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Assessing the visual quality of rural landscapes

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Abstract

This paper presents a methodology for assessing the visual quality of agricultural landscapes through direct and indirect techniques of landscape valuation. The first technique enables us to rank agricultural landscapes on the basis of a survey of public preferences. The latter weighs the contribution of the elements and attributes contained in the picture to its overall scenic beauty via regression analysis. An application based on two Mediterranean rural areas in Andalusia in Southern Spain is presented. The photos used in the survey included man-made elements, positive and negative, agricultural fields, mainly of cereals and olive trees, and a natural park. There were 10 panels, each containing 16 photos, and 226 participants ranked the best four and worst four pictures of each panel. Each participant ranked an average of 7.3 panels. The results show that perceived visual quality increases, in decreasing order of importance, with the degree of wilderness of the landscape, the presence of well-preserved man-made elements, the percentage of plant cover, the amount of water, the presence of mountains and the colour contrast.

Keywords: Landscape assessment; Visual quality; Landscape elements; Landscape value

1. Introduction

The term landscape used in this paper is restricted to its visual properties, including human-made elements and physical and biological resources (Daniel and Vining, 1983; Amir and Gidalizon, 1990). In this sense, we move from the structural and scenic approach to landscape to the perceived landscape, and hence, to a subjective impression of what the real landscape is like (Muir, 1999). As Laurie (1975) points out, landscape evaluation may be defined as "the comparative relationships between two or more landscapes in terms of assessment of visual quality".

In line with this subjective impression Tuan (1979, p.89) wrote: "Landscape... is not to be defined by itemising its parts. The parts are subsidiary clues to an integrated image. Landscape is such an image, a construct of the mind and of feeling". Beauty in landscape comes from two main sources which cannot be separated: from the object and from the observer (Laurie, 1975, p.107). Therefore, the landscape perceived by one person is not the same as that perceived by another.

In this paper, we attempt to assess the importance of individual elements in explaining preferences for certain landscapes. Hull and Revell (1989) express this broad approach to landscape as "the outdoor environment, natural or built, which can be directly perceived by a person visiting and using that environment. A scene is the subset of a landscape which is viewed from one location (vantage point) looking in one direction...".

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1.1. Landscape evaluation techniques

In assessing landscape visual quality there is an assumption that landscapes have an intrinsic or objective beauty (Shuttleworth, 1980a) which, although being a subjective response of the observer (Polakowski, 1975), can be quantified via the presence of certain dimensions (Buhyoff and Riesenmann, 1979; Dearden, 1980). As Briggs and France (1980) point out, there are two main approaches to the evaluation of landscape:

- *Direct methods* compare the scenic preferences of members of the public for landscapes in order to reach a consensus (Arthur et al., 1977; Briggs and France, 1980; Pérez, 2002).
- *Indirect methods* evaluate the landscape on the basis of the presence and/or intensity of designated features (Fines, 1968). Such methods aggregate landscape components in order to obtain a total value, implying that overall scenic quality is the sum of its parts (Linton, 1968; Tandy, 1971; Land Use Consultants, 1971). This approach has been criticised by some authors (Crofts and Cooke, 1974) for the subjectivity implied in the valuation of the components of the landscape. Moreover, this method does not capture any interactive effects of the individual components (Dunn, 1976).

Likewise, Crofts (1975) describes two types of technique for landscape evaluation: preference and surrogate component techniques, whereas, Arthur et al. (1977) used the terminology of public preference models and descriptive inventories methods. These classifications are similar to those of direct and indirect methods, respectively.

Shafer et al. (1969) presented a compromise between descriptive methods and preference models, namely, holistic models such as psychophysical and surrogate component models (Buhyoff and Riesenmann, 1979). This approach has found favour in recent years and is supported by the use of statistical techniques to determine the mathematical relationships that exist between landscape components and the scenic preferences of observers (Palmer, 1983; Daniel and Vining, 1983; Buhyoff et al., 1994; Wherrett, 2000; Real et al., 2000; Daniel, 2001). This is the approach selected in the present paper.

