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Rural Landscape Simplification and Provision of Cultural Ecosystem Services

A Case Study in the Argentine Pampas

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ABSTRACT: In recent decades, the rural landscape of the Argentine Pampas has undergone a process of simplification due to the increased land allocated to crops, replacing pastures and grasslands, with a substantial increase in soybean area. In 2016-2017, a survey was conducted to analyze changes in cultural ecosystem services in this region. Pergamino citizens relate landscape improvement in terms of aesthetic and recreational values to increasing its complexity since they prefer more winter crops, grazing areas, native vegetation, trees, and birds. The significant relationship between sociodemographic variables and preferences for landscape attributes is consistent with the notion that aesthetic perception is constructed from personal experiences and background.

Simplificación del Paisaje y Provisión de Servicios Ecosistémicos Culturales. Un Estudio de Caso en las Pampas de Argentina

RESUMEN: En las últimas décadas, el paisaje rural de la Pampa argentina ha experimentado un proceso de simplificación debido al aumento de tierras destinadas a cultivos, reemplazando pasturas y pastizales, con un aumento sustancial de la superficie sojera. En 2016-2017, se realizó una encuesta para analizar cambios en los servicios ecosistémicos culturales en esta región. Los ciudadanos de Pergamino relacionan la mejora en el valor estético y recreacional del paisaje con el aumento de su complejidad, ya que prefieren más cultivos de invierno y áreas de pastoreo, vegetación nativa, árboles y aves. La relación significativa entre las variables sociodemográficas y las preferencias por los atributos del paisaje es consistente con la noción de que la percepción de la belleza del paisaje se construye a partir de experiencias personales.

KEYWORDS / *PALABRAS CLAVE*: Rural landscapes, individual preference, cultural ecosystem services, landscape simplification, aesthetic values / *Paisaje rural, preferencias individuales, servicios ecosistémicos culturales, simplificación del paisaje, valores estéticos*.

JEL classification / *Clasificación JEL*: Q57.

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1. Introduction

Agricultural landscapes provide a considerable variety of benefits to society. The ecosystem services (ESs) framework facilitates the assessment of the multiple services from rural landscapes and the identification of trade-offs between different land use scenarios (van Zanten *et al*. 2014a). The ESs approach acknowledge the importance of agriculture's capacity to produce food, fiber, and energy (*provisioning* ecosystem services) and highlight the existence of other less evident benefits: *regulating* (e.g., carbon sequestration) and *cultural ecosystem services* (e.g., recreation, aesthetic values) (Haines-Young & Potschin, 2013). When agriculture is managed uniquely to optimize *provisioning ESs,* the other ESs may be in peril.

The definition and analysis of cultural ecosystem services (CESs) are highly complex due to their intangible and subjective nature (Kosanic & Petzold, 2020). CESs are defined as all the immaterial and generally non-consumptive outputs of ecosystems that affect people's physical and mental states (Haines-Young & Potschin, 2013). In contrast to other ESs, CESs are associated to communities' cultural values and ties; in other words, they mostly contemplate the production of social experiences (Daniel *et al*., 2012). Hence CESs are co-produced by ecosystems and society, so their production and valuation are closely linked. Therefore, there is no objective metric for the production of aesthetics values to establish that a site provides a greater volume of aesthetic service without appealing to people's behaviour or preferences.

Russell *et al*. (2013) emphasize the importance of ecosystems' cultural and psychological contributions to human wellbeing. These authors identified four channels of human interactions with ecosystems that should be considered in the assessment of CESs: (a) knowing: meditating on an ecosystem or the notion of an ideal ecosystem; (b) perceiving: distant interactions with ecosystem elements; (c) interacting: direct, active, physical and multisensory interactions with ecosystem elements; and (d) living within: daily interactions with the ecosystem we inhabit. To relate these interactions with ecosystems to human wellbeing, CESs are generally assessed in terms of aesthetics functions, recreation possibilities, tourism, cultural heritage, and spiritual values (Daniel *et al*., 2012; van Zanten *et al*., 2014a). These categories are generally not separable or mutually exclusive, and intertwining is also present between CESs and other ESs (i.e., aesthetics and nutritional characteristics of food preferences).

The aesthetic value of rural landscapes is considered a significant aspect of CES assessment (e.g., Häfner *et al*., 2018; Assandri *et al*., 2018; Van Zanten *et al*., 2016; Sayadi *et al*., 2009). People find beauty in various rural landscape aspects, and these perceptions are often linked to recreational activities or cultural heritage (Assandri *et al*., 2018). Landscape beauty is assessed by perception-based surveys, in which aesthetic quality is measured based on choices, ratings, or other metrics (Daniel *et al*., 2012; van Zanten *et al*., 2014a). In many studies, photographs are used, and respondents are asked to provide an aesthetic value for different landscapes (e.g.,

van Zanten *et al*., 2016). Some studies focus on landscape-level beauty, while others use an attribute-based perspective. The former considers the valuation of complete landscape scenarios; hence, their results are context-specific and cannot be extrapolated. The latter find a relation between aesthetic and recreational values and landscape attributes such as agricultural land use, agricultural practices (i.e., confined or pasture-based livestock), the prevalence of landscape elements (e.g., trees, riparian areas), and the presence of wildlife, etcetera (van Zanten *et al*., 2016).

The attention for the loss of CES has increased strongly in recent years. In particular, there is growing concern for the loss of aesthetic values of rural landscapes associated with the simplification and intensification of agriculture (e.g., Kosanic & Petzold, 2020). Rural landscape simplification, defined as the reduction in land cover heterogeneity and the decrease in uncultivated areas (Landis, 2017; Cerezo *et al*., 2011), is a common trend in regions in which agriculture is managed to maximize provisioning ESs. Monocultures of high-yielding crops with extensive use of inputs have led to negative environmental impacts on air, water, soil air and biodiversity, and CESs (Landis, 2017).

Most studies on people perceptions on rural landscape CESs have been conducted in developed countries, in particular in Europe (Kosanic & Petzold, 2020). Managing rural landscapes to increase the supply of CESs is an explicit goal in agricultural policy for European agriculture. The most important policy instruments are agri-environmental programs (Van Zanten *et al*., 2014b), which include voluntary economic instruments as incentives to manage rural land in a way that improves the landscape, protects biodiversity, and the quality of water, air, and soil.

CESs in rural landscapes and the trade-offs between CESs and provisioning ESs have been scarcely studied in South America. A recent study in south-central Chile shows a clear preference for landscapes with native vegetation (Nahuelhual *et al*., 2018). In Argentina, Abraham *et al*. (2014) studied the landscape perception of urban residents in Mendoza city. Vineyards and mountains characterize the landscape in this area and are visited by tourists every year. The authors indicated that the residents appreciated the aesthetic value of agricultural landscapes with vineyards.

