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Preferences for Sustainable Production Practices in Extensive Livestock Systems

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Abstract

We use a discrete choice experiment along with behavioral measures of risk and time preferences to analyze the preferences of Uruguayan cattle producers for three types of sustainable livestock practices: improved grazing systems, sustainable intensification, and silvopastoral approaches. The results indicate that, on average, producers favor sustainable intensification, are indifferent to improved grazing practices, and require monetary compensation to adopt silvopastoral systems. A latent class model reveals significant preference heterogeneity, identifying two distinct producer profiles: one inclined to adopt the proposed practices and another that requires stronger incentives. These findings underscore the importance of designing differentiated policy instruments tailored to the characteristics and motivations of diverse producer types.

Keywords:
Choice experiment, cattle farming, sustainability
JEL: Q1, Q2, Q5

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1. Introduction

The grazing sector is an important source of income and livelihoods and provides nourishment for more than 1.3 billion people globally, accounting for 17 percent of the total global energy intake (Nin-Prat et al., 2019). The sector also exerts substantial pressure on the environment. It generates 12% of global greenhouse gas (GHG)

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emissions, with cattle alone responsible for more than 60% of that total (FAO, 2023). It also contributes to deforestation, water pollution, and soil degradation (Steinfeld et al., 2006; Herrero et al., 2015; Thornton and Herrero, 2010). These effects are particularly pronounced in extensive grazing systems, which combine low productivity per hectare with high emissions intensity (Petermann and Buzhdygan, 2021; Arndt et al., 2022).

Although many sustainable livestock practices offer clear environmental and economic benefits, adoption rates remain low in much of the Global South (Knowler and Bradshaw, 2007; Kassie et al., 2015; Dessart et al., 2019). Structural and institutional barriers—such as land size, credit constraints, insecure tenure, low economic returns and limited extension services—are known to constrain uptake (Delaroche, 2020; Jara-Rojas et al., 2020; Xin et al., 2025).

This paper examines producers' preferences for a package of sustainable livestock practices relevant to regions with extensive livestock systems—improved grazing, sustainable intensification, and silvopastoral systems—using a discrete choice experiment (DCE) in Uruguay. DCEs have become a useful tool to study farmers' preferences and policy design, but relatively few focus on extensive livestock systems, and fewer still evaluate preferences for bundled climate-smart practices (Ruto and Garrod, 2009; Glenk and Colombo, 2011; Villanueva et al., 2015; Bougherara et al., 2021).

Beyond "classical" determinants, such as farm scale and farmers' sociodemographic characteristics, we also test whether behavioral traits—specifically, risk and time preferences—help explain willingness to adopt. Although lab-in-the-field methods have generated robust measures of these traits (Naranjo et al., 2019; Bonjean, 2023), few studies have embedded them into the preference structure of DCEs or used them to explain latent class heterogeneity (Fischer and Wollni, 2018; Ali et al. 2021; Hannus et al., 2020; Bougherara et al., 2021; Angioloni and Cerroni, 2025). This is the first study to elicit these behavioral traits for Uruguayan livestock farmers. Previous work studied the general population (Gandelman and Hernández-Murillo, 2015), and other studies in Latin America targeted row crop farmers (Gonzalez-Rodriguez et al. 2018).

Uruguay offers a strategically relevant setting for this study. Extensive cattle ranching dominates both land use and agricultural exports, and livestock is the primary source of the country's greenhouse gas emissions. At the same time, Uruguay has emerged as an innovator in climate policy, most notably by issuing sovereign sustainability-linked bonds tied to livestock-sector emissions targets. This dual condition—a country with high emissions intensity in livestock that is also a frontrunner in results-based climate finance—makes Uruguay an instructive case for understanding how producers respond to bundled, performance-oriented mitigation incentives.

Our findings defy common assumptions in two ways. First, farmers show willingness to pay for sustainable intensification (USD 22–28/ha/year)—a surprising result given that participants in mitigation programs typically require compensation. Second, although behavioral traits like risk aversion and impatience are often thought to influence adoption, we find that most preference heterogeneity is explained by farm and demographic characteristics. Farmers are indifferent toward improved grazing and express strong aversion to silvopastoral practices—especially at high adoption levels (willingness to accept, WTA, of USD 12–21/ha/year). The latent class model reveals two producer types: class A (81%) broadly reflects the average response, and class B (19%) includes small-scale, older farmers less engaged in sustainable practices and less willing to adopt them. Including behavioral variables to explain class membership improves the precision of the farm and farmers' characteristics estimates and helps to distinguish more clearly the differences in preferences for sustainable practices. In the model that includes behavioral variables to explain class membership, class B farmers' coefficients on improved grazing techniques and a medium level of sustainable intensification practices are negative and statistically significant, revealing that these farmers require compensation to adopt these practices. Nevertheless, behavioral variables do not significantly predict class membership, since none of them are statistically significant in explaining class membership. We argue this may be consistent with the short-term, low-risk, and relatively familiar nature of the proposed practices—suggesting that behavioral traits may matter only in high-risk, long-horizon decisions.

This paper makes three main contributions to the literature. First, it adds evidence on DCEs in extensive livestock systems—an understudied setting, especially in Latin America. Second, it provides insight into farmers' preferences for bundled climate-smart interventions. Third, it shows that the relevance of behavioral traits in adoption models may depend on context, supporting their use in some, but not all, policy environments.

The rest of the paper is organized as follows. Section 2 presents the geographical and institutional context of the survey. Section 3 describes the choice experiment design. Section 4 summarizes the responses to the behavioral questions. Section 5 outlines the model specification. Section 6 describes the variables used in the models and the sample. Section 7 reports the results. Finally, Section 8 concludes.

2. Geographical and Institutional Context

Uruguay is a prominent beef producer, located in La Pampa grasslands area. Animal production takes place in extensive farming systems that rely on natural grasslands. Beef production is a major component of Uruguay's agriculture sector and the primary land use (accounting for more than 80% of agricultural land). Historically, beef has been the main export product, with forestry products having gained share in recent years. It is also an important source of livelihoods, with almost 50,000 cattle production units and around 65,000 livestock producers.

Cattle production is responsible for 68% of GHG emissions in the country (Ministerio de Ambiente, 2022), mainly from enteric fermentation. Although Uruguay has recently invested in the promotion of sustainable practices to mitigate the sector's emissions, it does not offer subsidies to incentivize their adoption. Sustainable practices in livestock production are embedded in Uruguay's nationally determined contribution (NDC) under the Paris Agreement and in sustainability-linked bonds recently issued by the government, which ties interest rates to reductions in GHG emissions intensity.

Public and private institutions have a long history in the country, with organizations that represent livestock producers dating to the 19th century. The country also has a robust animal health system, with the beef production chain monitored by the Ministry of Livestock, Agriculture, and Fisheries and related institutions. The ministry also manages an internationally recognized system that traces the movement and location of individual bovine animals from birth. In addition, several other public institutions, such as the National Meat Institute (abbreviated INAC, for its name in Spanish), the Department of Agronomy of the University of the Republic, and the National Institute of Agricultural Research (INIA), carry out research on beef production and animal science and provide technical advice to firms along the value chain. Instituto Plan Agropecuario is the main public organization that offers training and advisory services to more than 4,000 cattle producers across Uruguay.