It is worth noting that there exist more complex classifications of landscape evaluation techniques. Daniel and Vining (1983) split the methods into ecological, formal aesthetic, psychophysical, psychological and phenomenological models. García and Cañas (2001) divide the methods into five categories: direct models, models to predict public preferences, indirect models, mixture models and economic evaluation models.

As in several earlier works that have attempted to assess the scenic preferences of observers, we used photographs of the rural landscapes (Dunn, 1976; Law and Zube, 1983; Shafer and Brush, 1977; Shuttleworth, 1980b; Wherrett, 2000; Pérez, 2002). This approach is based on the assumption that aesthetic judgements of panels provide an appropriate measure of landscape quality (Daniel and Vining, 1983). Descriptions of the use of pictures in public preference models versus other methods, mainly direct observation, can be found in Stewart et al. (1984), Shelby and Harris (1985), Bernaldez et al. (1988), Hull and Stewart (1992) and Silvennoinen et al. (2002).

The following sections of this paper consist of three main parts. The first explains the methodology followed in this research. The second presents the results of the survey on landscape public preferences and the mathematical model. Finally, some conclusions are outlined.

2. Methodology

The methodology followed in this paper can be divided into five distinct parts. First, using geographic information systems, the area of study was classified into relatively homogeneous landscape units. Second, we took photos that were intended to cover the most important land uses within each unit. Third, we assessed the scenic beauty of the landscape via a survey of observer preferences. Fourth, after measuring the visual quality assigned to each scene on a derived interval scale, we evaluated the intensity of the landscape attributes and elements present in each image using categorical or nominal variables. Finally, we regressed the explaining variables against overall picture value in order to obtain the contribution of each component to perceptions of visual quality of the landscape.

2.1. Splitting the area into homogeneous units

Using geographical information system techniques the area of study, the northern part of the Province of Cordoba in Andalusia, Spain, was divided into homogeneous units from a visual point of view. The variables used for the classification were land use, altitude and slope (gradient). From the CORINE land cover 1/50,000 (European Environment Agency, 1995), four types of land use were identified: buildings and infrastructures, wet areas, agricultural fields and forestry. In terms of gradients, the area was classified according to the Stevenson (1970) intervals: less than or equal to 1%, between 1 and 5%, between 5 and 10%, and more than 10%.

2.2. Photography

More than 400 photos were taken in the study area between February and April 2001, with the aim of capturing the most relevant features of the rural landscape of each unit. The photos were taken using an HP 1000 digital camera on clear days. For example, if the most important crop in a particular unit was olive trees, we looked for olive tree fields on flat or mountainous areas, with or without herbaceous cover, with or without man-made elements, either positive (typical Andalusian white houses, farm-buildings and beauty spots) or negative (power lines, industries and roads), with or without other herbaceous crops, etc. The result is a wide variety of pictures of olive trees fields with most of the elements that were to be included in the visual quality regression analysis.

2.3. Panels

A selection of photos was made for presentation to observers on 10 panels, with 16 scenes on each panel. The 160 scenes were assigned strictly randomly to the 10 panels.

2.4. Survey of observers' preferences

Following a convenience sampling design (Malhotra and Birks, 2000), the sample of 226 subjects consisted of agricultural students (58%), participants in a landscape valuation course (22%), art students (11%) and farmers from the study area (9%). Each subject ranked an average of 7.33 panels, so that the total number of scores for each of the 160 photos was $226\cdot(7.33/10) = 166$.

Observers were asked to choose the four photos they liked best and the four they liked least. The "best" was given a score of +4 points, the second best +3 points, and so on. The "worst" was scored −4 points, the second worst −3 and so on. The eight pictures not chosen were each allocated 0 points. Then, we obtained an average visual quality index (AVQ index) for each scene, which was the dependent variable in the visual quality regression model.

The treatment of the AVQ index as interval data and the 10-panel design address two issues that must be clarified. First, although, under the assumption of transitivity, there are some procedures to derive an interval scale from rankings (Turstone, 1959; Hays, 1967; Albaum et al., 1977; Traylor, 1983), these are cumbersome and may not justify the effort involved since some authors (Lobovitz, 1967, 1970; Kim, 1975; Binder, 1984; Zumbo and Zimmerman, 1993) argue that there is little error in treating ordinal data as interval. Furthermore, Givon and Shapira (1984), Crask and Fox (1987) and Jaccard and Wan (1996) support this treatment providing that the scale items have at least five and preferably seven categories (in our study we have nine, since the scores range from −4 to +4).