Some studies have assessed the impacts on the rural landscape simplification in terms of CESs in the Southern Pampas, Argentina. Auer *et al*. (2017) assessed perceptions of rural landscape simplification (agriculturalisation) in the last two decades and identified rural landscape features that generate identity, sense of place, and cultural heritage in Balcarce county. Their results showed a trade-off between the increase in commodity production (provisioning ESs) and the loss of CESs. The authors highlighted the loss of landscape beauty as a consequence of agricultural landscape simplification. In turn, Auer *et al*. (2018) evaluated the impact of rural landscape simplification on recreation and tourism in the Mar Chiquita basin. They developed an indicator of opportunities for recreation and tourism. Their results showed trade-offs between landscape simplification and opportunities for recreation and tourism.

2. Rural landscape simplification in the Argentine Rolling Pampas

Argentina is a key player in world agricultural markets. This country is among the main exporters of major agricultural products (3rd place for corn, 1st place for soybeans oil, and meal, 7th place for wheat, and 5th for beef. Source: https://www.usda.gov/oce/commodity/wasde, 2022). Soybeans, corn, wheat, and beef represent together more than half of the value of the total exports in Argentina (INDEC, 2022a). The Pampas (Buenos Aires, Córdoba, Entre Rios, La Pampa and Santa Fe) provides more that 90 % of these exports (INDEC, 2022b). The current landscape in this region differs significantly from its natural condition since agriculture has replaced the native grassland that used to cover the major part of the area (Solbrig & Viglizzo, 1999). In the last three decades, the production of cereals and oilseeds has been significantly increasing. Land planted with annual crops almost doubled from 1990 to 2017 and soybean plantings increase by 300 % in the same period (source: www.datosestimaciones.magyp.gob.ar). The notable growth of soybean production was supported by simple management, based on GMO glyphosate-resistant varieties, under no-till, with low costs, and high working capital recovery levels (Satorre & Andrade, 2021; Cabrini & Calcaterra, 2016).

Grass-fed livestock production competes with cropland in the Pampas. Until the 1990s, 100 % of beef cattle were finished on grasslands and pastures, in some cases with grain supplementation (Arelovich *et al*., 2011). In the last 30 years, with a decrease in the land assigned to livestock production, the number of cattle heads has decreased and finishing cattle confined in feedlots became a frequent practice (source: http://www.senasa.gob.ar/cadena-animal/bovinos-y-bubalinos/informacion/informes-y-estadisticas).

These transformations in agricultural production systems are related to changes in different aspects of the rural landscape in the Pampas including reducing trees, natural and spontaneous vegetation areas, and bird diversity (Weyland *et al*., 2014; Carreño & Frank, 2012; Cerezo *et al*., 2011).

The current study is focused on the northeastern Pampas, the Rolling Pampas, the area with the highest yields per unit of land in corn and soybeans crops (Occhiuzzi *et al*., 2018). In this area with high potential for the generation of provisioning ESs, no other study has evaluated whether there are losses in aesthetic and recreational values, key elements of CESs, due to landscape simplification.

The objective of this study is to assess perceptions and preferences for different landscape attributes in terms of their contribution to aesthetic and recreational values in the Argentine Rolling Pampas. The assessment of CESs, and the trade-offs and synergies with other ESs, is essential to support policies that reconcile agricultural production with ecosystems conservation and communities' welfare.

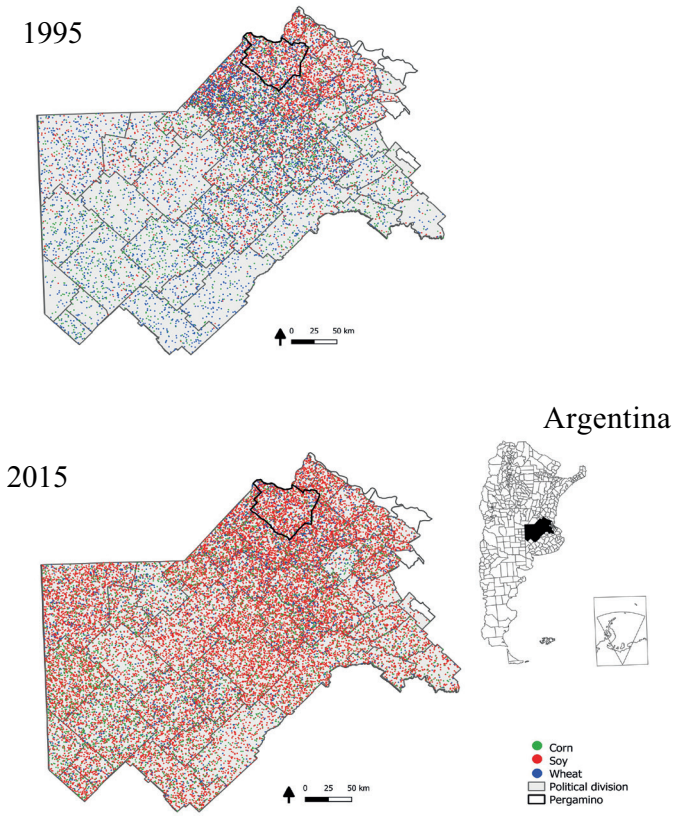
3. Data

3.1. Study area

This research was conducted in Pergamino county, Northern Buenos Aires, Argentina (Figure 1). This area (299,178 ha) is paradigmatic of the Rolling Pampas, the most highly productive agricultural zone in the country, with a mild climate and highly fertile soils in an evenly undulating sedimentary landscape. Summer crop yields are 30 % above national on average in the last 5 years period (source: www.datosestimaciones.magyp.gob.ar).

FIGURE 1

Study area: Pergamino, Buenos Aires, Argentina. Land use changes 1995-2015.



