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Stated preference methods and landscape ecology indicators: an example of transdisciplinarity in landscape economic valuation

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Abstract: This paper addresses the representation of landscape complexity in stated preferences research. It integrates landscape ecology and landscape economics and conducts the landscape analysis in a three-dimensional space to provide ecologically meaningful quantitative landscape indicators that are used as variables for the monetary valuation of landscape in a stated preferences study. Expected heterogeneity in taste intensity across respondents is addressed with a mixed logit model in Willingness to Pay space. Our methodology is applied to value, in monetary terms, the landscape of the Sorrento Peninsula in Italy, an area that has faced increasing pressure from urbanization affecting its traditional horticultural, herbaceous, and arboreal structure, with loss of biodiversity, and an increasing risk of landslides. We find that residents of the Sorrento Peninsula would prefer landscapes characterized by large open views and natural features. Residents also appear to dislike heterogeneous landscapes and the presence of lemon orchards and farmers' stewardship, which are associated with the current failure of protecting the traditional landscape. The outcomes suggest that the use of landscape ecology metrics in a stated preferences model may be an effective way to move forward integrated methodologies to better understand and represent landscape and its complexity.

Keywords: Transdisciplinarity; Landscape Indicators; Geographical Information Systems; Stated Preferences; Willingness to Pay Space; Content Validity

1. Introduction

In environmental economics, the conventional approach for conducting stated preferences (SP) studies for valuing landscape has been to design a survey, select a set of attributes, describe their changes, mostly through qualitative levels (for example, 'low, medium, high' or 'no action, some action, a lot of action'), often using percentage changes, and simplified graphical representations of the landscape, and elicit respondents' preferences for these attributes (Campbell, 2007; Colombo et al., 2015; Domínguez-Torreiro and Soliño, 2011; Giergiczny et al., 2015; Hanley et al., 2007; Newell and Swallow, 2013; Rambonilaza and Dachary-Bernard, 2007).

In this paper, we develop a method for valuing, in monetary terms, landscape components represented by visual indicators using a SP technique supported by a thorough use of landscape ecology metrics and methods. We apply our method to the Sorrento Peninsula in Italy to better understand the economic value of the landscape components. Such information should help policy makers with decisions about potential programs to address landscape preservation in this area.

Our approach, uses elements that define and analyse landscape commonly used by landscape practitioners, policymakers, planners and landscape scientists, and has the advantage of producing willingness to pay (WTP) estimates that are particularly appealing to non-economists. By estimating the WTP for landscape visual indicators, this method also conforms to the recommendations of the European Commission (2000) and the European Landscape Convention (Council of Europe, 2000), which call for a thorough use of landscape visual indicators as metrics for evaluating landscape changes. This approach sets up a landscape typology using a parametric method and GIS-techniques (Van Eetvelde and Antrop, 2009) to identify landscape types. Next, it describes landscape types in terms of characteristics, and quantifies these characteristics through landscape visual indicators. Finally, the method uses the visual indicators as quantitative variables in a SP survey and estimates WTP values for the visual indicators of landscape. To the best of our knowledge, such a methodology has been used only in revealed preferences (RP) studies (Bastian et al., 2002; Germino et al., 2001; Hilal et al., 2009). No application of such an integration of analytical tools from different disciplines for landscape representation has been found in SP studies.

The loss of the traditional landscape under the pressure of economic drivers and lack of an effective landscape policy is a well documented phenomenon that has affected most of the Mediterranean landscapes (Antrop, 2006), of which the Sorrento Peninsula in Southern Italy represents an insightful example. The landscape of the Sorrento Peninsula is a complex mountainous landscape with a long history of traditional agricultural practices intertwined with small settlements, which is now facing growing problems from rapid and poorly regulated development. In the last decades the traditional and iconic Peninsula landscape has undergone profound changes: a massive urbanization has affected its multi-layered - horticultural, herbaceous, arboreal - terraced structure, with loss of biodiversity, and an increasing risk of landslides (Amministrazione Provinciale di Napoli, 2009).

Local planning guidelines for the Sorrento Peninsula call for the protection of the traditional landscape and agricultural activities (Regione Campania, 1987). In addition, more recently, local authorities, recognizing the link between the welfare of the local community and the traditional Peninsula landscape, have enquired about the economic value of the features of the Peninsula landscape (Comune di Sorrento, 2011) to support the enforcement of new strategies for landscape management.

The remainder of the paper is organized as follows: in section 2, we review the concept of landscape and its monetary value; in section 3, we introduce the case study of the landscape of the Sorrento Peninsula; in section 4, we describe the steps of the methodology, from the landscape analysis and classification to the experimental design of the SP survey; in section 5, we lay out the economic and econometric models; in section 6, we report the results of the econometric models; in section 7, we present a welfare calculation and in section 8 we conclude with a discussion on the policy implications of our approach for valuing landscape.

2. Valuing landscape

Different disciplines have elaborated their own definition of landscape (Lifran, 2009). The current trend in the literature is to apply the term as a synthesis of both physical/quantitative and perceptive/semiotic definitions (Aznar et al., 2008). In its multidimensional nature, landscape is now defined through the perception that people have of all its bio-physical and socio-cultural components and their interactions (Council of Europe, 2000). Indeed, people's perception transforms land into landscape. This definition is in line with the holistic and complex character of landscape (Antrop, 2006; Antrop et al., 2013) and has brought together many disciplines to study people's preferences and their relationship with landscape structural components. The quality of a place is determined by the interaction of the landscape's biophysical features with the subjective perception and judgment of the individual viewer (Bousset et al., 2009; Burgess et al., 2009; Daniel, 2001; Dramstad et al., 2006; Sevenant and Antrop, 2010; Soini et al., 2009).

This perspective poses a challenge for economic valuation. Indeed, landscape research in economics is not as well developed as in geography, ecology and sociology (Lifran, 2009). Landscape ecology and landscape preference studies offer a wealth of information that economic valuation methodologies can benefit from, but currently ignore. In particular, they can assist in explaining the relationship between individual preferences and landscape's structural components, which is critical for the adequate representation of landscape and its attributes in economic models to overcome the common oversimplification of landscape complexity (Schaeffer, 2008; Swanwick et al., 2007).

