

Land Use Policy

Socio-economic, structural, and policy drivers of agroforestry in Great Britain

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Response to Reviewers:	

Highlights

- Adoption barriers are practice-specific: silvoarable needs market infrastructure
- Farmers are more likely to adopt small woods and windbreaks
- The likelihood of adoption depends on the region and farm type
- Farmer identity dictates uptake: lifestyle identity reduces AF adoption likelihood
- Effective policy: practice-specific incentives + outreach by farmer traits

Socio-economic, structural, and policy drivers of agroforestry in Great Britain

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2 **Socio-economic, structural, and policy drivers of agroforestry in Great Britain**

3 **Abstract**

4 Agroforestry (AF) is widely recognised as an effective approach for addressing the climate,
5 biodiversity, and food security impacts of modern agriculture, yet its adoption remains
6 limited. This paper examines the economic, structural, social and policy factors influencing
7 farmer adoption of eight AF practices in Great Britain. Survey data from 315 farmers,
8 including a Best-Worst Scaling (BWS) experiment, are analysed using a spatial multivariate
9 ordered probit model. Farmers show a higher intention to adopt low-intensity practices (e.g.,
10 small woods, windbreaks) compared to more transformative integrated systems (silvoarable,
11 silvopasture and agrosilvopasture). The BWS results suggest that the level of financial
12 support is an important consideration when evaluating AF schemes, Farmers prefer schemes
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14 that the factors affecting the likelihood of adoption differ across the eight practices
15 considered. We argue that strategies aiming to increase AF uptake must be practice-specific
16 and designed to address the distinct technical and perceptual barriers associated with different
17 AF systems (e.g. targeted financial support, and building market infrastructure for
18 silvoarable, coupled with demographically-tailored outreach that aligns scheme
19 communication with farmer identity, age, and location). Scaling up AF requires
20 differentiated, evidence-based interventions that reflect farmer priorities and preferences for
21 specific AF practices.

22

23 **Keywords:** agroforestry adoption, agri-environmental schemes, best-worst scaling, farmers
24 decision-making, spatial analysis

25

26 **1. Introduction**

27 Agroforestry (AF), the integration of trees with crops or livestock systems, is a land-use
28 approach that can enhance multifunctional ecosystem services (ES) delivery (Baker et al.,
29 2025) in comparison to conventional agriculture (Burgess and Rosati, 2018; García de Jalón
30 et al., 2018b; Kay et al., 2018). Its potential benefits include climate change mitigation
31 through carbon sequestration or regulation of local microclimate effects (Kay et al., 2019),
32 biodiversity promotion (e.g. increasing the presence of breeding farmland birds (Whittingham
33 et al., 2009), the creation of habitats for pollinators and other species (Image et al., 2023), and
34 protection against flooding (Carroll et al., 2004). Along with environmental and climate
35 benefits (Mosquera-Losada et al., 2018), AF can also support productive ES through
36 supporting yields and improving animal welfare (Broster et al., 2017), while supporting food
37 production and having the potential to improve farm productivity and financial performance
38 (García de Jalón et al., 2018b). Despite this compelling portfolio of benefits, the widespread
39 adoption of AF by farmers remains limited in many regions internationally (Borremans et al.,
40 2016; den Herder et al., 2017; Irwin et al., 2022; Sereke et al., 2016; Sharma et al., 2017).

41 Farm-level decisions regarding AF adoption are made by farmers, landowners or other key
42 stakeholders with relevant influence (García de Jalón et al., 2018a; Valdivia and Poulos,
43 2009), and therefore understanding such decisions requires examining the farmers' decision-
44 making calculus, which is influenced by economic, structural, social and attitudinal factors
45 (Brown et al., 2021; Celio et al., 2014; Jin et al., 2024). Furthermore, the design of policy
46 incentives, including payment schemes, contract flexibility, and administrative complexity,
47 plays a critical role in shaping uptake (Brown et al., 2021; Celio et al., 2014; Jin et al., 2024).
48 Research into farmer adoption needs to account for both intrinsic motivations and the
49 extrinsic policy framework. Much of the existing literature analyses farmers' intention to
50 adopt AF as a single, undifferentiated practice (Felton et al., 2023; Irwin et al., 2022; Sereke
51 et al., 2016). However, AF adoption is likely to vary significantly across AF practices, as
52 each practice has distinct technical requirements and economic implications. The
53 effectiveness of different AF practices also depends on the biophysical and farm
54 characteristics.

55 The UK presents a critical and informative context in which to investigate these adoption
56 dynamics. With approximately 3.3% of agricultural land under agroforestry (den Herder et
57 al., 2017), uptake lags behind national ambitions. The UK Climate Change Committee
58 recommends a major expansion of AF to 10% of suitable land by 2050 to meet the
59 government's net-zero emission targets (Climate Change Committee, 2025). Historically, UK
60 farmers received support for AF under the European Union's Common Agricultural Policy
61 (e.g. Natura 2000 payments, forest-environmental payments and support for non-productive
62 investments) (European Commission, 2005). Post-Brexit, UK and devolved governments are
63 developing new domestic policy mechanisms to incentivise AF uptake, such as the AF Plan
64 Grant within the Environmental Management Scheme, Sustainable Farming Incentive (SFI)
65 and/or a Countryside Stewardship (CS) agreement, which offer financial support to
66 farmers/land managers to design, create and maintain an AF system (UK Government, 2025).
67 Currently, initiatives such as the Tree Planting Taskforce and reforms to the Woodland
68 Carbon Code aim to support tree cover expansion by making it easier for land managers to
69 stack multiple revenue streams from multiple ES markets.

70 This combination of ambitious targets, low adoption rates, and evolving policies presents a
71 valuable and timely research context for examining the barriers to, and facilitators of,
72 farmers' adoption of AF. The results can offer useful lessons for other countries trying to
73 increase AF as they show how structural, policy, social and economic factors influence
74 farmers' willingness to integrate trees on farms. This study contributes to the AF adoption
75 literature by providing a novel approach applied within a policy-relevant setting. First, we
76 investigate farmers' intentions to adopt eight distinct agroforestry practices to identify which
77 practices hold the most appeal to farmers, and why. Second, we explicitly incorporate
78 farmers' preferences for key policy design characteristics (e.g., payment duration, scheme
79 administrator) as factors influencing adoption likelihood. Finally, we examine spatial
80 heterogeneity in adoption intentions across UK regions, acknowledging that local conditions
81 and farming cultures may significantly influence adoption rates. By integrating these
82 dimensions, our analysis aims to provide policymakers and advisors with tailored evidence to

83 design more effective, context-sensitive support strategies that accelerate agroforestry
84 adoption.

85 The following sections discuss the factors that can influence farmers' intention to adopt AF
86 (section 2); outline the methodology and data used in this study (section 3); present and
87 discuss the results and offer policy recommendations (section 4); explain the research
88 limitations and future research (section 5); and summarise the findings (section 6).

89

90 **2. Analytical framework**

91 **2.1 Factors affecting AF practices adoption**

92 Research on AF adoption has identified a diverse set of enabling and constraining factors,
93 including economic, social, structural and, policy factors.

94 Farmers' adoption decisions are often driven primarily by direct economic factors. These
95 include barriers such as high upfront investment and ongoing maintenance costs, uncertain or
96 long-term financial returns, and fears that trees will interfere with core farm operations
97 (Felton et al., 2023; Irwin et al., 2022; Tosh, 2021). Conversely, the potential opportunities
98 for income diversification through timber, non-timber tree products (e.g. fruits, nuts), carbon
99 credits, or ecosystem service payments can serve as a significant economic incentive
100 (FitzGerald et al., 2021; Iversen et al., 2023)

101 Policy design and implementation can influence farmers' decisions to adopt AF practices
102 (Norton et al., 2024). Evidence from agri-environmental schemes (AES) shows that farmers'
103 enrolment is highly sensitive to scheme attributes. Farmers' willingness to participate is
104 influenced by the level, timing and certainty of payments, contract length and flexibility, and
105 the complexity of administrative requirements (Mamine et al., 2020; Ruto and Garrod, 2009;
106 Schulze et al., 2024; Tyllianakis and Martin-Ortega, 2021). Complex bureaucracy has been
107 found to be a barrier to AF adoption (Hasler et al., 2022; Micha et al., 2015). Upfront
108 payments, simplified application processes, and schemes that minimise obligations for
109 collaboration or public access are more likely to encourage uptake (Abdul-Salam et al., 2022;
110 Schulze et al., 2024; Villamayor-Tomas et al., 2019). Furthermore, uncertainty over policy
111 changes, the administrative burden of claiming payments and the lack of knowledge around
112 woodland management are commonly cited barriers in the forest management literature
113 (Lawrence and Dandy, 2014). Insufficient knowledge around the financial and legal impacts
114 of AF can also be a barrier to uptake among interested farmers (Hood et al., 2025).

115 The adoption of new land use practices is not purely a rational economic calculation but is
116 deeply embedded in the social context and personal identity. The concept of the "good
117 farmer" is a powerful social norm; practices that align with this identity are more readily
118 adopted. A productivist identity, centred on food production and maintaining tidy, working
119 land, can be a significant barrier to AF adoption. Conversely, a conservationist or "land
120 steward" identity that values environmental management can be a strong enabler (Burton,
121 2004; Dixon et al., 2022; Jin et al., 2024). Thus, farmers may oppose AF if they want to

122 manage the land for food production and maintain the land to a specific appearance, whereas
123 farmers who prioritise conservation values (e.g. balancing profit with nature-positive
124 outcomes) may favour AF as a means of realising these values (Lawrence and Dandy, 2014).
125 In addition, farmer concerns about tree-specific diseases have also been reported in the
126 literature as an AF adoption barrier (Houndjo Kpoviwanou et al., 2024). Social networks and
127 regional traditions also play a role in increasing the likelihood of AF adoption, as learning
128 from peers can reduce the associated perceived risks (Rois-Díaz et al., 2018). Rois-Díaz et al.
129 (2018) found that older farmers were less likely to implement AF practices in general when
130 studying AF adoption in eight European countries including Spain (high nature and cultural
131 value, high value trees, and livestock AF), Italy (silvopasture), Greece (high nature and
132 cultural value, silvoarable), Portugal (high nature and cultural value), France (silvoarable),
133 Germany (high nature and cultural value, silvoarable), UK (high value trees, arable AF, and
134 Hungary (silvopasture). Similarly McGinty et al. (2008) reported a negative association
135 between age and AF adoption in Brazil. Neupane et al. (2002) found negative association
136 between age and education level and adoption in Nepal (exotic fodder and grass species),
137 whereas Nkamleu and Manyong (2005) did not find evidence of a similar relationship in
138 Cameroon (agrosilvopastoral). In contrast, Beyene et al. (2019) reported a positive
139 association between age and the adoption of AF practices (silvoarable).

140 Structural conditions may include broader systemic, biophysical and farm-level conditions
141 and can be important in relation to the practical feasibility of AF adoption. Land tenancy,
142 which is common in the UK, with 31% of farms being mixed tenure and 14% wholly
143 tenanted (DEFRA, 2024), is a critical structural constraint; insecure tenancies or short-term
144 leases directly conflict with the long-term investment in trees, often requiring landlord
145 consent (Barnes et al., 2022; Borremans et al., 2018; FitzGerald et al., 2021; Perks et al.,
146 2018). Farm characteristics and location are also important factors in AF adoption.
147 Biophysical factors such as soil type, topography, and climate determine the suitability of
148 land for different AF practices (Abdul-Salam et al., 2022; Pattanayak et al., 2003).
149 Operational characteristics, including farm size, enterprise type (i.e. farm main income), and
150 existing infrastructure, influence the capacity and economic rationale for adoption (Beyene et
151 al., 2019). Finally, access to knowledge, technical advice, and supply chains for inputs or
152 markets are essential structural enablers or barriers (Reeg, 2011; Sereke et al., 2016).

153

154 **2.2 Conceptual Framework**

155 Based on previous research, we develop a multidimensional conceptual framework to explain
156 farmers' AF adoption decisions for specific AF practices. The framework, depicted in Figure
157 1, integrates four categories of decision determinants: economic, structural, policy and social
158 factors (Figure 1).

159 *Economic factors* refer to perceived benefits, such as income diversification (FitzGerald et
160 al., 2021; Iversen et al., 2023), perceived opportunities such as job creation, ecosystem
161 service payments, and rural economy support (Sharma et al., 2017), and perceived barriers
162 such as business investment and maintenance costs (Tosh, 2021), increased workload (Felton

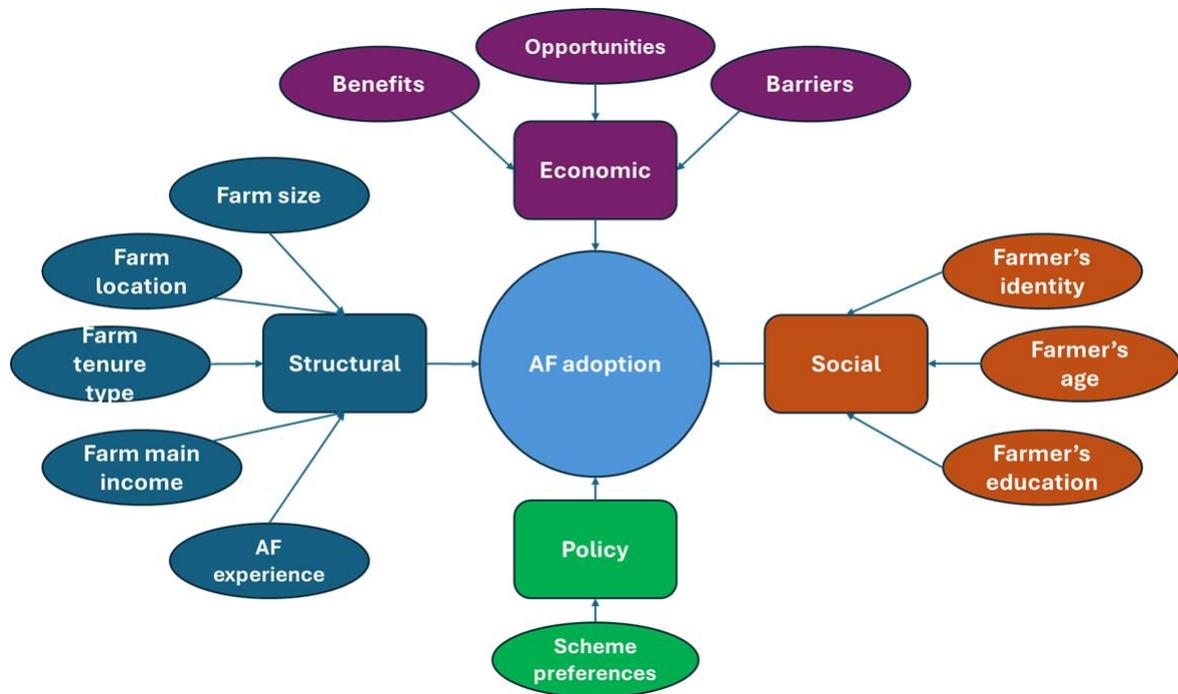
et al., 2023), low short-term financial returns, and fears of interference with core farm operations (Irwin et al., 2022).

Structural factors are the fixed features of the farm and the farmer that enable or constrain adoption. This dimension includes farm characteristics such as farm size and location, which influence biophysical suitability and opportunity costs (Abdul-Salam et al., 2022; Beyene et al., 2019); tenure type, where short rental agreements can preclude long-term investments such as tree planting (Barnes et al., 2022; Perks et al., 2018) and farmers’ prior experience with AF.

Policy factors relate to farmers’ AF preferences for AF scheme characteristics. The literature on AES highlights that adoption is sensitive to contract length, payment levels, administrative burden and flexibility (Ruto and Garrod, 2009; Schulze et al., 2024).

Social factors include the subjective perceptions, identities, and norms that shape farmers' behaviour. The key element here is farmer identity (e.g. productivist by conservationist) (Burton, 2004). This dimension also accounts for socio-demographic characteristics such as age and education level (Pattanayak et al., 2003; Rois-Díaz et al., 2018).