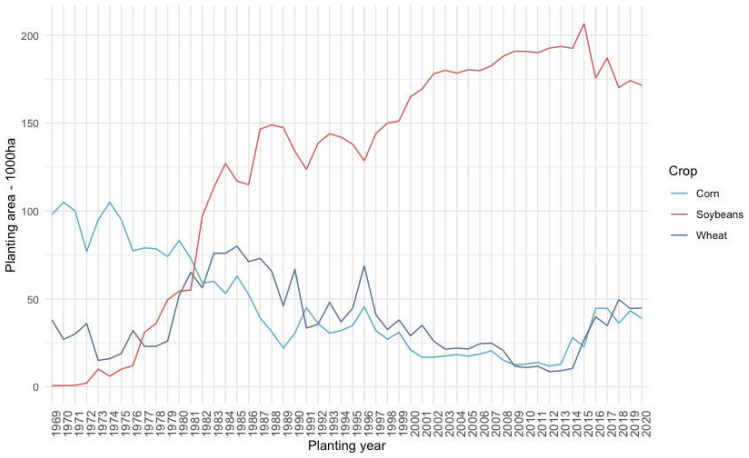
Note: Each dot represents 500 ha planted with the respective crop.
Source: GIS group INTA (*Instituto Nacional de Tecnología Agropecuaria*) – Pergamino, Argentina.

Agriculture and textile activities are the basis of Pergamino's economy. Pergamino county is a key player in the seed industry, being declared in 1997 "Capital of the Seed" based on the importance of breeding and seed production activities in the area (source: https://www.pergamino.gob.ar/). Crop production is the main farming activity, the median operated land is 408 ha, and 70 % of the land is operated under lease (Bitar *et al.*, 2020).

Figure 2 shows land use changes in the county of Pergamino. The greatest change occurred towards the mid-1980s, when soybeans showed a significant increase in area, with a drop in other crops. These changes reached a peak towards the middle of the 2010s and from then on, land allocation to different activities has remained more stable.

FIGURE 2

Pergamino's total areas planted 1969/70-2019/20 for corn, soybeans and wheat



Source: Own elaboration based on data form National Ministry of Agriculture, Livestock and Fisheries (MAGyP).

3.2. Data collection

The study data were collected in a survey of the inhabitants of Pergamino City, the capital city of Pergamino County, to assess their preferences for aesthetic features of rural landscapes (Pergamino City has 95,000 inhabitants, the 86 % of total population in Pergamino County: www.pergamino.gob.ar). The period in which the survey was carried out was from June 2016 through May 2017. Controlled quota sampling was used in this study. The population was grouped into 5 geographical areas of residence; then, each area was divided into 4 age ranges; and finally, each range was classified by sex. This gave a total of 40 groups (Table 1). To avoid selection bias, interviewers were not allowed to select more than one person from the same social group (i.e. family, classmates or sports team).

TABLE 1

Quota sample from the population of Pergamino inhabitants

			Number of observations per group				
			Age (years)				Total
			<30	30-49	50-69	≥70	
Zone	Centre	Females	6	7	10	2	25
		Males	6	6	4	2	18
	East	Females	8	6	7	5	26
		Males	7	9	6	3	25
	North	Females	11	8	7	3	29
		Males	6	5	5	2	18
	West	Females	8	10	7	1	26
		Males	6	7	6	2	21
	South	Females	5	9	6	2	22
		Males	6	6	3	3	18
Total			**69**	**73**	**61**	**25**	**228**

Source: Own elaboration.

The questionnaire was structured in three parts (Cabrini *et al*., 2023). The first part (questions 1-3) was about habits, customs and experiences of inhabitants in the local rural landscape. The second part (questions 4-7) asked for the preferences for local rural landscape attributes. The third part (question 8) collected sociodemographic characteristics.

The first step in the analysis of landscape perception was the selection of relevant attributes that may contribute to the provision of landscape aesthetic values in the area of study. Landscape attributes were selected for two reasons. First, they had undergone significant change in recent years as is described in previous section. Second, they may contribute to the provision of landscape aesthetic values based on previous research (Van Zanten, 2014a). Nine landscape attributes were validated through a pilot questionnaire conducted in 2016. The pilot sample (n = 25) included one or two inhabitants of each neighborhood in Pergamino. Based on the results of the pilot survey the research team decided on some changes to attributes' description and the scale used to evaluate them. These nine attributes are listed below:

- Soybean area
- Winter crops area
- Pasture area

- Presence of livestock
- Birds diversity
- Presence of trees
- River quality
- Presence of native or spontaneous vegetation
- Presence of confined animal production.

In assessing landscape attributes, interviewees were asked to consider the aesthetic value of the landscape, based on how much they "enjoy watching, visiting or simply knowing that it is there" (Please refer to supplementary material for complete information on the survey questionnaire). Data analysis includes descriptive statistics that summarize habits and customs related to outdoor activities in the local area. The descriptive statistics were also computed for people's preferences for each of the nine landscape attributes.

As in Junge *et al*. (2015) and van Zanten *et al*., (2016), sociodemographic and behavioural variables were included in the survey (Table 2). A probit model was fitted to estimate the relationship between people's preferences and people's sociodemographic characteristics. A total of nine binomial models were estimated, one for each landscape attribute.

A binomial model is applied to variables that adopt only two values[1]. Since in our case, the options available for each attribute were four, they were regrouped to take the binomial form[2]. Therefore, the most frequently chosen option for each attribute was classified as 1, whereas the remaining options were classified as 0.

Probit models are based on the theory of the random utility (McFadden, 1973). In these models, the individual derives utility from the different alternatives available. Utility is not directly observable, instead, what we have is the final choice made by the individual, which reveals the alternative with the highest utility. Thus, the dependent variable is a dummy variable that indicates the option reporting the highest level of utility to the individual.

Random utility models consider utility as a function of the individual's observable characteristics (deterministic component) and a random component (an error term that follows a normal distribution). This model estimates the probability that each

[1] In general, 0 (the non-choice of an option) and 1 (the choice of an option).

[2] The original answers are four mutually exclusive options, for this reason a multinomial model was estimated to explains the probability of choosing each of the four categories. No significant models were found for any of the nine attributes. Then, it was decided to regroup the four options into two new options, where the option with the highest number of responses takes the value 1 and 0 in the rest of the cases. For example, in the "Soybean area" attribute, the binomial variable differentiates those who choose "Less Soybean area" versus "no Less Soybean area".

individual will choose an option between two available alternatives conditional on their observable characteristics (Table 2 presents the explanatory variables).

Given the nonlinearity of the model, its parameters do not asses directly the marginal effects of the explanatories variables. To obtain them, the differential of the model with respect to the variable of interest must be calculated (see Maddala, 1983) for more detail). The marginal effects depend on both the values of the estimated parameters and the values of the explanatory variables. Hence, they are usually reported for some cases of interest, like average or modal values of the explanatory variables.

