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# Protected Areas and Agricultural Biodiversity Conservation—Do Parks Increase AES Adoption?

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## ABSTRACT

Although both protected areas and agri-environment schemes (AES) aim to conserve biodiversity, the interaction between the two policy instruments is unknown. We investigate the effects of listing a region as a protected area (a regional nature park) on the uptake of biodiversity conservation AES within the region. Using panel data of all Swiss farms between 2005 and 2020, and survey data on 15 Swiss regional nature parks established between 2008 and 2018, we analyse the effects of park establishment on farmers' adoption of three types of AES for biodiversity conservation (action-based, result-based, and agglomeration) in a heterogeneity-robust difference-in-differences framework. Overall, parks significantly increase the adoption of result-based AES. Moreover, the park effect depends largely on the agricultural baseline where parks are established. In regions with relatively more intensive agricultural production and lower AES adoption beforehand, the establishment of parks increases the adoption of result-based and agglomeration AES, evidencing synergies between the two policies. Such effects are not observed in regions with more extensive agricultural production and high AES adoption prior to park establishment. Moreover, the effects of park establishment increase over time. Therefore, when introducing a new policy aimed at integrating biodiversity conservation into agriculture, it is important to account for baseline situations and identify synergies between intended and existing policies.

**JEL Classification:** Q57, Q15, Q58, Q18

## 1 | Introduction

Policy actions that address the key drivers of biodiversity loss are urgently needed to conserve, restore, and sustainably use the biosphere upon which humanity depends (IPBES 2019). Globally, land use changes due to agriculture have been a major direct driver of biodiversity loss (e.g., Leclère et al. 2020; Pe'er et al. 2014). Therefore, policy measures to increase biodiversity in agriculture are crucial to slowing down and reversing biodiversity loss. Agri-environment schemes (AES) have been major policy instruments for integrating biodiversity conservation in agriculture, typically by providing individual farmers with incentives for extensive production (e.g., Hasler et al. 2022; Uthes and Matzdorf 2013). Moreover, protected areas are expected to hold an increasingly important place on the global policy agenda to conserve biodiversity (Bareille et al. 2023; Maxwell et al. 2020; Watson et al. 2014). For instance, the Kunming-Montreal Global Biodiversity Framework sets a target to designate at least 30% of terrestrial and water areas as protected areas by 2030 (GBF 2023). Regional nature parks, which aim to integrate nature and biodiversity conservation into sustainable land use and socioeconomic development, are one type of large-scale, less stringent protected area (EUROPARC 2023). With the common objective of promoting biodiversity, regional nature parks and AES may interact in their influence on farmers' decisions to conserve biodiversity. However, the direction and magnitude of the effect of regional nature parks on the uptake of AES have remained undocumented thus far.

In this study, we investigate the effects of protected areas in the form of regional nature parks on farms' participation in AES within these areas. Our analyses focus on Switzerland, where, over the past two decades, a number of regional nature parks have been established. The two key objectives of these parks are (i) to conserve and enhance the quality of nature and landscape and (ii) to strengthen sustainable economic development within the parks (NHG, Art. 23g).[1] Relevant to the agricultural sector, parks usually pursue these objectives by promoting environmentally sustainable agriculture and agricultural products produced within parks (also see Section 2.2 for more details). Specifically, we examine the overall and dynamic effects of regional nature parks on farmers' participation in three different types of AES for biodiversity conservation—action-based, result-based, and agglomeration—in terms of the fractions of agricultural land enrolled in AES and AES payments per hectare of agricultural land.[2] Furthermore, we examine whether the effects of regional nature parks vary across agricultural baselines in the region where a park is established (the agricultural baseline is represented by the landscape type of the park region) and potential variations across the types of support parks offer to farmers. These aggregate and heterogeneous effects inform the interaction between regional nature parks and AES, indicating potential synergies or trade-offs, and factors that could govern the interaction between the two policies.

In our context, we define a synergy as *the establishment of regional nature parks increasing AES adoption*, and a trade-off as *the establishment of regional parks decreasing AES adoption*.[3] Using a difference-in-differences (DiD) framework, we analyse a combination of farm-level panel census data on the AES adoption of over 42,465 Swiss farms between 2005 and 2020 and park-level survey data on AES-related support to farmers by 15 regional nature parks established between 2008 and 2018. As parks in our study were established in different time periods, we deploy a heterogeneity-robust DiD estimator designed for staggered treatment timing (Callaway and Sant'Anna 2021). We use multiple strategies to support the conditional parallel trends assumption, which include matching, doubly robust estimation (Sant'Anna and Zhao 2020), and sensitivity analysis for robust inference under potential violations of the assumption (Rambachan and Roth 2023).

A large stream of the literature has investigated factors that influence farmers' adoption of AES and conservation practices (for reviews, see, e.g., Schaub et al. 2023; Zimmermann and Britz 2016). The literature also provides evidence that protected areas can effectively conserve biodiversity while maintaining agriculture and supporting the livelihood of farmers (e.g., Naughton-Treves et al. 2005; Donia et al. 2017; Sims and Alix-Garcia 2017). Regarding their roles in nature conservation and ecosystem services, AES and protected areas are mainly discussed in a comparative manner in the literature (e.g., Batáry et al. 2015; dos Santos et al. 2015; Paulus et al. 2022; Whittingham 2007), whereas their interaction is seldom empirically assessed.

Although empirical evidence on the interaction between protected areas and AES is scant, previous studies on regional nature parks have provided insights into the mechanism that could drive the synergies or trade-offs between the two policy instruments. Evidence suggests that regional nature parks may facilitate AES implementation by reducing transaction costs, providing relevant support, encouraging farmers' active involvement in conservation, and fostering more positive attitudes toward biodiversity (Décamps 2010; de Sainte Marie 2014; Fleury et al. 2015). By contrast, regional nature parks' conservation objectives may be compromised when farmers only favour the economic opportunities associated with parks (e.g., improved marketing), which may lead to trade-offs between parks and AES adoption (de Sainte Marie 2014; Trachsel et al. 2020).

Our study draws on two strands of literature on environmental and agricultural policies to investigate the interactions between policy instruments that promote biodiversity. We contribute to the literature on the role of protected areas in conserving biodiversity (e.g., Bailey et al. 2016; Naughton-Treves et al. 2005). We provide empirical evidence of the role of regional nature parks in integrating biodiversity into agriculture. Our study also adds to the literature on AES adoption, with a focus on the optimal policy mix for nature conservation in rural areas (Robalino et al. 2015; Sims and Alix-Garcia 2017; Zárrate Charry et al. 2022). We quantify the effects of park status on farmers' AES adoption and discuss the implications for policy design to bring about synergies between protected areas and AES. The diversity of regional nature parks in our sample in terms of establishment time, agricultural baseline, and park support offered to farmers provides a unique setting for examining the heterogeneous effects of parks along these dimensions and the potential mechanisms for parks to impact AES adoption.

We find that overall, farms inside regional nature parks are more likely to outperform farms in non-park areas with similar natural and socioeconomic conditions in result-based AES, with a 12% overall increase in adoption among farms inside parks relative to the pre-treatment period due to the park effect. Moreover, the park effect depends largely on a region's agricultural baseline, which is characterised by its landscape. In regions with relatively more intensive agricultural production and therefore lower pre-park AES adoption, parks increase the adoption of result-based and agglomeration AES by 51% and 74%, respectively, evidencing synergies between the two policies. Such synergies do not apply to regions with an agriculture baseline characterised by extensive production and relatively high AES adoption before park establishment. These results are robust to alternative outcomes (i.e., AES payments) and alternative model specifications. Furthermore, the dynamic park effects indicate the gradual development of parks' influence on farmers' AES adoption.

The rest of this paper is organised as follows. In Section 2, we provide background on protected areas in the form of regional nature parks and AES in Switzerland and empirical hypotheses on their interaction. Section 3 presents the empirical strategy, and Section 4 presents the data. In Section 5, we present and discuss the results. Section 6 concludes the study.

## 2 | Background and Empirical Hypotheses

In this section, we provide overviews of AES and park policies in Switzerland and the independent policymaking processes behind these policies. We then discuss the potential interaction between the two policy instruments and derive our hypotheses accordingly.

### 2.1 | Agri-Environmental Schemes for Biodiversity Conservation in Switzerland

AES have been a key policy instrument to incentivise farmers to provide ecosystem services worldwide. In Switzerland, AES for biodiversity conservation were introduced in 1993 to encourage farmers to enrol their agricultural land as various ecological focus areas (EFA). Farmers receive direct payments as compensation upon fulfilling the respective requirements of the AES. Currently, three types of biodiversity conservation AES are available in Switzerland.

1. *Action-based AES*: reward farmers' compliance with management requirements, for example, extensively managed grasslands and flower strips on croplands, on the ecological focus area enrolled in the scheme (e.g., Wuepper and Huber 2022). Since 1999, as part of a cross-compliance scheme regulated by the Swiss government, farmers must enrol at least 7% (3.5% for special crops) of their total utilised agricultural area in action-based AES to be eligible to receive agricultural direct payments.
2. *Result-based AES* (introduced in 2001): provide *bonus payments on top of action-based schemes* for specific biodiversity outcomes, that is, occurrence of targeted indicator species (plants, insects, and other animals) on the ecological focus area (Elmiger et al. 2023).
3. *Agglomeration AES* (introduced in 2001): provide *bonus payments on top of action-based schemes* for spatially connected ecological focus area (e.g., Huber et al. 2021).

The Swiss Federal Office for Agriculture (FOAG) designs the AES at the federal level (FOAG 2022). The available schemes, requirements,[4] and amounts of direct payment are legislated in the direct payment ordinance (DZV 2024). Farmers across different Swiss regions are offered identical action- and result-based AES, and all schemes are funded by the agricultural budget of the Federal Office for Agriculture. Projects of agglomeration AES are initiated bottom-up, for example, by farmers or local/cantonal authorities, and thus the availability of agglomeration AES depends on the projects organised within a given region. However, all agglomeration projects across Switzerland must follow the same requirements defined by the Federal Office for Agriculture and offer identical per-hectare direct payments. Agglomeration projects are funded up to 90% by the Federal Office for Agriculture and the rest by regional resources (DZV 2024). Upon fulfilling the cross-compliance requirement, farmers' participation in AES is voluntary.