Figure 1. Conceptual Framework of Factors Influencing Farmer Adoption of Agroforestry Practices



3. Methods

This study examines AF adoption within the UK, which represents a relevant setting due to its national net zero-targets, low AF uptake, and post-Brexit transition in agricultural policy.

186 AF is widely recognised as a key land-based strategy for climate change mitigation and
187 adaptation globally, yet many countries face similar gaps between policy ambition and AF
188 adoption (Buttoud, 2013; Santiago-Freijanes et al., 2021). Our findings provides insights into
189 how farmers respond to policy instruments and incentives in this context, offering
190 transferable lessons for other nations designing or reforming agri-environmental schemes.
191 For instance, this study is directly relevant to current EU policy debates where increasing AF
192 uptake is embedded in the EU Farm to Fork Strategy (European Commission, 2020b) and the
193 EU Biodiversity Strategy for 2030, which explicitly calls for greater use of AF support under
194 rural development, stating that “the uptake of agroforestry support measures under rural
195 development should be increased as it has great potential to provide multiple benefits for
196 biodiversity, people and climate” (European Commission, 2020a)”. Although AF is eligible
197 under both first and second pillar of the CAP 2021-2027, uptake remains low, signalling the
198 need for better-designed incentives.

3.1 Survey questionnaire

201 In collaboration with the UK Department for Environment, Food and Rural Affairs
202 (DEFRA), we designed an online survey questionnaire to gain a comprehensive
203 understanding of farmers’ views and attitudes towards the adoption of AF in Great Britain
204 (England, Scotland and Wales). The survey questionnaire was administered by a marketing
205 company (Potentia-Insight) to a panel of farmers in England, Wales and Scotland during
206 September and October 2023. Our sample includes a total of 315 responses. Table A1 in the
207 Appendix presents the geographical distribution of our sample, which was designed to be
208 representative of farmers in Great Britain. The distribution across countries closely aligns
209 with the proportion of the agricultural workforce in each devolved nation (Appendix A)
210 (DEFRA, 2024). While regional balance was the primary sampling focus, we note that the
211 median farmer age in our sample is 46 years, which is lower than the national median of 62
212 years for England (DEFRA, 2025). The survey questionnaire took farmers, on average, 28
213 minutes to complete. Ethics approval was provided by Newcastle University ethics
214 committee on 26th January 2023 (reference 28794/2022).

215 The survey questionnaire included an introductory section that explained the study's aim and
216 outlined the terms and conditions for participation. This was followed by sections that asked
217 questions about the farmers’ existing AF adoption; potential barriers to adoption as perceived
218 by farmers; farmers' intention to adopt AF in the future; farmers’ perceptions and attitudes
219 linked to agriculture; and farmers’ self-reported identity. Farmers were asked to evaluate a
220 total of 34 statements covering potential opportunities (5), benefits (10), and barriers (19)
221 associated with the adoption of AF, as well as 19 more statements capturing views on
222 farmers’ identity using a 5-point Likert scale (Felton et al., 2023). A best-worst scaling
223 (BWS) exercise, in which farmers were asked to choose among different AF scheme
224 characteristics, was also included. The final section included questions on the farm
225 characteristics and the socio-demographic background of the farmer. The survey

226 questionnaire, which includes the questions analysed in this paper, is provided in
 227 Supplementary Material 1.

228 To measure farmers' preferences for the features of AF schemes, we conducted a Best-Worst
 229 Scaling (BWS) experiment (case 1) (Finn and Louviere, 1992; Louviere et al., 2015). BWS is
 230 a method designed to study and quantify individual choices (i.e., measure preferences among
 231 multiple options). The BWS method is grounded in Random Utility Theory, which posits that
 232 individuals select the option they perceive as maximising their utility. We considered a total
 233 of 13 features (Table 1). In the BWS task, participants were presented with 13 sets of 4 items
 234 and asked to select the "most important feature to be included in the AF scheme" and the
 235 "least important feature to be included in the AF scheme" within each set. A balanced
 236 incomplete block design (BIBD) was used to ensure that all scheme features are equally
 237 represented and compared, enabling us to infer individual preferences for each item based on
 238 the responses. Since each attribute was shown to respondents four times and took either a
 239 value of -1 or 1, the average total score for each attribute ranges between -4 and 4, with
 240 higher values indicating a stronger preference. The R Package AlgDesign was used to
 241 generate the BIBD (Wheeler, 2004).

242 We use the average BWS scores for each of the scheme features as explanatory variables in
 243 the AF adoption model.

244

245 **Table 1.** AF scheme features

Feature #	Feature
1	The level of monetary support (payment)
2	Includes upfront payment
3	Includes non-monetary support (e.g. training, advisory, marketing assistance with tree-derived yield)
4	Allows you to select the scheme type (e.g. government, private sector, public-private partnership)
5	Requires collaboration with other farmers (joint/common agroforestry areas)
6	Allows public access to land
7	The length of the AF scheme contract
8	Establishes a minimum planting density
9	Requires planting native species
10	Excludes livestock from the AF scheme
11	Includes additional payment for additional AF management options
12	How the performance is evaluated (e.g. based on measurable outcomes, changes made to the farmland, or both)
13	Includes a withdrawal penalty*

246 *This variable was removed in the econometric analysis due to multicollinearity

247 Louviere et al. (2015) show that best and worst data can be summarised by subtracting the
248 worst count for each attribute (i.e., the total number of times an attribute is selected as "least
249 important") from the best count for that attribute (i.e., the total number of times an attribute is
250 selected as "most important").

251 To assess farmers' intention to adopt AF, we asked farmers to indicate how likely or unlikely
252 they were to adopt (or continue adopting) the following AF practices in their farm in the next
253 5 years: silvoarable; silvopasture; agrosilvopasture; riparian buffer strips;
254 windbreak/shelterbelt systems; wood pasture and parkland; traditional orchards; and small
255 woods. The answers were recorded on a 5-point Likert scale (from extremely unlikely to
256 extremely likely). The selected AF practices, which were discussed with Defra, were
257 presented to farmers with a description of each AF type (the descriptions are included in
258 Supplementary material 2).

259 The survey questionnaire included a farm characteristics section, which collected information
260 on farm size and farmed area, main income of the farm, type of farm tenure (owned and/or
261 tenanted, owned land, full agricultural tenancy, farm business tenancy, seasonal agreements),
262 and socio-demographic information such as age, gender and farmers' level of education. We
263 also collected the outcode (i.e. first part of the UK postcode) to obtain the approximate
264 geographic coordinates (latitude and longitude) of the farm location. For the latter step, we
265 used Postcodes.io API, an open-source service that provides detailed information about
266 postcodes, including their geographical coordinates and administrative regions.

267 Based on this information, we produced a spatial distribution map of farmers' likelihood of
268 adoption by AF type. The Inverse Distance Weighted (IDW) spatial interpolation function
269 was used in the QGIS software. This deterministic method calculates a weighted average of
270 the unknown likelihood of adoption based on the values surrounding known likelihood of
271 adoption, assuming that closer points to the unknown location have a greater influence on the
272 estimated value than those farther away (Pereira et al., 2022). Each point in the map is
273 calculated using the equation (1) below.

$$Z_p = \frac{\sum_{i=1}^n \left(\frac{Z_i}{d_i^p} \right)}{\sum_{i=1}^n \left(\frac{1}{d_i^p} \right)} \quad (1)$$

274 where Z_p is the value (likelihood of adoption) of the unknown point that needs to be
275 interpolated; Z_i is the value (likelihood of adoption) of the known point, d_i is the distance to
276 a known point; n is the number of observations, and p is the distance coefficient, which is
277 selected by the user (we use a distance coefficient of 2, which is most commonly used)
278 (Ahmad et al., 2021; Paramasivam and Venkatramanan, 2019).

280

281 **3.2 Principal component analysis and Econometric model**

282 3.2.1 Principal Component Analysis

283 We conducted Principal Component Analyses (PCAs) for statements related to the
 1 284 opportunities, benefits, and barriers associated with AF adoption, as well as farmers' identity
 2 285 (full results are available in Supplementary Material 3). To determine the number of
 3 286 components to retain, we employed the Kaiser criterion, which recommends retaining
 4 287 components with eigenvalues greater than or equal to 1. We used Cronbach's alpha and the
 5 288 Kaiser-Meyer-Olkin (KMO) measures to assess the reliability and suitability of data for the
 6 289 analysis (Kaiser, 1970). All scores for the components obtained were rescaled to a 1-5 scale
 7 290 to facilitate interpretation (Areal, Riesgo, et al., 2012) and had a Cronbach's alpha equal to or
 8 291 greater than the 0.70 minimum value standard, ensuring their internal validity and a KMO
 9 292 greater than 0.60, ensuring the dataset is suitable for conducting PCA. The components were
 10 293 subjected to varimax rotation to simplify the structure and enhance interpretability. Using this
 11 294 criterion, the % of total variance captured by PCA for opportunities, benefits, barriers, and
 12 295 good farmers was 46%, 57%, 57%, and 66%, respectively. All components obtained were
 13 296 retained for analysis, as the levels were considered acceptable given the high dimensionality
 14 297 and complexity of the dataset. The components obtained from the PCAs were used as
 15 298 explanatory variables in a multivariate ordered probit model to investigate the likelihood of
 16 299 farmers adopting AF practices.

300 3.2.2 Econometric model

301 We estimate the likelihood of adopting different agroforestry practices using a spatial
 302 multivariate ordered probit model. This approach simultaneously accounts for the correlation
 303 between the multiple adoption decisions and controls for spatial dependence. We model
 304 spatial spillovers through a spatial lag variable, which captures the influence of adoption in
 305 neighbouring farm locations. This is informed by a spatial weights matrix constructed using
 306 farm coordinates and the Haversine distance formula. We further control for underlying
 307 geographic variation by including both linear and squared terms of latitude and longitude.

308 The observed stated likelihood to adopt each of the AF practices i ($i = 1, \dots, 8$) can be
 309 represented as:

$$310 \quad y_i = \{1 \text{ if } z_i \leq \tau_1 \ 2 \text{ if } \tau_1 < z_i \leq \tau_2 \ \dots \ k \text{ if } z_i > \tau_{k-1} \quad (2)$$

311 Where z_i is the latent variable (i.e. unobservable) willingness to uptake AF practice i , τ_s are
 312 unknown parameters to be estimated; and y_i is the stated likelihood of adopting a specific AF
 313 practice i . The errors (unobserved factors) influencing the latent variables are assumed to
 314 follow a multivariate normal distribution, allowing for correlations among the ordinal
 315 outcomes. We can represent our model as follows:

$$316 \quad Y_i = \rho WY_i + X\beta_i + \varepsilon_i \quad (3)$$

317 Where Y_i is a vector of the stated likelihood of adopting AF practice i ; ρ is the spatial
 318 dependence parameter; W is a spatial weight matrix or connectivity matrix; X is a matrix of
 319 measurable explanatory variables common to all AF practices, which includes the principal
 320 components obtained to capture economic factors, farmers' preferences for AF scheme
 321 characteristics obtained through the BWS experiment, regional dummy variables, longitude
 322 and longitude coordinates, and farm and farmer characteristics; β_i is a vector of parameters

associated with the explanatory variables for each AF practice; and ε_i captures all the unobservable factors not taken into consideration. The spatial weight matrix is defined as

$$W = \exp(-distance_{ij}) \quad (4)$$

where the matrix elements w_{ij} are based on the distance between locations i and j . The negative exponent ensures that as the distance increases, the weight approaches zero.

Our dependent variable Y_i is farmers' response to the following question on AF adoption: "Please indicate how likely you are to adopt (or continue adopting) the following AF practices in your farm in the next 5 years?"

The answers were recorded on a 5-point Likert scale ranging from extremely unlikely to extremely likely. The farmers were asked this question for the eight AF types considered in this study: silvoarable, silvopasture, agro-silvopasture, riparian buffer strips, windbreaks, wood pastures, parklands, traditional orchards, and small woods.

4. Results and Discussion

Farmers' intention to adopt AF varies considerably across different practices, though absolute scores on the 1-5 likelihood scale remain moderate overall (Table 2, Figure 2). Overall, intention to adopt is higher for smaller-scale interventions such as small woods (3.26) and shelterbelts (3.13), followed by wood pasture (2.73) and traditional orchards (2.71). In contrast, uptake potential is markedly lower for more integrated systems such as silvoarable, silvopasture, agrosilvopasture, and riparian buffers (2.48), silvopasture (2.22), agrosilvopasture (2.19), and silvoarable (1.91). These results align with the historically limited area under AF in the UK, as well as documented low intention to adopt complex silvoarable systems (den Herder et al., 2017; Newman et al., 2018).

Figure 2 reveals distinct spatial patterns in adoption likelihood, reflecting the variation in suitability by region. These geographical differences have ecological relevance. For instance, in regions showing higher farmer interest in practices such as hedgerows and woodland creation, preferences align with models identifying the same practices as the most effective for enhancing bumblebee abundance and landscape-level pollination services (Image et al., 2023).

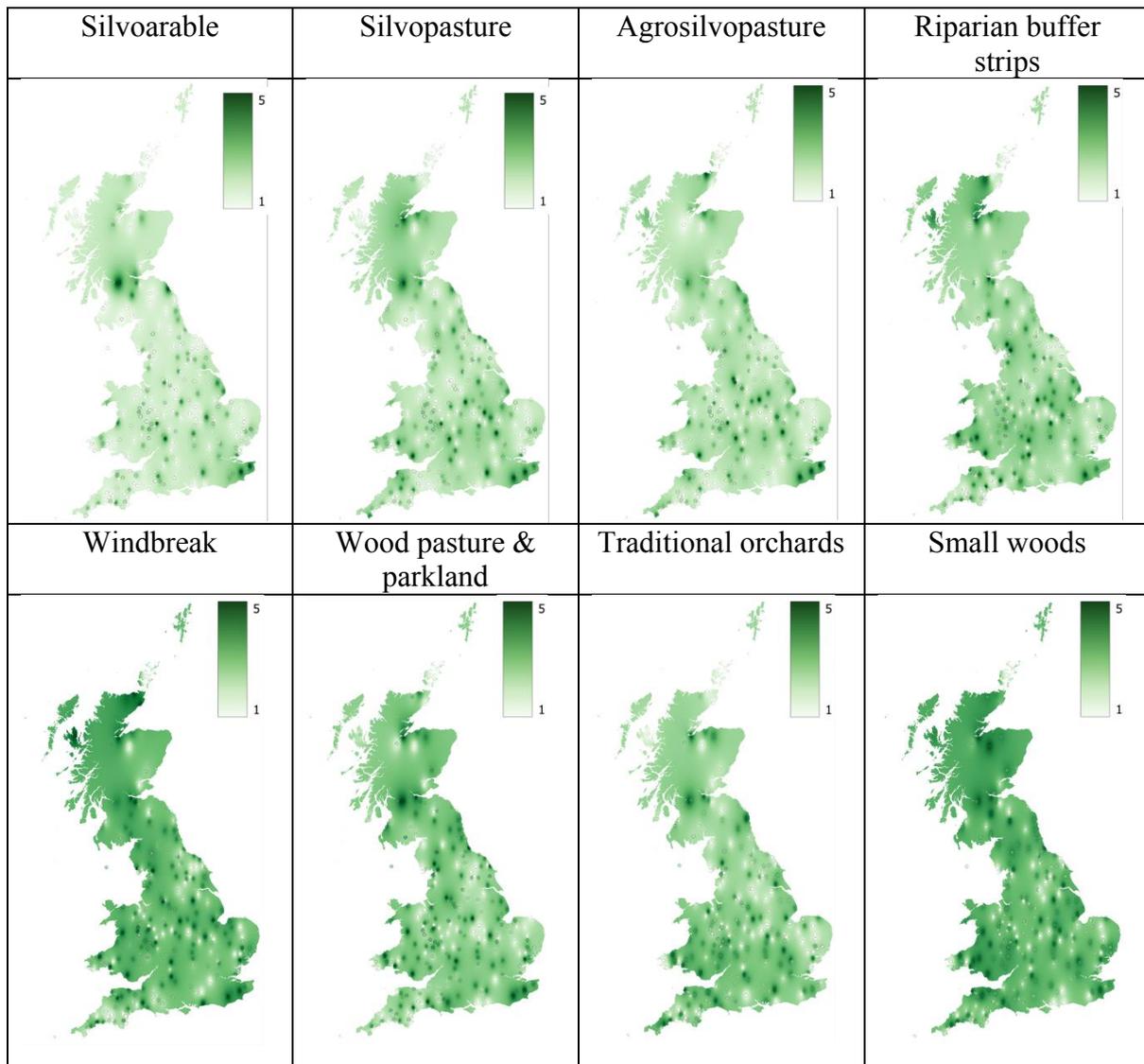
Descriptive statistics for all the variables included in the models are provided in Supplementary Material 3.