TABLE 2

Description of sociodemographic variables included in the probit models for rural landscape perception, Pergamino city, Argentina

Variable	Definition
Sex	Dummy: 1, if male
Age	Categorical: Age1 (under 30 years old, base category); Age2 (30-50 years old); Age3 (50-70 years old); Age4 (above 70 years old)
Educational level (Educ)	Categorical: Educ1 (No education and Elementary school completed, base category); Educ2 (High school completed); Educ3 (University degree)
Occupation (Ocup)	Categorical: Ocup1 (Employee, base category); Ocup2 (Free-lance and employer); Ocup3 (Student); Ocup4 (Retired)
Time spent outdoors in the proximity of their place of residence during last year (Time)	Dummy: 1, if spends in local landscape 30 days or more per year
Occupation related to agriculture3 (Agro)	Dummy: 1, if its occupation is centred in agricultural sector
Household size (Size)	Categorical: S1 (1 member, base category); S2 (2 members); S3 (3-4 members); S4 (more than 4 members)
Respondent monthly income (Income)	Dummy: 1, if income is under $15,000 (U$S 1000)

Source: Own elaboration.

[3] This variable identifies with 1 those individuals whose activity is directly related to the agricultural sector, for example, farmers, agricultural employees, agricultural services, agricultural engineers, etc. While it takes the value 0 if the activity is not directly related to the agricultural sector, for example, public employees, tourist activity, environmental protection, etc.

Each variable's marginal effects reported an increase or decrease –defined by the coefficient sign– in the modal individual's probability of choosing an attribute holding the other variables constant. Based on sample data, the modal individual is a woman between 30 and 50 years old, with a high school degree, employed outside the agricultural sector with a monthly income superior to ARS 15,000, who lives in a household of 3-4 members, and who spends less than 30 days outdoors in the region.

Finally, classical goodness-of-fit measures are not usefull in probit models (Hagle & Mitchell, 1992; Tardiff, 1976; Yazici *et al*., 2007); instead, the model's predictive capacity is calculated, measured by the following indicators:

- *Sensitivity* (true positive rate): The proportion of observed 1's that were predicted to be 1's.
- *Specificity* (true negative rate): The proportion of observed 0's that were predicted to be 0's.

Finally, the general classification is the proportion of total observations correctly classified by the model.

4. Results

Table 3 shows descriptive statistics of sociodemographic characteristics from the sample. The first two variables listed in the table, **sex** and **age**, were employed to define the groups for sampling, along with the neighborhood, and therefore quota sampling reproduced the population structure. The data for **education level**, shows that the proportion of people with university degree (37 %) is higher compared to the population values for this region (around 20 %, based on data from 2010 Population Census). Nevertheless, with the inauguration of a Northwestern Buenos Aires University at Pergamino in 2002, the proportion of population with university degree may have increased at the time of the survey.

4.1. Outdoors: Time spent, sites most visited and recreational activities

Half of the respondents spent more than 30 days per year outdoors (no farther than 20 km from their place of residence). While urban parks, including those along waterways, were the most frequently selected as the most visited, open landscapes with crops, pastures, and prairies, and rural areas along waterways were considered the second most visited place by a significant proportion of Pergamino inhabitants (Figure 3).

The most popular recreational activities were *walking* (63 % of respondents) and *picnics and barbecues* (48 %). *Running, soccer, and other sports* (19 %), *fishing* (13 %), and *rural biking* (8 %) were less popular (Figure 4).

Respondents showed a strong bond with the landscape of their region. More than 80 % stated that they like living and spending time in the landscape (Table 4). More than 60 % expressed a feeling of identification with the landscape, and 54 % mentioned that they missed the landscape when they travel to other places.

TABLE 3

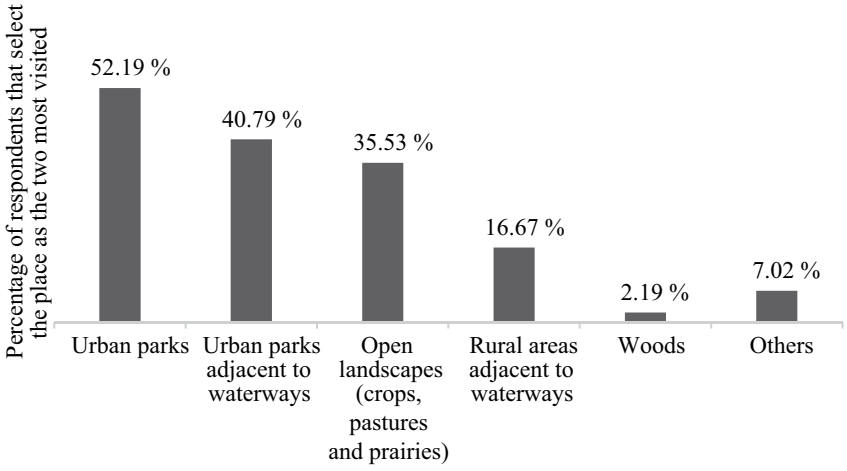
Descriptive statistics of sociodemographic variables in the survey of rural landscape perception, Pergamino City, Argentina (2016-2017)

Variable	Category	Frequency	%
Sex	Female	128	56.14
	Male	100	43.86
Age	< 30	69	30.26
	30-50	73	32.02
	50-70	61	26.75
	> 70	25	10.96
Education level	No education / Elementary school completed	58	25.44
	Highschool completed	86	37.72
	University degree	84	36.84
Occupation	Employee	98	42.98
	Free lance	54	23.68
	Student	26	11.40
	Retired	37	16.23
	Unemployed	8	3.51
	Others	5	2.20
Household size	1 Member	28	12.28
	2 Members	70	30.70
	3-4 Members	105	46.05
	> 4 Members	25	10.96
Occupation related to agriculture	No	192	84.21
	Yes	36	15.79
Respondent monthly income	< $Ar 15,000 (U$S 1000)	84	36.84
	> $Ar 15,000 (U$S 1000)	135	59.21
	Missing values	9	3.95
Time spent in local rural landscapes	< 30 days	115	50.44
	> 30 days	113	49.56

Source: Own elaboration.

FIGURE 3

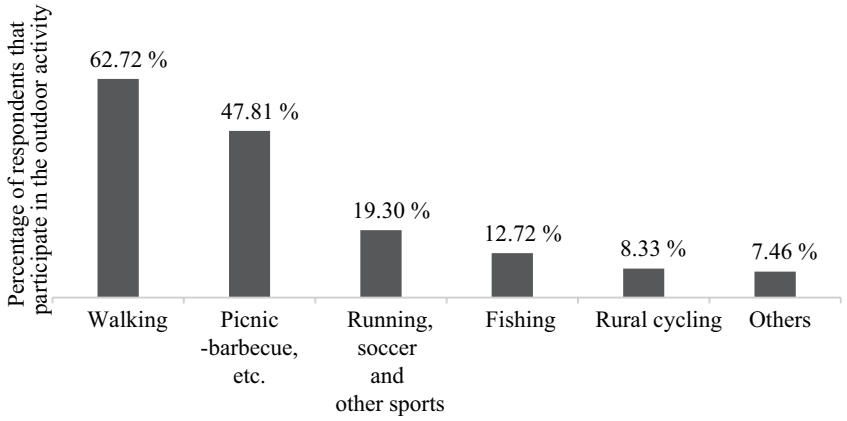
Outdoor sites most visited by Pergamino citizens



Source: Own elaboration.