The second issue deals with the allocation of pictures in each panel. To what extend the AVQ index of each scene is dependent on the other pictures in the panel? Since the pictures were assigned strictly random we can argue that the expected value of visual quality on each panel is the same. In order to test the assumption of equal expected values per panel we carried out a second experiment consisting on the rating by 26 people of 30 pictures taken randomly from the 160 set. Each respondent ordered the pictures from high to low preference and selected the best scene (or scenes) with a score of 100. Then the remaining pictures were rated between 0 and 100 with respect to the best print(s). There were no restrictions on how the subjects used the numbers on the scale, therefore, they were allowed to use the same number for more than one scene.

Our hypothesis is that the ranking of scenes is approximately the same from both experiments. Whereas, the rating of 30 scenes produces an interval scale variable, its application get more difficult as

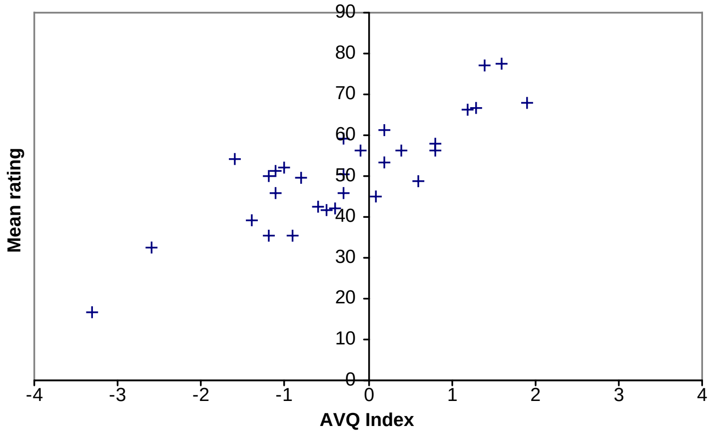

Fig. 1. Comparison of AVQ index and mean rating of 30 random scenes.

the number of scenes increases. Yet, we needed more than 150 pictures to have enough degree of freedom for the regression analysis. The 10-panel design allows increasing this number with less effort from the respondents. Fig. 1 shows the AVQ index calculated from the ranking of pictures within each panel and the mean rating of the 30 pictures.

As we can see, there is a strong positive correlation ($r = 0.85$) between the AVQ index and the mean rating. The concordance of both experiments makes us to support the initial hypothesis of equal expected values and the statistical validity of the derived interval scale variable.

2.5. Assessing the intensity of the landscape attributes and elements

In order to measure the intensity of the landscape attributes and elements present in the picture, a group of six researchers from our Research Institute and the

Table 1
Scale of measurement of landscape attributes and elements

Variable	Scoring
Water movement	No movement = 0; movement = 1
Amount of water	No water = 0; river = 1; lake = 2; dam = 3
Percentage of land covered by vegetation	0–25% = 0; 25–50% = 1; 50–75% = 2; 75–100% = 3
Type of vegetation	No vegetation = 0; herbaceous and bushes = 1; mix vegetation (bushes + trees) = 2; trees = 3
Horizon	Almost flat = 0; slightly wavy = 1; some mountains = 2; mountains dominate the scene = 3
Presence of positive man-made elements (sights and typical houses)	None = 0; one element = 1; two elements = 2; three or more elements = 3
Presence of negative man-made elements (roads, industries, power lines, etc.)	None = 0; one element = 1; two elements = 2; Three or more elements = 3
Number of colours	One colour = 1; two colours = 2; three or more colours = 3
Internal contrast	Weak colour contrast = 0; clear colour contrast = 1
Presence of alignments	None = 0; presence of alignments = 1
Scale effect	No element presents scale effect = 0; presence of scale effect = 1
Focal view	No focal view = 0; focal view = 1
Texture	Smooth = 1; medium = 2; rough = 3
Degree of wilderness	Houses + roads + other = 0; few isolated elements = 1; crops without man-made elements = 2; wild vegetation = 3

University of Cordoba scored each of the 160 photos according to the scale of measurement shown in Table 1.