Table 2. Likelihood of adoption per AF type (scale 1-5)

AF practice	Mean	Std dev
Silvoarable	1.91	1.11
Silvopasture	2.22	1.24
Agrosilvopasture	2.19	1.18

Riparian buffer strips	2.48	1.30
Windbreak	3.13	1.32
Wood pasture and parkland	2.73	1.36
Traditional orchards	2.71	1.47
Small woods	3.26	1.33

Figure 2. Spatial distribution of the likelihood of farmers adopting AF practices in the next 5 years (1=Extremely unlikely; 5= Extremely likely)



To understand how policy design may influence farmers' intention to adopt AF practices, we conducted a BWS experiment evaluating farmer preferences for 13 AF scheme characteristics (Table 3). The results indicate that the level of financial support is important to farmers. Furthermore, farmers prefer AF schemes that offer financial support (including upfront payments and additional payments for additional AF management options). Schemes that

366 require farmers to plant native species, and provide non-monetary assistance such as training,
 367 advice, and marketing assistance are also more appealing. Farmers also prefer having the
 368 flexibility to choose between schemes offered by the government, private and blended
 369 finance (public-private partnerships). Conversely, schemes that permit public access to their
 370 land, exclude livestock, impose withdrawal penalties, or mandate collaboration with other
 371 farmers are less preferred.

372

373 **Table 3.** Farmers’ preferences for AF scheme characteristics

Rank	Feature	Score*
1	The level of monetary support (payment)	2.65
2	Includes upfront payment	1.85
3	Includes additional payment for additional AF management options	1.15
4	Requires planting native species	1.12
5	Includes non-monetary support (e.g. training, advisory, marketing assistance with the produce of trees)	0.50
6	Allows you to select the scheme type (e.g. government, private sector, public-private partnership)	0.30
7	How the performance is evaluated (e.g. based on measurable outcomes, changes made to the farmland, or both)	0.26
8	The length of the AF scheme contract	-0.08
9	Establishes a minimum planting density	-0.50
10	Requires collaboration with other farmers (joint/common agroforestry areas)	-1.16
11	Includes a withdrawal penalty	-1.50
12	Excludes livestock from the AF scheme	-1.80
13	Allows public access to land	-2.80

374 *Average score per attribute ranges between -4 and 4.

375 We incorporated these preference scores into our econometric model to assess their
 376 relationship with the likelihood of adoption.

377 The results of the spatial multivariate ordered probit models are presented visually in Figures
 378 3–8 (full results in Supplementary Material 3). Findings indicate that economic, structural,
 379 social, and policy factors influence the adoption probability for each of the eight AF
 380 practices, although the relevance of these factors varies by practice. A significant correlation
 381 exists between the error terms of the eight adoption equations, supporting the multivariate
 382 approach and indicating that common unobserved factors influence adoption across practices
 383 (Appendix B).

384 Consistent with our conceptual framework, the following subsections present the econometric
 385 results, organised by the four key determinants of adoption: economic, structural, social and
 386 policy factors. Policy recommendations are provided under section 4.5.

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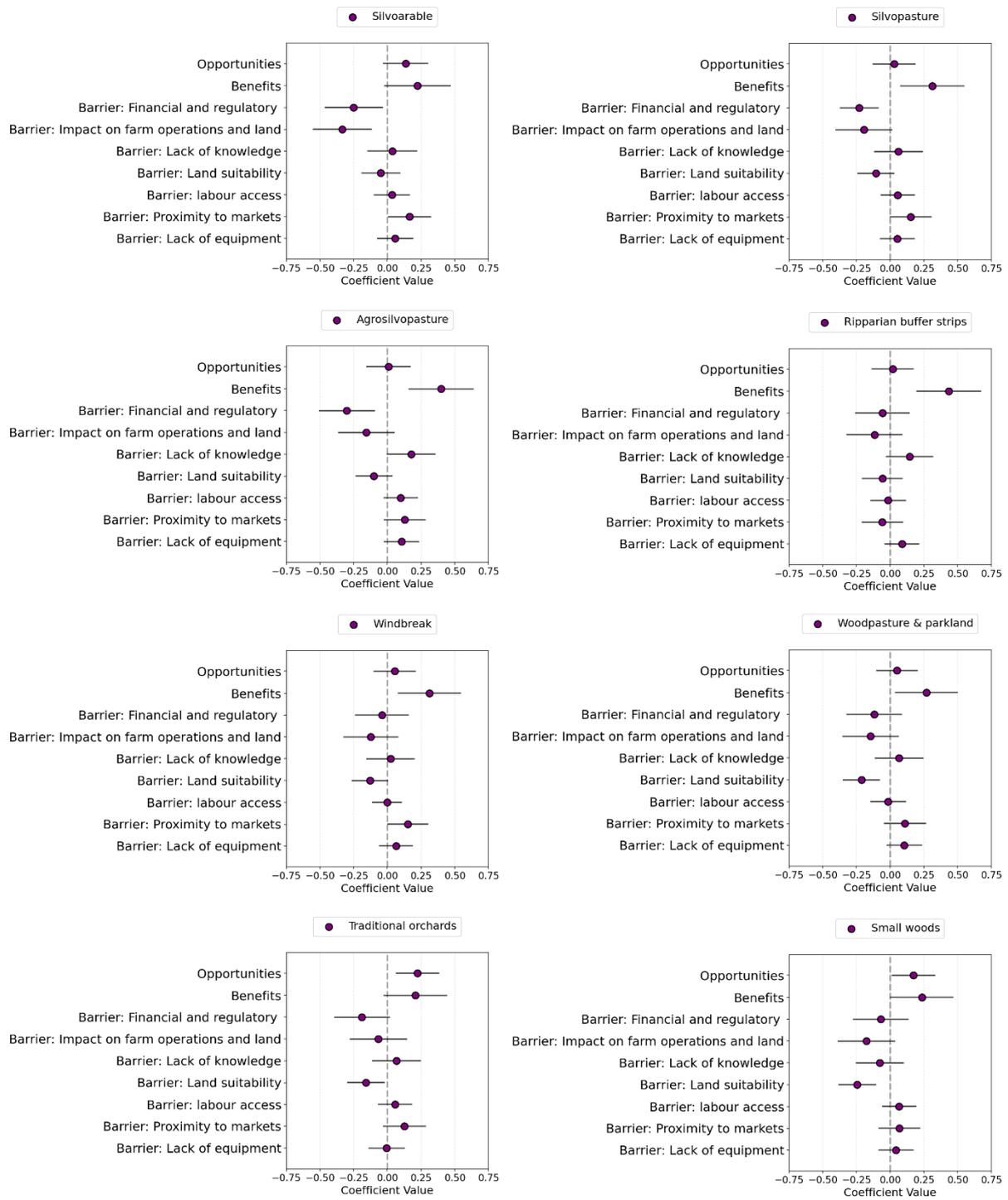
388 4.1 Economic factors

1
2 389 Different economic considerations were associated with the likelihood of adopting various
3 390 AF practices (Figure 3). Specifically, our results suggest that farmers who associate
4 391 environmental and economic benefits with AF are more likely to adopt silvopasture,
5 392 agrosilvopasture, riparian buffer strips, windbreaks, and wood pasture and parkland practices.
6 393 This relationship was not significant for silvoarable, traditional orchards or small woods. We
7 394 further find that farmers' positive views regarding the potential opportunities of adopting AF
8 395 practices are generally not associated with a higher likelihood of adopting these practices, if
9 396 other factors are held constant, with the exception of traditional orchards and small woods.
10 397 This finding reveals a degree of scepticism about adoption AF practices unless it is "easy",
11 398 even from farmers who have favourable opinions on AF benefits and opportunities. These
12 399 generally do not translate into adoption, except for low-risk practices. This demonstrates that
13 400 awareness and perceived opportunity may be insufficient to increase the likelihood that
14 401 farmers implement these changes. Consequently, promoting certain AF practices (e.g.
15 402 silvoarable) requires moving beyond highlighting long-term benefits and opportunities. To
16 403 enhance the adoption of AF practices that are influenced by farmers' perceived opportunities
17 404 and/or benefits of AF, a broader communication of AF benefits and opportunities could be
18 405 considered or enhanced if already in place. For instance, the use of TV edutainment to
19 406 influence farmers' decisions to implement changes of agricultural practices has been shown to
20 407 be an effective way to influence farmers' practices (Areal et al., 2020; Clarkson et al., 2018).

21
22 408

23 409 Perceived barriers can explain reluctance to introduce and maintain trees in farmland. Key
24 410 barriers to adopting silvoarable, silvopasture, and agrosilvopasture AF practices included
25 411 financial constraints such as high upfront costs, low or delayed returns, and burdensome
26 412 regulatory requirements. Financial barriers, such as poor financial returns and a reduction in
27 413 the value of the land, along with regulatory barriers have been previously identified as
28 414 important obstacles for AF adoption (Lawrence and Dandy, 2014; Valatin et al., 2016). For
29 415 example, high levels of paperwork have been identified as a factor explaining low grant
30 416 uptake for woodland expansion services (Lawrence and Dandy, 2014). To overcome financial
31 417 and regulatory barriers to silvoarable, silvopasture and agrosilvopasture adoption, the
32 418 introduction of upfront cost support, along with annual payments, could be considered.
33 419 Perceived risks included fears that AF may impact on other farm operations, the landscape,
34 420 and the value of the land, and were linked to a lower likelihood of adopting silvoarable
35 421 practices. Another important perceived barrier was the potential unsuitability of the land for
36 422 adopting AF practices, particularly in relation to planting trees for wood pasture and
37 423 parkland, traditional orchards, and small woods. Poor land location has been identified
38 424 previously as a reason for not planting woodland (Watkins et al., 1996). Perceived
39 425 importance of market proximity was not a significant factor for most AF practices, except for
40 426 silvoarable adoption. Finally, barriers such as a lack of knowledge about markets, tree
41 427 planting and management, a lack of equipment, or poor access to labour were not found to be
42 428 significantly relevant to the adoption of the AF practices considered in our study.

429 **Figure 3.** Influence of economic factors on farmers' intention to adopt AF practices
 430 (Coefficient Estimates with 90% Confidence Intervals)



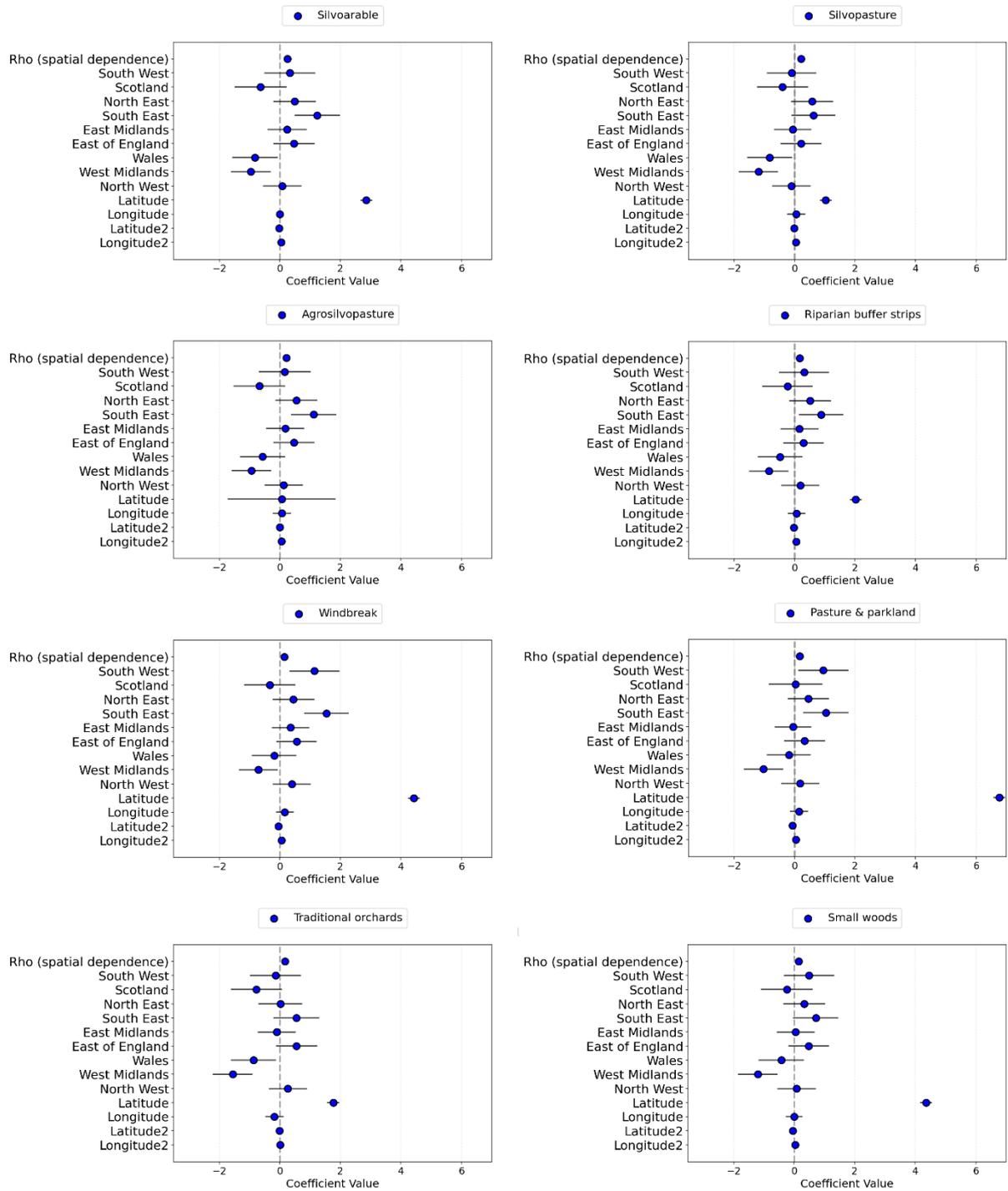
433 **4.2 Structural factors**

434 Adoption of AF by farmers is also influenced by structural factors, including geographical
 435 conditions (climate, topography, soil type), the farm's main activity/income, the type of
 436 tenancy agreement and prior AF experience (Figures 4-6).

437 Geographical region dummies and GIS coordinates (longitude and latitude) were used to
1 438 capture geographically-specific factors, which have been found to be relevant in farms' AF
2 439 adoption decisions (Abdul-Salam et al., 2022). At the regional level, relative to farmers in
3 440 Yorkshire and the Humber, which is the reference region, farmers in the South East of
4 441 England are more likely to adopt silvoarable, agrosilvopasture, riparian buffer strips,
5 442 windbreaks, and wood pasture and parkland, whereas farmers in the Southwest of England
6 443 are more likely to adopt windbreaks, wood pasture, and parkland. Adoption likelihood was
7 444 significantly lower in the West Midlands compared to Yorkshire and the Humber. Farmers in
8 445 Wales also showed a lower propensity to adopt silvoarable, silvopasture, and traditional
9 446 orchards relative to the same baseline region. The positive and significant coefficient
10 447 associated with latitude and the negative coefficient of latitude squared moderate these
11 448 results, indicating that the likelihood of adopting AF practices increases moving northwards,
12 449 but at a decreasing rate. The positive and significant coefficient for longitude squared
13 450 suggests a non-linear relationship, where the likelihood of adopting AF practices initially
14 451 increases as one moves eastwards, but then decreases after reaching a certain point.