3. Choice Experiment

3.1. Survey

The survey has three main sections: (1) questions on producer and farm characteristics, including adoption status of sustainable practices and perceptions regarding their benefits and costs; (2) the discrete choice experiment; and (3) behavioral questions. The DCE is presented before the behavioral section to avoid introducing potential biases into the choice tasks.

The DCE comprised a series of choice cards, each presenting producers with three hypothetical agri-environmental programs, one of which was the status quo. Administered by the government, these programs offered payments in exchange for the adoption of the aforementioned sustainable practices.

The survey was distributed via a Qualtrics link shared through WhatsApp by the Instituto Plan Agropecuario to different producers' groups. The distribution method aligned with the organization's standard practice for administering surveys to its network of producers. Importantly, before we ran the final survey, we conducted semistructured interviews with nine producers and ran two pilots with 35 producers each, aimed at identifying and addressing potential design and methodology issues.

3.2. Attribute Selection

The attributes used in the choice experiment were selected based on a review of the literature, expert consultations, and the nine semistructured interviews with producers. The goal was to identify production practices that reduce GHG emissions from the cattle sector in Uruguay. A summary of the sustainable practices in extensive systems is provided in Appendix 1. The semistructured interviews were used to determine the attribute levels and to refine the survey's vocabulary and language. Varying attribute levels allowed us to assess producers' preferences across a range of program designs.

The hypothetical agri-environmental programs in the survey had four attributes: (1) incorporating artificial pastures and/or forage crops in the grazing area, (2) sustainable intensification practices, (3) silvopastoral practices, and (4) payment. The first attribute has the objective of increasing overall pasture production and quality and reducing the stocking rate in the natural grasslands grazing area, especially in periods of forage shortages. It includes grass-leguminous fodder mixtures and annual crops (corn, sorghum, oats, barley) that can be used for animal feed. The levels of this attribute are the percentage increase of their share in the total farm area: increases of 0%, 1%, 5%, and 10%, relative to the existing level.

For the second attribute, we considered four sustainable intensification practices:

1. Seasonal adjustment of stocking rate: rotating cattle based on forage availability and herd requirements, monitoring weight and body condition, and adjusting accordingly.
2. Defining breeding periods and categorizing females: reproductive planning, health monitoring, and grouping cows for nutritional and reproductive management.
3. Prebreeding bull review and pregnancy diagnostics: semen quality checks, hormone testing, and recordkeeping.
4. First pregnancy at two years and postcalving nutrition: tracking weight, scoring body condition, providing supplementary diets, and using artificial insemination for heifers.

This second attribute has four levels: (1) no practices adopted, (2) first practice adopted, (3) practices 2, 3, and 4 adopted, and (4) all practices adopted.

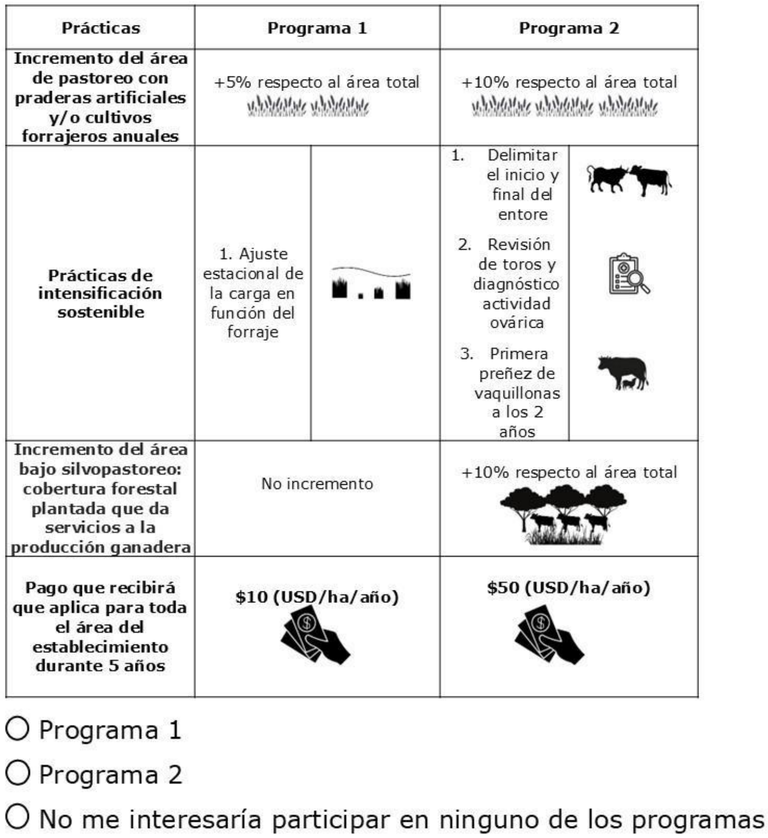
The third attribute is the silvopastoral system, which integrates trees, natural grasslands, and livestock in the same area, where trees are planted at an optimized density such that they do not compete for resources with the natural grassland. The levels of the attribute refer to the increase in the area under silvopastoral management as a share of the total farm area: increases of 0%, 1%, 5%, and 10%, relative to existing levels.

The fourth attribute is the payment. Levels were inferred from Instituto Plan Agropecuario's reports (*Carpetas Verdes*), which include reports on costs and revenues, with six values: USD 10, 20, 30, 40, 50, and 60 per hectare of the total area, applied to the entire farm area.

Before participants were shown the choice cards, they were informed that the objective was to understand their preferences for program options to promote sustainable practices. Each card would display two hypothetical programs offering annual payments per hectare of the entire farm, conditional on implementing the listed measures. The text also mentioned that the practices would be monitored and that the reporting of the practices implemented would be performed via "sworn statement," which is a widely used, legally binding document in Uruguay by which an individual or entity declares information to be true under oath. The five-year contract duration reflects standard practices in agri-environmental schemes (Bougherara et al., 2021; Guerrero, 2021; OECD, 2022).

An example choice card is shown in Figure 1. Each participant was shown six such cards and asked to choose their preferred option on each.

Figure 1: Example of choice card



Prácticas	Programa 1	Programa 2
Incremento del área de pastoreo con praderas artificiales y/o cultivos forrajeros anuales	+5% respecto al área total	+10% respecto al área total
Prácticas de intensificación sostenible	1. Ajuste estacional de la carga en función del forraje	1. Delimitar el inicio y final del entore 2. Revisión de toros y diagnóstico actividad ovárica 3. Primera preñez de vaquillonas a los 2 años
Incremento del área bajo silvopastoreo: cobertura forestal plantada que da servicios a la producción ganadera	No incremento	+10% respecto al área total
Pago que recibirá que aplica para toda el área del establecimiento durante 5 años	$10 (USD/ha/año)	$50 (USD/ha/año)

○ Programa 1

○ Programa 2

○ No me interesaría participar en ninguno de los programas

3.3. Experimental Design

The full factorial design of the choice experiment—that is, the number of unique choice cards that can be constructed from the selected attributes and levels—consists of 384 profiles. To reduce the number of evaluations while preserving statistical efficiency, a D0-efficient design was generated using Ngene. The final design was divided into six blocks of six choice cards each, resulting in a total of 36 unique cards.

4. Behavioral Factors

Although the empirical literature is mixed, behavioral traits such as risk aversion and impatience have been linked to the failure to adopt agricultural innovations in some settings (e.g., Liu, 2013; Yesuf and Bluffstone, 2009), but others report limited effects (Ward and Singh, 2015). Most of the evidence comes from observational studies or lab-in-the-field experiments. Only a few discrete choice experiments have incorporated such traits into the analysis (e.g., Fischer and Wollni, 2018; Bougherara et al., 2021). We include experimentally elicited measures of risk and time preferences to explore whether they help explain preference heterogeneity in our discrete choice setting.