FIGURE 4

Outdoor activities, Pergamino, Argentina



Source: Own elaboration.

TABLE 4

Survey respondents' relationship with landscape, Pergamino, Argentina

Statements	% of respondents who agree
I like living in this landscape	86
When I am absent, I miss the landscape of my region	54
I like spending time in the landscape of my region	89
I feel very identified with the landscape of my region	63

Source: Own elaboration.

4.2. Preference for landscape attributes

Based on their perception of aesthetics and recreational values, Pergamino inhabitants showed a strong preference for *the presence of trees, pastures, livestock, bird diversity, and winter crops,* (respondents' preference for more presence ranged from 73 to 57 %, respectively). Moreover, only a tiny proportion of people were willing to have less of these five attributes (Figure 4).

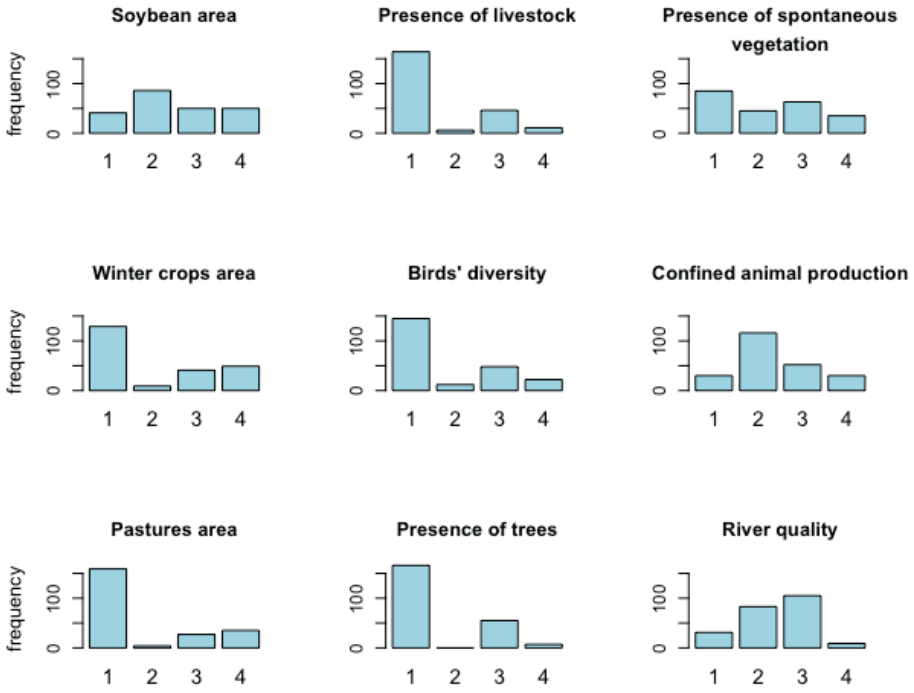
The attributes with the highest frequency of negative preference were *soybean area* and *confined animal production*, with 38 and 51 % of respondents, respectively, preferring *less*; however, there were also 18 and 16 % of people that would like more of these attributes. Finally, regarding river quality, the majority of respondents indicated that it was bad or regular.

For none of the attributes, the option *as current* was the most selected. The range was from 12 to 27 % for the different attributes.

River quality and the *presence of trees* were the most selected attributes that could contribute to rural landscape improvement in terms of aesthetic and recreation values. On the other hand, the least selected were *confined animal production*, *presence of native/spontaneous vegetation,* and *winter crops* (Figure 5).

FIGURE 5

Frequency of answers about preferences for rural landscape attributes, Pergamino, Argentina



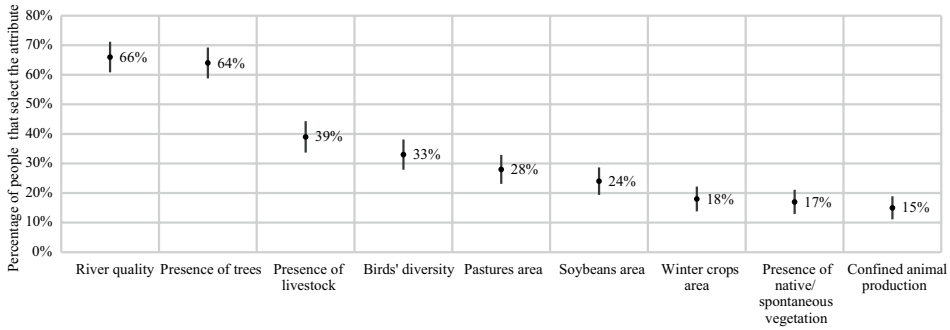
Survey question: 'This question refers to your perception about the aesthetic value of the landscape, please consider how much you enjoy watching, visiting or simply knowing that it is there. What is your perception about the (*attribute*, e.g. Soybean area) in your region? I would prefer: 1. More, 2. Less, 3. As current, 4. Don't know/No opinion/Am indifferent.'

***** For *River quality* the question was formulated in a different way: 'What is your opinion about the river quality? 1. Good, 2. Regular, 3. Bad, 4. Don't know/No opinion/Am indifferent.**'**

Source: Own elaboration.

FIGURE 6

Selection of the main attributes for rural landscape improvement aesthete and recreation values, Pergamino, Argentina



Note 1: Survey question: 'Please select within the nine attributes presented in the previous questions, the three that you would consider more relevant for rural landscape improvement in your region, by increasing or decreasing their presence in the landscape'.
Note 2: Vertical lines represent de 95 % confidence intervals for the proportion of people that select the attribute as one of the three most relevant for Pergamino rural landscape improvement.

Source: Own elaboration.

4.3. Probit regression results

Table 5 presents the estimated parameters in binomial probit models for each attribute (statistically significant parameters are highlighted). Due to missing values, the sample size varied between 188 and 211. In the case of the presence of livestock, one of the categories of age (*age4*) was lost due to the absence of variability.

In general terms, sociodemographic characteristics significantly impacted the perception of those landscape attributes in which responses showed greater variability, such as *soybean area* and *confined animal production*.