2.6. Regression analysis

First, we carried out a correlation analysis in order to identify the variables that had the strongest relationships with the dependent variable (AVQ). For the interval scale variables we used Kendall's Tau, since many scores had the same rank, while for the dummy variables the biserial coefficient was calculated (Field, 2000, p. 92).

3. Results

As examples of the type of photos presented on the panels, Figs. 2 and 3 show the "best" and "worst" four photos as determined by the subjects.

The median scores of the explanatory variables for the images are shown in Table 2. As previously explained, the intensity of the components perceived in the picture are measured according to Table 1.

The correlation analysis of the interval scale variables is presented in Table 3. According to these results, landscape visual quality increases, as expected, with the area of water visible, the degree of wilderness,

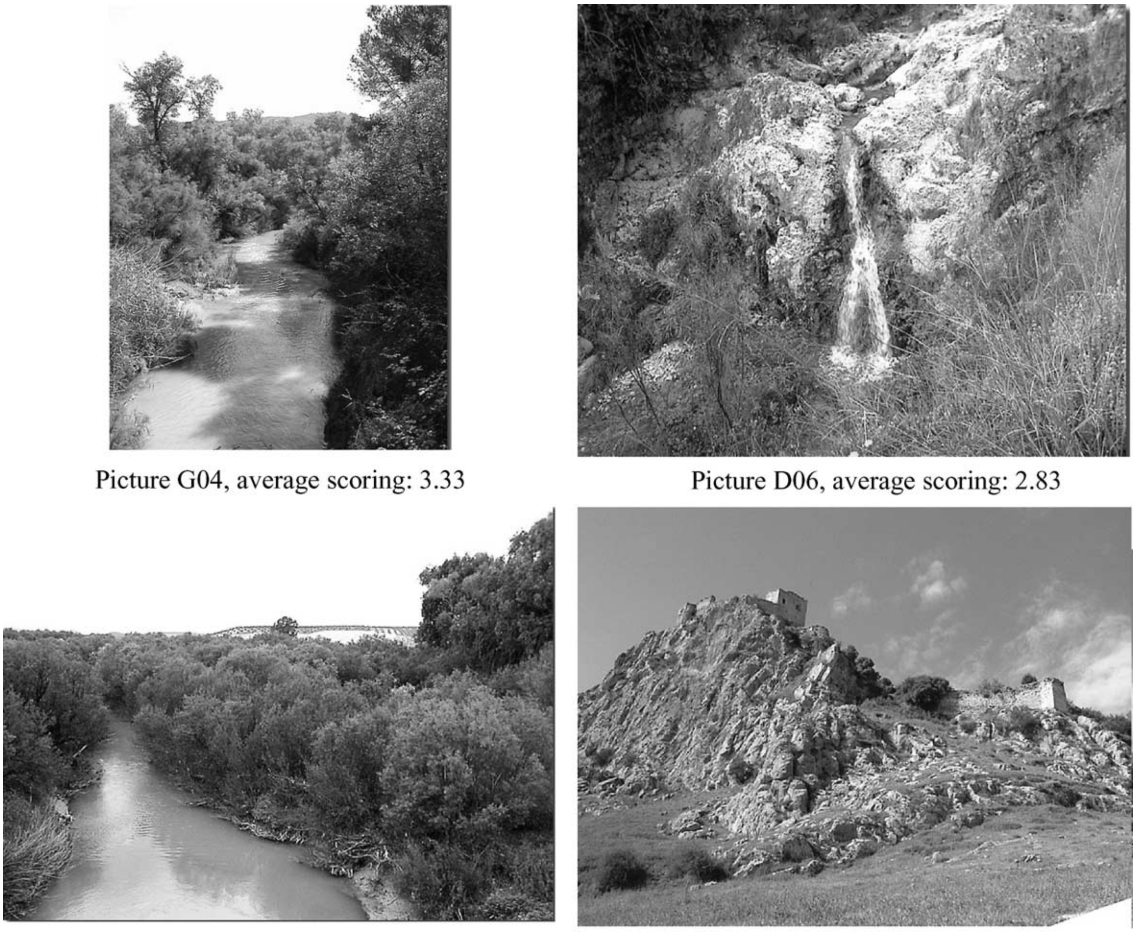

Fig. 2. "Best" four pictures and scoring.