We acknowledge that AES adoption does not automatically translate into biodiversity outcomes (Wunder et al. 2025). Nonetheless, the literature shows that all AES types in Switzerland can contribute to higher biodiversity if they are taken up more widely (Zimmert et al. 2024). Moreover, among the three types of AES, result-based AES represent a higher quality level of biodiversity conservation than action-based AES and are thus more closely associated with biodiversity outcomes (Meier et al. 2021; Riedel et al. 2019; Schaub et al. 2025). This is because result-based AES require reaching actual biodiversity outcomes (i.e., higher species diversity). As such, result-based schemes are of particular interest to policymakers in reaching environmental outcomes, as they reduce the uncertainty in the delivery of such outcomes by mitigating moral hazards (Hanley et al. 2012). In addition, agglomeration AES facilitate landscape-level coordination of conservation practices, which is crucial in reaching many biodiversity outcomes that require spatial connectivity of conservation efforts (Huber et al. 2021; Meier et al. 2024; Westerink et al. 2017).

### 2.2 | Regional Nature Parks in Switzerland

The concept of "Park of National Importance" was introduced in 2007 with the revision of the Swiss Federal Act on the Protection of Nature and Cultural Heritage (NHG 2007), which is enforced by the Federal Office for the Environment. Parks of national importance include three categories: national parks, nature discovery parks, and regional nature parks. A common basic prerequisite for all parks is "high nature and landscape values" (NHG, Art. 23e).

Our study focuses on regional nature parks ("parks" hereafter), as they are the only category that hosts agricultural activities. The Swiss regional nature parks fall under the broader concept of European "Nature Regional Landscape Parks," with the common aims of integrating biodiversity protection with sustainable land use and promoting socioeconomic development (EUROPARC 2023). Unlike strictly protected areas, such as national parks, which strongly focus on nature conservation, regional nature parks have two main objectives: (i) to conserve and enhance the quality of nature and landscape and (ii) to strengthen sustainable economic development within the parks (NHG, Art. 23g).[5] Prior to 2022, Switzerland had 15 parks, established between 2008 and 2018 and covering over 10% of the country's surface area (Figure 1).[6] The parks are located in rural areas with two large landscape types: Alps and Jura. The Alps region is dominated by mountains (50%) and mountain ranges (47%). The Jura region mainly contains hills (58%) and valleys (21%), as well as some mountains (15%) (ARE 2011).

The creation of a park is a collective decision that undergoes three phases. In phase 1 (feasibility), a feasibility study takes place to ensure that the region meets the prerequisite of high natural and scenic value and the commitment of local residents and authorities. In phase 2 (establishment), a charter is drafted, which serves as the core planning tool of the park. This phase lasts up to 4 years, during which time the park can apply for the "candidate" label from the Federal Office for the Environment. At the end of this phase, conditional on the residents' acceptance of the park and the Federal Office for the Environment's approval of the charter, the park is established and enters phase 3 (operation). The park can then implement various projects planned in the charter, leveraging financial support from the Federal Office for the Environment, respective cantons, communes, and self-sought sources.

Throughout the process of park creation, the involvement of local residents and interest groups is crucial. Two referenda,

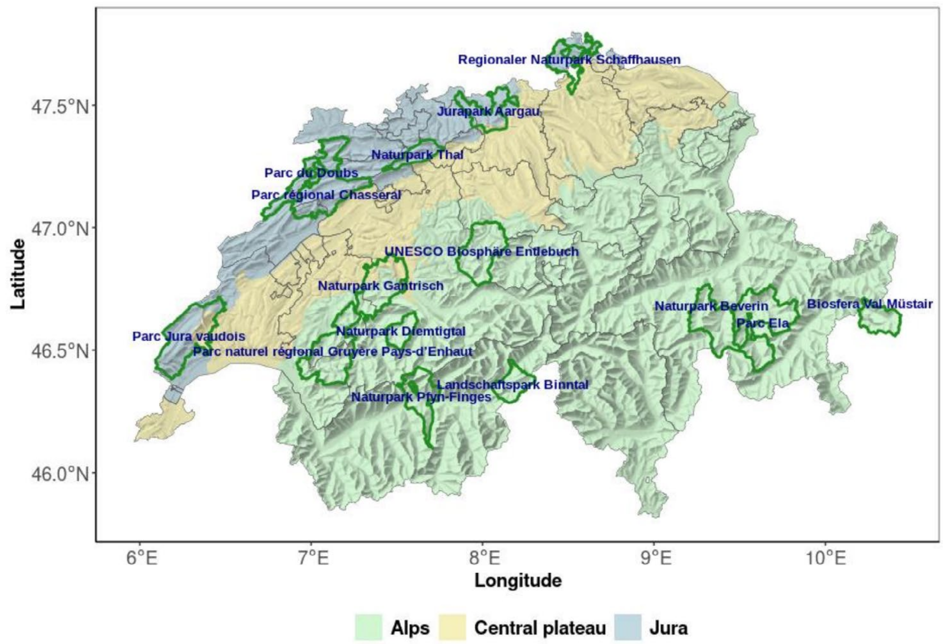



**FIGURE 1** | Distribution of regional nature parks over the large landscape types in Switzerland: Alps (lower right), Central Plateau, and Jura (upper left). Dark green polygons mark park boundaries at the time of park establishment (see Table 2 for details). [Colour figure can be viewed at wileyonlinelibrary.com]

each at the end of the feasibility and establishment phases, ensure that the establishment of a park is accepted by the majority of residents in the region. Swiss studies on the acceptance of parks by local residents indicate that the primary motivation for residents to support or accept the park is the expectation of value creation in the regional economy, for example, via tourism, the marketing of regional products, and cooperation across sectors (Glauser 2011; Imhof 2018; Karthäuser 2008; Toscan 2007). The expectation for enhanced nature conservation and living environments may also constitute a motivation, although only among small interest groups (Frick and Hunziker 2015; Toscan 2007; Zbinden 2019). Conversely, opposition to parks arises mainly from doubts about the park's ability to enhance the regional economy and fear of future restrictions on, for example, the development of infrastructure, agriculture, and leisure activities in Switzerland (Glauser 2011; Imhof 2018; Karthäuser 2008; Toscan 2007). In particular, although parks do not impose any restrictions, almost all studies in Switzerland documented the fear of future restrictions among some residents (which did not come true after park establishment). This is a common misconception about parks because the term "nature park" is often associated with nature conservation or confused with national parks and nature reserves (Glauser 2011; Toscan 2007; Trachsel et al. 2020). Hence, communication and clarification about what a park does and does not embody, for example, via information campaigns conducted prior to park establishment, are crucial for parks to convince residents (Butticaz 2013; Glauser 2011; Imhof 2018; Reutz et al. 2020; Toscan 2007).

Farmers constitute an important interest group for parks, and their acceptance of parks plays a role in the success of park establishment. The existing literature on Swiss parks indicates that the incentives for farmers to accept or oppose parks are largely consistent with those among the general public. The primary motivations for farmers to support or accept parks are economic opportunities such as (agro)tourism, direct marketing of products, and integration into the regional value chain. By contrast, some farmers are sceptical about the potential benefits of parks and fear that parks would impose restrictions on agricultural activities (Butticaz 2013; Glauser 2011; Müller 2015; Toscan 2007; Trachsel et al. 2020).

Since parks are not legislators, they do not impose restrictions on agriculture or displace agricultural policies. To clarify farmers' misconceptions that parks would impose restrictions, many parks conduct persuasive work to convince farmers prior to establishment (Frick and Hunziker 2015; Glauser 2011; Toscan 2007; Zbinden 2019). Overall, however, parks are perceived as an opportunity for agriculture in terms of additional income and showcasing the role of farmers as caretakers of the regional landscape (Butticaz 2013; Trachsel et al. 2020).[7] Studies that presented voting statistics within parks indicate that consistent with the general public, majority votes in favour of the park were achieved among farmers (Butticaz 2013; Frick and Hunziker 2015; Müller 2015; Trachsel et al. 2020). Once established, it is common for parks to organise and coordinate projects to promote sustainable agriculture, such as conducting agglomeration projects for biodiversity conservation and setting up landscape elements. For these projects, parks also provide various types of support, such as information events, consultancy services, and financial support (e.g., funds for preliminary studies of agglomeration projects and setting up landscape elements).[8] Participation in such projects is voluntary. Parks also promote the marketing of agricultural products produced within parks, for instance, via product labels and the direct marketing of products.

Table 1 summarises the parks and AES in terms of their design and implementation. The two policy instruments are designed within separate political decision processes (in particular, the

TABLE 1 | Summary of the policy design and implementation of parks and AES.

| Dimension | Parks: Regional nature park | AES: Action-based | AES: Result-based | AES: Agglomeration |
|---|---|---|---|---|
| Introduction | 2007 | 1993 | 2001 | 2001 |
| Design and administration | Federal Office for the Environment | Federal Office for Agriculture | Federal Office for Agriculture | Federal Office for Agriculture + canton |
| Financing | Canton + Federal Office for the Environment | Federal Office for Agriculture | Federal Office for Agriculture | Up to 90% from the Federal Office for Agriculture |
| Implementation: Initiation and application | Park authority from commune(s) | NA (available to all farmers) | NA (available to all farmers) | NA[a] |
| Implementation: Decision to participate | Vote by residents in relevant communes | Individual farmer | Individual farmer | Individual farmer |
| Implementation: Decision frequency | Every 10 years | Enrol annually | Enrol annually | Enrol annually[b] |
| Implementation: Final approval (including funding) | Federal Office for the Environment | Federal Office for Agriculture | Federal Office for Agriculture | Federal Office for Agriculture + canton |

[a]The agglomeration scheme is available nationwide. To adopt the scheme, farmers need to participate in an agglomeration project, which can be initiated by farmers or other actors (and farmers can be involved in the project development). These projects need to be approved by the Federal Office for Agriculture before implementation (Huber et al. 2021).

[b]Farmers can enrol new land annually. For land enrolled in an agglomeration project, the current minimum contract period is 8 years. Land enrolled in agglomeration projects must also be enrolled in action-based schemes.

Federal Office for the Environment and the Federal Office for Agriculture belong to different federal departments and design the respective policies independently) and are implemented at different administrative units. Nonetheless, as we discuss in the next subsection, interactions between the two policy instruments may result in parks influencing AES adoption.