4.1. Time Preferences

To capture producers' time preferences, we employed a multiple price list approach (Coller and Williams 1999, Harrison et al. 2002). More precisely, we asked respondents to make a series of eight choices. Each choice was between receiving a certain sum of money (USD 10,000) within a year or a larger amount within two years. Thus, each choice involved an implied annual interest rate in dollars,[2] which varied between 1% and 30%. Table 1 presents the choices along with the implied discount rate bounds, as well as the distribution of choices.

Table 1. Distribution of switching points and corresponding implied annual discount rate bounds

Switch point	Respondents	Lower bound (%)	Upper bound (%)
1	24 (91%)	0.0	1.0
2	1 (0.4%)	1.0	2.5
3	13 (4.9%)	2.5	4.0
4	18 (6.8%)	4.0	5.5
5	23 (8.7%)	5.5	7.0
6	45 (17.1%)	7.0	10.0
7	42 (16.0%)	10.0	20.0
8	20 (7.6%)	20.0	30.0
Never switch	77 (29.3%)	30.0	—
Total	**263 (100%)**		

The structure of the questionnaire implies that we should expect subjects to pick Option 1 for the very first questions before switching to Option 2 for the subsequent ones, without switching back. Our data show that of the 274 individuals who completed the questions, only 11 (3.8%) made such unexpected switches.

Among the 263 respondents who provided consistent answers, the distribution of time preferences reveals marked polarization. On one end of the spectrum, 21% of individuals are willing to wait an additional year for relatively modest returns—5.5% or less—indicating low discount rates. On the other end, almost 70% require returns above 7% to postpone payment by one year, reflecting a relatively high degree of impatience. Notably, nearly 30% never switch to the larger-later option, suggesting that even a 30% annual return is not sufficient to justify waiting an extra year.

[2] We follow the approach of delaying both payments (e.g., one year vs. two years) to reduce the influence of present bias and other immediacy effects. This allows for a cleaner approximation to long-run time discounting (Harrison et al. 2002, Frederick et al. 2002). Brañas-Garza et al. (2023) provide evidence that both hypothetical and fully incentivized multiple price lists yield equivalent estimates of time preferences.

4.2. Risk Preferences

Participants also completed a risk preference task involving a series of seven binary lotteries, following the ordered lottery design introduced by Eckel and Grossman (2002, 2008). Each lottery offered a 50-50 chance between a low and a high monetary payoff. Choices were designed to reflect increasing levels of risk and expected return. Specifically, the first five lotteries offer both higher expected returns and higher standard deviations. The sixth and seventh options offer the same expected return (USD 20,000) but progressively greater risk, with the final option having the highest variance. Participants were asked to select the lottery in which they would most prefer to participate.

Table 2 presents the structure of each lottery, along with the distribution of participants' choices. The implied constant relative risk aversion (CRRA) intervals are also shown, following standard calibration assumptions. A substantial share of participants (36%) chose the safest option with no variance, consistent with a CRRA coefficient above 3.56—typically interpreted as highly risk averse. Another 20% selected the second lottery, consistent with moderate levels of risk aversion. As the risk-return trade-off increases, the proportion of participants choosing each subsequent option declines, with only about 4% each selecting lotteries 5 and 6. Interestingly, 11% of participants selected the riskiest option, which implies risk-seeking behavior under CRRA assumptions. These findings suggest that although most producers are risk averse to varying degrees, a nonnegligible minority are willing to accept substantial risk for the chance of higher returns.

Table 2. Summary of 50-50 lottery choices in risk preference task

Choice	**Low payoff (USD)**	**High payoff (USD)**	**Expected return**	**Std. dev.**	**Respondents**	**CRRA interval**
1	11	11	11	0	99 (36%)	> 3.56
2	9	17	13	5.6	56 (20%)	[1.20, 3.56]
3	7	23	15	11.3	39 (14%)	[0.74, 1.20]
4	5	29	17	16.9	29 (11%)	[0.52, 0.74]
5	3	35	19	22.6	11 (4%)	[0.40, 0.52]
6	2	38	20	25.4	11 (4%)	[0, 0.40]
7	0	40	20	28.2	29 (11%)	< 0
Total					**274 (100%)**	

5. Modeling Approach for Discrete Choices

In this study, we use standard modeling approaches for discrete choice experiment data, which build on Lancaster's (1966) theory of consumer choice and McFadden's (1973) random utility framework. Because this framework is well known, we sketch it only briefly here. The main assumption is that the utility a cattle producer derives from selecting a given alternative consists of two components: an observable, deterministic part and an unobservable, stochastic error term. The deterministic component reflects the effect of the alternative's attributes on utility, and the random component captures unobserved influences and idiosyncratic preferences.

The probability that producer i selects alternative j among J available options depends on the relative utilities of all alternatives. Formally, following Lancsar and Louviere (2008)

$$\Pr(Y_i = j) = \Pr\,(U_{ij} > U_{ik})\ \ \forall\, k \neq j,$$

where utility is specified as

$$U_{ij} = \beta X_{ij} + \varepsilon_{ij},$$

with X_{ij} representing a vector of attribute levels for alternative j and producer i, β denoting the vector of preference parameters for these attributes, and ε_{ij} the error term.

Applied to the choice experiment implemented in this paper, we define this utility function as

$$\begin{aligned} U_{ij} = \beta_0 + \beta_1 grazing_1 + \beta_2 grazing_2 + \beta_3 grazing_3 + \beta_4 intens_1 + \beta_5 intens_2 + \beta_6 intens_3 \\ + \beta_7 silvopast_1 + \beta_8 silvopast_2 + \beta_9 silvopast_3 + \beta_{10} payment + \varepsilon_{ij} \end{aligned}$$

We estimate a multinomial logit and a mixed logit model, in which the β parameters are treated as random variables and the probability that producer i selects alternative j is

$$\Pr(Y_i = j|\beta_i) = \frac{e^{\mu\beta_s X_{ij}}}{\sum_{k=1}^{J} e^{\mu\beta_i X_{ik}}},$$

where μ is a scale parameter (typically normalized to 1 in estimation). The vector of parameters of interest β is estimated using simulated maximum likelihood, using the Apollo R package (Hess and Palma, 2019, 2022). Variables grazing, intens, silvopast, and payment refer to the analyzed practices and their levels (described in the next section).