21 452 We further find that unobserved spatial heterogeneity plays a role in farmers' willingness to
22 453 adopt AF practices. The spatial dependence parameter ρ , which captures the spatial
23 454 dependence of AF adoption (i.e. the association between a farmer's likelihood of adopting
24 455 AF practices and the neighbouring farmers' likelihood of adopting AF practices), is
25 456 statistically significant for all AF practices. These findings suggest that the presence of
26 457 underlying spatial processes shapes AF adoption beyond observable political or
27 458 administrative boundaries, such as local topography, shared informal knowledge, or local
28 459 networks (Areal, Balcombe, et al., 2012). Hence, local conditions need to be considered in
29 460 any scheme that aims to increase AF adoption rates.

34 461 **Figure 4.** Influence of structural factors on farmers' intention to adopt AF practices (1:
35 462 regional/spatial) (Coefficient Estimates with 90% Confidence Intervals)

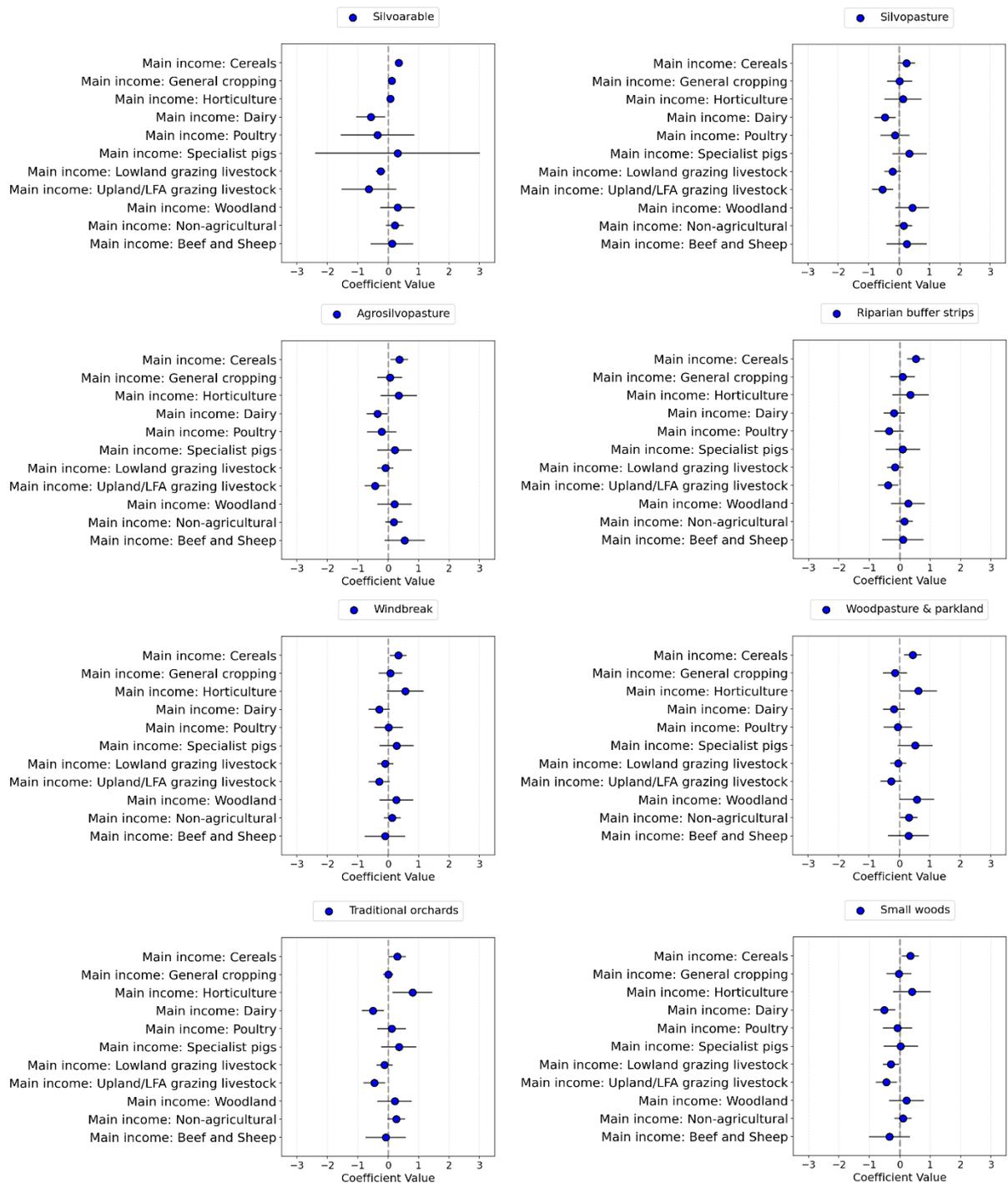


463

464 The farm's main source of income is found to be associated with the likelihood of adopting
 465 AF practices. Farms where the main income comes from cereal production are more likely to
 466 adopt all forms of AF, with the exception of silvopasture and traditional orchards. Our results
 467 further suggest that the adoption of traditional orchards, wood pasture and parkland is more
 468 likely to happen in horticultural farms. Farms where the main income does not come from
 469 agricultural production (e.g. diversification enterprises, agri-environmental schemes) are
 470 more likely to adopt wood pasture and parkland. Dairy and upland/Least Favourable Area
 471 (LFA) livestock farms are less likely to adopt silvoarable, silvopasture, traditional orchards
 472 and small woods. In addition, upland/LFA livestock farms are less likely to adopt

473 agrosilvopasture and riparian buffer strips. Lowland grazing livestock farms are less likely to
 474 adopt small woods. Pearson and McConnachie (2023) note that dairy farmers' values
 475 regarding animal health and welfare may favour the planting of hedgerows and tree cover.
 476 This finding differs from that of Irwin et al. (2022), who found that dairy farmers in Ireland
 477 are generally positive about adopting AF practices on marginal areas of their farms.
 478 However, given that dairy farming is time-demanding, current incentives may make AF
 479 practices unappealing.

480 **Figure 5.** Influence of structural factors on farmers' intention to adopt AF practices (2: Main
 481 income) (Coefficient Estimates with 90% Confidence Intervals)

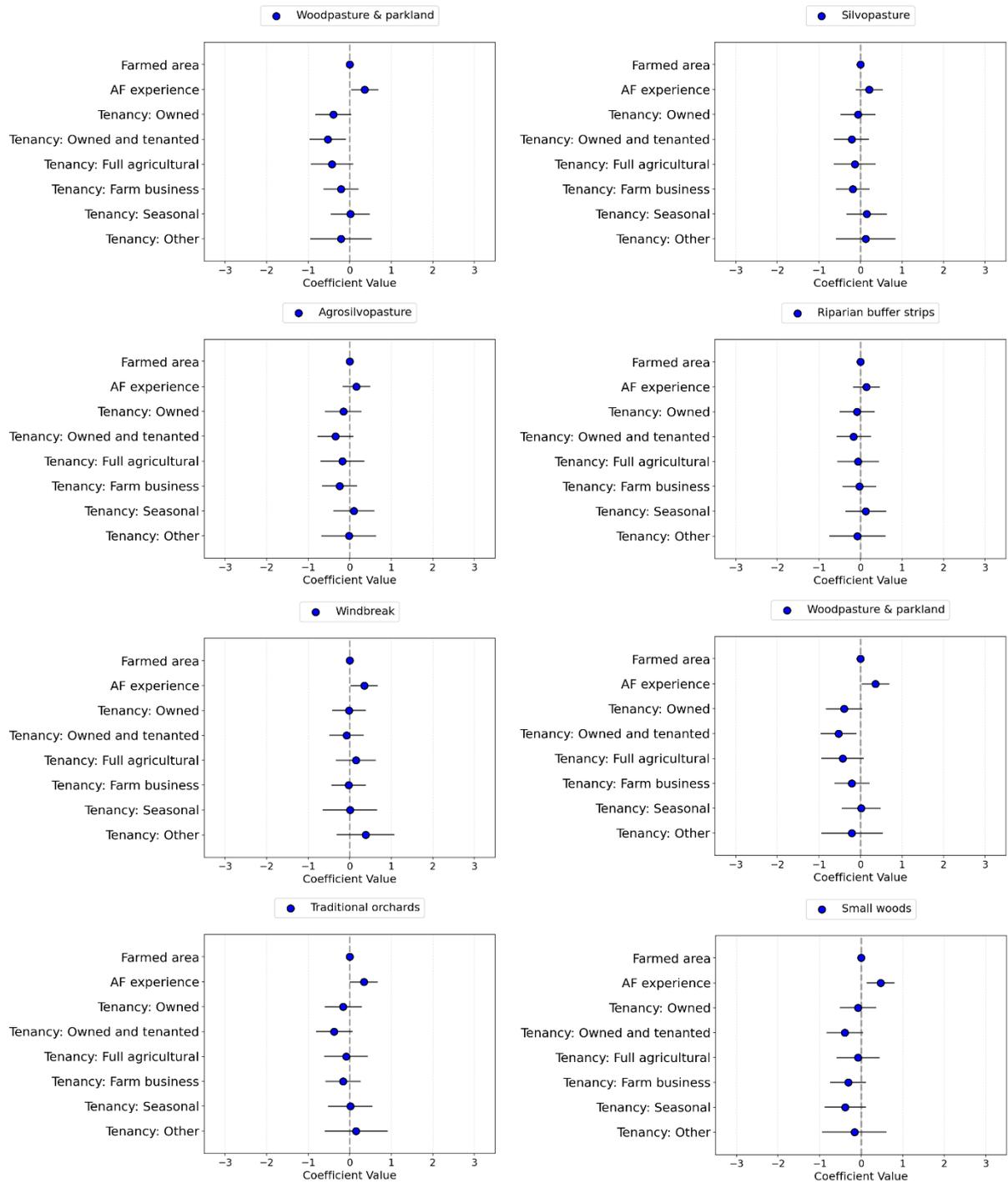


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483 In relation to tenancy type and the adoption of AF practices, Watkins et al. (1996) identified
1 484 the tenant farmer's need to consult with landowners as a reason for not planting woodland.
2
3 485 However, we find that tenancy type is not associated with the likelihood of adopting AF
4 486 practices when controlling for economic, social, policy and other structural factors.
5

6 487 A factor discouraging adoption of AF practices is that farmers lack experience with AF
7
8 488 (Barnes et al., 2022; Rois-Díaz et al., 2018). Here, farmers' experience with AF practices is
9 489 positively associated with the adoption of windbreaks, wood pastures, and parklands, as well
10 490 as traditional orchards and small woods (i.e., farmers with experience in these AF practices
11 491 are more likely to adopt them in 5-year practices than farmers with no experience). This
12 492 indicates that the likelihood of adopting silvoarable, silvopasture, agrosilvopasture, riparian
13 493 buffer strips, wood pasture and parkland is not dependent on farmers' experience with AF.
14 494 Barnes et al. (2022) advocate for a dual approach to policy intervention that distinguishes
15 495 between past adopters (experienced farmers) and those reluctant to adopt as an initial step in
16 496 AF implementation. These findings suggest that the successful implementation of this dual
17 497 approach would need tailoring to specific AF practices. Farm area was found not to be
18 498 associated with the likelihood of adoption, which is in line with Felton et al. (2023).
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24 499 **Figure 6.** Influence of structural factors on farmers' intention to adopt AF practices (3:
25 500 Farmed area, AF experience and tenure type) (Coefficient Estimates with 90% Confidence
26 501 Intervals)
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504 4.3 Social factors

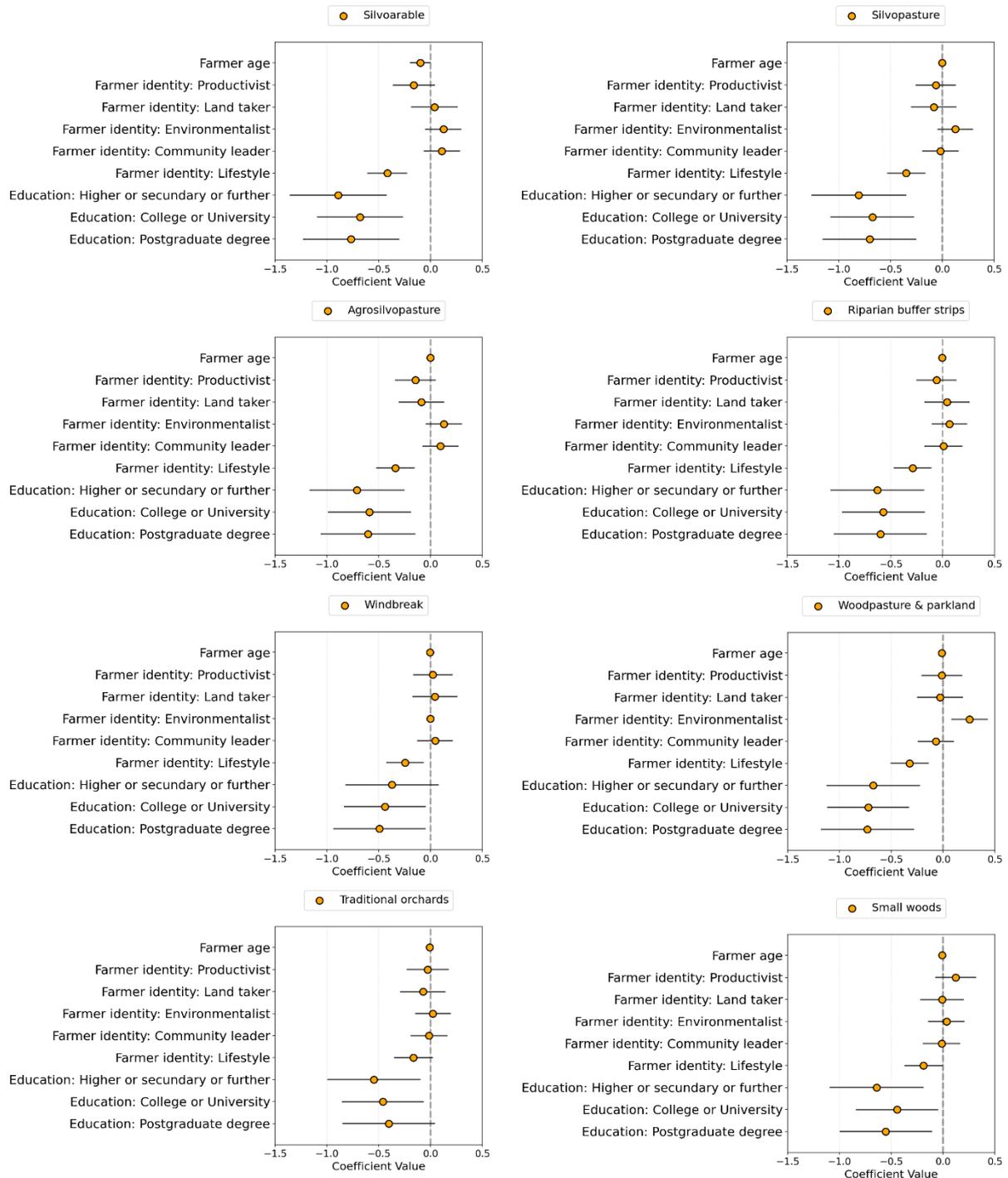
505 Social factors, such as farmers' age, education, and identity, influenced the adoption of
 506 different AF practices in various ways (Figure 7). The farmer's age was found to be
 507 negatively correlated with the adoption of silvoarable and wood pasture and parkland. Older
 508 farmers were less likely to adopt these practices, potentially due to the perceived amount of
 509 time required for the delivery of economic payments; however, no difference in adoption by
 510 age was found for other AF practices. However, this finding should be interpreted with the

511 awareness that our sample is overrepresented by relatively younger farmers compared to the
1 512 national population. The findings are partially in line with Rois-Díaz et al. (2018), who found
2 513 that older farmers were less likely to implement AF practices in general. Farmers whose
3 514 highest level of education is primary/secondary school up to 16 years are more likely to adopt
4 515 AF practices than farmers with higher education levels.

