

Understanding the distribution of protected areas on the territory must also involve an analysis of the pressures on habitats and biodiversity. These threats are multiple (Cherrier et al. (2021)): some are global but have different consequences depending on the territory, such as global warming (Hinojos-Mendoza et al. (2015)). Others may be more localised, such as soil artificialisation or some types of pollution. These pressures must be integrated in our logistical model, as decisions to protect must be made with regard to the pressures that weigh on the species and habitats concerned. We assume that decision-makers prefer protecting areas where pressures are relatively low, in order to increase the chances of success of the protection policy, and to reduce the costs of setting up protected areas.

[17] https://www.statistiques.developpement-durable.gouv.fr/corine-land-cover-0, downloaded in October 2021

We use the Corine Land Cover (CLC) database for 2018 at the most precise level (level 3)[18] and include six pressure variables in our logistic model, computed to be usable with the municipal borders of 2021[19]:
- The proportion of the municipal territory occupied by arable land;
- The proportion of the municipal territory occupied by transport infrastructure, obtained by summing the surface area of road and rail networks, port harbour and airport areas;
- The proportion of the municipal territory occupied by industrial activities or waste disposal sites;
- The number of tourists per hectare in a year approached thanks to second homes and caravan pitches;
- Population density (inhabitants per hectare).

We also use the complete INSEE file[20] in order to characterise the nature of housing in each municipality and the pressure on municipalities to build new housing, which weighs on the construction of new housing, and therefore on the dynamics of expansion of the urban area of the municipalities. Variables included are:
- The share of the population under 25 (as a proxy for the pressure on the construction of new housing);
- The share of houses (which, at equal density, provides an indicator of the occupation of municipal surface by inhabitants);
- The share of vacant dwellings (which, if low, may indicate that the pressure on a municipality to build new housing is strong);
- The share of dwellings built before 1970 (we assume that a municipality the dwellings of which were built a relatively long time ago will focus more on renovation of the housing stock than on the construction of new dwellings);
- The share of non-leaving population, *i.e.* One minus the share of inhabitants who left the municipality in 2020 as a proportion of the population in 2021 (we assume that the higher the share of inhabitants leaving the municipality, the lower the pressure on real estate).

### C. SOCIO-DEMOGRAPHIC, ECONOMIC AND POLITICAL CONTROL VARIABLES ($X_C$)

Some variables can neither be considered as belonging to the group of ecological variables nor to the group of pressures, but can still influence the decisions of decision-makers with respect to the establishment of protected areas.
The socio-economic data we use is from INSEE for the year 2021, and includes indicators relating to the activities of the inhabitants, the age of the municipal population, the characteristics of housing, the number of births or deaths and the level of education of the inhabitants as recorded for year 2018, during the 2019 population census. We identified several socio-professional categories of inhabitants based on these variables, there is a possibility that belonging to these categories may play a role in the desire to have natural areas in one's municipality (Faccioli et al. (2020)) and consequently in voting decisions in local elections, which would therefore directly impact the preferences of local elected officials. We retained the following variables:
- Share of the municipal population classified as professionals and managers;

[18] https://www.statistiques.developpement-durable.gouv.fr/corine-land-cover-0, downloaded in October 2021
[19] The municipality of Sigy-en-Bray (76) was excluded because of a split of municipalities in 2018
[20] https://www.insee.fr/fr/statistiques/5359146, downloaded in October 2021

- Share of the municipal population assimilated to farmers;
- Share of the municipal population unemployed at the time of the census;
- Share of the municipal population that is inactive but not retired.

As pro-environmental behaviours of tourists depends on their socioeconomic status (Dolnicar and Leisch (2008)), it is possible that demand for high proximity to nature also depends on tourits' revenue, hence we included the following variable in our model:

- Share of 3-star or more rooms in the total number of hotel rooms and camping spaces in the municipality.

Finally, we used political data regarding election results made available by the French Ministry of the Interior and Overseas Territories[21]. We assumed that the probability that a local elected official decides to protect his or her territory increases with the share of inhabitants with pro-ecological opinions, who are more likely to pressure their elected representatives in favour of nature protecton.We used the results of the European elections of 2019[22], the variable used being:

- Result of the Europe Ecologie - Les Verts (EELV) party (in percentage of voters) in the 2019 European elections in the municipality.

### D. EXPLANATION OF THE CALCULATION OF THE IRREPLACEABILITY INDEX WITH MARXAN.

Irreplaceability is calculated using the spatial optimisation software Marxan, we use the same calculation method as UMS Patrinat (Lévêque and Witté (2019)). The software simulates 100 different optimal protected area networks, the irreplaceability index of a territory corresponds to the number of times it has been included in an optimal network.

Marxan seeks to find the protected area network that minimises the costs associated with including each unit of land and excluding species. In this work, the inclusion of a 10*10 km square in the protected area network is assigned a cost of 1. The non-inclusion of a species in the network is associated with a cost of 5000. This cost is so high that the inclusion of half of the metropolitan territory is less costly than the exclusion of a single species, thus it ensures that all species are included in each optimal network.