### 2.3 | Empirical Hypotheses on the Interaction Between Parks and AES Adoption

To formulate the empirical hypotheses, we discuss potential synergies and trade-offs between parks and AES under the framework in Schaub et al. (2023). Specifically, we discuss how the establishment of parks could interact with (i) opportunity costs of AES adoption relative to benefits and (ii) behavioural aspects of farmers' decision-making regarding AES and therefore influence farmers' uptake.

Synergies between parks and AES may arise from their common objective of conserving nature. From the parks' perspective, facilitating the implementation of agricultural policies, such as AES, contributes to reaching parks' conservation objectives (Butticaz 2013). By providing targeted support in projects that promote biodiversity conservation in agriculture, parks may reduce farmers' opportunity cost of AES adoption via learning, increase revenues of implementing AES (Fleury et al. 2015; Tyllianakis and Martin-Ortega 2021), and lower the transaction cost of AES (Décamps 2010; Mack et al. 2019; Vernimmen et al. 2000). Furthermore, within a park, farmers' role as caretakers of the regional landscape is better recognised, which may shape farmers' perceptions of conservation activities as a service rather than as a task (Butticaz 2013). A more positive perception of conservation may, in turn, foster a more positive attitude of farmers toward AES and thus facilitate AES adoption from the behavioural aspects of farmers' decision-making (Dessart et al. 2019).

Conversely, trade-offs between regional nature parks and AES may arise from the parks' objective to strengthen the regional economy. Promoted marketing of agricultural products may improve market conditions for farmers within parks (de Sainte Marie 2014; Trachsel et al. 2020), potentially leading to higher prices for farms within parks, higher opportunity costs for extensive production required by AES, and, eventually, a trade-off between profit opportunities and biodiversity conservation.

As such, the establishment of a park may entail either synergies or trade-offs with agricultural biodiversity conservation. Therefore, we may expect the growth of AES adoption inside parks to surpass, fall behind, or be on par with farms outside parks. Accordingly, we formulate the following null hypothesis:

**Hypothesis 1.** *Park status has no impact on the degree of farmers' AES adoption.*

Among the abovementioned factors, the opportunity cost relative to the benefit of AES differs systematically, even before the introduction of parks, which in turn governs the interaction between parks and AES. As we present in Section 2.2, parks are located over two distinct landscape types in Switzerland: Alps and Jura. The landscape types correspond to distinct land use patterns in terms of agricultural production and biodiversity conservation, echoing the classification of agricultural zones (valley, hill, mountain I–IV) in Switzerland (Figure A1a in the Supporting Information). In particular, compared to the Jura region (consisting of a mixture of valley, hill, and lower-elevation mountain farms), the Alps region (primarily comprising mountain farms) features less intensive agricultural production and richer biodiversity due to greater difficulties in agricultural activities (Meier et al. 2021; OPAL 2013). This further implies that farms in the Alps region face lower opportunity costs for AES before park establishment, since AES in most cases require extensive production. Accordingly, AES adoption was much higher in the Alps region than in the Jura region prior to park establishment (Figure A2a), consistent with previous evidence that AES adoption depends on the farm production system and landscape context (Knowler and Bradshaw 2007; Paulus et al. 2022).

We use the term "agricultural baseline" to summarise the abovementioned differences between the Alps and Jura regions in terms of landscape, production patterns, and, consequently, the implementation of AES prior to the introduction of parks. We hypothesise that the agricultural baseline could govern the extent to which parks in these two regions are able to influence farmers' AES adoption. More generally, the interaction between a new environmental policy, namely parks in our context, and an existing agricultural policy, namely AES, is likely to depend on the basis on which the new policy is introduced.[9] This gives the second hypothesis:

**Hypothesis 2.** *The effect of park status on AES adoption depends on the agricultural baseline in the region.*

Apart from the different agricultural baselines across the Alps and Jura regions, the local-centric park management strategies suggest that the support regarding sustainable agriculture that parks provide to farmers may further influence the opportunity cost relative to the benefit of AES. To investigate the relevant support provided by parks in February 2023, we conducted a survey among all 15 parks in our study. The survey was sent electronically and filled out by a staff member of the park management responsible for nature and biodiversity conservation in agriculture, with a 100% response rate. The survey covers questions regarding parks' support to farmers in biodiversity-promoting measures, including whether the park offers the following support measures: external consultancy services or consultancy services provided by the park management, information events, financial support, and other support measures. Respondents separately specified whether support measures were provided for action-based, result-based (including support for indicator species and landscape elements), and agglomeration biodiversity conservation AES. We group these support measures into informational support and financial support. For each type of AES, we then identify parks that offer informational and financial support, respectively. The associated hypothesis is as follows:

**Hypothesis 3.** *The effect of park status on AES adoption depends on the type of support a park offers to farmers.*

The investigations under Hypotheses 2 and 3 correspond to two types of potential mechanisms for parks to interact with AES, namely the basis for the implementation of park policy (i.e., agricultural baseline in our context) and specific factors embedded in the implementation of the park policy (i.e., support offered to farmers).[10]

## 3 | Empirical Strategies

### 3.1 | Outcome and Treatment Definitions

Our main outcomes of interest are farmers' degree of adoption of each biodiversity conservation AES, which we measure with the share of the total utilised agricultural area (*UAA*) in each farm that is enrolled as ecological focus area (*EFA*) into action-based, result-based, and agglomeration AES, respectively. That is, for each type of AES, for farm $i$ in year $t$, the outcome is $a_{it} = \frac{EFA_{it}}{UAA_{it}}$, where each ecological focus area is a subset of the total utilised agricultural area. The estimated treatment effect is the difference in $a_{it}$ before and after treatment and across treatment groups. We note that although some AES in our study (i.e., result-based and agglomeration AES) are relatively closely associated with biodiversity outcomes, our study does not directly assess the environmental impacts of these AES. Rather, we focus on AES adoption as the outcome.

To test Hypothesis 1, we estimate a pooled treatment effect of all 15 parks, with the treatment defined as the establishment of a park, albeit aware of the potentially different effects of parks located over the two distinct agricultural baselines.

To test Hypothesis 2, we define the establishment of a park in each of the two agricultural baselines as a separate treatment. This is equivalent to considering the treatment as the interaction between park status and the agricultural baseline, which yields two treatments: $park \times Jura$ and $park \times Alps$. We estimate the effects of parks by comparing the degree of AES adoption by farmers within parks on each landscape type with their respective comparison groups that share similar landscape characteristics.[11] Should the effects of parks depend on the agricultural baseline, we would find different treatment effects across the two landscape types.

To test Hypothesis 3, we define each treatment as the combination of one type of support and one agricultural baseline, or equivalently, the interaction of $park\ support_s \times landscape_l$, where $s$ denotes the type of support with $S = \{informational, financial\}$, and $l$ denotes the landscape with $L = \{Alps, Jura\}$. If the park effect depends on the type of support offered to farmers, the estimated effect for the subset of parks that offer a certain support would differ from the effect of all parks in the given agricultural baseline.

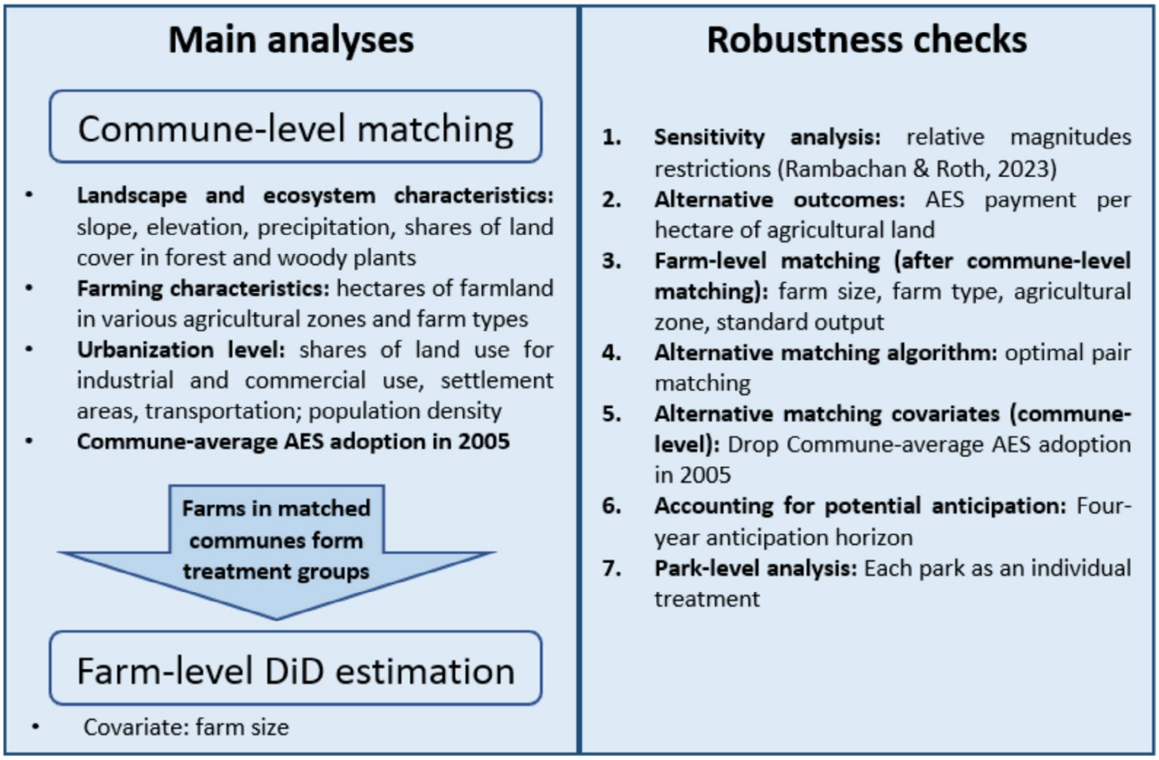



**FIGURE 2** | Summary of empirical strategies. [Colour figure can be viewed at wileyonlinelibrary.com]

**TABLE 2** | List of parks by year of establishment.

| Park name | Year established | Number of communes | Number of farms in park (2020) | Landscape type |
|---|---|---|---|---|
| UNESCO Biosphäre Entlebuch | 2008 | 7 | 794 | Alps |
| Naturpark Thal | 2010 | 8 | 181 | Jura |
| Biosfera Val Müstair | 2011 | 1 | 47 | Alps |
| Jurapark Aargau | 2012 | 26 | 406 | Jura |
| Landschaftspark Binntal | 2012 | 4 | 35 | Alps |
| Naturpark Diemtigtal | 2012 | 1 | 101 | Alps |
| Naturpark Gantrisch | 2012 | 18 | 887 | Alps |
| Parc Ela P | 2012 | 4 | 65 | Alps |
| Parc naturel régional Gruyère Pays-d'Enhaut | 2012 | 9 | 179 | Alps |
| Parc régional Chasseral | 2012 | 20 | 313 | Jura |
| Naturpark Beverin | 2013 | 7 | 77 | Alps |
| Naturpark Pfyn-Finges | 2013 | 9 | 163 | Alps |
| Parc du Doubs | 2013 | 13 | 301 | Jura |
| Parc Jura vaudois | 2013 | 28 | 241 | Jura |
| Regionaler Naturpark Schaffhausen | 2018 | 11 | 215 | Jura |

*Note:* The composition of the commune reflects the initial park perimeters, with the numbers of communes harmonised to the year 2021 following Engist (2021).