7 516 Farmers' identity can also play a role in AF adoption. Farmers who consider a "good farmer"
8 517 to be someone who sees farming as a lifestyle, helps friends and neighbours with farming,
9 518 and values landscape aesthetics are less likely to adopt AF practices, with the exception of
10 519 traditional orchards. This may be because these farmers perceive AF adoption as a potential
11 520 threat to the social and cultural benefits they derive from their farms, making them reluctant
12 521 to change their current land use practices (Howley et al., 2015). Such a stewardship-oriented
13 522 ethos, which emphasises tradition, mutual support, and aesthetic appreciation of the rural
14 523 environment, needs to be carefully considered when promoting AF practices among British
15 524 farmers. Farmers who consider a "good farmer" to be someone who minimises negative
16 525 impacts of farming on wildlife, minimises the use of pesticides/fungicides that harm wildlife
17 526 health, maintains habitat for wildlife, manages for both profit and environment, and considers
18 527 long-term conservation of farm resources before short-term profits are more likely to adopt
19 528 wood pasture and parkland. This is consistent with US research, where farmers with an
20 529 environmentalist identity were more likely to plant trees and shrubs on their farmland (Dixon
21 530 et al., 2022). Kam and Potter (2024) point out an increase in demand for land from new non-
22 531 farming/lifestyle landowners (e.g. people interested in carbon markets), increasing the
23 532 heterogeneity of land ownership. These new non-farming/lifestyle landowners may have
24 533 different attitudes towards agri-environmental schemes compared to farmers, with social and
25 534 environmental implications.

35 535

37 536 **Figure 7.** Influence of social factors on farmers' intention to adopt AF practices (Coefficient
38 537 Estimates with 90% Confidence Intervals)



538

539 4.4 Policy factors

540 Understanding how farmers' preferences for AF scheme features may influence the adoption
 541 of AF practices is key to tailoring schemes to better meet farmers' needs, thereby increasing
 542 farmers' uptake of AF practices.

543 Farmers who prefer monetary payment and non-monetary support (e.g. training, advisory,
 544 marketing assistance with the produce of trees) as a feature of an AF scheme express a higher
 545 likelihood of adopting some of the eight AF practices studied (specifically, silvopasture,
 546 agrosilvoapsture, windbreaks and traditional orchards). Farmers who consider the payment

547 level as an important feature in an AF scheme indicate a higher likelihood of adopting each of
1 548 the AF practices analysed, with the exception of small woods. The use of upfront payments
2 549 has been previously found to increase the likelihood of adoption, but these need to be
3 550 (perceived to be) significant (Abdul-Salam et al., 2022). A preference for upfront payments
4 551 was not found to influence the probability of adoption. However, the upfront cost involved
5 552 represented the main financial and regulatory barrier to adoption of silvoarable, silvopasture
6 553 and agrosilvopasture practices.

10 554 Likewise, our results suggest that farmers who prefer schemes that allow public access to
11 555 land and require planting native species are more likely to adopt silvopasture,
12 556 agrosilvopasture, riparian buffer strips, windbreak and traditional orchards. In addition,
13 557 farmers who perceive schemes allowing public access to their land or requiring native tree
14 558 species to be planted, unappealing, are more likely to plant woodpark and parkland. As
15 559 shown in Table 3, allowing public access to land is the least preferred option of an AF
16 560 scheme, with 91% of farmers disliking public access. Hence, introducing this feature as part
17 561 of an AF scheme would possibly need to be linked to strong incentives such as a monetary
18 562 “compensation” for allowing public access. Farmers who prefer schemes with an established
19 563 minimum planting density are more likely to adopt agrosilvopasture, riparian buffer strips,
20 564 windbreaks, and traditional orchards.

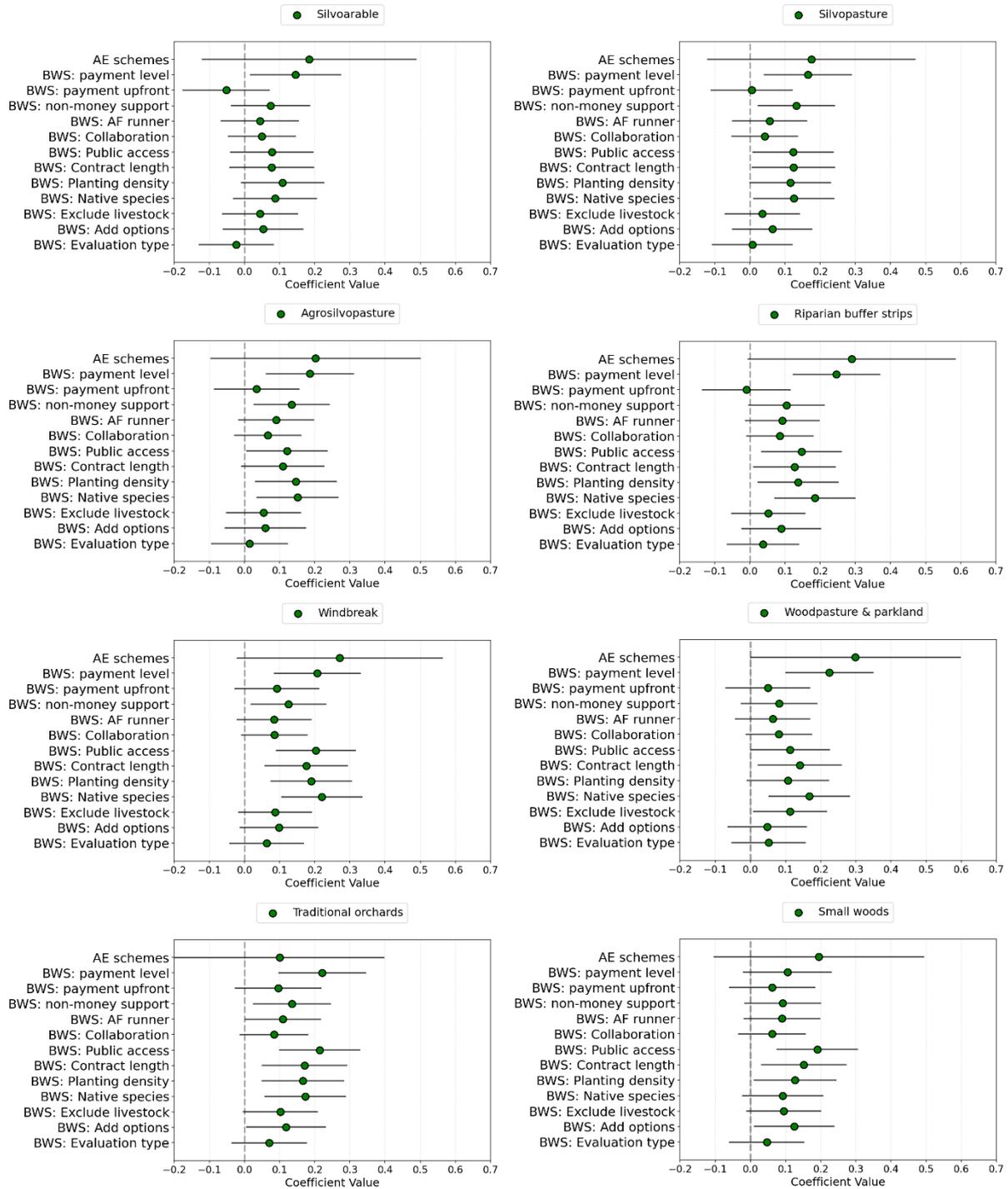
26 565 Farmers who showed a preference for schemes allowing them to select the type of scheme
27 566 (e.g., government, private sector, public-private partnership) or requiring collaboration with
28 567 other farmers were neither more nor less likely to adopt AF. To incentivise farmers to
29 568 collaborate within an AF scheme, the introduction of communication strategies and specific
30 569 monetary compensation may be necessary. Previous research on the relationship between
31 570 collaboration with other farmers and the adoption of AF practices has yielded mixed results.
32 571 Villamayor-Tomas et al. (2019) found that the need to coordinate tree planting with other
33 572 farmers was negatively associated with farmers’ participation in an AF scheme. In addition,
34 573 Emery and Franks (2012) report that such collaboration with other farmers would be more
35 574 likely if a lesser amount of land is taken out of production, or if the change were minimal.

41 575 Excluding livestock from the AF scheme was a characteristic disliked by the majority of
42 576 farmers in the sample (78%). Farmers’ preferences regarding the livestock were not found to
43 577 influence the probability of adopting AF practices, except for planting wood pasture and
44 578 parkland. In this case, the more acceptable it was for farmers to exclude livestock as part of
45 579 the AF scheme, the more likely they were to adopt wood pasture and parkland.

49 580 Farmers who considered the scheme contract length as important were more likely to adopt
50 581 all AF practices, except for silvoarable and agrosilvopasture. Farmers who considered the
51 582 planting density an important characteristic of an AF scheme were more likely to adopt AF
52 583 practices with the exception of silvoarable, silvopasture and wood pasture and parkland.

55 584 Finally, the likelihood of AF uptake did not differ significantly across farmers with different
56 585 preferences regarding how the performance is evaluated (e.g. based on measurable outcomes,
57 586 changes made to the farmland, or both).

587 **Figure 8.** Influence of preference over scheme characteristics on farmers' intention to adopt
 588 AF practices (Coefficient Estimates with 90% Confidence Intervals)



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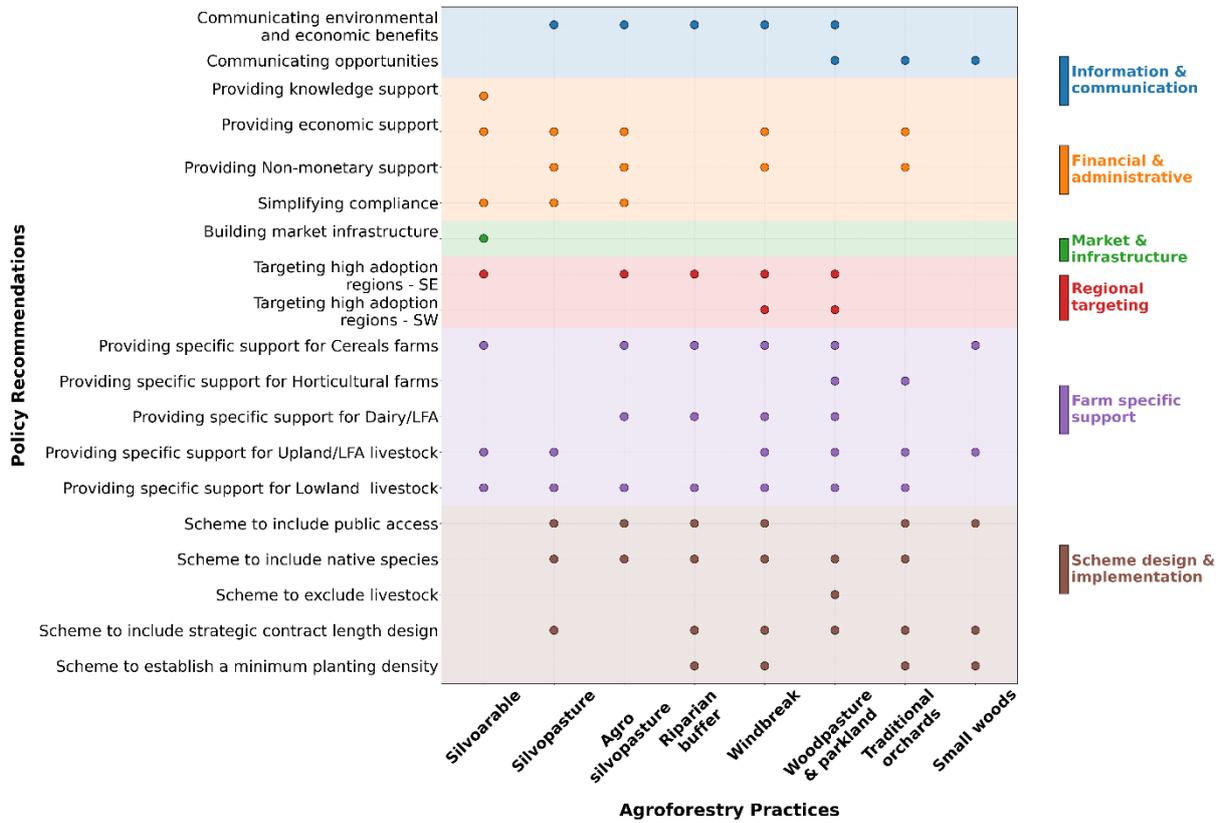
590

591 **4.5 Policy recommendations**

592 Figure 9 presents a policy-practice alignment matrix showing recommended policy
 593 interventions to encourage adoption of agroforestry practices. Each dot indicates a specific

594 policy recommendation applicable to a given AF practice, with dots coloured by policy
 595 category. Empty spaces indicate that no specific recommendation was identified.

596 **Figure 9.** Policy-AF practice Matrix: Recommended policy interventions to encourage AF
 597 adoption



598
 599 While Figure 9 summarises which policy interventions are relevant for different AF practices,
 600 effective implementation of these policies also requires considering farmer characteristics.
 601 An efficient AF policy should focus on targeting farmers and AF systems that are more likely
 602 to provide environmental benefits at relatively low cost (of implementing a policy). In this
 603 regard, the analysis can be used to design strategies specific to each of the eight AF practices
 604 studied. For instance, strategies aiming to increase silvoarable adoption could primarily target
 605 young farmers who do not view farming as a lifestyle choice, with a full agricultural tenancy
 606 and farms located in cereal-growing areas, such as the Southeast, Northeast, East of England,
 607 and Yorkshire. Also to increase uptake, policymakers should develop strategic contract
 608 designs that balance duration with flexibility and financial security. This means offering
 609 secure, long-term agreements with clear exit options and risk mitigation to align with farmer
 610 priorities.

611
 612 **5. Research limitations and future research**

613 This study does not include Northern Ireland farms, which does not allow us to derive
 614 conclusions and generalise the results to the UK level. We find that AF adoption varied
 615 across the UK which may be attributed to differences in traditional practices, biogeographic

616 conditions and types of farming practiced. However, further research is needed to explore this
617 issue in more detail. Qualitative methods may enable a more in-depth examination of the
618 underlying reasons for these differences.

619

620 The composition of our sample, which disproportionately includes younger farmers relative
621 to the national farming population is a limitation. Given that prior research (Rois-Díaz, 2018)
622 suggests older farmers may be less inclined to adopt agroforestry, this age bias could have led
623 to an overestimation of overall enthusiasm for AF practices in the wider farming community.
624 Consequently, the actual level of interest and potential adoption rates among the regional
625 population may be lower than those indicated by our study.

626 Research on AF adoption could be expanded to not only examine not only the practices that
627 farmers are willing to adopt, but also consider the specific tree species and the area they are
628 willing to enrol in an AF scheme. This would assist the design and implementation of more
629 targeted and effective policies aiming to increase the presence of trees on farmland and the
630 tree cover in the UK.

631

632 **6. Conclusions**

633 The UK and devolved governments have introduced policies to increase the tree cover and
634 meet net-zero and environmental goals. AF can play an important role in achieving these
635 goals, yet farmer uptake remains low. Using a survey of farmers across England, Scotland
636 and Wales, we analysed how economic (perceptions of barriers, benefits and opportunities),
637 structural (farm characteristics), social (farmer identity and demographic characteristics) and
638 policy (preferences for the characteristics of an AF incentive scheme) factors influence the
639 likelihood of adoption of eight distinct AF practices.

640 Economic, structural, social, and policy factors can influence AF adoption, but their influence
641 varies significantly by practice. The results suggest that, over the next five years, adoption is
642 forecast to be greater for low-intensity practices, such as small woods, windbreaks, and
643 traditional orchards, compared to integrated systems, including silvoarable, silvopasture, and
644 agrosilvopasture.

645 Our analysis offers valuable insights for designing more effective policies to promote AF
646 adoption in the UK. Even when farmers see benefits in agroforestry, that positive view rarely
647 leads to adoption—unless the practice is low-risk and simple. Promoting awareness and long-
648 term opportunities is not enough to overcome farmers’ hesitation toward more complex
649 practices like silvoarable systems. Policy must therefore address practical barriers and reduce
650 perceived risk to turn favourable opinions into actual adoption. We find that a combination of
651 tailored interventions is required. Three main findings should guide future strategy: a)
652 adoption is practice-specific so policy cannot be uniform across the UK and in relation to
653 agricultural practices; b) effective agroforestry policy requires a dual strategy of practice-
654 specific support (e.g., market infrastructure for silvoarable) and demographically-tailored

655 outreach (e.g., identity-aligned messaging for different farmers); and c) by targeting specific
656 regions and farm types—for instance, focusing silvoarable support on cereal and livestock
657 farms in South East England—policy can be optimised to align with local suitability and
658 farmer profiles, thereby increasing uptake efficiency.