For a species to be considered as included in the network, it is necessary that a certain share of the territory it occupies in metropolitan France is covered by protected areas of this simulated network, this share depends on the vulnerability of the species. Five categories of species are established by UMS Patrinat, these categories represent the vulnerability of the species and depend on the more or less important part that the species occupies on the French territory (the more a species occupies a large territory, the less vulnerable it is considered) as well as on the fragmentation of the territory occupied by the species (the more the area of occupation is fragmented, and therefore non-continuous, the more vulnerable the species is considered). Each species is assigned a threshold depending on its category. The protected area network calculated by Marxan must meet this

[21] https://www.data.gouv.fr/fr/datasets/resultats-des-elections-europeennes-2019/, downloaded in January 2022

[22] These elections are not closer to 2021 than the 2022 presidential elections and are structurally more favourable to the green parties than the other national elections, with the EELV party obtaining 13.48% of the vote in the 2019 European elections, compared to 2.31% in the 2012 presidential elections, 6.36% in a coalition with the Socialist party in 2017 and 4.63% in 2022. However, we prefer to use the European elections, which are less subject to the strategic behaviour of voters because of the voting system (Duverger (1955)).

threshold for the software to consider that the species is included in the protected area network. For example, the most vulnerable species have a threshold of 0.5, and for a species belonging to this category to be considered as included in the network, it is necessary that 50% of the territory occupied by the species is covered by protected areas simulated by Marxan.

There are two reasons for the match between richness of " with status "species and irreplaceability in some regions. First, a rich region is one in which the probability of finding rare species is higher than in a relatively less rich region. These rare species have a strong positive impact on the irreplaceability of the municipality in which they are found, since destroying biodiversity in this municipality means destroying a significant part of the species' occupied territory. Secondly, high richness in a given unit of space allows Marxan to reduce its space cost if it integrates this unit into its network rather than several different units where the same species are found but more widely.

It is also possible to note that some areas have a relatively high level of irreplaceability and low richness (this is the case of the Ardennes): 929 municipalities in mainland France are in the 10% of municipalities with the most irreplaceable biodiversity and have less than 5 species " with status " on their territory (national median). Other regions have a low level of irreplaceability and a high level of richness (this is the case of the Cotentin Peninsula). This mismatch is due to the fact that even a low number of species can result in high irreplaceability in a territory if one or more of these species is poorly represented in the rest of the metropolitan territory. At the same time, a large number of very common species in the territory does not necessarily imply that the territory is highly irreplaceable.

## E. Results of the Logit Models

This table shows the results of the logit models for each scenario. These models are those used to estimate the propensity scores of each municipality for matching purposes. The results of this analysis are broadly similar to those found with a linear probability model. The effect of some variables of secondary importance no longer appears to be significant in the logit models for certain scenarios. (This is the case for the green vote share for scenarios 2 and 3).

Table X presents the coefficients and Table XI presents the margins of the logit models.

TABLE X

LOGIT MODELS RESULTS (COEFFICIENTS)