Furthermore, an accurate representation of landscape and its changes is an issue of *content validity* in economic valuation studies, defined as the ability of the survey instrument used in a valuation study to measure the value of the good, and resulting welfare estimates, in an appropriate manner (Johnston et al., 2012; Mitchell and Carson, 1989). This implies that the landscape indicators used in SP studies must be ecologically meaningful and able to quantitatively measure and represent landscape's structural and spatial complexity in the model, as well as reflect the way individuals perceive landscape and its changes.[1] Finally,

[1] Humans have a holistic perception of landscape, they perceive the whole through its components, but such components are interconnected so that "the whole is always more than the sum of its components" (Antrop and Van Eetvelde, 2000, p.45). Humans assess and judge how the single components are interconnected with respect to some general criteria that have evolutionary roots, as from the evolutionary theories (prospect-refuge theory of Appleton, 1996; information processing theory of Kaplan and Kaplan, 1989), along with cultural and personal roots (as in the tripartite paradigm of Bourassa, 1991). Kaplan and Kaplan (1989), for instance, suggest that individuals form their preferences assessing coherence, complexity, legibility and mystery of landscape and its components. Indeed, Tempesta (2010) empirically demonstrates how the effects of each single component on people's perception and then preferences vary depending not only on its characteristics but also on the context and its visibility. Any approach not taking that into account is missing the landscape dimension and more likely is valuing merely the effects of land use changes.

the outcome of valuation studies must be interpretable by scientists and politicians (Johnston et al., 2012).

Geographical Information Systems (GIS) can provide the essential technical tool for capturing spatially explicit variables and integrating ecological indicators in valuation models (Bateman et al., 2002; Hilal et al., 2009). Economists have been increasingly integrating GIS and spatial analyses, particularly in RP analysis (eg. in hedonic price models), where analytical methodologies from geography and landscape ecology quantitative indices (metrics) have been more widely included (Bockstael, 1996; Cavailhes et al., 2009; Des Rosiers et al., 2002; Dubin, 1992; Geoghegan et al., 1997; Hilal et al., 2009; Kestens et al., 2001).

Notwithstanding the fact that preferences are affected by spatial attributes (Johnson et al., 2002) and spatial patterns (Broch et al., 2013; Brouwer et al., 2010; Moore et al., 2011; Tait et al., 2012), not much effort has been exerted to integrate GIS and spatial analysis within SP studies. Indeed, spatial analytical tools like GIS are mostly used for presenting study areas and for mapping results (Campbell, 2007; Hanley et al., 2007; Scarpa et al., 2007), but have been rarely used in the spatial definition of environmental components (Johnson et al., 2002; Englund, 2005).

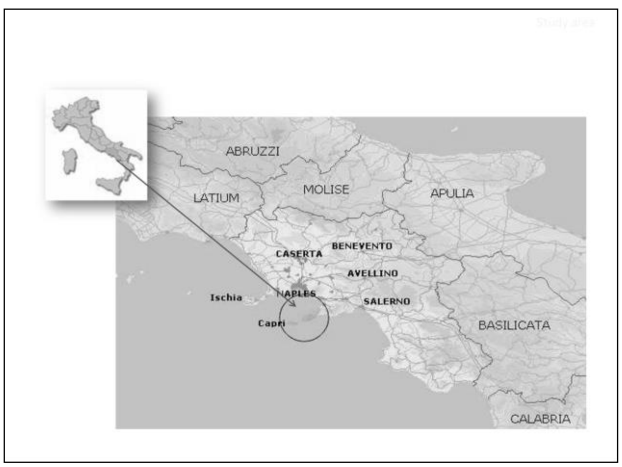
3. The Sorrento Peninsula

The Sorrento Peninsula (figure 1), in Southern Italy, presents a complex landscape with a mix of settlements and orchards along the slopes of the mainly mountainous territory (Mazzoleni et al., 2004). It is an elongated and mountainous peninsula on the southern borders of the Gulf of Naples, well-known for its naturalistic beauty, with almost half of its area covered by natural vegetation and rich in biodiversity (Amministrazione Provinciale di Napoli, 2009). The land is predominantly covered with olive groves, tightly interwoven with low maquis, garrigue, steppe and lemon groves. Mixed deciduous coppiced woods and relics of chestnut cover the low mountain areas (Mazzoleni et al., 2004). The Peninsula preserves a strong rural character (Fagnano, 2009). A large proportion of the labour force is employed in the agriculture sector, which produces several high quality products, certified by the European Protected Designation of Origin (PDO) and the Protected Geographical Indication (PGI) schemes, including extra virgin olive oil, and the "Lemon of Sorrento", used to make the lemon liqueur Limoncello (Amministrazione Provinciale di Napoli, 2009). The Peninsula landscape is characterized by traditional agricultural systems (olive orchard, vineyards and citrus groves) along the terraced hill slopes. The agricultural space is organized in small horizontal plots, dating back to the medieval period, providing effective soil erosion and surface runoff control (Gravagnuolo, 2014). The Peninsula presents a typical example of a complex Mediterranean landscape, where traditional terraced agricultural activities, interwoven in the urban fabric, produce high quality local produces (Palmentieri, 2012; United Nations, 1994).

Since the 1960s, the Sorrento Peninsula has been undergoing profound changes under the pressure of urban expansion, due to increasing tourism and residential demands. The landscape along the coastline has been transformed in a dense conurbation, altering the historical equilibrium with the surrounding rural landscape. Most of the multi-layered orchards (horticultural, herbaceous, arboreal), which for centuries have provided a high level of landscape heterogeneity and biodiversity, are disappearing. The terraced landscapes are being abandoned, increasing the risk of landslide, and the massive urban expansion has changed the character of the original settlements (Amministrazione Provinciale di Napoli, 2009).

Like in most Mediterranean landscapes, in the Peninsula as well different activities are competing for land, whilst the traditional settlements are rapidly disappearing under the pressure of economic drivers and lack of comprehensive landscape policies. The polarization between intensive and extensive uses of land, characterizing many European landscapes in the last decades (Antrop, 2006), is determining the loss of its unique landscape.