Finally, we estimate a latent class model to identify different types of farmers with similar preferences for the programs and individual and farm characteristics. This approach helps characterize the heterogeneity of preferences identified through the mixed logit model in a way that facilitates policy recommendations. Indeed, a latent class model allows for the identification of segments of the farming population that would require different policy interventions for the adoption of sustainable livestock farming practices. Conditioned on belonging to class *c*, the probability of individual *i* choosing alternative *j* is defined as

$$\Pr(Y_i = j|\beta_c) = \frac{e^{\mu\beta_c X_{ij}}}{\sum_{k=1}^{J} e^{\mu\beta_c X_{ik}}}$$

The probability of choice of alternative *j* in a choice card, over *S* classes, is therefore defined as

$$\Pr(Y_i = j|\beta_i) = \sum_{s=1}^{S} M_{i,s} \frac{e^{\mu\beta_s X_{ij}}}{\sum_{k=1}^{J} e^{\mu\beta_i X_{ik}}}$$

with $M_{i,s}$ the probability that individual *i* belongs to class *s*, which depends on individuals' characteristics (vector Z_n) and an error term $\mu_{i,s}$:

$$M_{i,s} = \alpha_s Z_n + \mu_{i,s}$$

with α_s the vector parameters representing the weights of individual characteristics Z_n in the probability of class membership. This probability itself is estimated using a multinomial logit model, as follows:

$$M_{i,c} = \frac{e^{\alpha_c' Z_i}}{\sum_{S=1}^{S} e^{\alpha_c' Z_i}}$$

6. Variable Construction and Sample Description

This section describes the sample and the variables used in the econometric models. Table 3 reports the description and summary statistics for all variables used in the models. Of the farmers who completed the survey, 78% were male, with an average age of 50 years. Their production units varied substantially, averaging 898 hectares but ranging from very small holdings to operations exceeding 15,000 hectares. Appendix 2 provides a more detailed summary of land-use and socioeconomic variables.

In addition to sociodemographic and farm structure data, we collected information on management practices and constructed a set of behavioral and attitudinal variables (see Section 4 for impatience and risk aversion) for inclusion in the models that capture producers' heterogeneity. The sustainability index variable takes a value of 1 if the producer implements the practice of seasonal adjustment of stocking rate and 2 if the producer also implements at least one other intensification practice (Section 3.2[3]).

To summarize the environmental preferences into a single metric, we constructed an environmental awareness index by assigning numerical values to responses from five statements capturing perceptions of environmental issues and the role of producers. Participants indicated their level of agreement with the following statements: (1) "Global warming is a serious threat," (2) "Livestock practices negatively affect the environment," (3) "Environmentally friendly livestock practices can improve the state of the environment," (4) "I feel that my production activities contribute to local environmental problems," and (5) "I feel that my production activities contribute to international or global environmental problems (e.g., global warming)." Responses were scored as 3 for "agree," 2 for "neither agree nor disagree," and 1 for "disagree." The index was calculated as the sum of these scores. On average, respondents neither strongly agreed nor disagreed with the statements, suggesting a moderate level of environmental awareness.

To approximate producers' perception of social norms, we defined a binary variable equal to 1 if the respondent agreed with the statement "Producers in my community are willing to adopt (or have already adopted) sustainable practices," and 0 otherwise. Only 30% of respondents perceive that their peers are moving toward adoption of sustainable practices. We also measured altruistic behavior with this question: "How willing are you to make material sacrifices to contribute to good causes without expecting anything in return?" Possible responses ranged from 0 (not willing) to 10 (very willing). On average, producers report a moderate level of altruism (6).

Risk aversion was elicited through a set of lottery tasks and reverse-coded from 1 ("risk seeking") to 7 ("extremely risk averse"), based on Table 1. The discount rate was derived from the intertemporal choice tasks, calculated as the midpoint between upper and lower switching points in Table 2, assigning 50% to respondents who never switched.

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[3] The practices are (1) defining breeding periods and categorizing females (reproductive planning, health monitoring, and grouping cows for nutritional and reproductive management); (2) prebreeding bull review and pregnancy diagnostics (semen quality checks, hormone testing, and recordkeeping); and (3) first pregnancy at two years and postcalving nutrition (tracking weight, body condition scoring, supplementary diets, and using artificial insemination for heifers).

Finally, the bottom part of Table 3 provides a description of the attributes included in the models: grazing (grazing1, grazing2, grazing3), intensification (intens1, intens2, intens3), silvopastoral management (silvopast1, silvopast2, silvopast3), and payment.

Table 3. Variables reflecting sustainable practices

Variable	Description	n	Mean	SD	Min	Max
Gender	Dummy variable (1=Male)	274	0,78	0.41	0	1
Age	Age of respondent	274	50	14	20	83
Surface	Farm area (ha)	274	898	1.439	0.0	15821
Sustainability index	Categorical variable (1 = implemented seasonal adjustment of stocking rates; 2 = seasonal adjustment of stocking rates + one more sustainable intensification practice)	274	1	0.79	0	2
Environmental awareness	Index of environmental perceptions (1–3 scale per item; sum of 5 items)	274	2	0.39	1	3
Social norm	Dummy = 1 if agrees community adopts sustainable practices	274	0.30	0.46	0	1
Altruism	Willingness to sacrifice for good causes (0–10 scale)	274	6	3	0	10
Discount rate	Implied discount rate (%)	274	21	19	0.5	50
Risk aversion	Risk preference (1 = risk seeking; 7 = extremely risk averse)	274	5	2	1	7
grazing1	Increase area of artificial pastures and/or forage crops by 1%	—	—	—	—	—
grazing2	Increase area of artificial pastures and/or forage crops by 5%	—	—	—	—	—
grazing3	Increase area of artificial pastures and/or forage crops by 10%	—	—	—	—	—
intens1	Implementation of seasonal adjustment of stocking rate	—	—	—	—	—
intens2	Implementation of (1) defining breeding periods and categorizing females, (2) prebreeding bull review and pregnancy diagnostics, and (3) first pregnancy at two years and post-calving nutrition	—	—	—	—	—
intens3	Implementation of (1) seasonal adjustment of stocking rate, (2) defining breeding periods and categorizing females, (3) prebreeding bull review and pregnancy diagnostics, and (4) first	—	—	—	—	—

	pregnancy at two years and postcalving nutrition					
silvopast1	Increase area of under silvopastoral management by 1%	—	—	—	—	—
silvopast2	Increase area of under silvopastoral management by 5%	—	—	—	—	—
silvopast3	Increase area of under silvopastoral management by 10%	—	—	—	—	—
payment	USD/ha/year that corresponds to total farm area	—	—	—	—	—

A common critique of DCEs is their limited external validity, often due to nonrepresentative samples. This issue arises because accessing microdata to construct representative samples—and contacting farmers in particular—can be challenging. To check the representativeness of our sample to the population, Table 4 compares the distribution of selected characteristics of our survey respondents with data from the 2016 Nationally Representative Livestock Survey, which provides the most up-to-date information on livestock producers.

Despite some discrepancies, the sample aligns reasonably well with the population along most dimensions. Discrepancies are observed in the share of smallholders and the share of respondents whose household nonfarm income is higher than 50% of total income. Nevertheless, we address this issue by applying our preferred specification to resampled data that replicates the herd-size distribution reported in the 2016 National Livestock Survey. The results remain robust under this sample (see Section 7).

Table 4. Comparison of own survey and 2016 National Livestock Survey respondents

Variable	**Own survey (%)**	**2016 National Livestock Survey (%)**
Owners	0.72	0.64
Household off-farm income higher than 50%	0.32	0.11
≤ 299 head of cattle	0.45	0.66
300 to ≤ 999 head of cattle	0.32	0.24
≥ 1,000 head of cattle	0.21	0.10

7. Results

7.1. Mixed logit model

Table 5 reports the results of the mixed logit (MXL) model, which accounts for preference heterogeneity among respondents, run with Apollo (Hess and Palma, 2019).