| | Scenario 1 P1-3/None | Scenario 2 P1-2/None | Scenario 3 P1/None | Scenario 4 P1-3/rest | Scenario 5 P1-2/rest | Scenario 6 P1/rest |
|---|---|---|---|---|---|---|
| **Set A variables :** | | | | | | |
| Irrepleceability | 0.00894*** | 0.00953*** | 0.0106*** | 0.00930*** | 0.00932*** | 0.00652*** |
| | (0.000614) | (0.000646) | (0.000940) | (0.000593) | (0.000590) | (0.000745) |
| Nb. of observations | -0.0000655* | -0.0000594 | -0.0000817** | -0.0000568 | -0.0000344 | 0.00000710 |
| | (0.0000327) | (0.0000413) | (0.0000295) | (0.0000363) | (0.0000348) | (0.0000195) |
| Richness of with status species | 0.0484*** | 0.0513*** | 0.0583*** | 0.0470*** | 0.0469*** | 0.0288*** |
| | (0.00125) | (0.00130) | (0.00155) | (0.00120) | (0.00113) | (0.000915) |
| Share of wetlands | 12.33*** | 13.32*** | 16.33*** | 11.92*** | 12.93*** | 6.961*** |
| | (1.633) | (1.662) | (1.877) | (1.535) | (1.511) | (0.978) |
| Share of bare nature | 3.698*** | 3.252*** | 2.279** | 3.655*** | 1.552** | 0.499 |
| | (0.860) | (0.850) | (0.876) | (0.796) | (0.567) | (0.381) |
| Share of forest | 1.263*** | 1.232*** | 1.433*** | 1.140*** | 0.826*** | 0.815*** |
| | (0.0747) | (0.0774) | (0.106) | (0.0715) | (0.0698) | (0.0858) |
| Coastal dummy | 2.363*** | 2.505*** | 2.827*** | 2.154*** | 2.468*** | 1.597*** |
| | (0.187) | (0.188) | (0.202) | (0.166) | (0.166) | (0.0917) |
| **Set B variables :** | | | | | | |
| Density of tourism | 0.171 | 0.138 | 0.0929 | 0.147 | 0.0489 | 0.0745 |
| | (0.105) | (0.100) | (0.0999) | (0.0964) | (0.0780) | (0.0461) |
| Share of industrial areas | -3.362*** | -3.512*** | -2.385** | -3.126*** | -2.895*** | -0.669 |
| | (0.515) | (0.549) | (0.732) | (0.505) | (0.519) | (0.601) |
| Share of transport infrastructures | -2.195** | -2.357** | -3.840** | -2.061** | -2.078* | -2.299* |
| | (0.796) | (0.858) | (1.391) | (0.785) | (0.823) | (1.110) |
| Share of arable lands | -1.560*** | -1.625*** | -1.849*** | -1.349*** | -1.329*** | -1.005*** |
| | (0.0547) | (0.0572) | (0.0876) | (0.0530) | (0.0538) | (0.0754) |
| Population density | -0.0438*** | -0.0420*** | -0.0596*** | -0.0431*** | -0.0370*** | -0.0369*** |
| | (0.00444) | (0.00468) | (0.00720) | (0.00435) | (0.00443) | (0.00545) |
| **Set A variables :** | | | | | | |
| Share of 3 stars and more rooms | 0.146* | 0.189** | 0.229* | 0.105 | 0.191** | 0.141* |
| | (0.0688) | (0.0711) | (0.0926) | (0.0658) | (0.0644) | (0.0688) |
| Unemployment rate | 1.520* | 1.282 | -0.645 | 1.849** | 0.433 | -2.173** |
| | (0.667) | (0.697) | (1.012) | (0.645) | (0.632) | (0.837) |
| Share of the population under 25 | -1.950*** | -2.032*** | -0.558 | -1.665*** | -1.122*** | 1.108*** |
| | (0.236) | (0.246) | (0.355) | (0.228) | (0.225) | (0.294) |
| Share of non-leaving population | -0.111 | -0.308 | 0.739 | -0.0954 | -0.153 | 1.415** |
| | (0.358) | (0.373) | (0.552) | (0.348) | (0.346) | (0.475) |
| Share of farmers | 0.487 | 0.0900 | -1.295** | 0.612* | -0.269 | -1.918*** |
| | (0.300) | (0.313) | (0.490) | (0.291) | (0.288) | (0.434) |
| Share of inactive population | -0.411 | -0.670* | -1.472*** | -0.348 | -0.757** | -1.665*** |
| | (0.254) | (0.265) | (0.400) | (0.246) | (0.245) | (0.343) |
| Share of executives and managers | -1.349*** | -2.117*** | -1.557** | -1.383*** | -2.181*** | -0.159 |
| | (0.350) | (0.370) | (0.536) | (0.340) | (0.341) | (0.441) |
| Share of vacant dwellings | 0.381 | 0.792** | 0.428 | 0.362 | 1.236*** | 0.612 |
| | (0.290) | (0.302) | (0.440) | (0.280) | (0.277) | (0.364) |
| Share of 1 room dwellings | -2.581* | -3.777** | -5.755*** | -2.736* | -4.120*** | -3.017* |
| | (1.154) | (1.225) | (1.700) | (1.121) | (1.141) | (1.395) |
| Share of houses | -0.389* | -0.309 | -1.271*** | -0.566*** | -0.338* | -1.060*** |
| | (0.162) | (0.169) | (0.225) | (0.156) | (0.151) | (0.161) |
| Share of dwellings built after 1970 | -1.158*** | -1.195*** | -1.789*** | -1.005*** | -0.905*** | -1.434*** |
| | (0.197) | (0.205) | (0.288) | (0.189) | (0.188) | (0.234) |
| Share of green vote | 0.00516* | 0.00464 | 0.00885* | 0.00739** | 0.000392 | 0.00531 |
| | (0.00251) | (0.00267) | (0.00384) | (0.00244) | (0.00236) | (0.00293) |
| Constant | 1.478*** | 1.530*** | 0.470 | 1.218** | 0.758* | -1.490** |
| | (0.399) | (0.416) | (0.605) | (0.387) | (0.384) | (0.506) |
| Pseudo R2 | 0.2048 | 0.2209 | 0.3111 | 0.1874 | 0.1798 | 0.1546 |
| Observations | 33643 | 31682 | 22093 | 34827 | 34827 | 34827 |

*Notes:* Standard errors in parentheses, $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.
Lines: variables included in the logit model, grouped by variable set (A, B and C). Columns: model results per protection scenario. Coefficients measure the logit coefficients of the variable. The number below the coefficients indicate the standard error. Bottom lines provide the pseudo-R2 and number of observations included for each model.