659 Successfully scaling up AF depends on moving beyond a one-size-fits-all approach. Future
660 policy must implement differentiated, evidence-based interventions that address both the
661 technical barriers of each AF practice and the perceptual barriers of different farmer groups.

662

663

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 49 874 **Appendix A. Farmers sample distribution per English Government Office Region and**
 50 875 **country**

51
 52 876
 53
 54 877 Table A1. Farmers sample distribution per country

Region	# Farmers	% total sample	% people employed in agriculture
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England	256	76.4%	72.0%
Scotland	37	11.0%	16.0%
Wales	42	12.5%	12.0%
Total	335	100.0%	100%

878

879

880 Appendix B. Error term correlations

881 The rho coefficients are direct correlation coefficients between latent errors of the equations.

882 They range between -1 and 1 measuring the degree of association between the unobserved

883 factors influencing the AF practices adoption. All coefficients are greater than 0 indicating a

884 positive correlation (i.e. a high likelihood of adopting a specific AF practice is linked to other

885 AF practices) (Roodman, 2011).

886 Table 12. Error term correlations

	mean	std.err.
rho_12	0.96	0.01
rho_13	0.96	0.01
rho_14	0.92	0.02
rho_15	0.88	0.02
rho_16	0.85	0.02
rho_17	0.79	0.04
rho_18	0.80	0.04
rho_23	0.98	0.01
rho_24	0.92	0.02
rho_25	0.90	0.02
rho_26	0.86	0.03
rho_27	0.82	0.04
rho_28	0.79	0.04
rho_34	0.91	0.02
rho_35	0.88	0.02
rho_36	0.84	0.03
rho_37	0.79	0.04
rho_38	0.76	0.05
rho_45	0.90	0.02
rho_46	0.86	0.03
rho_47	0.83	0.04
rho_48	0.82	0.04
rho_56	0.88	0.02
rho_57	0.83	0.03
rho_58	0.86	0.03
rho_67	0.87	0.02
rho_68	0.88	0.03
rho_78	0.90	0.02