Figure 1: The Sorrento Peninsula in South Italy



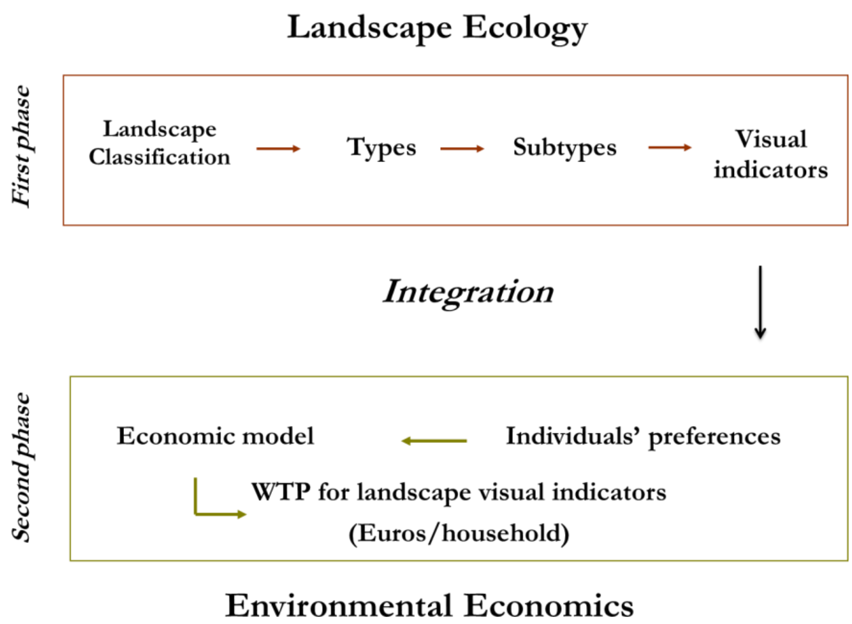
4. Methodology

The methodology is developed in two parts, as schematised in Figure 2. The first part, based on landscape ecology and GIS analysis of the study area, investigated landscape's structural and biophysical components. These components were used to classify landscape and identify landscape 'types' and 'sub-types' on the basis of ecological and perceptive criteria. A "viewshed"[2] analysis with the digital elevation model and photographs of the study area was then used to capture the view from the ground, as from the observer's viewpoint, and to quantify the landscape components (characteristics) in a three-dimensional space with a set of landscape ecological indicators. Such indicators, selected on the basis of their visual effect, were later used as quantitative variables for the second part, the economic valuation.

In the second part of the methodology, the relationship between landscape characteristics (as represented by the visual indicators) and individuals' preferences was investigated. For this purpose, we designed a hybrid stated-preference survey (Holmes and Boyle, 2005). This combines the advantages of the potentially incentive compatible response format of the single bounded contingent valuation (CV) referendum with an attribute-based method, where the attributes are the visual indicators arising from the landscape ecology analysis (ABM; Holmes and Adamowicz, 2003). While the CV method is consistent with people's holistic perception of landscape, the ABM still enables us to value the individual components of landscape (McConnell and Walls, 2005) observing respondents in a sequence of choices. As the perception of landscape quality varies greatly across individuals (Colombo et al., 2009; Hanley et al, 1998; Nahuelhual et al., 2004; Willis et al., 1995), our econometric analysis employs a Mixed Logit (MXL) model (McFadden and Train, 2000).

[2] A viewshed represents the visible area from a viewpoint. We used the ESRI ArcGIS Spatial Analyst tool that produces raster files where visible cells are assigned a number equal to the number of observers that can see those cells.