### 3.2 | Estimation Strategy—Main Analyses

We summarise our empirical strategies for the main analyses in the left panel of Figure 2. At the core of our analyses is a difference-in-differences (DiD) estimation at the farm level. Prior to the DiD estimation, we conduct commune-level matching to construct the control group. In the subsections below, we detail our rationale for the chosen strategies.

#### 3.2.1 | Difference-in-Differences Estimation and the Parallel Trends Assumption

To test the empirical hypotheses, we estimate the average treatment effect on the treated (ATT) for the treatment defined under each hypothesis. Since the parks in our study were established in different time periods, and all parks maintained their park status throughout the study period, our empirical setup contains staggered treatment timing. The difference-in-differences (DiD) literature has offered several estimators that circumvent the drawbacks of the traditional two-way fixed effects estimator in a multiple-period treatment setting (e.g., Borusyak et al. 2024; Callaway and Sant'Anna 2021; de Chaisemartin and d'Haultfoeuille 2020; Goodman-Bacon 2021; Sun and Abraham 2021; for reviews, see also de Chaisemartin and d'Haultfoeuille 2023; Roth et al. 2023). In particular, the two-way fixed effects estimator would produce biased estimates if the strong (and implausible) assumption of a homogeneous treatment effect across groups with different treatment timings is not satisfied, even if the study solely focuses on the overall or dynamic treatment effects. The estimators in the abovementioned studies, by contrast, are robust in settings with multiple treatment periods. We apply the doubly robust estimator proposed in Callaway and Sant'Anna (2021), given its generality compared to the other heterogeneity-robust estimators in terms of (i) flexibility in the aggregation of group-time average treatment effects to different types of heterogeneous treatment effects and (ii) allowing parallel trends to hold conditioning on covariates.

Let $G$ denote the time period when a farm was first treated (i.e., when the region became a park), $G_g = 1$ for all farms that were first treated in period g, and 0 otherwise; $G = \infty$ if a farm is never part of a park. That is, for each period $t$ that we observe, the outcomes, $t = 1, \dots, T$, each treatment group $g$ consists of farms inside of all parks established in period $g$, where $g = 2, \dots, T$, and the control group consists of farms never included in a park. Let $Y_{it}(0)$ denote farm $i$'s potential outcome, that is, AES adoption, at period $t$, if the farm were never treated. Let $Y_{it}(g)$ denote farm $i$'s potential outcome at period $t$ if the farm were in treatment group $g$.

The potential outcome framework with multiple treatment periods is given by:

$$Y_{it} = Y_{it}(0) + \Sigma_{g=2}^{T} \left[ Y_{it}(g) - Y_{it}(0) \right] \cdot G_{ig} \quad (1)$$

The group-time average treatment effect is the average treatment effect on the treated (ATT) for farms inside group $g$ of parks (i.e., parks established in period $g$) at period $t$:

$$ATT(g,t) = E\left[ Y_t(g) - Y_t(0) \mid G_g = 1 \right] \quad (2)$$

$ATT(g,t)$ can then be aggregated along the group and/or time dimension for summarised heterogeneous treatment effects. For instance, for an event-study type analysis, we aggregate along the length of treatment exposure to examine the dynamic treatment effect as the number of years since park establishment increases. This is relevant in our context, since it is likely that park policy takes time to take effect rather than immediately changing farmers' behaviour. We also aggregate along both the group and time dimensions for an overall park effect. We cluster bootstrapped standard errors at the farm level to account for serial correlation.

The estimation of $ATT(g,t)$ requires several key assumptions, namely the conditional parallel trend assumption, the limited anticipation assumption, and the common support assumption. We focus our discussion in the main text on the conditional parallel trend assumptions in our context and provide a summary of the limited anticipation assumption at the end of this subsection. We provide detailed discussions of the limited anticipation and common support assumptions in Section A2 in the Supporting Information.

*Conditional parallel trends assumption*: $E\left[ Y_t(0) - Y_{t-1}(0) \mid X, G_g = 1 \right] = E\left[ Y_t(0) - Y_{t-1}(0) \mid X, G = \infty \right]$ for all $g$ and all $t \geq g$.

This assumption implies that conditional on observed characteristics, the development of biodiversity conservation by farms inside and outside parks would have followed parallel paths in the absence of park status. This assumption is not formally testable, since for farms inside parks, the counterfactual post-treatment outcomes—that is, the untreated potential outcome for these farms in post-treatment periods had the region not become a park—is not observed. Nonetheless, we apply several strategies to enhance and test the plausibility of this assumption in our context, and discuss potential time-varying confounders.

The first strategy to ensure that $ATT(g,t)$ is recovered under conditional parallel trends is the doubly robust estimation approach by Sant'Anna and Zhao (2020). The approach combines the outcome regression approach by Heckman et al. (1997, 1998) and the inverse probability weighting approach by Abadie (2005), extended into multiple treatment periods in Callaway and Sant'Anna (2021). Both approaches reweight the never-treated farms based on the observed characteristics that influence the trends of AES adoption in the absence of parks, respectively via the conditional expectation of AES adoption (outcome regression) and the propensity score of being inside parks (inverse probability weighting). The purpose of reweighting is to assign higher weights to never-treated farms that are more similar to farms inside parks. The doubly robust approach combines these two approaches, which is consistent if either the outcome model or the propensity score model are correctly specified. In the DiD regression, we include farm size as a covariate.

#### 3.2.2 | Commune-Level Matching as a Strategy to Enhance Parallel Trends

The second strategy to enhance parallel trends is commune-level matching between park communes and never-treated communes prior to the DiD estimation. We describe our motivation. Although the conditional parallel trends assumption allows for covariate-specific trends, conceptually, these covariates should explain the trends of the outcome (i.e., farmers' AES adoption) without the treatment. Since decisions on AES adoption are made at the farm level, the DiD estimation should only include farm-level characteristics that affect the development of AES adoption as covariates. Many characteristics that are relevant to the likelihood of the region becoming a park are observed at the commune level. Some of these characteristics are relevant to commune-level AES adoption (e.g., agricultural landscape characteristics) but do not explain farm-level trends of AES adoption. Other characteristics (e.g., forest cover and population density) are not directly relevant to AES adoption. These characteristics, however, should be balanced in constructing the control group. In particular, some communes highly unsuitable for establishing parks in terms of natural and socioeconomic conditions (e.g., those in highly urbanised regions) have a very low probability of being treated. Including farms in these communes in the control group could reduce the proportion of treated farms in the sample to close to zero, which would violate the common support assumption. Therefore, we match the commune-level characteristics prior to the DiD estimation to construct appropriate commune control groups. This matching step indirectly supports the conditional parallel trends assumption because balancing covariates in the DiD estimation further imposes challenges to the common support assumption. We define never-treated communes as those that never received protected area status of any form throughout the study period.

In the main analyses, we apply nearest neighbour matching of commune characteristics based on generalised Mahalanobis distance (Diamond and Sekhon 2013). Following the literature (e.g., Ferraro and Hanauer 2014; Robalino et al. 2015; Sims and Alix-Garcia 2017), we match communes to the following natural, agricultural, and socioeconomic characteristics related to the suitability for park: landscape and ecosystem characteristics (slope, elevation, precipitation, and shares of land cover in forest and woody plants), farming characteristics (hectares of farmland in each agricultural zone and farm type), and urbanisation level (shares of land use for industrial and commercial use, settlement areas, transportation, and population density). In addition, to account for AES adoption before park establishment, which could further capture unobserved characteristics that vary across the treated and control groups and the Alps and Jura regions, we match commune-level adoption of each type of AES in 2005, calculated as the sum of land enrolled in each type of AES divided by the total agricultural land area in each commune. For analyses associated with Hypotheses 2 and 3, we construct separate control groups for each treated group. We present the matching statistics in Table 3.

#### 3.2.3 | Other Considerations of Key Assumptions

Although the doubly robust approach and matching enhance the credibility of the parallel trends assumption, valid concerns could be raised regarding potential time-varying unobserved confounders that correlate with both park establishment and AES adoption.[12] One potential concern could be that both parks and AES adoption are driven by an unobserved political agenda within which farmers may exercise their political power and bargain for more favourable AES options by steering whether a park is established in their region. This would not apply to our context, given that parks and AES belong to two independent policymaking processes (Table 1). In particular, the regional authority that implements park policies is unable to alter agricultural policymaking at the federal level. Another concern could be that a change in environmental attitudes in the region drives park establishment and changes in AES adoption. As discussed in Section 2.2, numerous studies in the Swiss context have shown that the primary incentive for local residents to support or accept park establishment is the expected economic benefits; thus, it is unlikely that environmental preferences would have driven park establishment in the studied regions. Moreover, the matching of pre-treatment AES adoption further accounts for the extent to which environmental attitude is embedded in AES adoption before park establishment. In Figure A3, we provide (informal) evidence that environmental attitudes, proxied by Swiss national council votes for pro-environmental political parties, have evolved in similar ways in park regions and the rest of Switzerland over the study period. Thus, it is unlikely that changes in environmental preferences would have driven park establishment. We consider Figure A3 as informal evidence because the absence of pre-treatment differences in trends does not necessarily justify the parallel trends assumption (Roth et al. 2023). In the robustness check section below, we detail a sensitivity analysis, following Rambachan and Roth (2023).