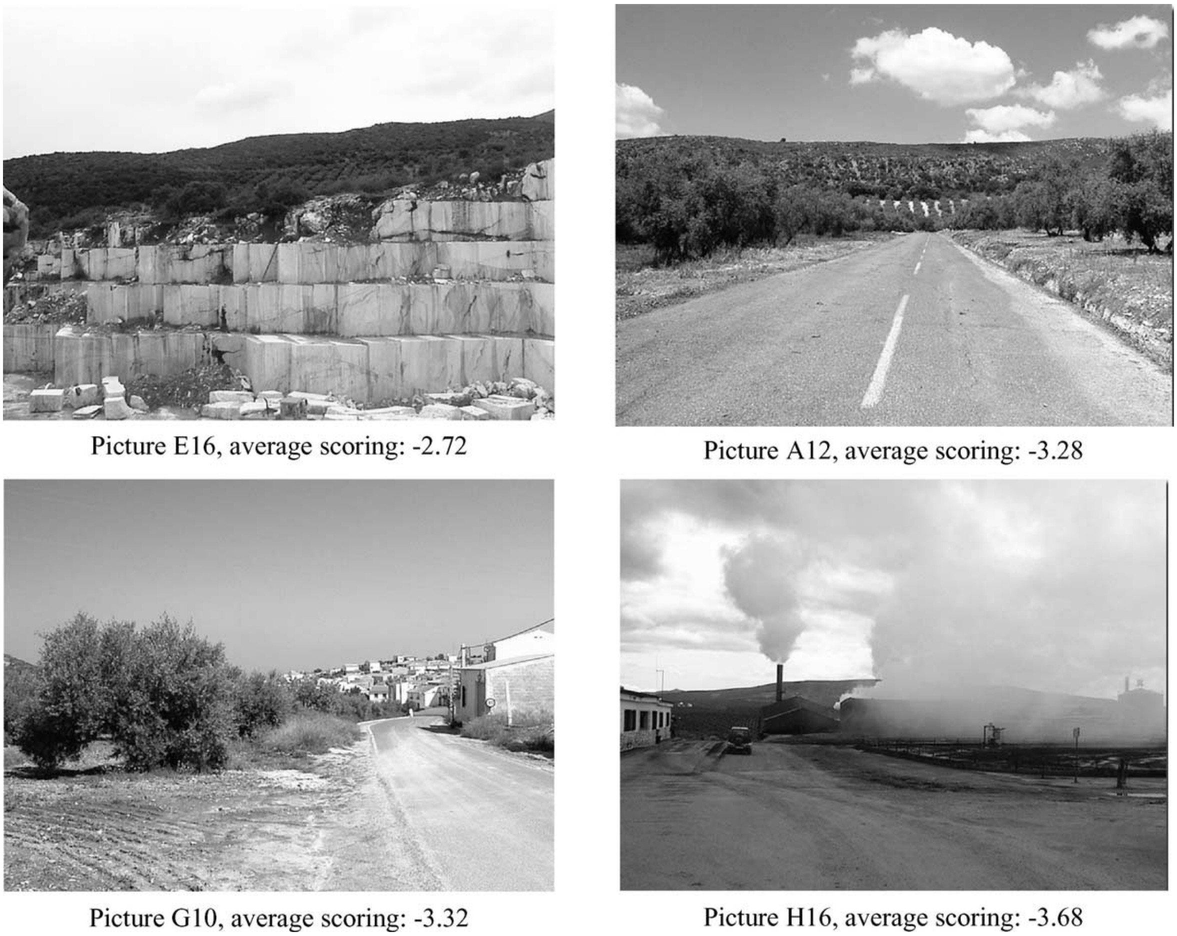

Fig. 3. “Worst” four pictures and scoring.

the presence of mountains (horizon) and the percentage of vegetation. On the other hand, it decreases with the growing presence of negative man-made elements (roads, electric power lines, industries, etc).

Table 4 also shows a statistically significant negative correlation between the average visual quality and the scale effect and a positive correlation with colour contrast.