The sex variable positively influenced the preference for a smaller soybean area and negatively affected the perception of bad water quality.

People in the age group 30-70 years old expressed a greater preference for reducing the area planted with soybeans and intensive animal production, and increasing the winter crop area and bird diversity. High education levels were positively related to the preference for more livestock and trees and a smaller soybean area.

Regarding occupation, freelancers, employees, and students preferred reduced soybean areas. Students showed a preference for less confined animal production. Retired people stated a marked preference for pastures and livestock, attributes related to the traditional rural landscape of Pergamino county. The retired also entertained a more favourable opinion about river quality than the rest.

An interesting result was the non-significance of the Agro variable for most of the attributes. One explanation is that the occupation captures part of the effect as many jobs and economic activities in the region are indirectly associated with the agricultural sector. However, multicollinearity problems were not detected in the models[4].

Those who spent more than 30 days outdoors per year in the region shared attribute preference choices with students. Except for its effect on the soybean area, the household size had a negative impact on the choice of attributes. In particular, larger households seemed to prefer an increase in bird diversity and fewer confined animal production.

Finally, low-income people showed a greater preference for native vegetation and reduced intensive animal production. This variable's low relevance may be due to its level of aggregation as a dichotomous variable and the fact that other variables, such as education and occupation, capture part of the effect.

TABLE 5

Perceptions of rural landscape attributes Pergamino, Argentina, probit models estimation results

Var.	Less soybean area	More winter crops area	More pastures area	More presence of livestock	More bird diversity	More presence of trees	Bad river quality	More presence of native vegetation	Less confined animal production
Sex	0.5460**	0.2960	0.1424	0.1972	0.1794	0.2533	-0.3284*	0.1415	-0.1742
	(0.2189)	(0.1993)	(0.2132)	(0.2254)	(0.2072)	(0.2092)	(0.1979)	(0.2007)	(0.2011)
Age2	0.6104**	0.5745**	0.2948	0.2526	0.6994***	-0.2331	-0.0759	0.0214	0.6528**
	(0.2846)	(0.2551)	(0.2716)	(0.2731)	(0.2620)	(0.2719)	(0.2506)	(0.2546)	(0.2609)
Age3	0.6036*	0.3706	0.3571	0.4374	1.1130***	-0.0845	-0.3041	-0.1672	0.8690***
	(0.3360)	(0.3046)	(0.3293)	(0.3342)	(0.3278)	(0.3311)	(0.3068)	(0.3189)	(0.3108)
Age4	-0.1429	0.5470	0.2579	-	0.5624	0.0544	0.3054	0.5081	-0.0606
	(0.5404)	(0.4855)	(0.5631)	-	(0.5395)	(0.5270)	(0.4960)	(0.5131)	(0.4931)

[4] The variance inflator factor values are below 3 for all estimated models.

TABLE 5 (CONT.)

Perceptions of rural landscape attributes Pergamino, Argentina, probit models estimation results

Educ2	0.2781	-0.1549	0.0829	-0.2204	0.1003	0.5020*	0.1429	0.1235	0.0684
	(0.2773)	(0.2559)	(0.2758)	(0.2938)	(0.2717)	(0.2714)	(0.2565)	(0.2689)	(0.2577)
Educ3	0.7543**	0.2696	0.2379	0.5734*	-0.0510	0.2913	-0.1840	0.4489	0.0581
	(0.2958)	(0.2734)	(0.2958)	(0.3201)	(0.2834)	(0.2835)	(0.2765)	(0.2832)	(0.2725)
Ocup2	0.5858**	0.0311	-0.0719	0.0051	-0.0103	-0.0863	-0.2546	-0.0905	-0.0087
	(0.2527)	(0.2435)	(0.2632)	(0.2649)	(0.2589)	(0.2549)	(0.2406)	(0.2457)	(0.2458)
Ocup3	0.8214**	0.0359	0.0188	0.4781	0.4354	-0.2250	0.4058	-0.1140	0.6226*
	(0.3579)	(0.3231)	(0.3333)	(0.3451)	(0.3280)	(0.3433)	(0.3294)	(0.3343)	(0.3325)
Ocup4	0.3975	0.5079	0.7809*	0.7608	0.3027	-0.0277	-0.8956**	-0.2020	0.2948
	(0.4270)	(0.3976)	(0.4584)	(0.5074)	(0.4577)	(0.4247)	(0.4243)	(0.4356)	(0.4019)
Time	0.5435***	0.2834	0.2462	-0.2425	0.0858	0.2736	0.0817	0.0676	0.3669*
	(0.2050)	(0.1916)	(0.2041)	(0.2153)	(0.1994)	(0.2030)	(0.1911)	(0.1946)	(0.1955)
Agro	0.1348	0.0465	0.1782	0.3468	0.0933	-0.0402	0.2426	-0.6014**	0.1052
	(0.2742)	(0.2678)	(0.2911)	(0.3154)	(0.2789)	(0.2828)	(0.2679)	(0.2872)	(0.2686)
S2	0.7021*	0.1327	-0.8240**	-0.3133	-0.3934	0.4421	-0.0446	-0.3083	-0.4341
	(0.3689)	(0.3147)	(0.3925)	(0.4074)	(0.3518)	(0.3371)	(0.3169)	(0.3206)	(0.3220)
S3	0.3568	0.1284	-0.5575	-0.2100	-0.5536*	0.1198	-0.1670	-0.2404	-0.2675
	(0.3505)	(0.2978)	(0.3748)	(0.3729)	(0.3315)	(0.3104)	(0.2969)	(0.3022)	(0.3043)
S4	0.3785	0.4475	0.0213	0.4433	-0.7446*	-0.0526	-0.0433	0.1222	-0.8327**
	(0.4343)	(0.3798)	(0.4696)	(0.4808)	(0.4005)	(0.3820)	(0.3720)	(0.3698)	(0.3862)
Income	0.1094	-0.0014	0.2359	0.1265	0.1257	-0.1922	-0.2179	0.3848*	0.4304**
	(0.2137)	(0.2037)	(0.2164)	(0.2186)	(0.2119)	(0.2174)	(0.2028)	(0.2058)	(0.2080)
Constant	-2.4500***	-0.7570*	0.3702	0.1309	-0.0164	0.1220	0.4044	-0.4923	-0.5140
	(0.5308)	(0.4291)	(0.4929)	(0.5274)	(0.4570)	(0.4424)	(0.4226)	(0.4328)	(0.4283)
N	211	211	209	188	210	211	211	211	211

Notes: The value for Age4 in "More presence of livestock" equation is not present because of lack of variability in the data.
Standard errors in parenthesis; (*) p-value < 0.1; (**) p-value < 0.05; (***) p-value < 0.01.