TABLE XI

LOGIT MODELS RESULTS (MARGINS)

| | Scenario 1 P1-3/None | Scenario 2 P1-2/None | Scenario 3 P1/None | Scenario 4 P1-3/rest | Scenario 5 P1-2/rest | Scenario 6 P1/rest |
|---|---|---|---|---|---|---|
| **Set A variables :** | | | | | | |
| Irrepleceability | 0.00168*** | 0.00174*** | 0.00133*** | 0.00179*** | 0.00179*** | 0.000753*** |
| | (14.75) | (14.94) | (11.39) | (15.88) | (15.98) | (8.77) |
| Nb. of observations | -0.0000123* | -0.0000108 | -0.0000102** | -0.0000109 | -0.00000661 | 0.000000820 |
| | (-2.00) | (-1.44) | (-2.77) | (-1.56) | (-0.99) | (0.36) |
| Richness of with status species | 0.00907*** | 0.00938*** | 0.00727*** | 0.00904*** | 0.00901*** | 0.00332*** |
| | (41.81) | (43.17) | (42.45) | (42.42) | (45.59) | (32.72) |
| Share of wetlands | 2.311*** | 2.434*** | 2.037*** | 2.294*** | 2.483*** | 0.803*** |
| | (7.58) | (8.04) | (8.75) | (7.79) | (8.59) | (7.13) |
| Share of bare nature | 0.693*** | 0.594*** | 0.284** | 0.704*** | 0.298** | 0.0576 |
| | (4.30) | (3.83) | (2.60) | (4.59) | (2.74) | (1.31) |
| Share of forest | 0.237*** | 0.225*** | 0.179*** | 0.219*** | 0.159*** | 0.0941*** |
| | (17.19) | (16.17) | (13.75) | (16.18) | (11.94) | (9.51) |
| Coastal dummy | 0.443*** | 0.458*** | 0.353*** | 0.415*** | 0.474*** | 0.184*** |
| | (12.70) | (13.44) | (14.16) | (13.07) | (15.02) | (17.63) |
| **Set B variables :** | | | | | | |
| Density of tourism | 0.0320 | 0.0251 | 0.0116 | 0.0282 | 0.00939 | 0.00860 |
| | (1.62) | (1.37) | (0.93) | (1.52) | (0.63) | (1.62) |
| Share of industrial areas | -0.630*** | -0.642*** | -0.298** | -0.602*** | -0.556*** | -0.0772 |
| | (-6.55) | (-6.42) | (-3.26) | (-6.21) | (-5.59) | (-1.11) |
| Share of transport infrastructures | -0.411** | -0.431** | -0.479** | -0.397** | -0.399* | -0.265* |
| | (-2.76) | (-2.75) | (-2.76) | (-2.63) | (-2.53) | (-2.07) |
| Share of arable lands | -0.292*** | -0.297*** | -0.231*** | -0.260*** | -0.255*** | -0.116*** |
| | (-29.90) | (-29.80) | (-21.53) | (-26.36) | (-25.47) | (-13.34) |
| Population density | -0.00821*** | -0.00768*** | -0.00744*** | -0.00830*** | -0.00711*** | -0.00426*** |
| | (-9.90) | (-9.01) | (-8.31) | (-9.96) | (-8.38) | (-6.78) |
| **Set C variables :** | | | | | | |
| Share of 3 stars and more rooms | 0.0274* | 0.0346** | 0.0285* | 0.0203 | 0.0367** | 0.0163* |
| | (2.12) | (2.66) | (2.47) | (1.60) | (2.97) | (2.05) |
| Unemployment rate | 0.285* | 0.234 | -0.0804 | 0.356** | 0.0832 | -0.251** |
| | (2.28) | (1.84) | (-0.64) | (2.87) | (0.69) | (-2.60) |
| Share of the population under 25 | -0.365*** | -0.371*** | -0.0696 | -0.320*** | -0.215*** | 0.128*** |
| | (-8.29) | (-8.28) | (-1.57) | (-7.33) | (-4.98) | (3.77) |
| Share of non-leaving population | -0.0208 | -0.0563 | 0.0923 | -0.0184 | -0.0293 | 0.163** |
| | (-0.31) | (-0.83) | (1.34) | (-0.27) | (-0.44) | (2.98) |
| Share of farmers | 0.0912 | 0.0165 | -0.162** | 0.118* | -0.0517 | -0.221*** |
| | (1.62) | (0.29) | (-2.64) | (2.10) | (-0.93) | (-4.42) |
| Share of inactive population | -0.0769 | -0.122* | -0.184*** | -0.0669 | -0.145** | -0.192*** |
| | (-1.62) | (-2.53) | (-3.68) | (-1.42) | (-3.09) | (-4.86) |
| Share of executives and managers | -0.253*** | -0.387*** | -0.194** | -0.266*** | -0.419*** | -0.0183 |
| | (-3.85) | (-5.73) | (-2.90) | (-4.07) | (-6.41) | (-0.36) |
| Share of vacant dwellings | 0.0713 | 0.145** | 0.0534 | 0.0697 | 0.237*** | 0.0706 |
| | (1.31) | (2.63) | (0.97) | (1.29) | (4.46) | (1.68) |
| Share of 1 room dwellings | -0.484* | -0.690** | -0.718*** | -0.527* | -0.791*** | -0.348* |
| | (-2.24) | (-3.08) | (-3.39) | (-2.44) | (-3.61) | (-2.16) |
| Share of houses | -0.0729* | -0.0565 | -0.159*** | -0.109*** | -0.0650* | -0.122*** |
| | (-2.40) | (-1.83) | (-5.67) | (-3.62) | (-2.24) | (-6.59) |
| Share of dwellings built after 1970 | -0.217*** | -0.218*** | -0.223*** | -0.193*** | -0.174*** | -0.165*** |
| | (-5.90) | (-5.84) | (-6.24) | (-5.31) | (-4.81) | (-6.13) |
| Share of green vote | 0.000966* | 0.000849 | 0.00110* | 0.00142** | 0.0000753 | 0.000613 |
| | (2.05) | (1.74) | (2.31) | (3.03) | (0.17) | (1.81) |
| Pseudo R2 | 0.2048 | 0.2209 | 0.3111 | 0.1874 | 0.1798 | 0.1546 |
| Observations | 33643 | 31682 | 22093 | 34827 | 34827 | 34827 |