Correlation analysis led us to select some explanatory variables for the multivariate analysis. The coefficients of the linear regression model are shown in Table 5. The regression analysis, as would be expected from the correlation analysis, suggests the importance of the degree of wilderness to explain the visual quality of landscape. It is also interesting to note how positively evaluated man-made elements improve the perceived quality of rural scenery.

In order to accept the above model we tested the normality of the residuals, multicollinearity and heterocedasticity.

3.1. Normality of the residuals

Due to the sample size ($n = 160$), the usual test procedures (the t and F tests) are still valid asymptotically (Greene, 1997, p. 341; Gujarati, 1995, p. 317), even though the residuals do not follow a normal distribution (Kolmogorov-Smirnov $= 0.08$, $P = 0.02$).

Table 2
Median scores of the explanatory variables for the best and worst pictures

	G04	D06	J03	A06	E16	A12	G10	H16
AVQ index	3.33	2.83	2.81	2.64	−2.72	−3.28	−3.32	−3.68
Water movement	1	1	1					
Amount of water	1	1	1	0	0	0	0	0
Degree of wilderness	3	3	3	1	1	1	0	0
Horizon	0	3	0	3	2	2	0	0
Presence of positive man-made elements	0	0	0	3	0	0	0	0
Presence of negative man-made elements	0	0	0	0	2	1	1	3
Percentage of vegetation	2	0	1	1	1	1	0	0
Type of vegetation	3	1	3	1	3	2	3	0
Number of colours	2	3	2	3	2	3	2	1
Texture	3	3	3	2	2	2	3	3
Scale effect	1	1	0	1	0	1	1	1
Focal view	1	0	1	0	0	1	1	0
Alignments	0	0	0	0	0	0	0	0
Colour contrast	1	1	1	1	0	0	0	0

3.2. Multicollinearity

According to Menard (1995), a tolerance value lower than 0.20 suggests a multicollinearity problem. The minimum value in our model was 0.64. Alternatively, following Myers (1990) and Bowerman and O'Connell (1990), a variance inflation factor (VIF) above 10 indicates the possible existence of a multicollinearity problem. In our model the maximum value was 1.57.

Table 3
Correlation analysis (Kendall Tau statistic)

		AVQ	Amount of water	Degree of wilderness	Horizon	Positive antropic	Negative antropic	Percentage of vegetation	Type of vegetation	Number of colours
Amount of water	Coefficients	0.30								
	Significance	0.00								
Degree of wilderness	Coefficients	0.40	0.26							
	Significance	0.00	0.00							
Horizon	Coefficients	0.15	−0.09	−0.02						
	Significance	0.04	0.22	0.79						
Presence of positive man-made elements	Coefficients	0.10	0.01	−0.34	0.08					
	Significance	0.16	0.90	0.00	0.27					
Presence of negative man-made elements	Coefficients	−0.29	−0.15	−0.39	0.02	−0.09				
	Significance	0.00	0.05	0.00	0.82	0.23				
Percentage of vegetation	Coefficients	0.26	−0.02	0.16	−0.09	−0.02	−0.10			
	Significance	0.00	0.78	0.02	0.20	0.80	0.17			
Type of vegetation	Coefficients	−0.05	0.12	−0.01	0.07	−0.08	−0.10	0.04		
	Significance	0.51	0.11	0.94	0.34	0.27	0.16	0.536		
Number of colours	Coefficients	−0.04	0.14	−0.06	−0.02	0.12	0.05	−0.24	−0.02	
	Significance	0.61	0.067	0.44	0.83	0.12	0.54	0.00	0.74	
Texture	Coefficients	−0.11	0.08	−0.12	0.23	−0.08	0.08	−0.18	0.22	0.00
	Significance	0.13	0.28	0.09	0.00	0.24	0.26	0.01	0.00	0.95

Table 4
Biserial correlation coefficients

		AVQ index	Water movement	Scale effect	Focal view	Alignments
Water movement	Coefficients	0.38				
	Significance	0.11				
Scale effect	Coefficients	−0.20	0.29			
	Significance	0.01	0.23			
Focal view	Coefficients	−0.13	0.57	0.28		
	Significance	0.10	0.01	0.00		
Alignments	Coefficients	−0.06	0.22	−0.17	0.09	
	Significance	0.49	0.36	0.04	0.25	
Colour contrast	Coefficients	0.33	0.03	−0.15	0.05	0.12
	Significance	0.00	0.91	0.05	0.51	0.14

3.3. *Heterocedasticity*

The White test (White, 1980) did not reveal any problem of heterocedasticity: $n{\cdot}R^2 = 160{\cdot}0.29 = 46.4$, for $X^2_{340.05} = 48.7$; hence we did not reject the null hypothesis of homocedasticity.