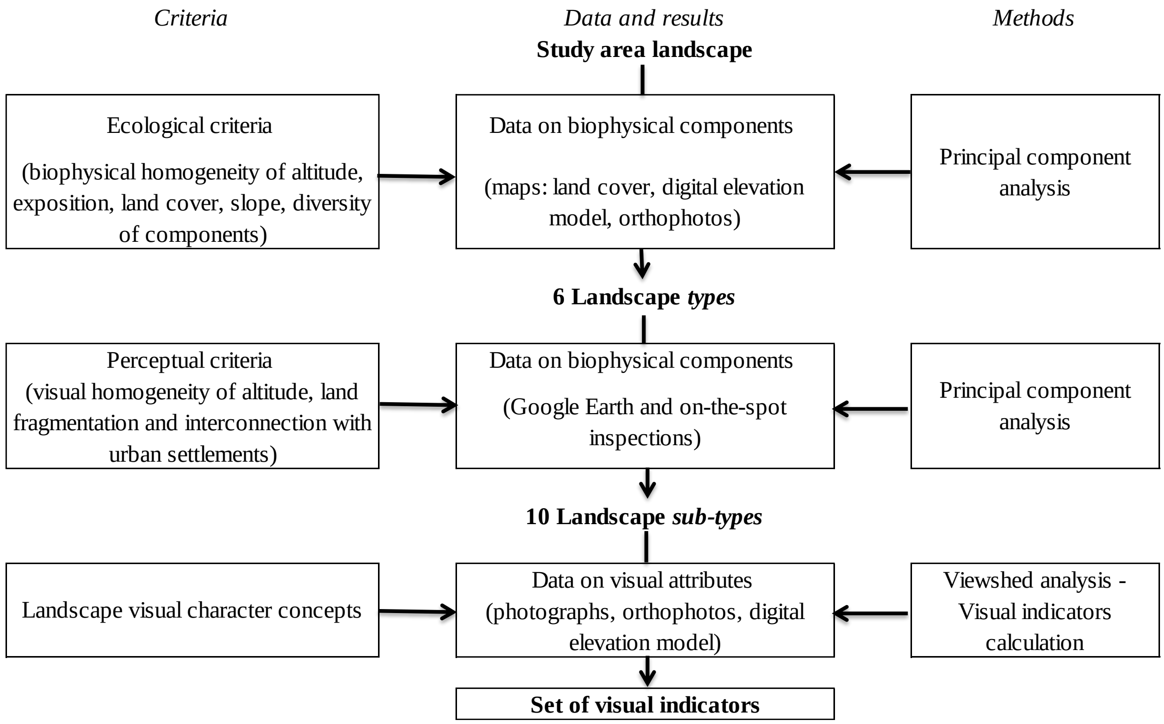
Figure 2: Two-phase methodology



4.1 Landscape Ecology

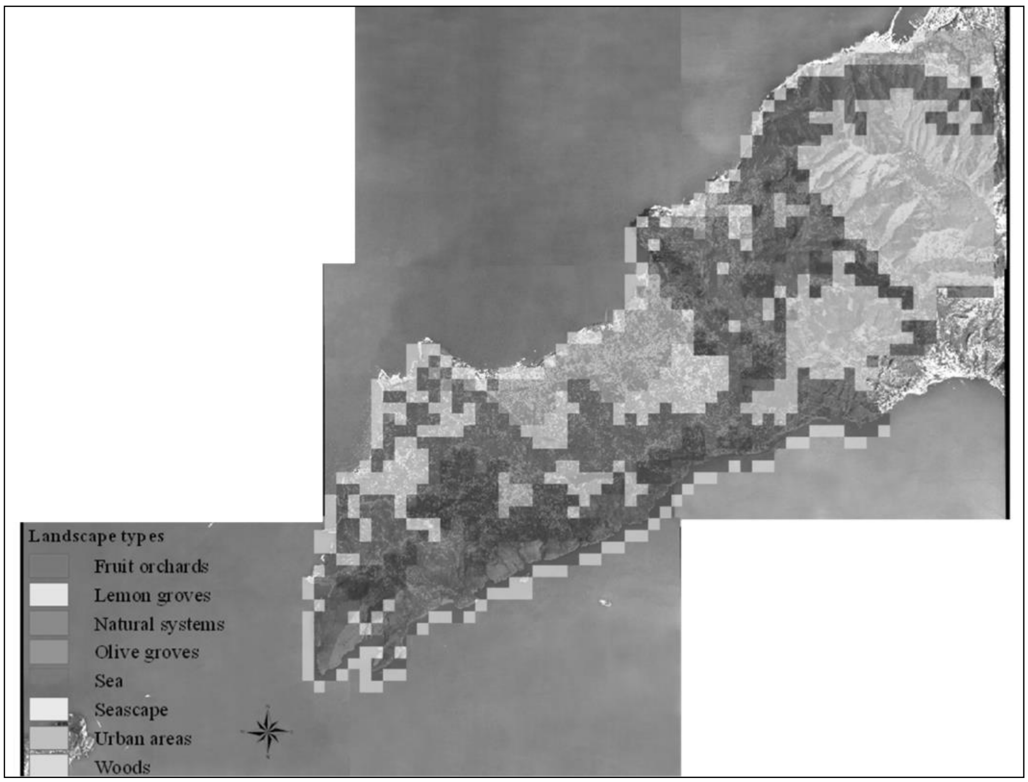
This part combined ecological criteria, perceptual criteria, and landscape visual character concepts (Ode et al., 2008) with GIS-based techniques and principal component analysis to produce a set of visual indicators for the Sorrento Peninsula (see figure 3).

Figure 3: Criteria, methods and data to produce the set of visual indicators



First, using a mixed set of ecological and perceptive criteria, we applied a classification procedure (Van Eetvelde and Antrop, 2009) to identify the spatial and ecological information on the landscape. Based on the ecological criteria, we used GIS techniques to analyse the biophysical components of the landscape, combining the land cover, the digital elevation model and the orthophotos of the area. From this first analysis, we identified six landscape types using principal component analysis (figure 4). Each of these types was characterised by homogeneous altitude, exposition, land cover, slope and degree of diversity (measured with landscape metrics) and can be labelled as: (i) *natural systems*, characterized by spontaneous Mediterranean vegetation, bare land and rock; (ii) *woods*, characterized by wooden areas with relics of chestnut; (iii) *urban*, corresponding to the densely urbanized areas on the main plain of the Peninsula; (iv) *lemon groves*, characterized by a complex system of lemon groves mixed with urban settlements; (v) *olive* *groves*, the predominant type of landscape in the Peninsula; (vi) *fruit orchards*, characterized by small parcels of mixed fruit trees, highly interwoven with other crops and settlements.

Figure 4: Landscape typology of the study area representing the 6 main types



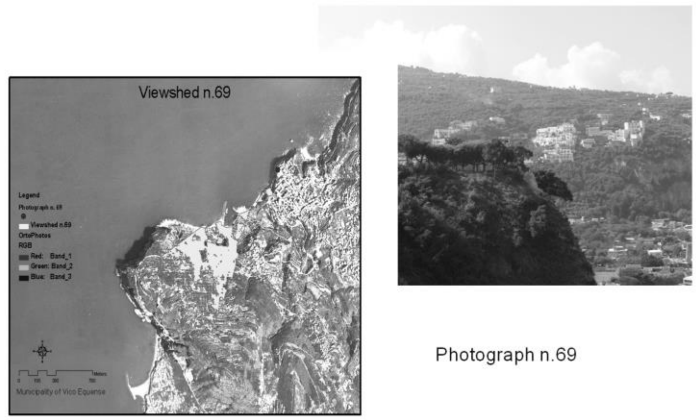
Next, using the perceptual criteria of visual homogeneity of altitude, land fragmentation and interconnections with urban settlements, and data on biophysical components from Google Earth and from on-site observations, we identified ten sub-types within the main six landscape types (table 1).

Table 1: Classification of the landscape types and sub-types

Type	***Sub-types***
"Natural Systems"	*1. High altitude natural systems* *2. Bare land at lower altitude*
"Woods"	*3. Wooded spots on high hills, ending in natural systems and urban settlements* *4. High mountain woods*
"Urban"	*5. Dense urban centre*
"Lemon groves"	*6. Lemon groves mixed with other crops and urban settlements*
"Olive groves"	*7. Olive groves on intermediate plain* *8. Olive groves on low hills* *9. Olive groves on low hills and mixed with other crops and urban settlements*
"Fruit orchards"	*10. Fruit orchards mixed with other crops and mixed with urban settlements*

We then applied a viewshed analysis by taking and georeferencing 332 photographs covering the whole study area to quantify the landscape characteristics through landscape concepts and visual indicators. An example of the viewshed analysis is reported in figure 5, where the brighter area on the orthophoto identifies the area depicted by the corresponding photograph.

Figure 5: Example of viewshed and corresponding photograph



These visual indicators were calculated for each of the 332 viewsheds using the software FRAGSTATS (McGarigal et al., 2002), ArcGIS and eCognition.[3] They were subsequently used as explanatory variables - landscape attributes - in the environmental economics model to explain the answers to the CV questions. The choice of the final set of eleven visual indicators identified with the viewshed analysis (table 2) was partly theory-driven (Ode et al., 2008), and partly driven by the ability of the indicator to represent the perceivable characteristics of the Sorrento Peninsula. The metrics selected had to be both unambiguously correlated with visual features that individuals would consider when assessing the landscape in the environmental economics part of the study, and easy to understand and interpret in a policy context: simplicity and directness were the final filters for the set of indicators.

[3] eCognition is an object oriented software for image analysis that classifies image objects extracted through image segmentation procedures. We used eCognition to extract very detailed layers on scattered urban settlements from the orthophotos.