Based on the strategies and discussions above, we contend that park establishment is (conditionally) exogenous to AES adoption in our context. If there remain unconsidered time-varying unobserved confounders that violate the conditional parallel trends assumption, we would detect evidence of such violations in pre-treatment periods in the event study (also see Section 3.3 for sensitivity analysis regarding the event study).

On the limited anticipation assumption (detailed in Section A2 in the Supporting Information), even though the possibility of a park is publicly discussed over the feasibility and establishment phases, it is unlikely that farmers would change their AES adoption over this period for several reasons. First, the establishment of a park is conditional on final votes in the region and approval by the Federal Office for the Environment. Second, the implementation of park policies does not affect farmers' options in terms of AES. Third, parks do not impose restrictions on agricultural practices; thus, they create no incentives for farmers to change their practices or AES adoption before park establishment (see Section 2.2 for detailed discussions of each point). Nonetheless, below, we conduct a robustness check that accounts for potential anticipation behaviour (Section 3.3).

### 3.3 | Robustness Checks

We apply several alternative estimation strategies and sensitivity tests to assess the robustness of our main results (right panel of Figure 2). First, we address the limitations of using event studies to test preexisting differences in trends, such as low power and the risk of exacerbating bias in the estimated treatment effects when incorrectly conditioning the estimation on parallel trends (Roth et al. 2023). For robustness inference of the estimated park effects in the case of potential violations of the conditional parallel trends assumption, we conduct the sensitivity analysis based on relative magnitude restrictions (Rambachan and Roth 2023). This test exploits the idea that the post-treatment counterfactual trends should not deviate largely from the observed pre-treatment trends and formally imposes restrictions on the possible magnitude of post-treatment violation of the parallel trends assumption relative to the maximum pre-treatment violation, denoted by $\overline{M}$. Specifically, we test the sensitivity of

**TABLE 3** | Covariates for commune-level matching.

| | All parks | All non-park | Matched non-park | Parks Jura | Matched non-park Jura | Parks Alps | Matched non-park Alps |
|---|---|---|---|---|---|---|---|
| Elevation (m) | 1018 | 711 | 982.0 | 793 | 773 | 1397 | 1387 |
| Slope (°) | 13.9 | 9.7 | 13.7 | 10.5 | 10.5 | 19.5 | 19.11 |
| Precipitation (mm/year) | 1108 | 1082 | 1131.6 | 1076 | 1088 | 1160 | 1200 |
| Forest (%) | 37.1 | 28.6 | 36.2 | 42.0 | 40.4 | 28.8 | 30.5 |
| Woods (%) | 2.9 | 1.8 | 2.8 | 3.0 | 2.8 | 2.7 | 2.9 |
| Arable farm (ha) | 21.0 | 43 | 17.3 | 33.0 | 27.2 | 0.9 | 0.3 |
| Cattle farms (ha) | 522.9 | 338[a] | 498.3 | 438.7 | 421.4 | 665.0 | 619.3 |
| Other farms (ha) | 28.0 | 20 | 28.1 | 18.0 | 14.6 | 44.7 | 49.8 |
| Valley (ha) | 78.3 | 245[a] | 88.0 | 103.6 | 93.0 | 35.7 | 45.8 |
| Hill (ha) | 107.0 | 57[a] | 86.9 | 110.6 | 96.1 | 100.9 | 96.7 |
| Mountain (ha) | 393.0 | 118[a] | 375.2 | 284.7 | 280.7 | 575.6 | 531.7 |
| Industrial and commercial (%) | 0.3 | 1.3[a] | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 |
| Settlement (%) | 3.2 | 7.9[a] | 3.2 | 3.7 | 3.8 | 2.3 | 2.4 |
| Transportation (%) | 2.2 | 4.4[a] | 2.1 | 2.5 | 2.4 | 1.7 | 1.6 |
| Population density (head/ha) | 1.2 | 4.3[a] | 1.1 | 1.3 | 1.3 | 0.9 | 0.8 |
| Action-based (%) | 18.2 | 14.6 | 17.9 | 15.6 | 14.8 | 22.7 | 22.9 |
| Result-based (%) | 4.3 | 1.9[a] | 4.0 | 4.0 | 3.4 | 4.9 | 4.6 |
| Agglomeration (%) | 4.1 | 2.0[a] | 3.8 | 3.1 | 3.2 | 5.7 | 5.4 |

*Note:* Mean values of covariates in commune-level matching for treated and (matched) control groups.
[a]Indicates that the covariate is not balanced between the treated and control groups before matching, either by standardised mean difference greater than 1 or variance ratio greater than 2. All covariates are balanced after matching. Units are indicated in parentheses (m: metre; mm: millimetre; %: percent; ha: hectare). Data on elevation and slope are from the Shuttle Radar Topography Mission, precipitation data are from MeteoSuisse, and land cover and land use data are from Arealstatistik 2004/2009 (a national survey). Agricultural characteristics and AES adoption are obtained from the census agri-political information system.

the estimated treatment effects under different values of $\overline{M}$. For instance, $\overline{M} = 1$ indicates that to invalidate an estimated treatment effect, post-treatment violations of the parallel trends assumption would need to be at least as large as the violation of parallel trends pre-treatment. Estimated treatment effects that hold under larger values of $\overline{M}$ therefore indicate stronger robustness of the estimates in the case of violated parallel trends.

Second, we conduct the analyses with an alternative outcome: AES payment per hectare of agricultural land.[13] Since the amounts of payment reflect (at least to a certain extent) the desired ecological quality of the respective AES, the effects of parks on payment complement the effects on AES adoption estimated in the main analyses. For this robustness check, we match commune-level pre-treatment AES payment per hectare instead of AES adoption.

Third, one potential concern regarding the matching step prior to the DiD analyses is that the estimated treatment effect may depend on the control group selected by the matching specification. To test whether this may be the case, we apply three variations of the matching step. (i) Additional farm-level matching of farm size, farm type, agricultural zone, and standard output as a measure of farm economic size, which is further controlled for in the DiD estimation. (ii) Alternative matching algorithms: instead of matching based on generalised Mahalanobis distance, we apply optimal pair matching based on Mahalanobis distance (Ho et al. 2007). (iii) We vary the set of matching covariates by removing AES adoption in 2005.

Fourth, although we do not expect anticipation behaviours to occur, to account for any potential behavioural change in terms of AES adoption in anticipation of park establishment, in one estimation, we specify an anticipation horizon of 4 years, which covers most parks' feasibility and establishment phases.

Lastly, given the park-specific strategies to support sustainable agriculture that motivate Hypothesis 3, as a robustness check, we further estimate treatment effects at the park level. That is, we consider each of the 15 parks as an individual treatment. The purpose of this analysis is twofold. First, park-level analyses allow us to estimate park effects without pre-defined grouping and compare park effects in more flexible ways. Second, by performing individual matching for each park, we again test the robustness of matching in the main analyses. To the extent that the DiD estimation is robust to alternative matching strategies, individually estimated park effects should follow the same patterns as estimates of pooled park effects in the main analyses.

## 4 | Data

We obtain the time of establishment and initial perimeters of parks in Switzerland from the Swiss Parks Network. Farm-level outcomes and covariates are from the census agri-political information system between 2005 and 2020. We restrict the sample to farms that meet the cross-compliance requirements for receiving any direct payments, which cover over 99% of the population, with 42,465 farms in 2020. We merge park boundaries with farm locations to obtain the treatment groups. This results in 4003 treated farms in 166 communes. Other data sources are reported in Table 3. Table 2 presents each park's time of establishment, landscape type, and the number of communes and farms within the park.

Table 3 presents the characteristics of communes that constitute parks, all communes outside parks, and matched communes for each group of parks. In Figure A1b, we plot matched communes for all parks (i.e., columns 1 and 3 in Table 3). These statistics confirm the distinctive baseline conditions between parks in the Alps and Jura regions.

Table 4 presents a summary of the survey on park support measures for farmers. Overall, parks tend to provide more support for result-based AES, followed by agglomeration AES. The fractions of parks that provide each type of support are comparable across the Alps and Jura regions, although slightly larger fractions of parks in the Jura region provide financial support.

## 5 | Results and Discussion

In this section, we present the results based on the testing of each empirical hypothesis introduced in Section 2.3.

**Hypothesis 1.** *Park status has no impact on the degree of farmers' AES adoption.*

Figure 3 shows the event study plots by type of AES up to 10 years after park establishment (i.e., 11 post-treatment periods). These dynamic effects highlight heterogeneous park effects over different lengths of treatment exposure—that is, the time since park establishment. Since our study period ends in 2020, and parks were established between 2008 and 2018 (Table 2), the number of post-treatment periods for each park ranges from 2 to 13. Therefore, the relevant number of parks underlying the estimated effects decreases as the number of post-treatment periods increases. For example, 8 years since park establishment correspond to parks established in or before 2012, and so forth.[14] Prior to park establishment, we find null park effects on all three types of AES. After park establishment, we find positive and statistically significant park effects over some years on result-based and agglomeration AES.

Figure 4 shows the estimated overall average treatment effect of all 15 parks on the adoption of each type of AES aggregated over all groups of parks and all time periods. For action-based AES, we do not find a statistically significant overall park

**TABLE 4** | Summary of survey data on park support for biodiversity conservation.

| | Action-based | | Result-based | | Agglomeration | |
|---|---|---|---|---|---|---|
| **Region** | **Informational** | **Financial** | **Informational** | **Financial** | **Informational** | **Financial** |
| Alps ($n = 9$) | 5 (56%) | 2 (22%) | 9 (100%) | 7 (78%) | 8 (89%) | 3 (33%) |
| Jura ($n = 6$) | 3 (50%) | 3 (50%) | 6 (100%) | 5 (83%) | 4 (67%) | 3 (50%) |

*Note:* Numbers indicate the number and percentage of parks that offer the respective type of support. For example, five out of nine (56%) parks in the Alps region offered informational support for action-based AES. If a park provides both informational and financial support to a given AES, it is counted under both types of support. Hence, the sum of parks that offer the two types of support could be larger than the total number of parks in the respective regions.