The main specification was selected after testing alternative specifications (see Appendix 3). Column 1 presents the estimates from our preferred specification, based on the full sample of 274 respondents and 1,644 observations. Following Bougherara et al. (2021), columns 2, 3, and 4 present robustness checks. In the second column, we exclude respondents who reported finding the exercise too complex, based on their answers to the follow-up questions. In the third column, we remove respondents whose survey completion times were either unusually short or long—specifically, those falling below the first quartile or above the third quartile of the response time distribution. Finally, the fourth column shows results from a resampled data set adjusted to match the producer composition of the 2016 National Livestock Survey, using bootstrapping techniques.

Focusing on results from column 1, the alternative-specific constant (ASC) is positive and statistically significant, implying that farmers tend to prefer the proposed program alternatives over the status quo (conditions without the program).

The coefficients for improvements in grazing area using artificial pastures and/or forage crops are positive but not statistically significant, indicating that producers are on average indifferent to this attribute. In contrast, coefficients for sustainable intensification practices are positive and statistically significant at the 1% level for all levels, suggesting that farmers are willing to pay for adopting these practices. Furthermore, preferences for this attribute increase with the number of practices (intensification) included in a program, reflecting the producers' perception that sustainable intensification can enhance profitability.

The coefficients associated with silvopastoral practices are negative and statistically significant at the 1% level for the highest level of adoption and at only the 10% level for the medium level, but not statistically significant for the lowest level of this practice. These findings suggest that producers generally perceive silvopastoral systems as restrictive and would require compensation to adopt such practices. The coefficient of the logarithm of the payment attribute is negative and statistically significant at the 1% level, indicating a clear preference for programs that offer higher per hectare payments.[4]

These estimates also highlight substantial heterogeneity in preferences, particularly for silvopastoral and sustainable intensification practices. This is reflected in the statistically significant standard deviations of the random coefficients ($\sigma's$) in the MXL model (the bottom 11 coefficients in the table) for sustainable intensification, silvopastoral, and payment attributes.

Overall, the results from these subsamples are consistent with those obtained using the full sample. Producers generally prefer participating in the proposed programs over maintaining the status quo. They appear indifferent toward improved grazing area, value sustainable intensification practices positively, and tend to dislike silvopastoral practices, especially at higher levels of adoption. Preference heterogeneity is also

[4] We assume the payment attribute is distributed as lognormal, to ensure purely positive responses to this attribute. A negative coefficient in the log of payment therefore indicates a positive effect on utility.

evident, as shown by the statistically significant estimates of the standard deviation parameters ($\sigma's$) for the ASC, sustainable intensification, silvopastoral, and payment attributes. Additionally, when respondents with extreme completion times are excluded, significant heterogeneity emerges for grazing parameters as well.

To test the robustness of our results to sample composition and to enhance external validity, the final column of Table 5 presents estimates from the MXL model using a resampled data set. This resampling was performed via bootstrapping techniques to approximate the distribution of cattle herd sizes observed in the 2016 national survey (Table 4). The resulting preference estimates are largely consistent with those obtained from the full sample, offering evidence of the external validity of our estimates. Moreover, preference heterogeneity remains significant across most attributes, including grazing practices.

Table 5. Mixed logit model estimates across subsamples

Variable	**All**	**Excl. complex**	**Excl. extreme duration**	**Resampled**
ASC	1.360*** (3.36)	1.363*** (3.23)	1.046* (1.91)	1.407*** (0.4220)
Grazing1	0.077 (0.50)	0.028 (0.17)	0.121 (0.49)	0.075 (0.149)
Grazing2	0.251 (1.49)	0.212 (1.23)	0.483 (1.60)	0.244 (0.159)
Grazing3	0.065 (0.39)	0.050 (0.31)	0.132 (0.47)	0.066 (0.152)
Intens1	0.604*** (3.64)	0.541*** (3.37)	0.741*** (2.72)	0.593*** (0.163)
Intens2	0.654*** (3.50)	0.787*** (3.89)	0.575* (1.72)	0.666*** (0.174)
Intens3	0.843*** (4.33)	0.919*** (4.26)	0.969*** (2.98)	0.837*** (0.175)
Silvopast1	-0.080 -0.45)	-0.065 (-0.35)	-0.109 (-0.41)	-0.075 (0.169)
Silvopast2	-0.298* (-1.66)	-0.257 (-1.37)	-0.480 (-1.52)	-0.301* (0.156)
Silvopast3	-0.649*** (-2.85)	-0.586** (-2.52)	-0.853** (-2.05)	-0.651*** (0.189)
Log(payment)	-1.600*** (7.86)	-1.520*** (-7.29)	-1.299*** (-4.79)	-1.608*** (0.206)
σASC	3.545*** (8.55)	2.959*** (6.88)	3.774*** (5.25)	3.584*** (0.401)
σGrazing1	-0.318 (-0.69)	-0.346 (-1.04)	0.170 (0.60)	0.298 (0.515)
σGrazing2	-0.113 (-0.35)	0.125 (1.04)	-0.927** (-2.01)	0.101 (0.537)
σGrazing3	0.715* (1.79)	0.237 (0.35)	1.407*** (2.67)	0.662* (0.356)
σIntens1	-0.013 (-0.15)	0.013 (0.22)	0.261 (0.87)	-0.029 (0.371)
σIntens2	-1.162*** (-3.05)	-0.955** (-2.11)	1.891*** (2.99)	-1.168*** (0.313)
σIntens3	-1.204*** (-4.08)	1.141*** (3.54)	-1.683*** (-3.57)	-1.206*** (0.259)
σSilvopast1	-1.155*** (-4.46)	1.155*** (4.07)	-1.270*** (-2.73)	-1.143*** (0.266)
σSilvopast2	-0.827** (-2.25)	-0.880** (-2.13)	-1.091* (-1.75)	-0.791** (0.317)
σSilvopast3	-1.356*** (-3.35)	1.320*** (2.91)	-2.236*** (-3.35)	-1.319*** (0.310)
σPayment	-1.153*** (-5.24)	1.144*** (3.76)	1.129*** (4.61)	-1.170*** (0.191)

Respondents	274	237	148	274
Observations	1,644	1,422	888	1,644

Notes: Robust t-statistics in parentheses. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Column 1 reports the main specification. Column 2 excludes respondents who reported finding the choice tasks too complex. Column 3 excludes respondents whose completion times were unusually short or long. Column 4 presents estimates from a resampled data set adjusted to match the distribution of production unit sizes in the population.

7.2. Latent class model

Although the MXL model provides evidence of preference heterogeneity, it does not identify the underlying sources of this heterogeneity. To explore these sources, we estimate a latent class model. The latent class model assumes that the sample consists of a finite number of unobserved (latent) groups of producers, each with distinct preference structures. Within each class, preferences are assumed to be homogeneous, but they can differ substantially across classes.

The model is essentially a conditional logit framework in which class membership is probabilistic and determined jointly with the choice model. The number of classes is specified by the researcher, guided by statistical fit criteria and interpretability (Greene and Hensher, 2003). Class membership probabilities can be modeled as a function of producers' characteristics—such as farm size, management practices, or behavioral attributes—allowing us to relate heterogeneity in preferences to observable differences among producers.

We estimated two latent class models with two classes each (the data did not support the estimation of a three-class specification because of nonconvergence of the model). The first model includes farm and producers' characteristics as explanatory variables in the class membership function. Specifically, we included the total area of the production unit, the producer's age, and the sustainability index.

The second model extends the membership function by incorporating behavioral variables: a continuous measure of impatience, proxied by the implied discount rate (see Table 1); the risk aversion variable (see Table 2); the altruism indicator; and the binary social norm variable.