*Notes:* $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$.
Lines: variables included in the logit model, grouped by variable set (A, B and C). Columns: model results per protection scenario. Coefficients measure the marginal effect of the variable on the probability of being protected. The number below the coefficients indicate the standard error. Bottom lines provide the pseudo-R2 and number of observations included for each model.

## F. STANDARDISED MEAN DIFFERENCES BEFORE AND AFTER MATCHING FOR EACH SCENARIO.

## TABLE XII

### Standardised mean differences, scenario 1

| | Standardized differences Raw | Matched |
|---|---|---|
| Irreplaceability | 0.36 | 0.0006 |
| Number of observations | 0.11 | 0.007 |
| Richness of "with status" species | 0.7 | 0.02 |
| Share of wetlands | 0.18 | -0.1 |
| Share of "bare" nature | 0.25 | 0.07 |
| Share of forests | 0.61 | 0.08 |
| Coastal dummy | 0.3 | -0.05 |
| Tourism density | 0.13 | -0.13 |
| Share of industrial areas | -0.07 | -0.05 |
| Share of transports infrastructures | -0.04 | -0.09 |
| Share of arable lands | -0.74 | 0.02 |
| Population density | -0.11 | -0.18 |
| Share of 3 stars and more rooms | 0.19 | -0.005 |
| Unemployment rate | 0.1 | -0.05 |
| Share of the population under 25 | -0.4 | -0.07 |
| Share of non-leaving population | -0.05 | 0.01 |
| Share of farmers | 0.02 | 0.05 |
| Share of inactive population | 0.002 | -0.02 |
| Share of executives and managers | -0.06 | -0.03 |
| Share of vacant dwellings | 0.05 | -0.01 |
| Share of 1 room dwellings | 0.05 | -0.07 |
| Share of houses | -0.23 | 0.07 |
| Share of dwellings built after 1970 | -0.08 | 0.08 |
| Share of green vote | 0.21 | 0.04 |

## TABLE XIII

### Standardised mean differences, scenario 2

| | Standardized differences Raw | Matched |
|---|---|---|
| Irreplaceability | 0.39 | 0.001 |
| Number of observations | 0.11 | 0.001 |
| Richness of "with status" species | 0.7 | 0.03 |
| Share of wetlands | 0.19 | -0.13 |
| Share of "bare" nature | 0.26 | 0.11 |
| Share of forests | 0.61 | 0.09 |
| Coastal dummy | 0.32 | -0.07 |
| Tourism density | 0.14 | -0.11 |
| Share of industrial areas | -0.07 | -0.04 |
| Share of transports infrastructures | -0.04 | -0.012 |
| Share of arable lands | -0.75 | -0.004 |
| Population density | -0.11 | -0.19 |
| Share of 3 stars and more rooms | 0.21 | -0.02 |
| Unemployment rate | 0.1 | -0.06 |
| Share of the population under 25 | -0.4 | -0.05 |
| Share of non-leaving population | -0.05 | -0.02 |
| Share of farmers | 0.003 | 0.07 |
| Share of inactive population | -0.005 | -0.05 |
| Share of executives and managers | -0.07 | 0.0006 |
| Share of vacant dwellings | 0.07 | -0.03 |
| Share of 1 room dwellings | 0.05 | -0.08 |
| Share of houses | -0.24 | 0.04 |
| Share of dwellings built after 1970 | -0.09 | 0.09 |
| Share of green vote | 0.2 | 0.06 |

## TABLE XIV

### Standardised mean differences, scenario 3

| | Standardized differences Raw | Matched |
|---|---|---|
| Irreplaceability | 0.52 | -0.06 |
| Number of observations | 0.16 | 0.03 |
| Richness of "with status" species | 0.94 | 0.04 |
| Share of wetlands | 0.29 | -0.22 |
| Share of "bare" nature | 0.32 | 0.21 |
| Share of forests | 0.62 | 0.09 |
| Coastal dummy | 0.46 | -0.05 |
| Tourism density | 0.21 | -0.07 |
| Share of industrial areas | 0.006 | -0.07 |
| Share of transports infrastructures | -0.01 | -0.17 |
| Share of arable lands | -0.86 | -0.01 |
| Population density | -0.06 | -0.33 |
| Share of 3 stars and more rooms | 0.33 | 0.003 |
| Unemployment rate | 0.1 | -0.12 |
| Share of the population under 25 | -0.36 | -0.15 |
| Share of non-leaving population | -0.05 | -0.07 |
| Share of farmers | -0.12 | 0.11 |
| Share of inactive population | 0.001 | -0.11 |
| Share of executives and managers | 0.004 | -0.03 |
| Share of vacant dwellings | -0.02 | -0.03 |
| Share of 1 room dwellings | 0.13 | -0.08 |
| Share of houses | -0.43 | 0.05 |
| Share of dwellings built after 1970 | -0.2 | 0.17 |
| Share of green vote | 0.28 | 0.12 |