Comparing the coefficients of the model with other studies on landscape assessment we find some common results. Zube et al. (1975), Daniel and Vining (1983), Knopf (1987), Orland (1988) and Purcell (1992) determine a negative relationship between man-made elements and visual quality, as we do for negative antropic elements. Furthermore, Purcell concludes that public prefer pictures highly typical with large amount of vegetation, as it occurs in our model with the percentage of vegetation. Likewise, in Dearden (1985) the presence of water and the degree of wilderness have a positive impact on the visual quality of the landscape. There are other authors that highlight the importance of water in the scene as well as the presence of trees (Ulrich, 1981; Herzog, 1985; Herzog and Bosley, 1992; Yang and Brown, 1992), in our study the effect of water on the visual quality coincides, however, the variable related to type of vegetation (herbaceous versus trees) did not result statistically significant in the regression analysis. Calatrava and Sayadi (2001, p. 270) give similar results through conjoint analysis with the percentage of vegetation as the most important attribute of the landscape, and the presence of positive antropic elements (typical Andalusian white houses in the mountains) the second. However, respondents showed a lower preference for unaltered landscape compared to agricultural fields.

We find also interesting similarities between Real et al. (2000) and the present paper. The former, in its first study, defines four main aspects to classify landscapes: the presence/absence of water, the artificiality of the scene, its roughness and the human presence. These four characteristics are included in the current model; this is, amount of water, degree of

Table 5
Regression analysis of the scoring on explanatory variables

Variables	Unstandardised beta	Standardised beta	t	Significance
Constant	−2.857		−7.989	0.000
Amount of water	0.445	0.175	2.969	0.003
Degree of wilderness	0.831	0.409	5.841	0.000
Horizon	0.319	0.172	3.013	0.003
Positive man-made elements	0.721	0.342	5.500	0.000
Negative man-made elements	−0.302	−0.134	−2.078	0.039
Percentage of vegetation	0.370	0.215	3.762	0.000
Colour contrast	0.496	0.165	2.764	0.006

$n = 160$; $R^2 = 0.52$; $R^2_{\text{adj.}} = 0.50$; $F = 24.03$ (Significance = 0.000).

wilderness, horizon and the presence of positive and negative antropic elements, respectively. In the same paper, the second study presents different regression models that confirm the positive (negative) relationship between the beauty of landscape and the amount of water (amount of humanised elements).

4. Conclusions

We have implemented a straightforward method for assessing the visual quality of rural landscapes. The same methodology can be applied to other areas in order to rank and explain the scenic beauty of landscapes. The information supplied by the model can enrich the decision-making process that has to evaluate competing sites for the location of recreational facilities that will suit a given target population.

According to the results, the degree of wilderness and positively evaluated man-made features play a key role in determining the visual quality of the rural scene. These are followed by the area of water and the colour contrast. Given that man-made features are among the most important elements of the perceived visual quality of the landscape, planning the modernisation of rural areas should include the impact of such features on the landscape and the possibility of using such features as a rural development tool. The other two elements that can be altered by landscape planners are the percentage of vegetation and the colour contrast. Thus, the multi-crop land allocation plus the use of natural cover between olive trees lead to a higher visual quality of the agricultural landscapes of Andalusia.

Finally, in considering the impact of the EU's Common Agricultural Policy on the landscape, we find two negative effects. The first is the reduction of crop diversity, since, as the results suggest, the greater the homogeneity of our agricultural landscape, the lower its perceived visual beauty, due mainly to the lack of colour contrast. Second, the maintenance in production of land of poor agricultural quality, as an alternative to forestry, decreases the perception of wilderness in the landscape, and thus its beauty.

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