Table 2: Landscape concepts and related visual indicators

Concept°	Visual Indicator		Mean	Median	Min	Max	St. dev.
Complexity	Patches*	Number of patches (different types/sub-types included in the viewshed)	113	78	7	684	123
	SHEI*	Shannon Evenness Index (0, predominance on one patch, to 1, perfectly even distribution of area across patches)	0.71	0.76	0.01	0.98	0.17
Visual scale	Tot Area**	Total area of the view (in hectares)	160	90	1.56	1080	220
	Openness**	Openness (% open land on the viewshed total area)	0.24	0.21	0	0.77	0.22
Naturalness	Nat Veget**	Natural vegetation (% of woods and natural systems on the viewshed total area)	0.4	0.35	0	1	0.31
Degree of urbanisation	Urban***	Surface of urban area (in hectares)	21	5	0	361	48
	AI*	Aggregation Index (0, no aggregation, to 1, one aggregated urban patch in the viewshed)	0.6	0.63	0	0.74	0.14
Encumbrance	Encumbr	Presence of disturbing elements in the view (detected from photographs; dummy variable)	0.3	0	0	1	0.46
Historicity	Heritage	Presence of heritage elements in the view (detected from photographs; dummy variable)	0.08	0	0	1	0.27
	Lemon	Presence of traditional lemon orchards in the view (detected from photographs; dummy variable)	0.28	0	0	1	0.45
Stewardship	Steward	Presence of farmers' stewardship in the view (detected from photographs; dummy variable)	0.23	0	0	1	0.42

°Ode et al., 2008; *FRAGSTATS; **ArcGIS; ***eCognition

4.2 Environmental Economics

Preference and WTP data were collected with an in-person 20 minute survey administered to a sample of 601 residents of the seven municipalities of the Peninsula of Sorrento between July and October 2009. The sample was stratified to fit the census data and to reflect the socio-demographic characteristics of the target population.

We elicited respondents' WTP for the preservation of each scenario using referendum-type format single bounded dichotomous choice CV questions (Arrow et al., 1993, Schlapfer, 2009). In order to increase the sampling efficiency of the CV survey, the selection of photos was guided by a sequential experimental design with Bayesian information structure (Ferrini and Scarpa, 2007; Sandor and Wedel, 2001), based on the eleven visual indicators obtained from the first part of the study. The efficiency criterion used was the *D-error* measure (Huber and Zwerina, 1996), which is computed considering the determinant of the asymptotic variance – covariance matrix and needs to be minimized in order to have a more efficient design.

Our experimental design was built starting from the available 332 photos, from which we selected the ones that optimized the design, given that each photo was described by a level of each visual indicator. We firstly set to 30 the minimum number of photos able to capture an efficient number of visual indicators. We then considered all possible combinations of 30 photos and selected the combination that minimised the determinant of the asymptotic variance – covariance matrix. Given that from the focus groups it appeared that the optimal number of photos that participants were able to process was six, each respondent was presented with a sequence of six scenarios, each based on one photograph and a 'cost' attribute. We blocked the design into 5 versions of the survey questionnaires, differing only in the value of the 'cost' and the set of photos. Each respondent was allocated to one of the five blocks of 6 photos each. Different respondents, therefore, saw different photos.

The "sequential" approach to the experimental design made possible to use the information becoming available during the survey (Scarpa et al., 2007): the first experimental design was constructed with no prior knowledge of the parameter values, as the parameter values were not known *a priori*; the second experimental design was updated with the information based on the pilot testing questionnaires; the final experimental design was run with the Multinomial Logit Model parameter estimates from the data collected with the first 200 questionnaire administration. Between the initial and the final experimental design, the only changes made were the selection of the 30 photos to administer to the respondents. No changes to the other parts of the questionnaire were introduced.

By including a "cost" attribute, each CV scenario allowed us to elicit the monetary values that people attach to landscape attributes and estimate the WTP for preserving the levels of the visual indicators. Following insights from focus groups, we set the cost attribute within a range of 5 to 100 Euros. The payment vehicle was described as a one-time tax to be paid in 2010 (the survey was conducted in 2009). Given that respondents faced 6 CV questions, to avoid possible issues of ordering and sequencing, they were informed that the valuations were independent from one another and that they would not sum up.

Table 2 reports the descriptive statistics of the visual indicators of the photographs used in the CV study. They provide a good description of the landscape of the Peninsula of Sorrento.

The landscape of the Sorrento Peninsula is quite complex, as described by the Shannon Evenness Index (SHEI) and the number of patches. On average, a viewshed/photograph is composed by 113 patches, indicating that, usually, a landscape type or sub-type appears in many patches within the same photograph. The average total area covered by each viewshed is 160 hectares, with about one quarter of each photo showing open land (Openness), and 40% of the area covered by natural systems. The photographs depict an average of 21 hectares of urban area with an aggregation index (AI) of 0.6. The photographs also show a low presence of disturbing elements, heritage elements, traditional lemon orchards and farmers' stewardship.

In the CV questions, respondents were asked to choose between two alternatives. The first alternative, represented by a photograph of the actual landscape and a value of the tax to implement a policy to maintain landscape in the same conditions as depicted in the photograph. The second alternative, corresponding to the *status quo*, involved no intervention to protect the landscape and no payment of any new tax. It was presented as a verbal description of the decay of the landscape and its visual attributes. The description focussed on how the landscape *visual indicators* would change if no intervention took place to preserve the landscape:

"In the last decades the landscape of the Sorrento Peninsula has experienced degradation and abandonment that are damaging the unique environmental, social and economic features of the Peninsula. If this process continues there is a risk that the following changes will occur:

- A decline in the presence of diverse landscape types, in terms of less diverse crops and cropping systems, producing a more uniform and monotonous landscape;

- Reduction in natural characteristics of the area;

- Greater urban expansion and sprawl;

- Reduced openness and vision of panoramic views due to uncontrolled vegetation growth and urban expansion;

- Increased elements that may reduce the beauty of the scenery, like infrastructures, aerial cables, burnt areas, and so on;

- Loss of traditional features (lemon orchards, historical buildings and settlements);

- Reduced farmer stewardship."

Respondents were instructed to look first at all the six photographs, considering carefully the corresponding values of the tax, and then to answer independently, for each scenario, closed-ended, single-bound discrete choice questions, such as the following one:

"*Please, consider this scenario: have a look at this landscape and imagine this is the only scenario you have to decide on and the only landscape type whose preservation you are asked to pay for: would you pay X€ value as a one-time payment to keep this landscape type as you see it now?* "

5. The econometric analysis

5.1 Theoretical model

We modelled respondents' choices using the Random utility framework (Hanemann, 1984; McFadden, 1974) which assumes that respondents select the option that maximizes their underlying utility function:

$$U_{nit} = -\alpha p_{nit} + \beta' X_{nit} + \varepsilon_{nit} \, . \qquad (1)$$

Equation (1) describes the utility function for respondent *n*, alternative *i* and choice occasion *t*; p_{nit} is the cost, α is the cost coefficient, X_{nit} a n-dimensional vector of choice attributes, comprising the eleven landscape visual indicators reported in table 2, and β is the vector of corresponding parameters. The error component, ε_{nit}, representing the unobserved part of the utility, is assumed to be Extreme Value Type I-distributed.