## TABLE XV

### Standardised mean differences, scenario 4

| | Standardized differences Raw | Matched |
|---|---|---|
| Irreplaceability | 0.36 | -0.008 |
| Number of observations | 0.11 | 0.05 |
| Richness of "with status" species | 0.7 | 0.06 |
| Share of wetlands | 0.18 | -0.11 |
| Share of "bare" nature | 0.25 | -0.04 |
| Share of forests | 0.56 | 0.05 |
| Coastal dummy | 0.3 | -0.05 |
| Tourism density | 0.13 | -0.04 |
| Share of industrial areas | -0.06 | 0.01 |
| Share of transports infrastructures | -0.04 | -0.04 |
| Share of arable lands | -0.67 | 0.002 |
| Population density | -0.1 | -0.16 |
| Share of 3 stars and more rooms | 0.18 | -0.02 |
| Unemployment rate | 0.1 | -0.03 |
| Share of the population under 25 | -0.36 | 0.03 |
| Share of non-leaving population | -0.05 | -0.03 |
| Share of farmers | 0.01 | 0.05 |
| Share of inactive population | 0.006 | -0.03 |
| Share of executives and managers | -0.05 | -0.03 |
| Share of vacant dwellings | 0.04 | 0.02 |
| Share of 1 room dwellings | 0.05 | -0.04 |
| Share of houses | -0.24 | 0.04 |
| Share of dwellings built after 1970 | -0.08 | 0.08 |
| Share of green vote | 0.21 | 0.02 |

## TABLE XVI

### Standardised mean differences, scenario 5

| | Standardized differences Raw | Matched |
|---|---|---|
| Irreplaceability | 0.37 | -0.04 |
| Number of observations | 0.14 | 0.0008 |
| Richness of "with status" species | 0.71 | -0.004 |
| Share of wetlands | 0.19 | -0.03 |
| Share of "bare" nature | 0.24 | 0.04 |
| Share of forests | 0.47 | 0.01 |
| Coastal dummy | 0.32 | 0.05 |
| Tourism density | 0.14 | 0.01 |
| Share of industrial areas | -0.05 | 0.01 |
| Share of transports infrastructures | -0.03 | -0.07 |
| Share of arable lands | -0.61 | 0.03 |
| Population density | -0.09 | -0.1 |
| Share of 3 stars and more rooms | 0.2 | 0.03 |
| Unemployment rate | 0.09 | -0.02 |
| Share of the population under 25 | -0.32 | -0.03 |
| Share of non-leaving population | -0.04 | 0.03 |
| Share of farmers | -0.01 | 0.02 |
| Share of inactive population | -0.006 | -0.01 |
| Share of executives and managers | -0.07 | 0.01 |
| Share of vacant dwellings | 0.06 | -0.07 |
| Share of 1 room dwellings | 0.04 | -0.05 |
| Share of houses | -0.23 | 0.04 |
| Share of dwellings built after 1970 | -0.09 | 0.06 |
| Share of green vote | 0.16 | 0.01 |

## TABLE XVII

### Standardised mean differences, scenario 6

| | Standardized differences Raw | Matched |
|---|---|---|
| Irreplaceability | 0.4 | -0.04 |
| Number of observations | 0.16 | 0.07 |
| Richness of "with status" species | 0.75 | 0.02 |
| Share of wetlands | 0.24 | -0.05 |
| Share of "bare" nature | 0.26 | 0.07 |
| Share of forests | 0.33 | -0.06 |
| Coastal dummy | 0.41 | 0.04 |
| Tourism density | 0.2 | 0.02 |
| Share of industrial areas | 0.06 | -0.01 |
| Share of transports infrastructures | 0.02 | 0.01 |
| Share of arable lands | -0.54 | 0.07 |
| Population density | -0.01 | -0.03 |
| Share of 3 stars and more rooms | 0.29 | 0.04 |
| Unemployment rate | 0.07 | 0.002 |
| Share of the population under 25 | -0.17 | -0.004 |
| Share of non-leaving population | -0.03 | 0.01 |
| Share of farmers | -0.15 | -0.003 |
| Share of inactive population | 0.004 | -0.01 |
| Share of executives and managers | 0.04 | 0.03 |
| Share of vacant dwellings | -0.07 | -0.05 |
| Share of 1 room dwellings | 0.13 | -0.04 |
| Share of houses | -0.4 | -0.0002 |
| Share of dwellings built after 1970 | -0.2 | 0.01 |
| Share of green vote | 0.2 | 0.01 |

## G. PROPENSITY SCORE DENSITY BY GROUP

This appendix presents, for each scenario, the estimates of the kernel densities of the propensity score (“score de propension” in the graph) for each of the two groups: treatment group and control group. The number in brackets in the title of each graph indicates the number of municipalities whose propensity score was too high or too low to be matched to other ones, these municipalities were removed from the ATE estimate for each scenario.