The latent class model that uses farm and farmers' characteristics to define producer types is presented in the first two columns of Table 6 (Model 1). The top part of the table includes the coefficient estimates of the choice attributes and their levels. The bottom part displays how farm and producers' characteristics affect the likelihood of belonging to class B. The mean probability of membership in class A in this model is 81% and for class B, 19%. Small-scale producers who are older and have low levels of adoption of sustainable intensification practices are more likely to belong to class B than to class A. All the explanatory variables for class membership are statistically significant at conventional levels. Class A producers dominate the sample and therefore their preferences toward the examined attributes are in line with those of the whole sample: they show an inclination for participating in the programs (ASC is positive and statistically significant), they do not exhibit strong preferences for grazing practices and tend to choose programs that include sustainable intensification practices, and they dislike high levels of silvopastoral practices. In contrast, class B farmers tend to dislike participating in the offered programs (ASC is negative and statistically significant), implying a fixed cost of changing from the status quo to the program. These producers would need to be compensated for adopting the grazing practices and seem to prefer low levels of sustainable intensification practices. In this class, silvopastoral coefficients are negative for high levels of this attribute but not statistically significant.

The last two columns of Table 6 display the results of the latent class model that includes behavioral traits for explaining class membership (Model 2). This model also includes two classes, with the same probabilities explaining class membership as Model 1. The probability of belonging to class B increases with age, smaller area, and low adoption of sustainable intensification practices. In this model, class B membership is positively associated with impatient, risk-averse, and less environmentally conscious producers, although none of these variables are statistically significant at conventional levels, indicating that class membership is mainly explained by more conventional variables. The precision of the farm and producers' characteristics estimates increases when we include behavioral characteristics. Additionally, including behavioral variables helps to distinguish more clearly the differences in preferences toward sustainable practices. In Model 2, all grazing attributes and the second level of sustainable intensification practices are negative and statistically significant for class B producers.

The lack of significance is consistent with the nature of most practices in the programs. Sustainable intensification measures—such as seasonal stocking adjustments and reproductive planning—are largely managerial changes that do not imply long delays in returns or significant increases in uncertainty. Previous studies show that such interventions often generate productivity gains within a single production cycle (Thornton and Herrero, 2010; de Haas et al., 2021a; de Haas et al., 2021b) and are generally classified as low-cost, high-return practices (FAO, 2014). Similarly, improved grazing through forage crops tends to be perceived as familiar and low risk (Fuglie et al., 2021; Modernel et al., 2016). Accordingly, it is reasonable that behavioral traits like risk and time preferences would not explain much variation in preferences for these options.

In contrast, silvopastoral practices—especially at higher levels of adoption—are associated with longer payback periods, higher upfront costs, and greater perceived risk (Jose et al., 2004; Nair, 2011). Yet these practices are generally disliked across classes, which may explain why behavioral traits also fail to predict their acceptance: producers may be uniformly averse to them, regardless of individual attitudes toward risk or time.

Alternative specifications splitting the sample by behavioral profiles (impatient vs. patient, risk averse vs. risk tolerant), using the full sample including an extended set of socioeconomic variables for class membership and only behavioral variables, are shown in Appendix 4. Results are largely consistent with those shown in Table 6.

Table 6. Latent class model estimates

	Model 1		Model 2	
Variable	**Class A**	**Class B**	**Class A**	**Class B**
ASC	1.315*** (6.09)	-1.567** (-2.25)	1.337*** (6.08)	-1.622** (2.92)
Grazing1	0.120 (1.04)	-0.696* (-1.81)	0.123 (1.1)	-0.72* (1.99)
Grazing2	0.189 (1.52)	-0.718 (-1.50)	0.172 (1.42)	-0.74* (1.98)
Grazing3	0.117 (1.04)	-0.797 (-1.64)	0.133 (1.23)	-0.939** (2.31)
Intens1	0.394*** (4.06)	0.630** (2.19)	0.419*** (3.59)	0.554 (1.9)
Intens2	0.516*** (3.79)	-1132 (-1.62)	0.563*** (4.94)	-1.221** (2.25)
Intens3	0.592*** (4.26)	0.098 (0.22)	0.642*** (5.85)	-0,002 (0.0)
Silvopast1	-0.066 (-0.55)	0.141 (0.31)	-0.056 (0.49)	0.256 (0.52)
Silvopast2	-0.188 (-1.52)	-0.166 (-0.31)	-0.202* (1.89)	0.161 (0.25)
Silvopast3	-0.400*** (-2.63)	-0.363 (-0.48)	-0.421*** (3.47)	0.051 (0.08)
Payment	0.204*** (8.94)	0.115* (1.84)	0.214*** (10.99)	0.14 (1.82)
Delta (intercept)		-3.798*** (-4.04)		-3.593** (2.7)
Surface		-0.00077** (-2.28)		-0.00079** (2.27)
Age		0.061*** (3.85)		0.058*** (3.15)
Sustainability index		-0.648* (-1.79)		-0.843** (2.2)
Discount rate				0.536 (1.37)
Risk aversion				0.307 (0.73)
Altruism				0.608 (1.32)
Environmental awareness				-0.064 (0.11)
Social norm				-0.478 (1.04)
Producers	274		263	
Observations	1,644		1,578	
BIC	2,924		2,800	
AIC	2,754		2,633	
Class membership probabilities	81%	19%	80%	20%

Notes: Robust t-statistics in parentheses. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

7.3. Willingness-to-accept estimates

Table 7 presents the marginal willingness-to-accept (WTA) estimates obtained from the MXL model for average producers (column 1) and those from class A and class B obtained from the latent class Model 1 in Table 6 (columns 2 and 3, respectively). On average, producers' WTA is approximately USD –105 per hectare per year to participate in the proposed programs, which means they are willing to pay for participating. Class A producers' WTA is USD –64, which indicates that these producers are willing to pay to participate. However, producers in class B display a negative preference for participation and would require compensation: their estimated WTA is USD 135 per hectare per year.

Results also suggest that producers' average WTA is negative and thus they are willing to pay to adopt improved grazing practices, although the coefficients are only marginally significant for medium levels of adoption. In contrast, producers exhibit a strong and statistically significant willingness to pay for sustainable intensification practices, likely because of the perceived productivity benefits. The average WTP for these practices ranges from USD 22 to USD 28 per hectare per year, depending on the level of adoption. When accounting for heterogeneous preferences, class A producers exhibit similar preferences for sustainable intensification practices as those of average producers, whereas class B producers would need to be compensated to adopt medium levels of sustainable intensification practices; none of the coefficients for this attribute, however, are statistically significant.

On the other hand, on average, producers require compensation to adopt silvopastoral practices. The estimated WTA for medium and high levels of silvopastoral adoption is USD 12.3 and USD 21.4 per hectare per year, respectively, indicating these practices are perceived as burdensome or less beneficial in the short term. For class A producers, only high levels of adoption of this practice are statistically significant and indicate an average WTA of USD 19 per hectare per year. For class B farmers, none of the silvopastoral coefficients were statistically significant.

A fundamental question is why the adoption of sustainable intensification practices remains limited, despite producers' perceiving them as beneficial. To explore this, the survey included questions on perceived barriers to adoption. Seventy percent of respondents identified high upfront costs as an obstacle.

Overall, the findings highlight the importance of aligning policy instruments with producers' preferences. Whereas sustainable intensification practices may be promoted by addressing upfront investment barriers, silvopastoral techniques adoption may require direct financial incentives.