As our investigation focused on WTP for landscape attributes, the specification of the utility function in WTP-space was the most convenient approach (Scarpa and Willis, 2010). As described by Train and Weeks (2005) the obtained utility function is:

$$U_{nit} = -\alpha\, p_{nit} + (\alpha\, w)'\, X_{nit} + \varepsilon_{nit} \ , \quad (2)$$

where *w* is the vector of WTP for each attribute computed as the ratio of the attribute's coefficient to the price coefficient: w = β / α. Note that equation (2) is equivalent to equation (1) when none of the parameters is random. An important feature of the WTP-space specification, in addition to allowing researchers to directly interpret attributes estimates in "money terms", is the possibility to test the spread of the WTP distribution directly using Log-likelihood tests (Thiene and Scarpa, 2009). Furthermore, in a Random Parameter Logit (RPL) model, the specification in WTP-space allows the analyst to directly specify a convenient distribution for WTP estimates (Train and Weeks, 2005). Given equation (2), the probability for respondent *n* of choosing "yes" to the preservation of landscape *i* in choice occasion *t* is described by the Multinomial Logit model (MNL) (Hanemann, 1984; McFadden, 1974) as:

$$\Pr(nit) = \frac{e^{V_{nit}}}{\sum_{j=1}^{J} e^{V_{njt}}} \quad (3)$$

where $V_{nit} = -\alpha\, P_{nit} + (\alpha\, w)'\, X_{nit}$ is the observed part of the utility function for the alternative *i* chosen among *j=1 …J* alternatives.[4]

People's preferences for landscape preservation are, by nature, heterogeneous (Morey et al., 2008; Nahuelhual et al., 2004). The presence of such heterogeneity is not detected by the standard MNL model. RPL models have been introduced to investigate such heterogeneity, by defining random parameters described by an underlying continuous distribution $f(\cdot)$ in the utility function. The range of variation is investigated through different distributional assumptions. The unconditional probability of a sequence of T choices can be derived by integrating the distribution density over the parameter values:

$$\Pr(nit) = \int \prod_{t=1}^{T} \frac{e^{V_{nit}}}{\sum_{j=1}^{J} e^{V_{njt}}} f(\alpha, \beta) d\alpha, d\beta. \qquad (4)$$

In estimating the RPL model the integrals were approximated numerically by means of simulation methods (Train, 2009) based on 1,000 Modified Hypercube Sampling draws (Hess et al., 2006). As the adopted utility specification in WTP-space (Equation 2) is non-linear in the parameters (Scarpa et al., 2006), our models were estimated in Pythonbiogeme

[4] As a reviewer has pointed out, rather than using a multinomial logit model, a binary logit model could be used instead. As the analyst has to model a dichotomous choice, a binary logit model would offer a simple model to analyse the data. Both models would yield the same result. We opted to use a multinomial logit model because its extension using random parameter logit models allow the analyst to overcome some limitations of the binary logit model: logit can only investigate observed heterogeneity, it may suffer from the independence of irrelevant alternatives and implies proportional substitution across alternatives (Train, 2009).

(BIOGEME 2.2 – Bierlaire, 2003), that allows for nonlinearities in the utility function. Furthermore, this software uses the version written in C of the Feasible Sequential Quadratic Programming (CFSQP) algorithm (Lawrence et al., 1997) to avoid the problem of local maxima in simulated maximum Log-likelihood.

5.2 Individual Conditional Posterior parameters and welfare analysis

WTP estimates for each attribute are not the only possible welfare analyses available from the outcome of RPL models. Indeed, we also computed the Consumer Surplus (CS) measure for each respondent. This involves the computation of posterior coefficients for each individual in the sample, conditional on the pattern of observed choices and based on Bayes' theorem (Huber and Train, 2001; Scarpa and Thiene, 2005; Scarpa et al. 2007; Train, 2009). The expected value of the parameter for each attribute *x* for each respondent *n*, given the observed sequence of T choices *y* and the estimated parameters from equation (4), can be approximated by simulation as follows:

$$\hat{E}\,[\beta_{x,n}] = \frac{\frac{1}{R}\sum_{r=1}^{R} \widehat{\beta_{x,n}^{r}}\, L(\widehat{\beta_{x,n}^{r}}|y_n, X_n)}{\frac{1}{R}\sum_{r=1}^{R} L(\widehat{\beta_{x,n}^{r}}|y_n, X_n)}, \qquad (5)$$

where $L(\cdot)$ is the posterior likelihood of the individual respondents for each draw $r \in R$ of $\widehat{\beta_{x,n}^{r}}$ from the distribution estimated based on Equation (4).

Once we have the posterior conditional parameters for each individual we can examine the welfare effects of specific policies for landscape preservation computing the CS log-sum formula, described by Hanemann (1984), for determining the expected welfare loss (or gain) associated with different policy scenarios:

$$CS_n = -\frac{1}{\alpha}\left[\ln \sum_{i=1}^{n} e^{V_i^1} - \ln \sum_{i=1}^{n} e^{V_i^0}\right] \qquad (6)$$

where CS_n is the individual n's surplus for a change from initial conditions V_i^0 (no plan is implemented and no tax is requested) to the conditions under the program V_i^1 (the landscape is preserved and the one-time tax is paid) and α is the cost parameter which represents the marginal utility of money.

6. Results

First, to assess whether our results can be used for policy recommendations, we compared the characteristics of our sample with the population of the Sorrento Peninsula. In our sample there are 54% males, 56% married, and 76% who have completed primary, secondary, or high school education. The average respondent is about 47 years old and has an average before tax income of €24,200.[5]

Using the 3,606 choices elicited from 601 respondents we ran different MNL and RPL model specifications to identify the model with the ability to fit the data best. A first analysis of the data shows that the Status Quo (SQ) was chosen in 41% of occasions, indicating that our questionnaire did not bias respondents to systematically choose an option of landscape conservation. The first model is an MNL model with only the visual indicators and the SQ as explanatory variables. The second model, RPL1, is a RPL model which explores unobserved heterogeneity only. The third model, RPL2, is a RPL model that adds socio-economic variables to explore the effect of both observed and unobserved preferences' heterogeneity in the sample.[6] The sign of the coefficient estimates, except for

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[5] Our sample compares quite well with the local population, which is comprised by 49% males, 49% of married people, and 79% of the population who has completed primary, secondary or high school education. The average age is about 46 years for adults older than 17 and the average before tax income is €23,774 (ISTAT, 2009).