Figure 3: Kernel density estimates of propensity score S1 (10)

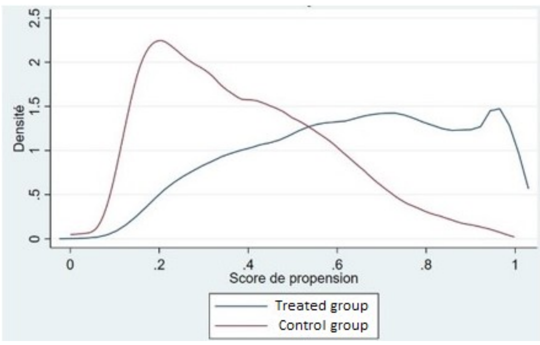



Figure 4: Kernel density estimates of propensity score S2 (13)

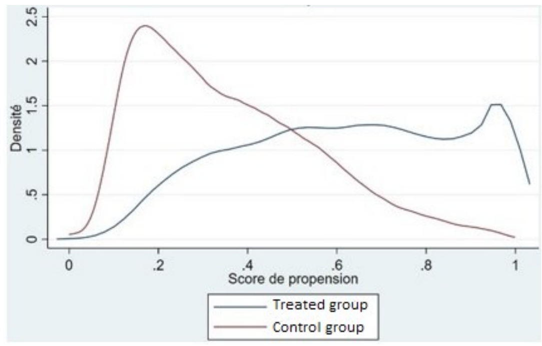



Figure 5: Kernel density estimates of the S3 (0) propensity score

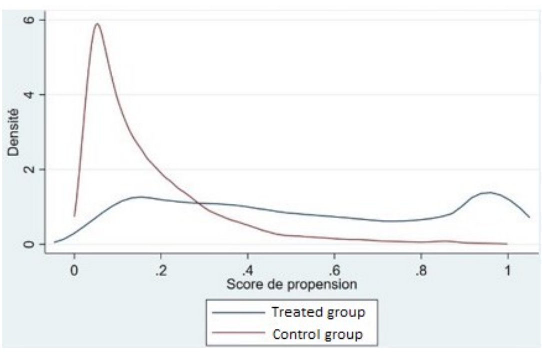



Figure 6: Kernel density estimates of the S4 propensity score (16)

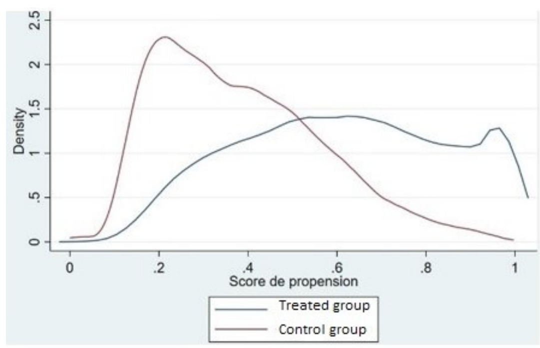



Figure 7: Kernel density estimates of the S5 propensity score (24)

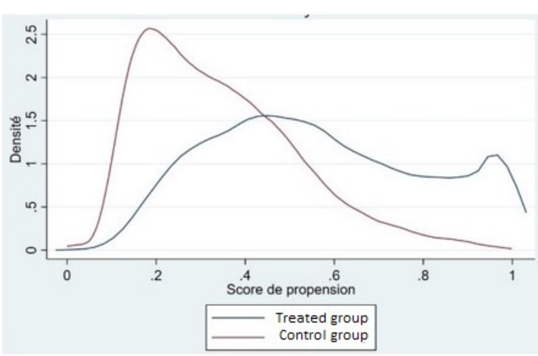
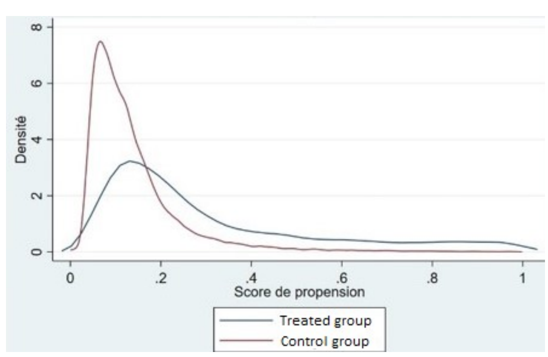



Figure 8: Kernel density estimates of the S6 propensity score (35)



## H. RESULTS OF PROPENSITY SCORE MATCHING INCLUDING OTHER SUBSETS OF VARIABLES

This appendix presents the results of propensity score matching for scenarios 1, 2 and 3. The combinations of sets of variables included in the explanatory variables of the logistic model are those not presented in the body of the article (*i.e.* set B alone, set C alone, sets B and C, sets A and C). In cases where set B is included in the explanatory variables of the logistic model (and only in the cases presented in this appendix), the variable 'tourism per hectare' has been replaced by its logarithm, following convergence problems with the logistic models. After checking, these convergence problems were not linked to a risk of collinearity or to the variable having a too strong predictive capacity.