Source: Own elaboration.

4.3.1. Marginal effects of sociodemographic characteristics

Table 6 shows the marginal effects, for the modal individual, of sociodemographic characteristics for each landscape attribute[5]. Only the statistically significant are reported. Each variable's marginal effect indicates an increase or decrease –depending on the coefficient sign– in the modal individual's probability of choosing an attribute keeping the other variables constant. The modal individual is a woman between 30 and 50 years old, with high school education, employed outside the agricultural sector with a monthly income greater than ARS 15,000 (U$S 1000), who lives in a 3-4 members household, and who spends less than 30 days in nearby outdoor areas.

The last row shows the estimated probability for a modal individual to choose each change in the attributes. The highest probability values were 79 % for 'more presence of trees', 71 % for 'larger pasture area', 64 % for 'less confined animal production' and 'bad river quality', and 62 % for 'more birds' diversity'.

The other values in the table are the estimated marginal effects. For example, the value on the upper left of the table (0.1409) indicates that a man had a 42.4 % (28.4 % + 14 %) probability of selecting a smaller soybean area, 14 % higher than a woman, ceteris paribus.

The magnitude of the coefficients ranged from 14 % to 32 %. The highest positive effects were for age3 (+ 32 %) concerning the selection of more bird diversity and less confined animal production. The highest negative effects were for ocup4 and size2 (-34 % and -31 %) regarding the selection of bad river quality and larger pasture area, respectively.

Marginal effects of sociodemographic variables enable to measure and compare the intensity of preference for each landscape attribute in the different socioeconomic groups, contributing to generate and more precise knowledge of Pergamino population cultural bond with rural landscapes and the welfare they obtained from them.

[5] Since the explanatory variables are dichotomous, the marginal effects are calculated for a change from zero to one.

TABLE 6

Estimated marginal effects of sociodemographic variables by landscape attribute, Pergamino, Argentina

Variables	Less soybean area	More winter crops area	More pastures area	More presence of livestock	More birds' diversity	More presence of trees	Bad river quality	More presence of native vegetation	Less confined animal production
Sex	0.1409**	-	-	-	-	-	-0.1292*	-	-
Age2	-	0.2006**	-	-	0.2716***	-	-	-	0.2381**
Age3	-	-	-	-	0.3195***	-	-	-	0.3147***
Age4	-	-	-	-	-	-	-	-	-
Educ2	-	-	-	-	-	0.1917*	-	-	-
Educ3	0.2120*	-	-	0.2194*	-	-	-	-	-
Ocup2	0.1538*	-	-	-	-	-	-	-	-
Ocup3	0.2366*	-	-	-	-	-	-	-	0.2371**
Ocup4	-	-	0.2588**	0.2811*	-	-	-0.3424**	-	-
Time	0.1401**	-	-	-	-	-	-	-	0.1445*
Agro	-	-	-	-	-	-	-	-0.1611**	-
S2	-	-	-0.3123**	-	-	-	-	-	-
S3	-	-	-	-	-0.1924*	-	-	-	-
S4	-	-	-	-	-0.2875**	-	-	-	-0.2900***
Income	-	-	-	-	-	-	-	0.1412*	0.1684**
Pr(y=1) for the representative individual	**0.284**	**0.537**	**0.708**	**0.438**	**0.618**	**0.793**	**0.638**	**0.294**	**0.639**

Notes: Only statistically significant marginal effects are reported. The variables take the following values for the representative (modal) individual: sex=0, age2=1, educ2=1, ocup1=1, time=0, agro=0, s3=1, income=0.

* Statistically Significant at the 0.10 level, ** Statistically Significant at the 0.05 level, *** Statistically Significant at the 0.01 level.

Source: Own elaboration.

4.3.2. The predictive capacity of probit models

Table 7 shows that the models have a relatively good predictive performance. The models could predict very well (sensitivity > 90 %) those individuals that chose larger areas of pastures, presence of livestock, bird diversity and trees, but could not classify (specificity < 40 %) those that did not choose them. Also, the prediction was good for those who did not choose a smaller soybean area or greater presence of native vegetation and did not show perception of bad water quality (specificity > 70 %).

TABLE 7

Predictive capability of Probit models to characterize the perceptions of landscape attributes of Pergamino rural landscape, Argentina.

Variables	Less soybean area	More winter crops area	More pastures area	More presence of livestock	More bird diversity	More presence of trees	Bad river quality	More presence of native vegetation	Less confined animal production
Sensitivity	43.04	77.97	96.67	90.77	88.89	98.68	53.06	34.62	68.52
Specificity	82.58	51.61	10.17	25.86	38.67	3.39	70.8	85.71	65.05
General	67.77	66.35	72.25	70.74	70.95	72.04	62.56	66.82	66.82

Notes: Sensitivity measures positive values correctly classified. Specificity measures negative values correctly classified. General measures positives and negatives correctly classified.

Source: Own elaboration.

5. Discussion

A significant proportion of Pergamino City inhabitants spend time in rural landscapes for leisure and sports, implying a strong connection between people who live in the city and the agricultural landscape. Therefore, the perception of rural landscape attributes is the result of different types of interactions with these agroecosystems (Russell *et al*., 2013): multisensory interactions with ecosystem elements from doing activities in rural landscapes, distant (mostly visual) interactions with ecosystem elements, and meditating on an ecosystem or the notion of an ideal ecosystem. Based on Russel *et al.* (2013), these interactions with the rural landscape can contribute to Pergamino inhabitants' wellbeing in different ways, such as physical and mental health and creativity.

In terms of preferences for rural landscape attributes based on aesthetic and recreation values, Pergamino citizens identify as positive an increase in land allocated to winter crops and pastures, the presence of livestock, birds, trees and native/spontaneous vegetation. These attributes are more frequently found in more

diversified farming systems; hence these results can be considered a preference for land use diversification (Codesido *et al*., 2015). On the contrary, they prefer reduced soybean area and confined animal production, attributes associated with more intensive production systems and landscape simplification. These preferences for landscape attributes show that there is a trade-off between rural landscape aesthetic values and landscape simplification in the area. The results are similar to those from other studies (Assandri *et al*., 2018; Junge *et al*., 2015).

Even when landscape attributes are, in part, case-specific, it is interesting to compare the preferences of Pergamino inhabitants with those in other regions. In a meta-analysis of European landscape attribute preferences, van Zanten *et al*. (2014a) reported that the presence of historic buildings, mosaic land cover, and livestock in the landscape display the top stated preferences. While historic buildings were not considered in this study, the other two attributes were valued positively as landscape attributes.