[6] We introduced interaction terms between socioeconomic variables and the Status Quo. As a reviewer has rightly pointed out, an alternative would be to introduce interaction terms between the socioeconomic variables and the landscape attributes. Such interactions would explain observed heterogeneity around the mean of the parameter estimates (Hensher et al, 2005, page 505-6). Given the large number of landscape

Heritage which is never statistically significant, remain the same across the three models. Results are reported in table 3.

Table 3: Results from MNL and RPL models

	MNL		RPL1		RPL2	
	Coeff.	| t-value |	Coeff.	| t-value |	Coeff.	| t-value |
Patches/100[a]	-12.90	5.68	-11.30	5.54	-11.30	5.25
SHEI	-81.60	3.58	-38.00	2.36	-43.60	2.92
Tot Area/1000[a]	55.20	3.12	47.70	2.76	53.90	2.6
Openness	70.10	5.49	22.90	2.37	39.20	4.18
Openness - σ	-	-	53.80	5.82	52.40	4.04
Nat Veget	64.20	5.88	46.10	6.52	36.60	5.52
Nat Veget - σ	-	-	26.90	4.00	3.32	0.26
Urban/100[a]	38.30	6.05	32.00	5.55	32.40	3.18
Urban/100 - σ	-	-	80.70	10.59	56.70	8.01
AI	27.90	1.09	26.10	1.37	38.90	2.15
Encumbr	-19.40	4.25	-5.72	2.04	-4.33	1.48
Heritage	-3.44	0.48	-4.43	0.86	3.59	0.64
Lemon	-15.00	2.96	-9.34	2.55	-11.50	3.10
Steward	-20.40	4.30	-27.60	7.22	-22.80	6.18
- ln(PRICE)	-3.86	71.68	-3.16	53.54	-3.26	42.32
- ln(PRICE) - σ	-	-	0.74	9.96	0.52	9.78
SQ	-2.27	8.23	-4.32	12.32	-2.08	5.53
SQ*Unemployed					-2.58	2.21
SQ*Female					-0.18	0.98
SQ*Partner					-0.0025	1.32
SQ*Age					-0.0016	0.41
SQ*YearsSorrento					-0.0009	1.15
SQ*Income/1000[a]					-0.0687	9.25
K	13		17		23	
LogLikelihood	-2067.037		-1732.52		-1703.37	
AIC	4148.074		3499.04		3452.74	
BIC	4228.549		3604.28		3595.74	
pseudo R^2	0.17		0.30		0.31	

[a] The variables Patches and Urban were divided by 100 and the variables Tot Area and Income were divided by 1,000 to normalize them and guarantee the convergence of the RPL models

attributes and socioeconomic variables, when we estimated such a model, we found very few statistically significant coefficient estimates.

The two RPL models presented in table 3 account for the panel nature of the data, as each individual was observed in six choice situations, and incorporates unobserved heterogeneity across individuals of the estimated marginal WTP (Breffle and Morey, 2000; Revelt and Train, 1998).

The Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC) and the pseudo-R^2 show that the RPL1 improves the fit of the data compared to the MNL, indicating that including unobserved heterogeneity is important. We chose normal distributions for all random WTP parameters, except for price, to allow the estimates to take on both negative and positive values. A lognormal distribution was assigned to the price coefficient to avoid behaviourally inconsistent results and to keep its estimate within the negative range (Hensher and Greene, 2003). In RPL1, we found heterogeneous preferences, captured by the spread of the statistically significant coefficients, only for landscape openness (Openness), naturalness (Nat Veget) and degree of urbanization (Urban), in addition to PRICE, and no evidence of heterogeneous preferences for the other visual indicators. To further test the effect of observed heterogeneity, we augmented the RPL1 model with socio-economic variables that were interacted with the Status Quo (SQ), as shown by the output of RPL2. This model is our preferred model, as it outperforms the other two models. Our discussion of the results, and policy recommendations, therefore, focuses on the RPL2 model output.

All coefficient estimates are highly significant, except for Encumbr and Heritage, confirming that the selected landscape attributes are important factors in explaining people's preferences for landscape preservation in the Sorrento Peninsula. The option of no intervention to preserve the landscape tends to be not preferred, as shown by the coefficient estimate for the status quo (SQ), which is negative and significant. The average cost coefficient, retrieved as the exponential of the price coefficient, is equal to -0.038. This confirms the expectation that individuals prefer, other things being equal, less expensive landscape preservation programs. The highly significant spread of the lognormal distribution highlights the presence of a variable marginal utility of income across the sample.

We found negative WTP for fragmented (Patches) and heterogeneous (SHEI) landscapes, suggesting that an increasing landscape heterogeneity is not preferred, a result that conforms with previous findings that claim that an increasing landscape heterogeneity makes individuals feeling less able to "interpret" and understand a landscape's complexity (Kaplan & Kaplan, 1982).

Respondents have a positive WTP for Tot Area, which represents the wideness of the landscape view. When we examined respondents' preferences for Openness, we concluded that, whilst the majority of respondents likes this feature of a landscape, as the sign of the coefficient estimate is positive and significant, about 23% of respondents do not like this characteristic, as shown by the estimate of the spread of the coefficient. This result can be explained by the fact that the landscape of the Peninsula is mostly a 'closed' and 'private' landscape, where properties and orchards are enclosed by fencing walls and hedges; yet, because of the mountainous morphology of the Peninsula, it suddenly opens up wide views where the line of walls and trees is discontinuous. Therefore, whilst openness is generally seen as an attractive feature of the landscape, some respondents do like 'closed' landscapes. This result is also supported by the psychology literature that indicates that a closed landscape recalls an idea of mystery, which many people find attractive (Appleton, 1996; Kaplan and Kaplan, 1989).

The positive sign of the Nat Veget coefficient shows that elements of naturalness are seen as desirable in landscapes, as confirmed by previous research (Herzog, 1985; Purcell & Lamb, 1984). The spread of the estimate for the coefficient of natural vegetation, Nat Veget – σ, is no longer statistically significant in RPL2 compared to RPL1, as a consequence of the inclusion of the socio-economic variables in the model.

On average, it is possible to observe a positive preference for the degree of urban settlements (Urban), even though the spread of the coefficient estimates reveals a wide heterogeneity in WTP for this attribute. The fact that the Peninsula landscape is typically a cultural, "built" landscape, shaped by human activities, explains why a large group of individuals (71%) have a positive WTP for the presence of urban settlements. The identity of this landscape and its characterizing features are strictly related to the intimate connection between orchards and dwellings, agricultural activities on small land parcels and traditional villages, leisure residences that for centuries have embellished both cities and countryside.