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Figure 1

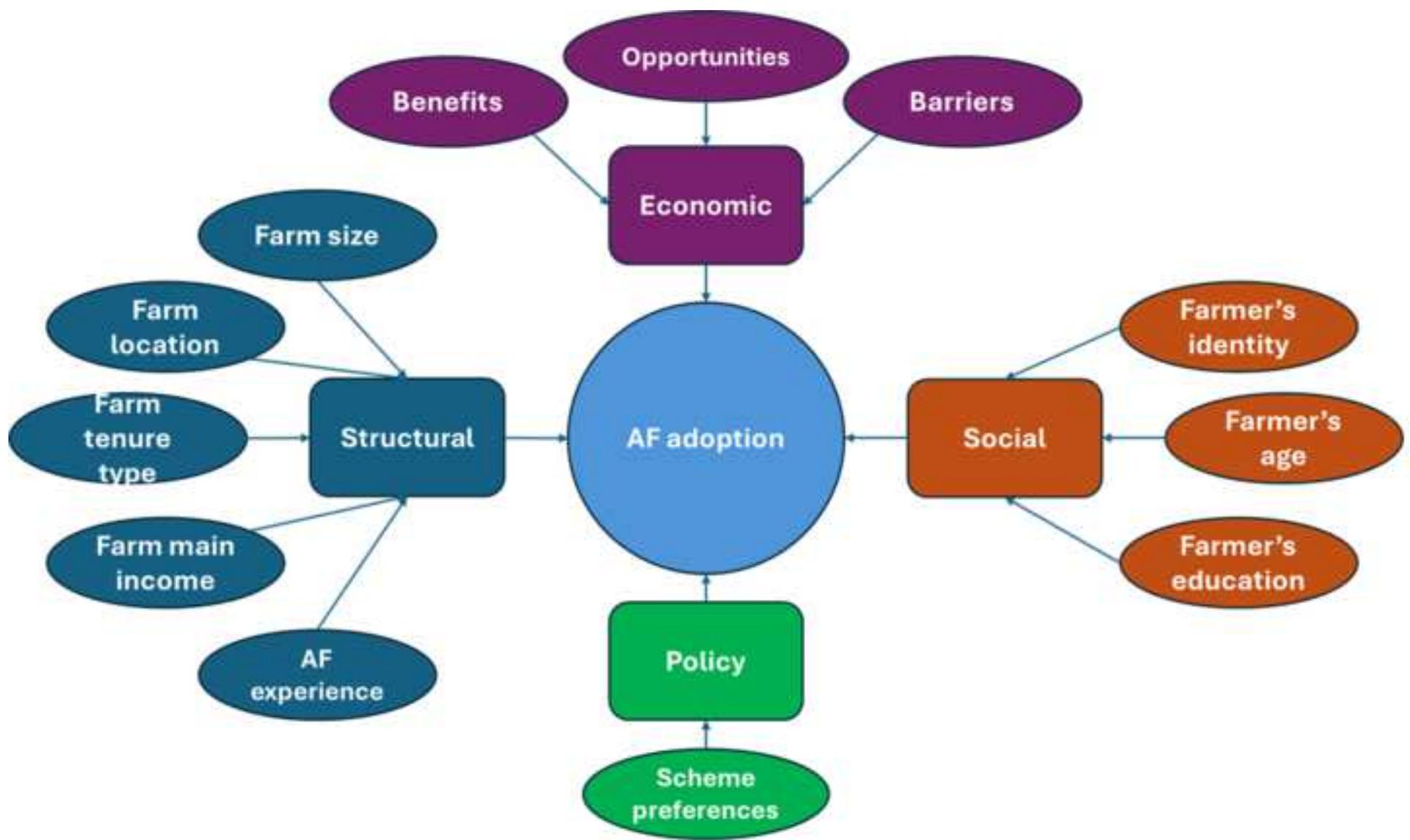


Figure 2

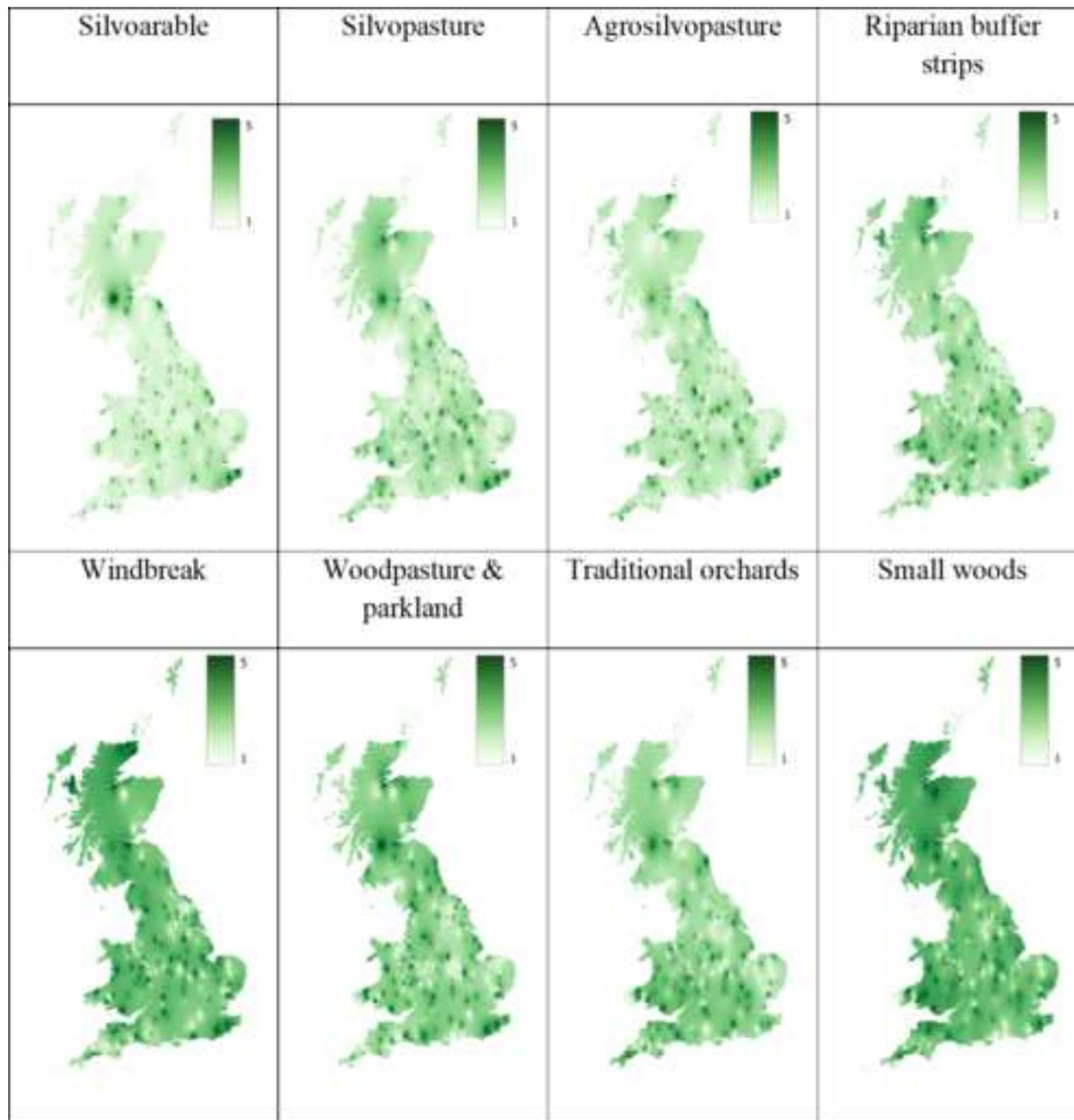
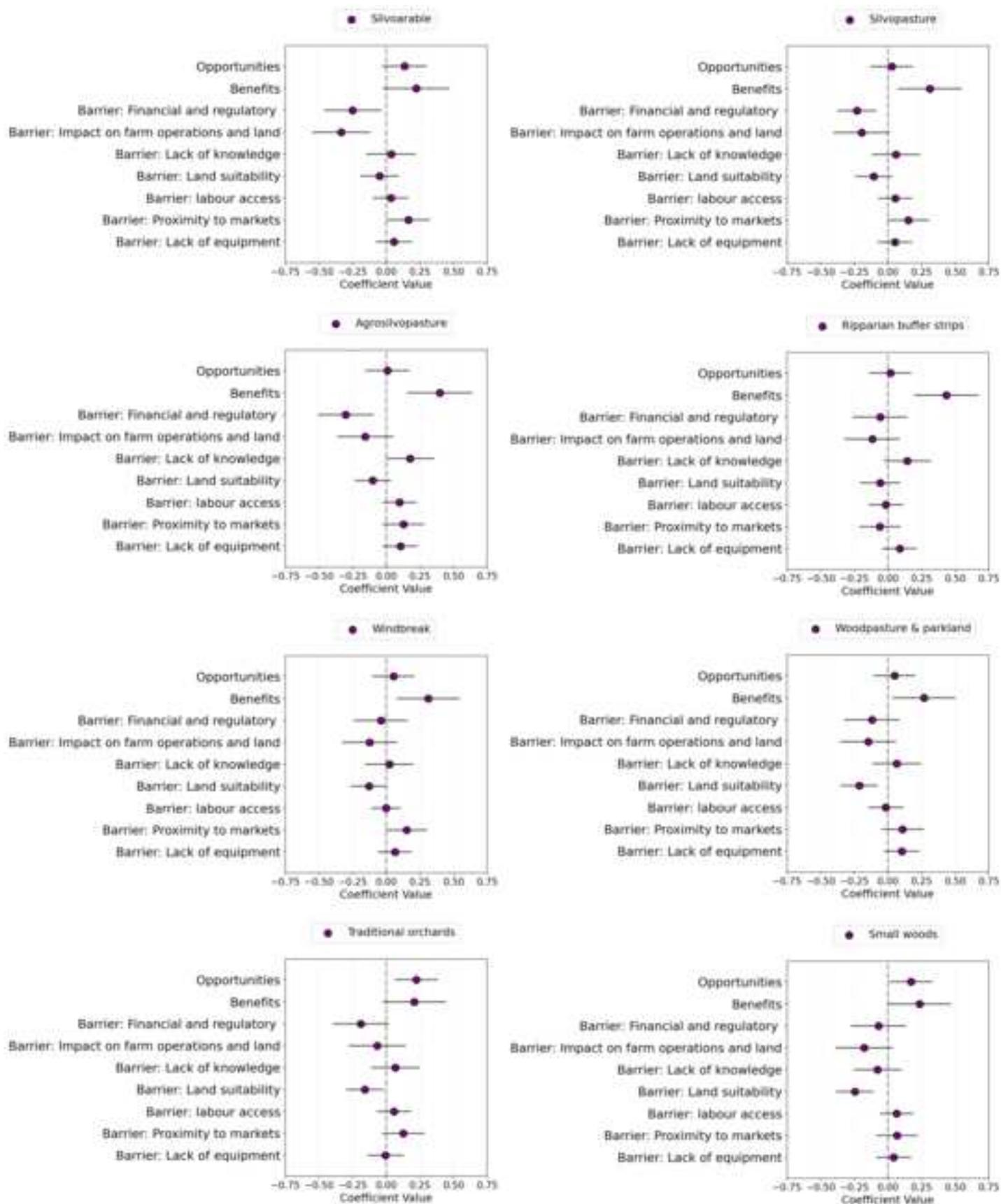
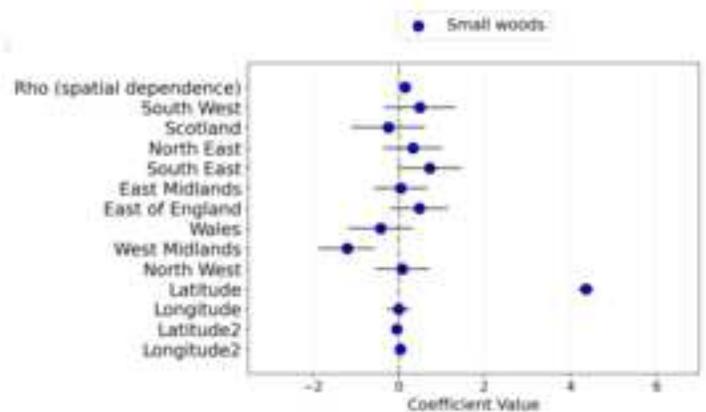
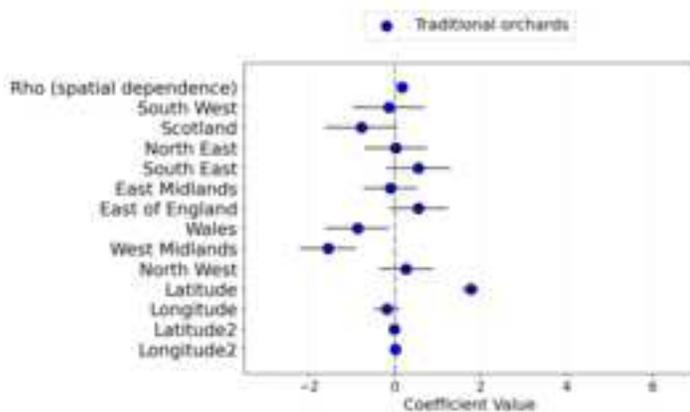
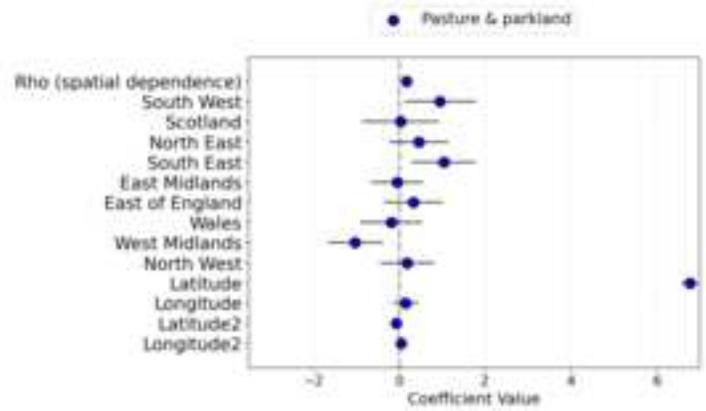
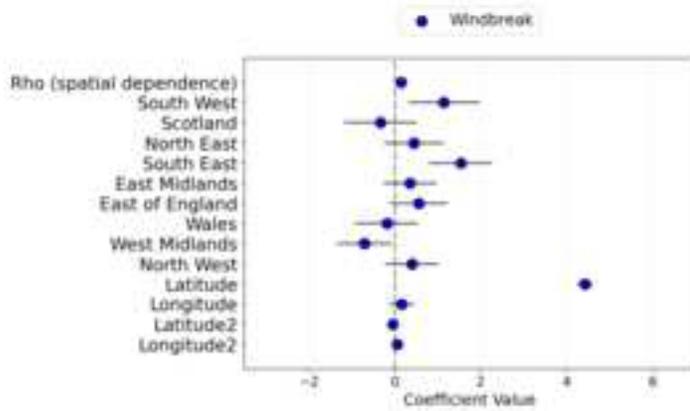
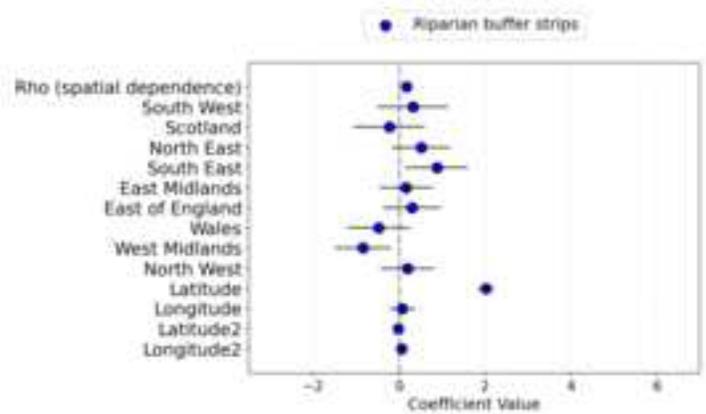
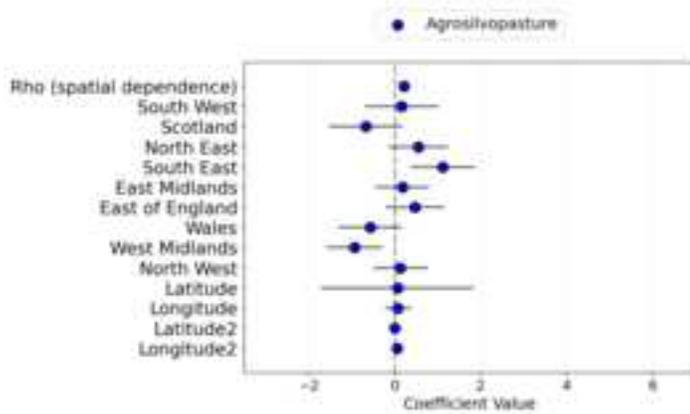
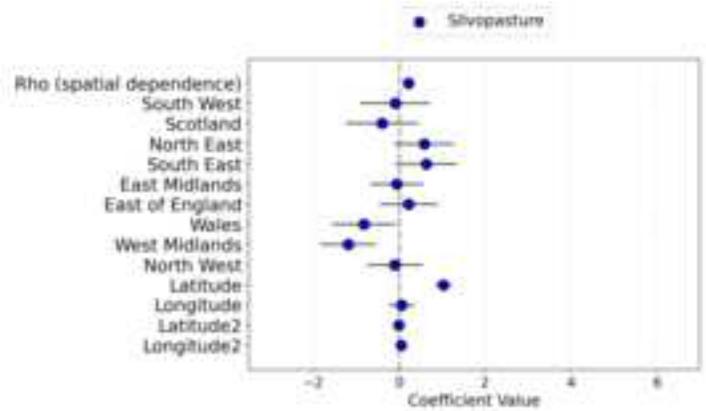
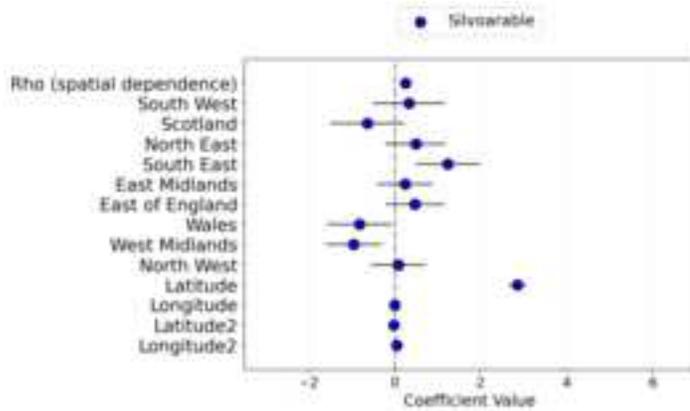
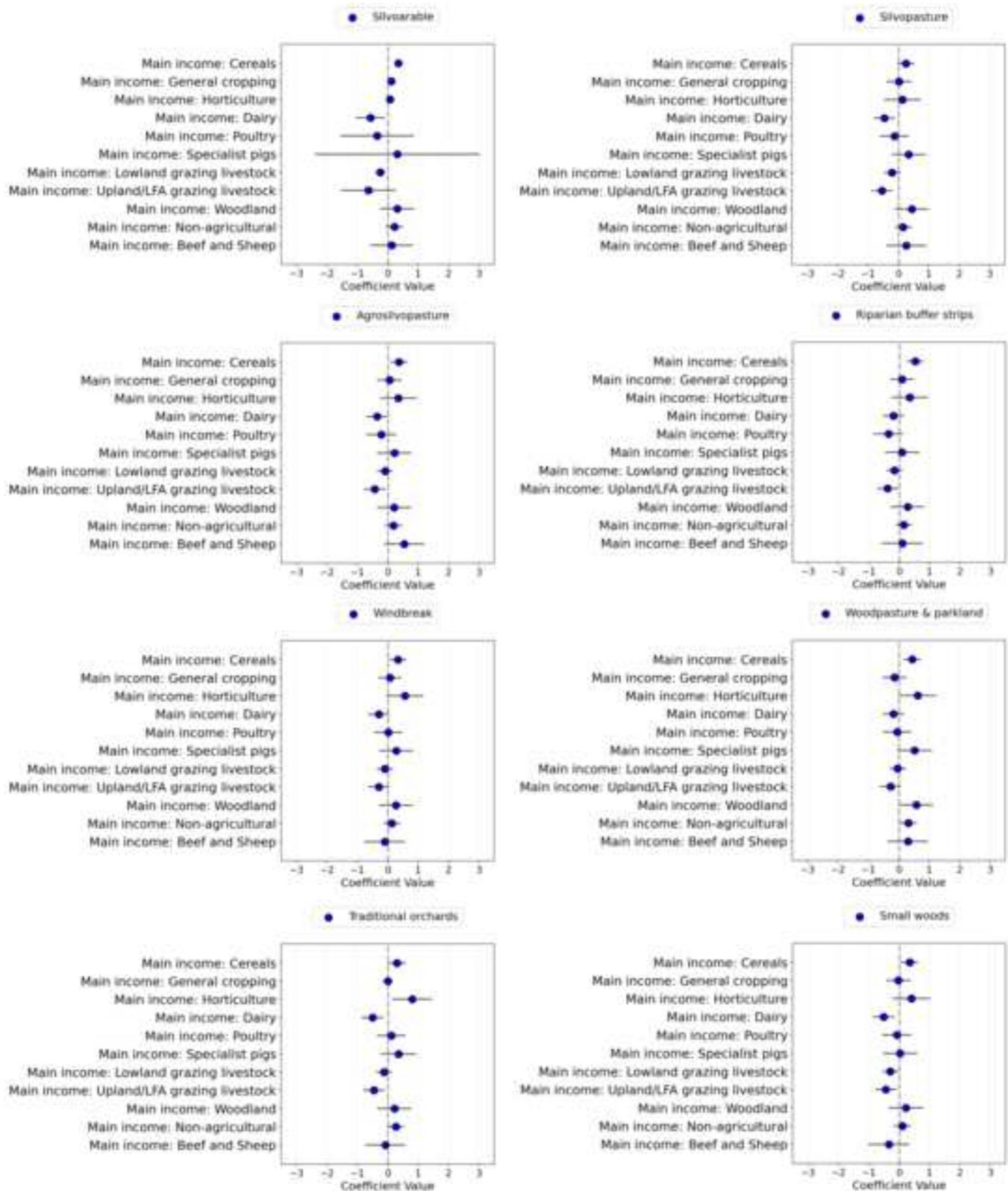
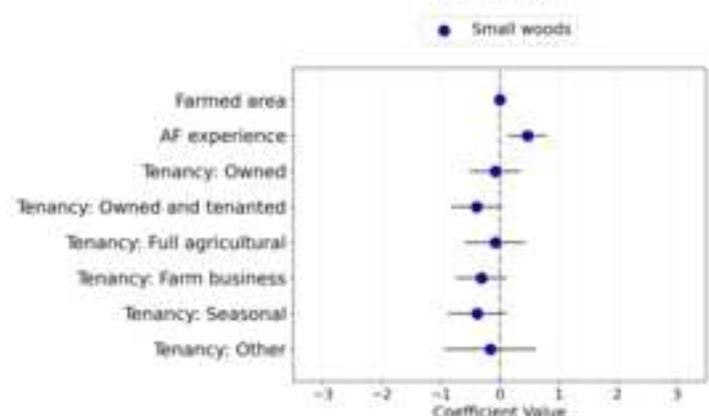
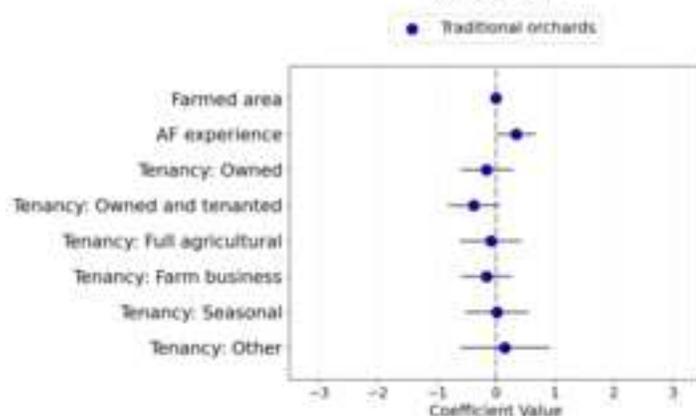
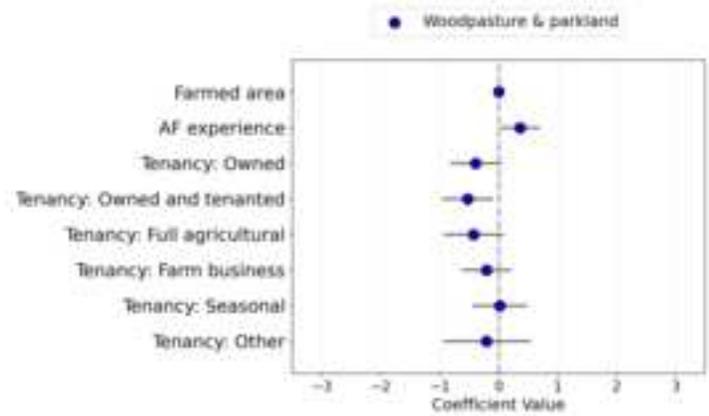
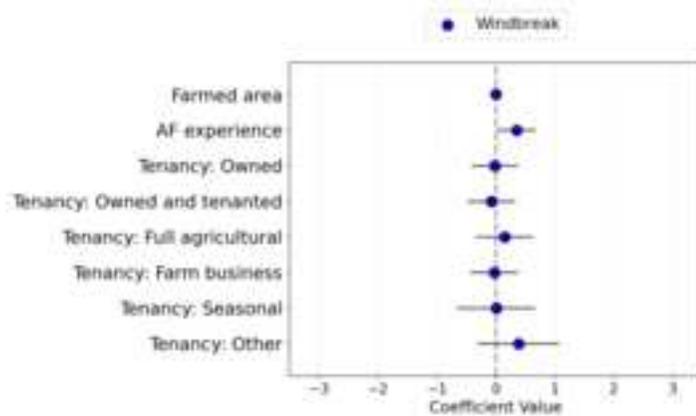
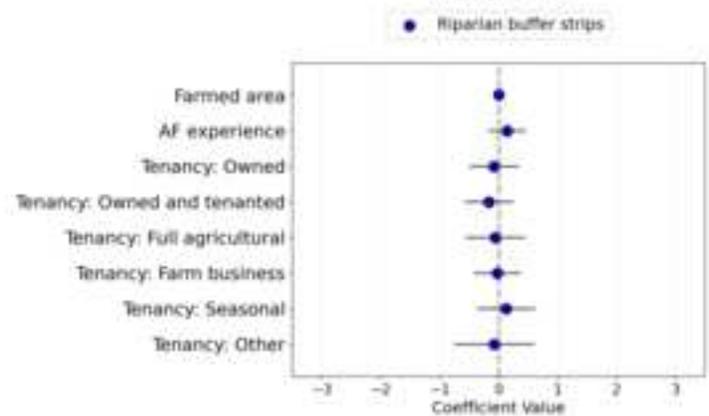
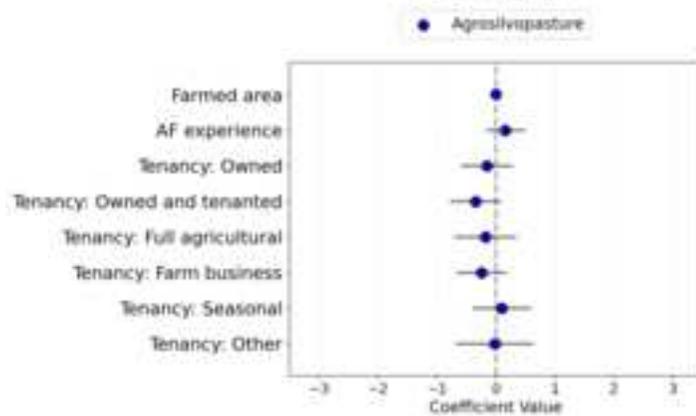
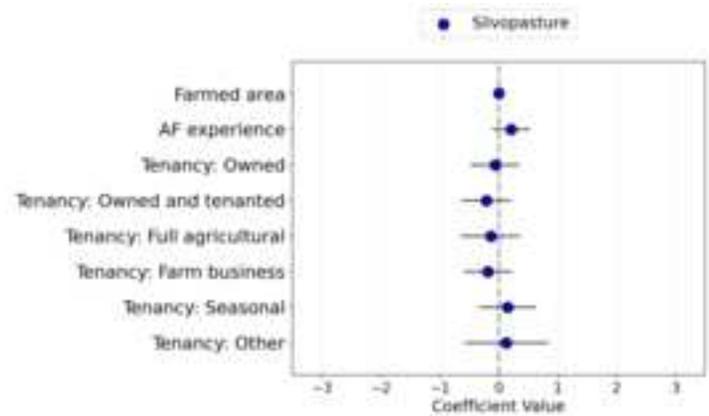
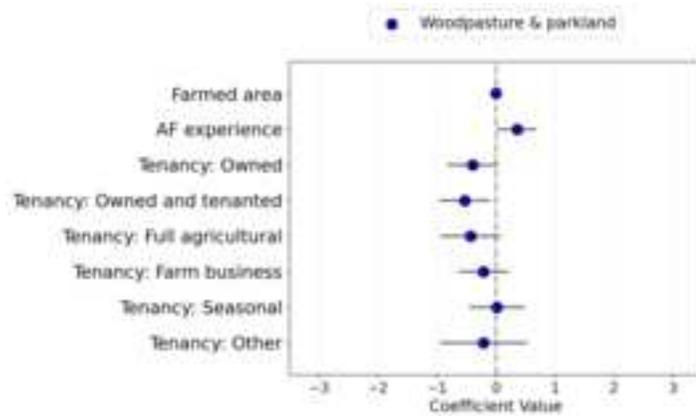