Some similarities with studies on rural landscape perception conducted in Argentina were found. Abraham *et al*. (2014) studied the landscape perception of urban residents in Mendoza city. Vineyards and mountains characterize the landscape in this area and are visited by tourists every year. The authors indicated that the residents appreciated the aesthetic value of agricultural landscapes with vineyards.

Also, strong similarities are found with the results that Auer *et al*. (2018) obtained for the southern Argentine Pampas, even when both have different production systems. The southern Pampas region has more soil and weather restrictions for cereal and oilseed production and is more suitable for tourism than Pergamino County in the northern Pampas. In line with the findings of this study, Auer *et al*. (2018) reported that the attributes positively related to the choice of places for recreation and tourism are good water quality, presence of animals and birds in the landscape, land use diversification, and rural houses inhabited. On the other hand, large areas with the same crops and feedlots are mentioned as the landscape attributes with negative perception.

Concerning the trade-off between agricultural production maximization and rural landscape aesthetic and recreational values, it is interesting to note that improving river water quality and increasing the presence of trees (the attributes chosen as the most important for landscape improvement by most respondents) can be achieved with only minor losses in agricultural productivity. Water quality assessment conducted on the Pergamino river indicated that implementing riparian strips and improving treatment in the urban sewage plant are the recommended management practices for decreasing and preventing river contamination (García *et al*., 2017; Torti & Andriulo, 2014). It was found that riparian buffer strips 30 m wide drastically reduce contamination risk (Darder *et al*., 2016). These buffer zones involve a very low proportion of arable land, with a significant impact on ecosystem conservation and aesthetic values.

There is an increasing interest in the incentives for developing woodlots in peri-urban areas and areas close to farmhouses and rural schools. In these areas, there are restrictions for pesticide use, and the presence of trees could not only contribute to landscape beauty but also serve as protection for pesticide drift (Ferrere & Signorelli, 2018). However, based on a study conducted in the central Pampas (Codesido *et al*., 2013), the presence of woodlots, particularly those with exotic perennial trees, is positively related to the abundance of pest birds. It would then be important to select tree species less attractive to pest birds to include in woodlots.

It is interesting to consider how landscape simplification is related to the environmental and economic performance of agroecosystems. Cabrini & Calcaterra (2016) estimated environmental and economic indicators of agricultural production systems in Pergamino (such as gross margin, direct production costs, and soil organic carbon). They found that a more balanced environmental and economic performance is associated with reducing the area assigned to full-season soybeans and increasing land use diversification. This study and others (Franzluebbers *et al*., 2014; Peyraud *et al*., 2014) highlighted the advantages of integrated field crops/grass-based livestock production systems in the Argentine Pampas region based on their agronomic and environmental impacts. Pacín & Oesterheld (2014) found that, in southwestern Buenos Aires, including livestock and increasing land use diversification are powerful risk reduction strategies. Other research conducted by Weyland *et al.* (2014) studied the relationship between landscape elements and bird diversity in the agroecosystems of the Rolling Pampas. The authors conclude that pastures, winter crops, and trees are key elements for determining bird species distribution. Cerezo *et al.* (2011) identify pastures and natural grassland species as positively related to bird richness or abundance.

This study also provided elements to understand the heterogeneity in rural landscape perceptions. Daniel (2001) states that the way people perceive the aesthetic values of landscapes depends on landscapes' physical features and the perceptual processes that these physical features evoke in the viewer. Hence, landscape beauty perception is constructed from each person's history, experiences, and education; therefore, many aspects influence how people enjoy rural landscapes. In this sense, our study found that middle-aged people (30-70 years old) tend to have preferences for landscape attributes that abounded in the past and they probably had the opportunity to experience and enjoy, and have recently suffered a sharp decrease. The choice for more natural/spontaneous vegetation is infrequent in people with a farming-related occupation, who might focus on agricultural productivity rather than on the recreational and aesthetic values of the rural landscape.

In terms of sex, there were very few significant results to inform, as in similar European studies (van Zanten *et al*., 2014a; Howley, 2011; Sayadi *et al*., 2009). Besides, it is interesting that education is positively related to selecting changes in the landscape that would decrease negative environmental impacts and increase animal welfare. These results are consistent with the findings of van Zanten *et al*.,

(2014a) in a meta-analysis of preferences for European landscape. Their results show that education is positively related with preference for multifunctionality, ecological restoration and wilderness of agrarian landscapes.

6. Conclusion

The Rolling Pampas of Argentina, a 3,200,000 ha area with a landscape originally dominated by natural grassland, is now one of the world's most productive agricultural regions for cereals and oilseeds. This study explores the multifunctionality of agroecosystems in this region by assessing the provision of CESs in rural landscapes. CESs generated by rural landscapes in Pergamino are relevant for people's wellbeing since most of the inhabitants enjoy spending time in rural areas for leisure.

The increasing land area allocated to a few annual crops in recent decades has generated a simplification of the rural landscape in Pergamino county and, based on people's perceptions, the consequent loss of attributes associated with landscape beauty. The significant relationship between sociodemographic variables, such as age, education, and occupation, and preferences for rural landscape attributes is consistent with the notion that landscape beauty perception is constructed from each person's experiences and background.

The similarities between Pergamino county and the rest of the Rolling Pampas allow for extrapolation of results to this wider geographical context. The inhabitants of this region have expressed growing concerns about the increase in the dependence of production systems on external inputs, mainly agrochemicals, associated with the simplification of agricultural production systems. More diverse land use schemes could have multiple benefits, including increasing landscape aesthetic value and the recreation resources available to the population.

While there are no national policies for landscape conservation in the central Pampas, a national bill[6] is under discussion. This bill promotes biodiversity in cultivated areas by establishing the mandatory conservation of a minimum area with natural species. At the county level, there have been in the last decades a few initiatives such as the Soil Conservation Law in Entre Ríos province. This law gives tax benefits to producers who apply certain agricultural practices that favour soil conservation (e.g., terrace farming).

This study contributes to the design of landscape conservation policies, offering evidence of the potential to increase Pergamino inhabitants' wellbeing by extending the presence of some rural landscape attributes without compromising in general terms agricultural productivity.

[6] Minimum Budgets for Biodiversity in Cultivated Environments.

Regarding the future agenda, more research is needed to address trade-offs and synergies among provisioning ESs, regulating ESs and CESs for the Argentine Rolling Pampas to support the design of policies fostering the incorporation of the multifunctionality of agricultural systems into the decisions made by farmers as land managers and custodians of the landscape.

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