Table 7. Marginal willingness-to-accept estimates (USD/ha/year)

Attribute	Mixed logit model	Class A	Class B
ASC	−105.8*** (−6.36)	−64.3*** (−4.57)	135.8** (2.17)
Grazing1	−8.6 (−1.36)	−5.9 (−1.06)	60.3 (1.18)
Grazing2	−10.1* (−1.93)	−9.3 (−1.58)	62.2 (10.1)
Grazing3	−7.1 (−1.64)	−5.7 (−1.05)	69.1 (1.09)
Intens1	−21.9*** (−7.48)	−19.3*** (−3.80)	−54.6 (−1.34)
Intens2	−24.4*** (−5.76)	−25.2*** (3.70)	98.1 (1.11)
Intens3	−28.3*** (−6.63)	−29*** (−4.06)	−8.5 (−0.23)
Silvopast1	2.6 (0.86)	3.2 (0.55)	−12.3 (−0.31)
Silvopast2	12.3*** (3.55)	9.2 (1.54)	14.4 (0.30)
Silvopast3	21.4*** (4.45)	19.6*** (2.69)	31.5 (0.46)

Notes: Robust t-statistics in parentheses. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. All values are expressed as marginal WTA (USD/ha/year). WTA estimates for MXL were derived from WTP-space coefficients. Class A and B refer to the two-class latent class model.

8. Conclusions

This study assesses cattle producers' preferences for adopting sustainable agricultural practices in Uruguay. Through a combination of discrete choice experiments and behavioral tasks eliciting and measuring risk and time preferences, we identify significant heterogeneity in producers' preferences for sustainable practices.

The results suggest that although sustainable intensification practices are generally liked and associated with productivity benefits, silvopastoral practices remain less appealing, likely because of perceived risks, costs, lack of familiarity, and less direct link with productivity. These findings highlight the need for tailored strategies to encourage sustainable practices in extensive livestock systems. Adoption of sustainable intensification practices involving herd management may not require large monetary incentives. In contrast, the adoption of silvopastoral practices may require additional resources.

Our latent class analysis uncovers two distinct farmer segments: a majority group inclined toward adoption and a minority who require stronger incentives to depart from the status quo. Although the elicitation of time and risk preferences showed an expected heterogeneity across producers, they were not statistically significant for explaining differences in attitudes toward sustainable practices. In contrast, conventional variables, such as age, farm area, and the level of adoption of sustainable practices, were statistically significant in explaining preference heterogeneity. Nevertheless, they appear to highlight differences in attitudes toward sustainable practices.

Designing agri-environmental schemes that address the behavioral and structural diversity of producers can improve both environmental outcomes and policy effectiveness. However, additional research is needed to reach a better understanding of livestock producers' behavioral characteristics, their decision-making processes, and how these factors affect preferences for sustainable practices.

An important aspect that could not be incorporated into the choice experiment is producers' relative preferences for different incentive mechanisms, such as tax deductions, subsidies, and cost-sharing arrangements. For instance, because of potential negative connotations, beef producers may favor tax deductions or government copayments over conditional payments. Exploring these preferences represents a promising direction for future research.

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Appendix 1. Sustainable Practices in Cattle Production

Sustainable practices to reduce emissions intensity and improve ecosystem services in livestock production include improved animal and feed management, diet formulation changes, and rumen interventions (Nabinger, 2011; Cubbage et al., 2012; Bussoni et al., 2015; Do Carmo et al., 2016; Jara-Rojas et al., 2020; Arndt et al., 2022; Caprarulo et al., 2022; Kelly, 2023). Examples of such techniques include feed processing, genetic selection, improved animal health, pasture management, increased feed levels, and enhanced forage quality. Other livestock practices, such as silvopastoral systems, also reduce net emissions by increasing carbon sinks through afforestation (Rivera et al., 2023). Our study focuses on three livestock techniques with the potential to reduce GHG emissions intensity (emissions per unit of output) and increase the provision of ecosystem services while maintaining and improving productivity: improved grazing area, sustainable intensification practices for herd management, and silvopastoral systems (Becoña et al., 2014; INIA, 2024; Eugène et al., 2021; Sancho et al., 2023).

In this study, improved grazing area involves establishing artificial pastures to increase forage availability and digestibility and reduce methane emissions (Eugène et al., 2021). Additionally, these pastures enhance adaptability to extreme weather events, reducing year-to-year output fluctuations (Becoña et al., 2014; Modernel et al., 2019). Sustainable intensification practices through herd management encompass multiple technologies and strategies. In rotational grazing, for example, farmers rotate the herd based on forage assessment instead of body condition. Research shows that this results in improved body condition, increased live weight, higher pregnancy rates, better milk yield, and heavier calves with earlier slaughter ages (Do Carmo et al., 2016; Claramunt et al., 2020). It also reduces emissions intensities by enhancing soil productivity, increasing carbon capture, boosting animal weight, and lowering the slaughter age (INIA, 2024). These techniques are consistent with Uruguay's NDC and other environmental goals, such as the National Adaptation Plan (República Oriental del Uruguay, 2022).

Many of these practices have the potential to improve profits because they improve productivity. A recent study conducted by Uruguay's National Institute of Agricultural Research (INIA) documents the economic and environmental gains of adopting improved grazing area and sustainable intensification practices in three production units in Uruguay (INIA, 2024).

Silvopastoral techniques, which integrate fodder plants, shrubs, and trees into livestock systems, also have the potential to enhance productivity (Lemes et al., 2021; Rivera et al., 2023) while providing valuable ecosystem services, including soil carbon sequestration (De Stefano and Jacobson, 2018; Rivera et al., 2023) and biodiversity habitat. Carbon sequestration in livestock systems is in line with mitigation objectives in the Uruguayan NDC. However, these practices remain relatively unfamiliar to many producers in the country and often require additional skills, such as knowledge of forest management, and investments, such as the expense of tree planting (Sancho et al., 2023).

Appendix 2. Detailed Summary Statistics

Table A.2.1. Detailed summary statistics

Variable	N	Mean	SD	Min	Max
Land use (ha)					
Permanent artificial pasture	125	202	555	0	5,000
Natural pasture	249	680	1.102	0	11,500
Improved natural pasture (cover crops)	150	177	237	0	1269
Annual forage crops	105	81	108	0	831
Orchard, fruit trees, vineyard	34	11	30	0	134
Artificial forest (dense, windbreak, shelter, shade)	99	65	130	0	750
Native forest	94	100	155	0	900
Production unit area	274	898	1.439	0	15,821
Head of cattle					

Bulls	218	15	23	0	220
Breeding cows, pregnant heifers	228	331	459	0	4,500
Cull cows or overwintering cows	166	70	78	0	350
Steers	172	182	390	0	3,400
Heifers	217	124	189	0	1,900
Calves	222	224	361	0	3,700
Labor force					
Family members	274	2	1	0	10
Employees	274	2	4	0	50

Appendix 3. Conditional Logit and Model Specification

Table A.3.1 presents estimates from three conditional logit models based on 274 respondents, totaling 1,644 observations. Column 1 reports results from a model that assumes linear effects for the grazing and silvopastoral attributes, each captured by a single dummy variable. Column 2 introduces a more flexible specification that accounts for nonlinear effects of the grazing and silvopastoral practices by including dummy variables for each level. The results largely confirm those in column 1: coefficients for grazing remain positive but statistically insignificant, while those for sustainable intensification remain positive, statistically significant, and increasing in magnitude. For silvopastoral practices, levels 2 and 3 yield negative and statistically significant coefficients (at the 10% and 1% levels, respectively), while level 1 remains insignificant. These findings provide evidence of nonlinear effects in both silvopastoral and sustainable intensification attributes.