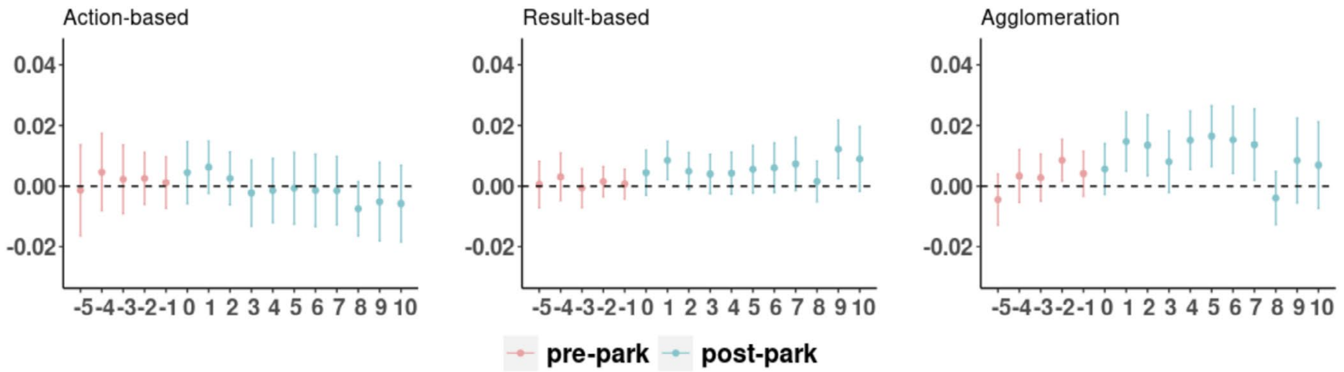



**FIGURE 3** | Estimated aggregated park effect over length of treatment exposure. On the horizontal axis, a positive value indicates the number of years after park establishment, and a negative value indicates the number of years before park establishment. Bootstrapped standard errors are clustered at the farm level. [Colour figure can be viewed at wileyonlinelibrary.com]

effect, and thus do not reject the null hypothesis. For both result-based and agglomeration AES, we find a positive overall effect, rejecting the null hypothesis. Farms inside parks on average enrolled 0.53 and 1.01 percentage point(s) more land into result-based and agglomeration AES after park establishment, respectively, compared to farms outside parks in regions of similar landscape and land use patterns. To place the estimate in context, prior to park establishment, farms inside parks, on average, enrolled 4.3 and 5.9 percentage points of farmland into result-based and agglomeration AES, respectively. The estimated effect thus translates to about 12% (result-based) and 17% (agglomeration) increase in adoption among farms inside parks relative to the pre-treatment period due to park effect (for comparison, the post-treatment average result-based and agglomeration AES adoption is 8.6 and 15.6 percentage points, respectively, among farms inside parks, corresponding to 100% and 164% total increase, respectively).

The positive effect on result-based AES adoption suggests that parks may be particularly effective in enhancing the quality of biodiversity conservation in the region, given that result-based AES represent a higher quality level in biodiversity outcomes compared to action-based AES (e.g., Meier et al. 2021). Since result-based payments are contingent on achieving biodiversity outcomes, the higher risk associated with the payments (compared to action-based AES) and the required knowledge and skills may hinder farmers' adoption of these AES (Gars et al. 2024; Hagemann et al. 2025). Support offered by parks, such as consultancy services and assistance with achieving indicator species, could mitigate these barriers. The positive park effect on agglomeration AES further suggests complementarity between the two policy instruments that differ in organisational structure. Transaction costs and a lack of communication in the coordination of agglomeration projects are key barriers to farmers' adoption of agglomeration schemes (Banerjee et al. 2017). By organising agglomeration projects and offering support, such as information events and preliminary studies, parks (a territorial environmental policy) can facilitate the spatial coordination of AES (individual farm-level contracts). Together with the null effect on action-based AES, these results suggest that parks do not necessarily increase the total land enrolled in AES. Rather, parks cause shifts of more land from being solely enrolled in action-based AES to also being enrolled in the two bonus schemes.

**Hypothesis 2.** *The effect of park status on AES adoption depends on the agricultural baseline in the region.*

Figure 5 shows the dynamic effects of parks in both landscape types as the time since park establishment increases. Recall that here, treatment is defined as $park \times landscape_l$, where $l$ denotes the landscape with $L = \{Alps, Jura\}$. We find different patterns of park effect across the two landscape types. For parks in the Alps region, we do not find statistically significant dynamic effects for action- and result-based AES in most periods. For agglomeration AES, we find negative effects beyond 7 years of the park operation, which are driven by parks established in or before 2012. For parks in the Jura region, we observe gradual development of the park effects: for all three types of AES, the magnitudes of park effect tend to increase with time since park establishment. The gradual development of park effects also suggests that unlike increased financial incentives for biodiversity conservation, which could see farmers' response in the following year (Mack et al. 2020; Wang et al. 2023), park policies may need longer time to take effect. Potential reasons may be, for instance, a gradual shift in farmers' attitudes toward AES, the learning time that farmers need to internalise support offered by parks, and the time needed to establish trustful collaboration between park management and farmers.

Figure 6 shows the overall park effects in the Alps and Jura regions. For parks in the Alps region, we find null effects on the adoption of all AES. By contrast, for parks in the Jura region, we find a positive effect on the adoption of each AES: 1.4 (action-based), 1.8 (result-based), and 3.2 (agglomeration) percentage points. To place these estimates in context, prior to establishing the parks, farms inside parks in the Jura region on average enrolled 14.7, 3.5, and 4.3 percentage points of farmland into action-based, result-based AES, and agglomeration AES. The estimated effects thus translate to 9.5%, 51%, and 74% increases in the adoption of action-based, result-based, and agglomeration AES, respectively, due to park effects among farms inside parks relative to the pre-treatment period (compared to 32%, 119%, and 241% total increases from pre-treatment to post-treatment for action-based, result-based, and agglomeration AES, respectively).

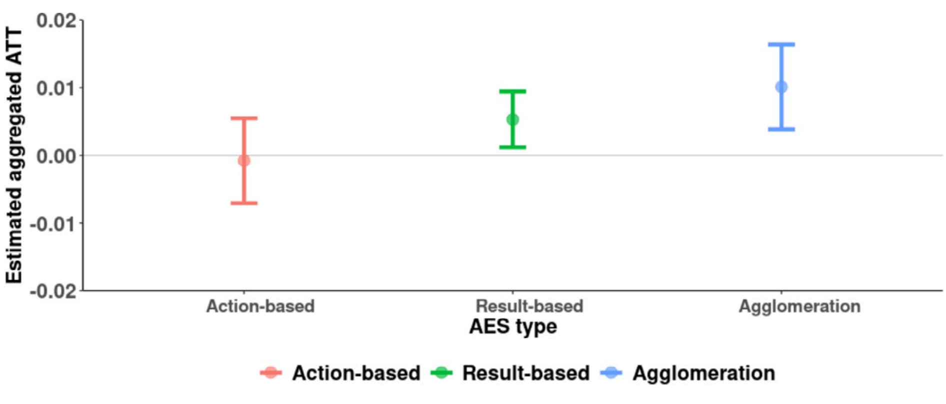
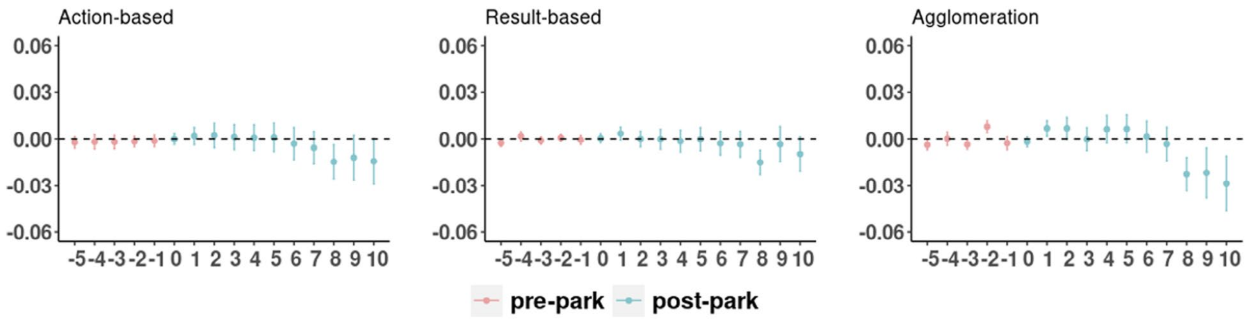
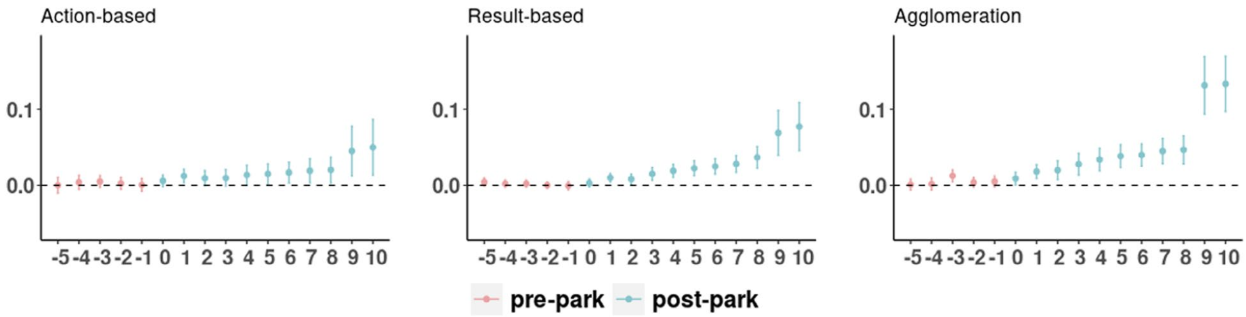



**FIGURE 4** | Estimated overall effect of parks by type of AES. Estimated aggregated treatment effects on the treated (ATT) are in terms of the percentage point of agricultural land enrolled in AES. Bootstrapped standard errors are clustered at the farm level. [Colour figure can be viewed at wileyonlinelibrary.com]




*(a) Alps*




*(b) Jura*

**FIGURE 5** | Estimated aggregated park effect over length of treatment exposure by agricultural baseline. On the horizontal axis, a positive value indicates the number of years after park establishment, and a negative value indicates the number of years before park establishment. Bootstrapped standard errors are clustered at the farm level. [Colour figure can be viewed at wileyonlinelibrary.com]