TABLE XVIII

PROPENSITY SCORE MATCHING RESULTS FOR THE ESTIMATION OF THE ATT

| Scenario | Logit Independant variables | ATT | AI Robust Standard error | Z | p-value | 95% Conf. Interval |
|---|---|---|---|---|---|---|
| Scenario 1 (P1-3/no protec) | set B | -82 | 52 | -1.58 | 0.114 | (-183) - (20) |
| | sets C | -1942 | 263 | -7.37 | $< 0.001$ | (-2458) - (-1426) |
| | sets A + C | -2526 | 588 | -4.3 | $< 0.001$ | (-3679) - (-1375) |
| | set B + C | -263 | 58 | -4.52 | $< 0.001$ | (-376) - (-149) |
| Scenario 2 (P1-2/no protec) | set B | -57 | 55 | -1.03 | 0.304 | (-165) - (52) |
| | sets C | -1883 | 269 | -7.00 | $< 0.001$ | (-2410) - (-1356) |
| | sets A + C | -1978 | 370 | -5.34 | $< 0.001$ | (-2704) - (-1252) |
| | set B + C | -245 | 56 | -4.36 | $< 0.001$ | (-355) - (-135) |
| Scenario 3 (P1/no protec) | set B | -22 | 93 | -0.24 | 0.812 | (-205) - (160) |
| | sets C | -3039 | 436 | -6.96 | $< 0.001$ | (-3894) - (-2183) |
| | sets A + C | -5589 | 2473 | -2.26 | 0.024 | (-10437) - (-741) |
| | set B + C | -129 | 104 | -1.23 | 0.217 | (-333) - (76) |

*Notes:* Set A includes ecological variables, set B includes pressure variables and set C includes socio-demographic and political variables.

## I. RESULTS OF PROPENSITY SCORE MATCHING ESTIMATIONS OF THE ATE

This section presents the estimates of the average treatment effect (ATE) using the propensity score matching method for scenarios 1, 2 and 3. The ATE is written as follows:

(4) $$E[R_{1i} - R_{0i}]$$

TABLE XIX

PROPENSITY SCORE MATCHING RESULTS FOR THE ESTIMATION OF THE ATE

| Scenario | Logit Independant variables | ATE | AI Robust Standard error | Z | p-value | 95% Conf. Interval |
|---|---|---|---|---|---|---|
| Scenario 1 (P1-3/no protec) | set A | -4202 | 1604 | -2.62 | 0.009 | (-7346) - (-1058) |
| | sets A + B | -813 | 107 | -7.56 | $< 0.001$ | (-1024) - (-602) |
| | sets A + B + C | -614 | 179 | -3.42 | 0.001 | (-965) - (-262) |
| | set B | -94 | 61 | -1.55 | 0.121 | (-213) - (25) |
| | sets C | -1628 | 176 | -9.27 | $< 0.001$ | (-1972) - (-1283) |
| | sets A + C | -1857 | 320 | -5.8 | $< 0.001$ | (-2484) - (-1230) |
| | set B + C | -264 | 55 | -4.8 | $< 0.001$ | (-371) - (-156) |
| Scenario 2 (P1-2/no protec) | set A | -4439 | 2060 | -2.15 | 0.031 | (-8477) - (-401) |
| | sets A + B | -627 | 169 | -3.7 | $< 0.001$ | (-960) - (-294) |
| | sets A + B + C | -674 | 118 | -5.7 | $< 0.001$ | (-906) - (-442) |
| | set B | -196 | 66 | -2.98 | 0.003 | (-324) - (-67) |
| | sets C | -1606 | 169 | -9.49 | $< 0.001$ | (-1938) - (-1274) |
| | sets A + C | -1486 | 207 | -7.15 | $< 0.001$ | (-1893) - (-1078) |
| | set B + C | -281 | 58 | -4.85 | $< 0.001$ | (-395) - (-168) |
| Scenario 3 (P1/no protec) | set A | -4017 | 2243 | -1.79 | 0.073 | (-8414) - (379) |
| | sets A + B | -146 | 259 | -0.57 | 0.571 | (-655) - (361) |
| | sets A + B + C | -90 | 350 | -0.26 | 0.797 | (-778) - (597) |
| | set B | 100 | 163 | 0.61 | 0.543 | (-221) - (420) |
| | sets C | -1752 | 178 | -9.85 | $< 0.001$ | (-2101) - (-1403) |
| | sets A + C | -2268 | 674 | -3.36 | 0.001 | (-3588) - (-946) |
| | set B + C | 42 | 82 | 0.51 | 0.607 | (-119) - (204) |

*Notes:* Set A includes ecological variables, set B includes pressure variables and set C includes socio-demographic and political variables.

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