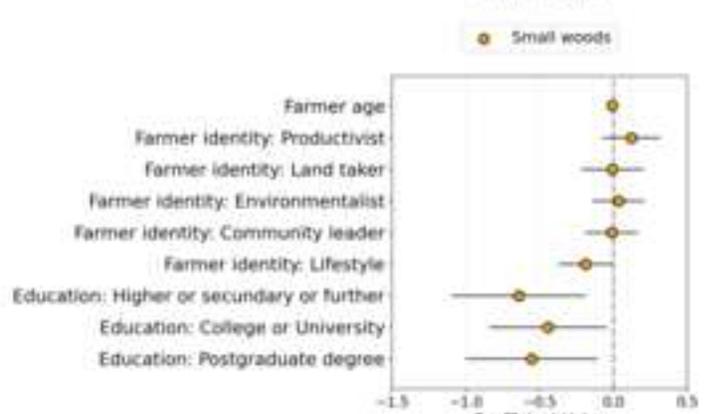
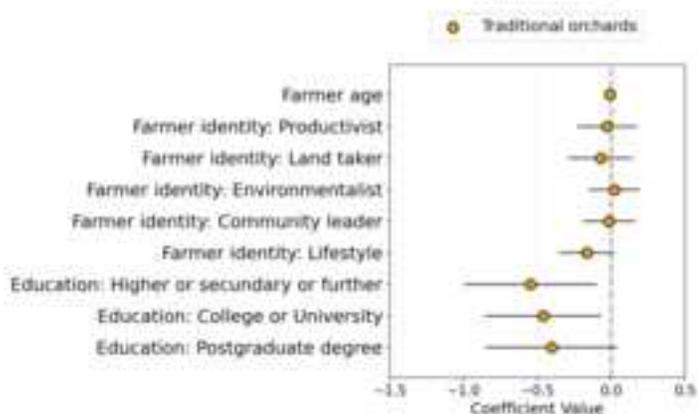
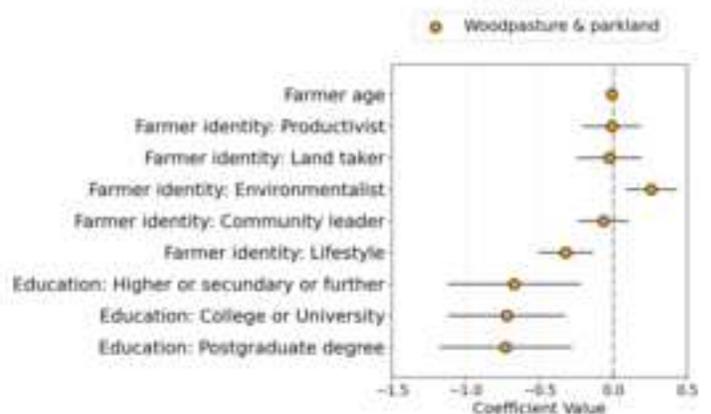
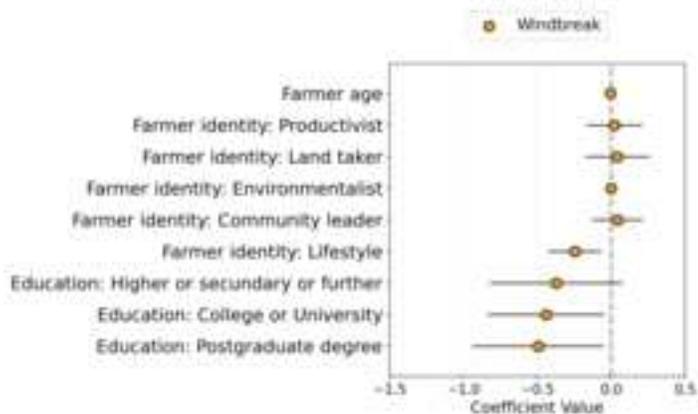
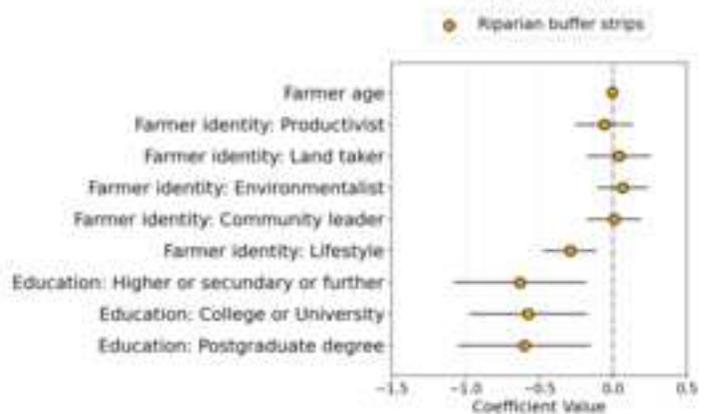
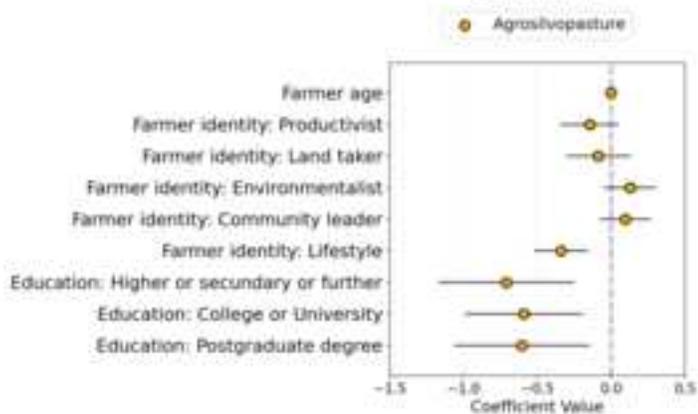
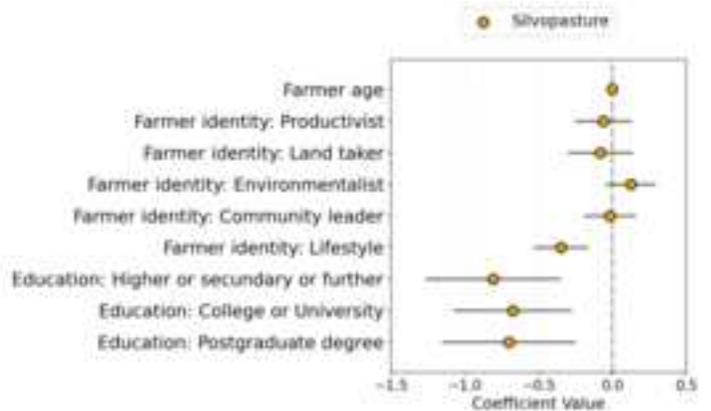
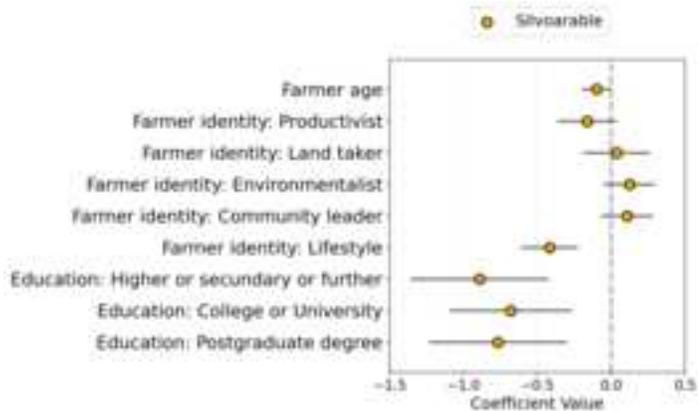
Figure 3

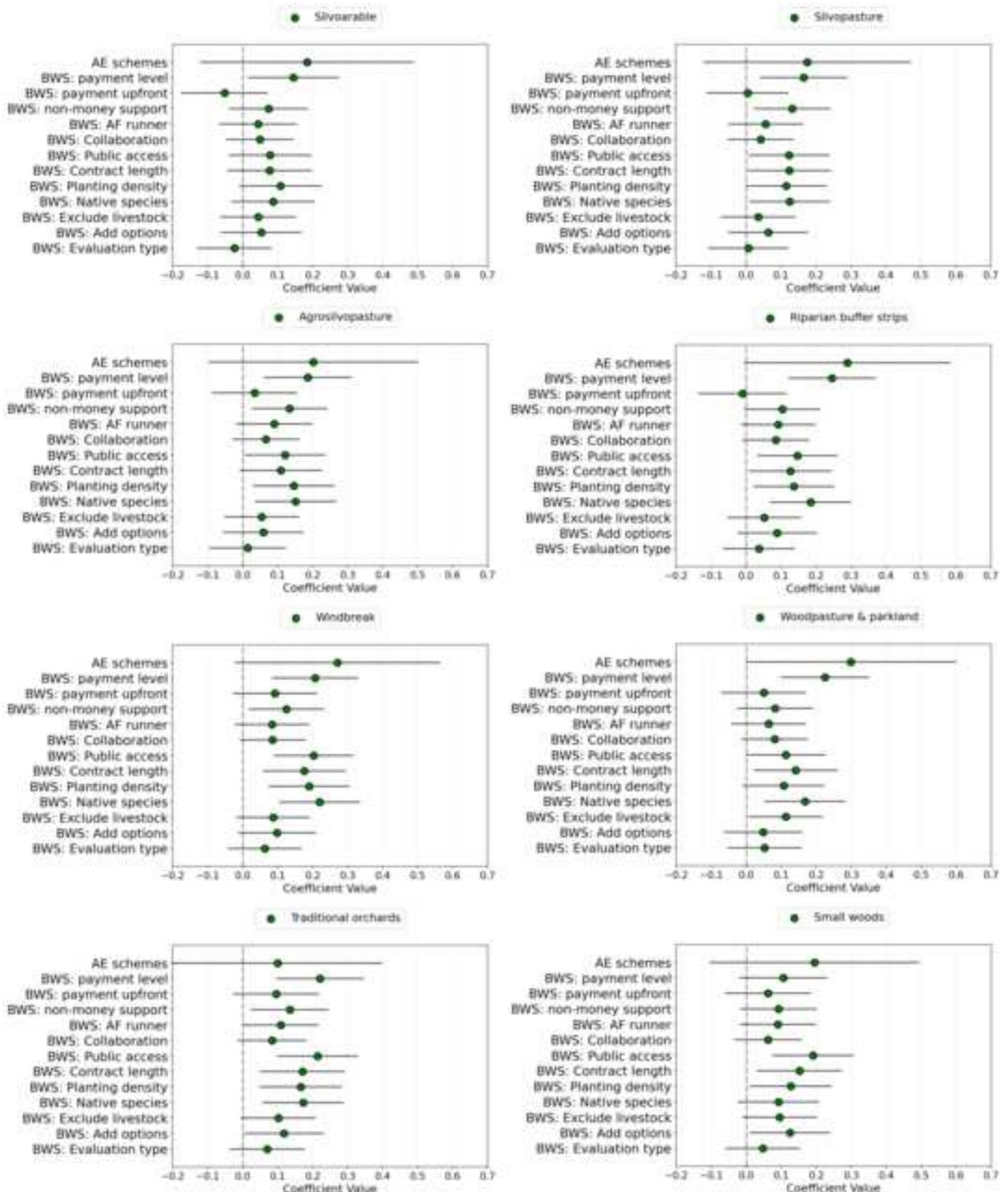


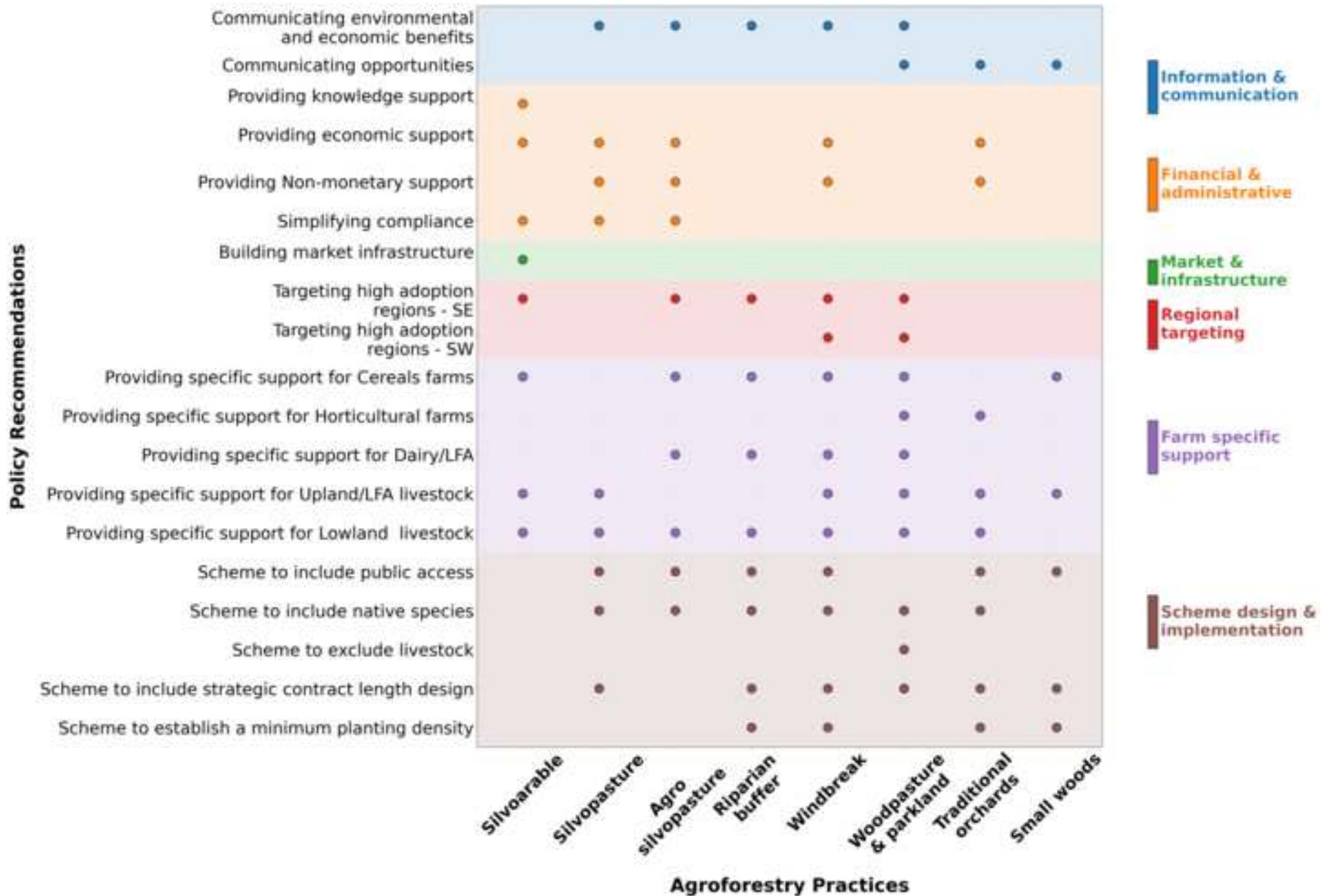


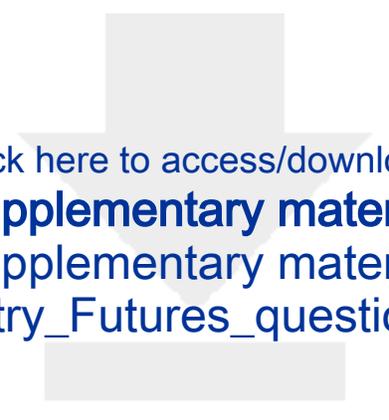












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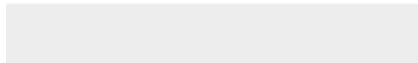
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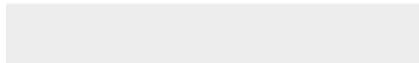
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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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