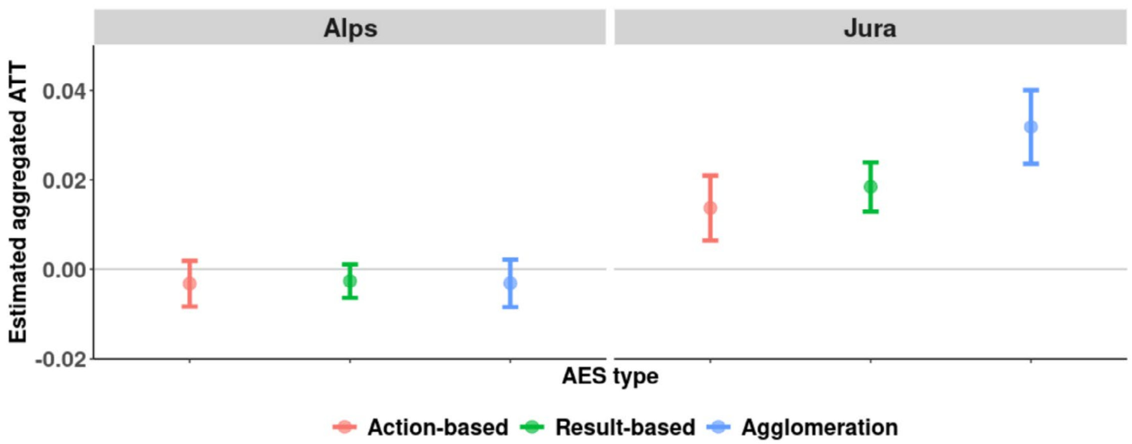



**FIGURE 6** | Estimated overall effect of parks by type of AES and agricultural baseline. Estimated aggregated treatment effects on the treated (ATT) are in terms of the percentage point of agricultural land enrolled in AES. Bootstrapped standard errors are clustered at the farm level. [Colour figure can be viewed at wileyonlinelibrary.com]

The differences in park effects across the landscape types indicate that the interaction between parks and AES depends on the agricultural baseline (characterised by landscape, production patterns, and consequently, implementation of AES prior to park establishment) in the region; thus, we do not reject Hypothesis 2. Compared to the pooled park effects estimated under Hypothesis 1, these results highlight the importance of accounting for the agricultural baseline. In the analyses regarding Hypothesis 2, agricultural baselines over the two landscape regions are separately accounted for by separately constructing control groups with comparable relevant characteristics. By contrast, to test Hypothesis 1, these characteristics are pooled over the two regions both for the treated and the control groups, which disguises the heterogeneity in the interaction between parks and AES. A comparison of the agricultural baselines in the Alps and the Jura regions thus sheds light on the differences in park effects in these regions. In particular, due to high levels of extensive production (and thus lower opportunity cost and implementation effort for AES), before park establishment, AES adoption in the Alps region is already much higher than in the Jura region (Figure A2a), leaving limited space for additional conservation practice via AES.

Moreover, for result-based and agglomeration AES, the payment per hectare in the Alps region increases at higher rates before park establishment than in the Jura region (Figure A2b), which may have provided greater incentives for farmers in both park and non-park regions to adopt AES. For the Jura region, relatively more intensive production and lower AES adoption before park establishment, combined with a lower increase in AES payments, imply relatively higher opportunity costs and implementation efforts for AES, but also more space for additional AES adoption. Over such a baseline, an additional policy, such as parks, is more likely to induce farmers' responses. These results over the two baselines are in line with our discussion in Section 2.3, that the interaction between a more recent policy (i.e., parks) and an existing policy (i.e., AES) may depend on the basis on which the new policy is implemented.

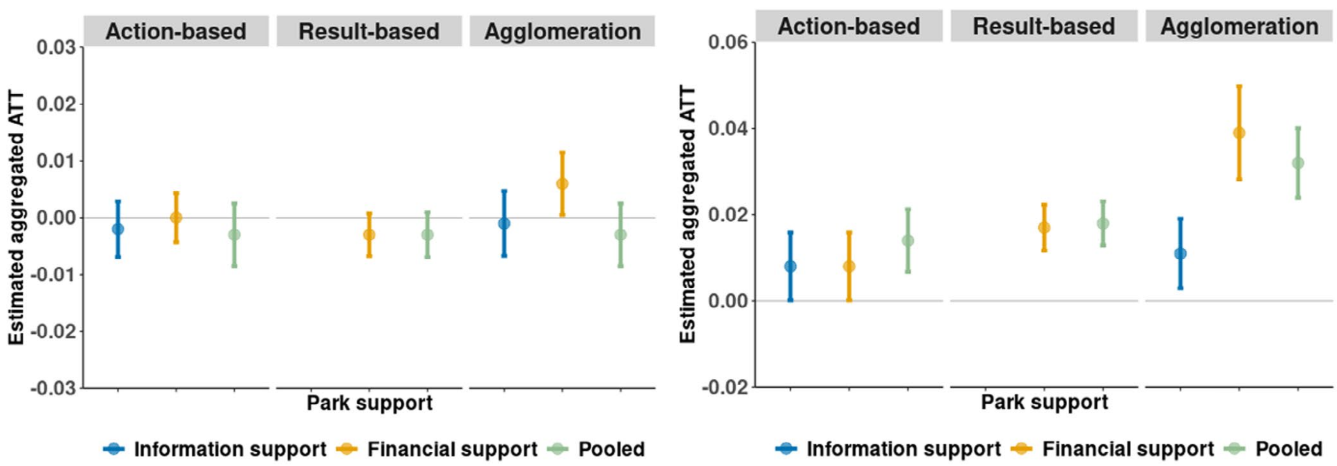
**Hypothesis 3.** *The effect of park status on AES adoption depends on the type of support a park offers to farmers.*

Figure 7 shows the estimated treatment effects of parks with informational support or financial support on the respective AES types, separated by landscape type. For comparison purposes, with the "Pooled" category, we replicate estimates in Figure 4, that is, the overall effects of all parks in each landscape–AES combination. If the park effect depends on a certain type of park support, the estimated effect of parks offering that support should differ from the pooled park effect. For result-based AES, since informational support was provided by all 15 parks (Table 4), we estimate only the effects of parks that provided financial support.

For each landscape–AES combination, the estimated effects of parks that provided either financial or informational support to farmers do not significantly differ from the pooled effect, as indicated by the overlapping confidence intervals in each panel. For agglomeration AES in the Jura region, the estimated effect of parks that offered information support is lower than that of parks that offered financial support, although both confidence intervals overlap with that of the pooled effect. Therefore, we do not find evidence that park support to farmers in either aspect is particularly effective in promoting the adoption of AES. We acknowledge that the binary measures of support do not reflect the intensity or quality of park support. Nevertheless, these results suggest that the effect of parks on AES adoption is unlikely to hinge on a particular form of support. Rather, it could be that the multitude of park policies influences farmers' decisions on AES adoption as a whole.

## 5.1 | Robustness Checks

We summarise the robustness check results in this section and report and discuss detailed results in Section A3 in the Supporting Information. First, the results of the sensitivity analyses in Figure A4 show that given potential violations of the conditional parallel trends assumption, the estimated effects on result-based and agglomeration AES adoption are robust, especially for parks in the Jura region, while the estimated park effect on action-based AES is not very robust. Second, the estimated park effects on AES payment (Figure A5) are largely consistent with the results from the main analyses with AES adoption as outcomes, both in terms of pooled park effects and park effects on result-based and agglomeration AES in the Jura region. Third, a comparison of the estimated effects across different model specifications (Figure A6) shows that park effects on result-based AES adoption (both for all parks and separate estimations by agricultural baseline) and park effects in the Jura region are robust to alternative specifications. Lastly,




*(a) Alps* *(b) Jura*

**FIGURE 7** | Estimated overall effect of parks by agricultural baseline, type of AES, and type of park support. The Category "Pooled" includes all parks in the respective group, regardless of support. Informational support for result-based AES applies to all parks, and hence no separate estimate. Bootstrapped standard errors are clustered at the farm level. The number of parks in each treatment is reported in Table 4. [Colour figure can be viewed at wileyonlinelibrary.com] results from the park-level analyses show that for parks in the Jura region, the signs of the estimated single park effects are largely consistent with the positive effects in all three types of AES, whereas for the Alps region, the pattern is not very clear (Figure A7). The park-level event studies further show that consistent with the main analyses, the estimated park effects on result-based and agglomeration AES tend to increase with the number of periods since park establishment (Figure A8).

Taken together, we consider the estimated positive effect of all parks on result-based AES adoption, and the effects on result-based and agglomeration AES in the Jura region are particularly robust to all alternative outcomes and specifications. The positive park effects on the adoption of result-based and agglomeration AES may arise from various behavioural factors discussed by Dessart et al. (2019), such as perceived costs and benefits, self-efficacy, and social norms (e.g., Bakker et al. 2021; Ritzel et al. 2025; van Dijk et al. 2016). For instance, information events on biodiversity-conserving practices within parks could have raised farmers' awareness of the environmental benefits and income opportunities of these schemes, and advisory services could have increased farmers' self-efficacy in fulfilling the requirements of these schemes. Parks could have also fostered positive norms toward nature and biodiversity conservation, which promoted farmers' participation in AES.

Moreover, parks may create favourable organisational conditions that facilitate the implementation of agglomeration projects. In particular, barriers for farmers to participate in agglomeration schemes include negative subjective norms toward conservation (Sander et al. 2024), and lack of information exchange between farmers (Banerjee et al. 2014). Various park activities may create platforms for farmers to share knowledge and experience, and foster positive norms toward conservation, which could help overcome these barriers. Furthermore, policies that go beyond the agricultural sector and encompass society at large, as well as those that foster stakeholder cooperation and information exchange, can increase farmers' adoption of biodiversity-promoting measures via better integration into their social networks (Klebl et al. 2024). Territorial policies such as parks can serve these purposes by highlighting the contributions of farmers' role in conservation (Butticaz 2013) and facilitating stakeholder cooperation across sectors (Trachsel et al. 2020).