Finally, column 3 presents a model in which the status quo alternative includes level 1 of sustainable intensification practices, consistent with the self-reported adoption of seasonal adjustment of stocking rate practice by 81% of respondents. The results mirror those from column 1: grazing practices remain statistically insignificant, sustainable intensification practices are positively valued, and higher levels are preferred. For silvopastoral practices, coefficients for levels 1 and 2 are negative but not statistically significant, while level 3 remains negative and statistically significant at the 1% level. Our preferred specification allows for nonlinear preferences across attribute levels, as reported in column 2.

Table A.3.1. Conditional logit model estimates

Variable	(1)	(2)	(3)
asc	−0.057 (0.33)	−0.098 (0.53)	0.083 (0.47)
grazing1	—	0.033 (0.34)	−0.007 (0.07)
grazing2	—	0.061 (0.57)	0.039 (0.37)
grazing3	—	0.069 (0.71)	0.088 (0.93)

grazing	0.023 (0.70)	—	—
intens1	0.400*** (4.58)	0.401*** (4.59)	—
intens2	0.419*** (3.77)	0.423*** (3.77)	0.239** (2.45)
intens3	0.498*** (4.52)	0.513*** (4.51)	0.337*** (3.31)
silvopast1	—	−0.052 (0.48)	−0.047 (0.43)
silvopast2	—	−0.190* (1.76)	−0.176 (1.62)
silvopast3	—	−0.350*** (2.77)	−0.341*** (2.71)
silvopast	−0.118*** (2.91)	—	—
payment	0.196*** (9.74)	0.195*** (9.80)	0.198*** (9.86)

Notes: Robust t-statistics in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Appendix 4. Alternative Specifications

Table A.4.1. Mixed logit model estimates, by behavioral profile

Variable	**Risk seeking**	**Risk averse**	**Impatient**	**Patient**
asc	1.033** (2.29)	1.926** (2.19)	0.762 (1.43)	1.713** (2.37)
grazing1	0.012 (0.06)	0.298 (1.03)	0.057 (0.19)	-0.069 (0.32)
grazing2	0.447** (2.14)	-0.228 (0.79)	0.114 (0.37)	0.135 (0.56)
grazing3	0.011 (0.05)	0.198 (0.67)	-0.004 (0.01)	0.007 (0.03)
intens1	0.538*** (2.84)	0.775*** (2.69)	0.768*** (2.79)	0.561** (2.53)
intens2	0.752*** (3.12)	0.517* (1.58)	0.775** (1.98)	0.758*** (3.02)
intens3	1.086*** (4.54)	0.295 (0.76)	0.925*** (2.69)	0.982*** (3.37)
silvopast1	0.093 (0.47)	-0.564 (1.18)	0.169 (0.46)	-0.152 (0.61)
silvopast2	-0.190 (0.91)	-0.621* (1.65)	0.029 (0.08)	-0.584* (1.93)
silvopast3	-0.676** (2.37)	-0.757* (1.71)	-0.462 (1.06)	-0.923** (2.43)
log(payment)	-1.598*** (6.73)	-1.567*** (3.74)	-1.428*** (3.94)	-1.487*** (6.12)
σasc	2.983*** (6.78)	-4.943*** (4.41)	3.446*** (6.38)	3.868*** (5.11)
σgrazing1	-0.219 (0.47)	-0.351 (0.54)	1.021 (1.55)	0.015 (0.33)
σgrazing2	-0.026 (0.25)	0.143 (0.23)	1.057* (1.78)	-0.050 (0.34)
σgrazing3	-0.778** (2.07)	0.048 (0.12)	-1.528** (2.06)	0.155 (0.56)
σintens1	-0.062 (0.65)	-0.008 (0.04)	-0.382 (1.11)	-0.319 (0.56)
σintens2	1.469*** (3.00)	0.700 (0.87)	-2.495*** (2.61)	-0.229 (0.27)
σintens3	-1.148*** (3.19)	-1.628** (2.22)	1.954*** (2.95)	-1.030** (2.91)
σsilvopast1	1.028*** (2.91)	-1.556** (2.00)	-1.816*** (3.09)	-1.019** (2.54)
σsilvopast2	-0.982** (2.29)	-0.400 (0.63)	1.079 (1.45)	1.088** (2.26)
σsilvopast3	1.570*** (3.30)	1.223* (1.78)	1.806** (2.39)	-1.584*** (2.66)
σpayment	-1.196*** (4.92)	-1.275*** (5.10)	-1.535*** (4.61)	-0.950*** (4.04)
Producers	194	80	139	124
Observations	1164	480	834	744
BIC	2063	868	1477	1329

AIC	1951	776	1373	1228

Table A.4.2. Latent class model estimates with farm and producers' characteristics variables

Variable	**Class A**	**Class B**
asc	1.305*** (5.99)	-1.569** (-2.08)
grazing1	0.121 (1.01)	-0.698* (-1.76)
grazing2	0.190 (1.44)	-0.723 (-1.50)
grazing3	0.118 (1.02)	-0.817 (-1.56)
intens1	0.394*** (4.04)	0.630** (2.15)
intens2	0.517*** (3.55)	-1.163 (-1.55)
intens3	0.593*** (4.01)	0.081 (0.17)
silvopast1	-0.066 (-0.54)	0.136 (0.30)
silvopast2	-0.191 (-1.53)	-0.133 (-0.22)
silvopast3	-0.401*** (-2.55)	-0.350 (-0.40)
payment	0.204*** (8.72)	0.116* (1.83)
delta (intercept)		-3.305*** (-3.31)
surface		-0.00074** (-2.13)
age		0.062*** (3.36)
male		-0.598 (-1.23)
income>50k		0.305 (0.71)
sustainability index		-0.406* (-1.90)
Producers	274	
Observations	1,644	
BIC	2,907.57	
AIC	2,756.23	
Class membership probability	81%	19%

Table A.4.3. Latent class model estimates with behavioral variables

Variable	**Class A**	**Class B**
asc	1.334*** (5.43)	-1.702** (-2.60)
grazing1	0.125 (1.08)	-0.745* (-1.82)
grazing2	0.164 (1.35)	-0.686 (-1.40)
grazing3	0.127 (1.13)	-0.900** (-2.01)
intens1	0.419*** (4.09)	0.557** (2.01)
intens2	0.560*** (4.01)	-1.218** (-2.16)
intens3	0.641*** (4.38)	-0.020 (-0.05)
silvopast1	-0.053 (-0.41)	0.163 (0.32)

silvopast2	-0.215 (-1.63)	0.260 (0.43)
silvopast3	-0.422*** (-2.63)	0.039 (0.06)
payment	0.214*** (8.95)	0.154** (2.18)
delta (intercept)		-1.474 (-1.35)
impatience		0.560 (1.52)
risk aversion		0.431 (1.22)
altruism		0.550 (1.31)
awareness		-0.155 (-0.31)
social norm		-0.485 (-1.15)
Producers	263	
Observations	1,578	
BIC	2,809.93	
AIC	2,659.74	
Class membership probability	80%	20%