## 6 | Conclusion

In this study, we investigate the effects of protected areas in the form of regional nature parks on farmers' voluntary adoption of biodiversity conservation agri-environmental schemes (AES). Our analyses of the effects of 15 Swiss regional nature parks established between 2008 and 2018 yield multiple robust findings. Overall, parks increase result-based AES adoption, suggesting positive effects on the quality (relative to action-based AES) of agricultural biodiversity conservation via enhanced result-based AES adoption in parks. Looking deeper, we find heterogeneous links between park effects and different agricultural baselines. In the Jura region, with relatively more intensive agricultural production and lower AES adoption before park establishment, we find positive park effects on the adoption of result-based and agglomeration AES, suggesting that parks increase both the quality and spatial connectivity of biodiversity conservation. In the Alps region with higher initial extensive production and AES adoption, we find null park effects. Further disaggregating by the type of support for biodiversity conservation, we do not find the park effect to depend on the particular type of support. In addition, the effect of parks resulting in a shift in farmers' AES adoption is a gradual process that may take several years to develop.

Our results bear policy implications for integrating biodiversity conservation in agriculture. We find that synergies may arise between protected areas (an environmental policy instrument) and AES (an agricultural policy instrument) to increase the quality and spatial connectivity of biodiversity conservation, both of which are crucial for improving biodiversity outcomes. However, such synergies depend largely on the baseline conditions where protected areas are introduced. In regions with relatively more intensive production and lower AES adoption, both (opportunity) costs and room for improvement (in terms of additional AES adoption) are relatively higher before protected areas are established. Given such baseline conditions, additional protected area policies may help lower the barriers to adopting result-based AES, such as higher financial risks and lack of appropriate advice (Gars et al. 2024; Hagemann et al. 2025). For instance, advisory services offered by parks may lower farmers' (perceived and actual) conservation costs by providing infrastructure within the park that facilitates AES participation, and increase farmers' self-efficacy regarding relevant practices. Moreover, information campaigns and exchanges with other farmers may lower farmers' willingness to accept an AES contract by shifting their perceptions of AES.

In regions where the effect of baseline agricultural policy support is relatively saturated, there is less room for farmers to respond to additional policies. Therefore, when considering a new policy, it is crucial that policymakers assess and account for baseline conditions, especially when the policy bears overlapping objectives with an existing one. In regions where it is relatively more challenging to implement AES at the baseline (i.e., regions with more intensively managed agricultural land and lower levels of biodiversity), parks can be more efficient and fruitful in enhancing AES adoption, especially AES closely linked to biodiversity outcomes (i.e., result-based and agglomeration AES), compared to regions where baseline adoption is high. For parks established in regions with intensive agriculture, efforts to promote sustainable agriculture and AES adoption may be an effective means of reaching parks' conservation goals. These implications also apply to similar agricultural policy contexts beyond our study, for instance, at the European level.

Furthermore, we find that park effects appear to increase with time after park establishment. This suggests that there may be a “settle-in” phase before protected areas generate an impact on farmer behaviour, which is relevant to both policy evaluation and managers of protected areas. Unlike financial incentives, such as those offered under AES, we expect parks to at least partially influence the behavioural aspects of farmers, for instance, by shaping their perceptions toward AES and conservation. Compared to the immediate response to financial incentives, such a self-regulatory mechanism could take longer to establish, yet it is independent of external incentives, and thus could be rather sustainable. Thus, long-term policy horizons are needed.

In general contexts where intensive agricultural production may impede the implementation of AES, our findings communicate a positive message in terms of leveraging an additional policy instrument to complement AES and enhance its adoption. The policy implications are particularly relevant to the almost 900 nature regional landscape parks in other European countries (EUROPARC 2023), and similar less stringent protected areas in other countries. While establishing parks requires suitable natural and socio-economic conditions, other policy instruments that lower farmers' conservation costs and/or willingness to accept AES contracts could serve a similar purpose. Our findings therefore provide empirical evidence of the benefit of using multiple policy instruments with the overlapping objective of promoting biodiversity conservation (Ring and Barton 2015; Bouma et al. 2019).

Our study has several limitations, with relevant implications for future research. Although the study quantifies the interaction between parks and AES adoption and establishes a clear link between park effects and agricultural baselines, it does not identify the mechanisms of park effects in terms of the specific factors in park policies that drive farmers' behavioural change. Future research on this type of mechanism is warranted. For instance, researchers could investigate potential qualitative differences in park support measures, especially in terms of farmers' participation in projects that offer such support, and explore changes in farmers' perceptions of AES due to parks. Such investigations, however, often require in-depth qualitative data and data on farmers' behavioural characteristics and thus could impose data challenges, especially for applying rigorous causal identification (El Benni et al. 2023). Moreover, the potential influences of parks on agriculture in aspects other than AES adoption, such as farmers' participation in short supply chains (e.g., via direct sales of agricultural products within parks) and environmental cooperatives, would also contribute to a holistic understanding of the effectiveness of protected areas in promoting agricultural biodiversity conservation and more environmentally sustainable agriculture in general. Furthermore, despite the link between AES adoption and biodiversity outcomes, our current study focuses on farmers' behavioural change (i.e., adoption of AES), and leaves direct assessments of environmental impacts due to park establishment as well as the cost-effectiveness of AES out of its scope. Future research could provide additional insights into the effectiveness of protected areas in enhancing biodiversity outcomes in agricultural landscapes. Such analyses again call for data of, for instance, indicators of biodiversity outcomes to be made available at large space and time scales to be compatible with rigorous empirical methods. In terms of policy cost-effectiveness, future research could extend our analyses to policy scenarios with varying AES payments based on farmers' individual willingness to accept AES contracts. Such policy scenarios are particularly suitable for assessing whether a new policy, such as the designation of protected areas, could increase the cost-effectiveness of AES by lowering farmers' desired compensation for adopting AES.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## Conflicts of Interest

The authors declare no conflicts of interest.


## Data Availability Statement

The data that support the findings of this study are available from Swiss Federal Office for Agriculture. Restrictions apply to the availability of these data, which were used under licence for this study. Data are available from the author(s) with the permission of Swiss Federal Office for Agriculture.

## Endnotes

[1] A key feature of the regional nature parks in our study is that they do not impose restrictions on the economic activities such as agriculture in the region (e.g., Toscan 2007). These parks are thus less stringent than national parks, which restrict economic activities and land use change in general (e.g., Pfaff et al. 2009). These parks are also less stringent than protected areas such as Natura 2000 areas in the European Union, which require farmers to adjust practices to be compatible with conservation (European Commission 2018). Administratively, regional nature parks in Europe are managed at similar levels as provincial/regional parks in some countries, such as Canada and South Africa, and state/regional parks in other countries such as parts of Australia, Mexico, and the United States of America.

[2] Throughout the paper, the term "AES" as well as terms for specific types of AES, that is, action-based, result-based, and agglomeration AES, all refer to AES for biodiversity conservation. In Switzerland, AES also cover other objectives, such as reducing pesticides. Participating in AES of a certain objective (e.g., biodiversity conservation) does not limit farmers' options to participate in other AES. This allows us to focus on biodiversity conservation AES without addressing farmers' participation in other AES.

[3] Our study considers the adoption of AES. The assessment of the cost-effectiveness of AES is out of the scope of the study. For studies in this respect, see, for example, Chabé-Ferret and Subervie (2013) and Wuepper and Huber (2022).

[4] For result-based AES, the specific lists of indicator species are defined by cantonal agricultural offices to account for the regional biophysical conditions.

[5] See, for example, D'Alberto et al. (2023) and Ritzel et al. (2023) on the socio-economic outcomes of farms within parks.

[6] Among these parks, Biosphere Reserve Entlebuch received UNESCO recognition in 2001 and was established as a regional nature park in 2008. In Switzerland, UNESCO biosphere reserves are subsumed in the category Regional Nature Park (Wiesli et al. 2022). Like the other Regional Nature Parks, Biosphere Reserve Entlebuch is not separated into core areas and buffer zones; instead, agriculture is allowed throughout the park. We thus do not distinguish this park from other parks despite its UNESCO recognition.

[7] These views are derived both from surveys and interviews with farmers inside parks, and from an interview by Butticaz (2013) with a former representative of the Swiss Farmers' Association, an organisation that represents interests of the agricultural community.

[8] These financial support measures are offered toward specific activities that facilitate biodiversity conservation and/or AES adoption, for example, preliminary studies of agglomeration projects and setting up landscape elements. These support measure do not add to or replace direct payments from AES, but rather facilitate farmers to receive the AES payments.

[9] Another reason to separately examine park effects in the two regions is that over time, through agricultural policy reforms, the Federal Office for Agriculture has adjusted direct payment rates for AES. The degree of adjustment varied across agricultural zones, which provided different (changes in) incentives for biodiversity conservation

by farms in the Alps region and the Jura region. For instance, in the policy reform in 2014, direct payment for "extensively used meadow" was unchanged for the valley and hill zones (strongly represented in the Jura region) but increased by 12% in two higher-elevation mountain zones (strongly represented in the Alps region). Consequently, biodiversity conservation by (more extensive) farms in the Alps regions may have followed paths different from (less extensive) farms in the Jura region.

[10] We acknowledge that parks also vary in other dimensions, such as language regions. However, in examining the heterogeneity of park effects, we focus on the dimensions that are most likely to govern the interaction between parks and AES adoption, namely agricultural baseline and park support. In a robustness check, we conduct park-specific analyses to allow for heterogenous effect in all dimensions.

[11] A major reason for separately examining the park effect in the two regions, rather than including a region indicator to interact with the park status, is that by separating the parks, we can create suitable control groups for each treatment group. We discuss this in more details later in this section.

[12] We note that parallel trends can also be compatible with selection on time-varying unobservables under certain time-series restrictions (Ghanem et al. 2022). However, in our case, we do not aim to focus on the time-series properties of the potential outcome but rather provide a detailed contextual discussion and sensitivity tests to justify the credibility of parallel trends in our context.

[13] These are the maximum payments farmers could receive for each AES from the Federal Office for Agriculture, which is not necessarily the amounts eventually paid to farmers. Nonetheless, based on information on lumpsum deduction, reclaims and back payments for result-based and agglomeration AES over the period 2005–2013, we could compare the actual payments farmers received with the maximum payment. Our calculations show that over the period 2005–2013, 0.6% of farmers' actual payment deviated from the maximum payment by over 5% (in both directions), with an average discrepancy of −0.02% (calculated as *repayment − deduction − reclaim*). These calculations indicate that the maximum payments are very close to the actual payments and thus would be a meaningful proxy of ecological quality of AES.

[14] For event studies with the exact numbers of post-treatment periods of each park, see park-level analysis in the robustness checks (Figure A8).

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** jage70017-sup-0001-Supinfo.docx.