The degree of aggregation of urban settlements (AI) is a positive determinant in explaining the utility associated with landscape preservation policies in the Sorrento Peninsula. We then found that the coefficient estimates for the presence of elements of heritage (Heritage) and of disturbing elements (Encumbr) are not statistically significant, suggesting that these visual indicators do not appear to be important explanatory variables in the preferences for landscape conservation in the Sorrento Peninsula.

Respondents were less likely to choose landscape settlements with the presence of lemon orchards (Lemon) and with elements of farmer stewardship (Steward). These results may sound counterintuitive, as agricultural activities have played an important role in shaping the character of the Peninsula landscape. In particular, lemon orchards, along with olive groves, have always represented a symbolic image of the Peninsula identity. However, in the last decades, farmers have replaced the traditional lemon orchard farming systems – based on chestnut wooden supporting structures and fascine covers – with cement stakes and black plastic net covers, widely considered an eyesore. From focus groups, we further learned that farmers, along with politicians and institutions, are blamed for not taking into account the consequences of their actions on the landscape. Therefore, we interpret the negative sign of the Steward coefficient, which accounts for the presence of farmer stewardship in the landscape, as an expression of respondents' protest towards the misuse that some farmers make of public financial resources.

To look at the effect of socio-economic variables, RPL2 includes interaction terms between the SQ and dummy variables measuring whether a person is unemployed (Unemployed), female (Female), lives with his/her partner (Partner), and other continuous variables measuring a respondent's age (Age), the number of years the respondent has lived in the Sorrento Peninsula (YearsSorrento) and the respondent's annual before tax income. The introduction of these variables show that unemployed respondents as well as people with higher income levels are less likely to choose the status quo, indicating that the preservation of the Peninsula landscape is a priority for a wide variety of residents.

Following the approach described in Section 3.2 and using the model outputs, we retrieved conditional posterior parameters for each individual in the sample. We then computed the

CS, based on the RPL2 estimates, for maintaining the landscape portrayed in ten photographs selected from the 332 used for the study. The photos, described in Table 4, capture the main landscape sub-types of the Sorrento Peninsula (the photographs are available as supplementary material). Table 5 shows the CS values for the 10 selected landscape frames.

Table 4: Representative photographs for the landscape types

Photo n.	Type	Sub-type
56	Woods	3. Woods on high hill ending in natural systems and urban settlements
59	Olive groves	7. Olive trees on intermediate plain
66	Urban areas	5. Dense urban centres
72	Fruit groves	10. Fruit mixed with other crops and urban settlements
109	Olive groves	8. Olive trees on low hills (between 200 and 400 m above sea-level)
117	Olive groves	9. Olive trees on low hill and more mixed with other crops and urban settlements
140	Natural Systems	2. Bare land at lower altitude (up to 400 m above sea-level)
166	Lemon groves	6. Lemon trees mixed with other crops and urban settlements[a]
301	Woods	4. High mountain woods with no urban settlements
332	Lemon groves	6. Lemon trees mixed with other crops and urban settlements[a]

[a] Photos n. 166 and 332 are described by the same landscape sub-types, but depict different views

Table 5: Consumer Surplus values from the RPL2 model for preserving the selected 10 landscape frames

Photo n.	**Consumer Surplus (CS)**			
	1st quantile	Median	3rd Quantile	Mean
56	68.45	100.64	167.34	114.54
59	-5.99	16.06	43.57	17.97
66	-106.88	-58.62	-19.78	-63.27
72	-8.04	31.12	66.21	29.84
109	0.10	30.69	60.52	30.79
117	-16.92	-1.37	23.92	2.68
140	46.28	60.05	83.21	64.16
166	-77.39	-36.54	-1.57	-38.89
301	50.93	64.70	87.86	68.83
332	-123.25	-46.55	2.43	-57.53

Most mean values are positive, indicating a general gain in welfare if the landscape preservation programs were implemented. The landscapes portrayed in photographs 66, 166 and 332 show a negative CS. These are landscapes characterized by a strong presence of urban areas. This result confirms that the presence of built areas – dense urban centres and olive groves mixed with urban settlements – and lemon groves are associated with a welfare loss. Positive values are associated with frames with a more natural character (photographs n.56, 140, 301), less intensive olive groves (photos n. 59, 109) and the mixed systems of small fruit orchards and sparse settlements (photo n. 72).

In general, the results show that the effects of landscape preservation on residents' welfare are heterogeneous, with a wide variance across individuals, producing a loss for some and a gain for others. The most valued policies appear to be those that would preserve those landscape frames where the predominant character is a natural environment which is becoming rarer in the Peninsula. This result seems to be consistent with similar findings in the literature, where people tend to express more concern and interest for rarer landscape types (Brander and Koetse, 2007).

7. Conclusions

Our results provide some indications to policy makers about the local community's preferences for landscape preservation policies on the Sorrento Peninsula. Residents would support a landscape programme that would preserve some of the current characteristics of the area. They prefer large open views and natural features and dislike heterogeneous landscapes and landscape characterized by the presence of many subtypes. This result supports the view that the current process of landscape fragmentation, due to urban sprawl and land cover changes, which is increasing landscape heterogeneity and reducing the natural elements of the landscape should be limited by new policies. Policymakers should further take into account that residents' preferences for heritage elements are not statistically significant and that our respondents dislike landscapes that feature lemon orchards and a presence of farmers' stewardship. We interpret this negative attitude of residents towards farmers as a need to re-address the role that farmers have played in shaping the current Peninsula landscape: residents do not like the present policies that have supported farmers' activities which are damaging the landscape. Farmers, in fact, have replaced the traditional lemon orchard farming systems – based on chestnut wooden supporting structures and fascine covers – with cement stakes and black plastic net covers, widely considered an eyesore. Policymakers should, therefore, reconsider the current farmers' subsidies structures that have failed to protect the traditional landscape. We also find that unemployed respondents are more likely to choose the Status Quo and that also respondents with higher incomes are more likely to choose the Status Quo.

This paper has presented a valuation of the Sorrento Peninsula landscape through a new methodology that bridges the gap between landscape ecology and non-market valuation. Landscape science is a term that covers the disciplines involved in landscape studies, including architecture, geography, history, ecology, and, more recently, economics. The integration of landscape economics provides the economic rationale for landscape assessment and management. However, to further advance such integration, it is crucial to effectively link economic models and landscape ecology models. This entails sharing or developing concepts and methodologies that can integrate all landscape dimensions.

On the one hand, the conventional approach in landscape economic valuation has been to use simplified graphical representations of the landscape. Such an approach limits the ability of the survey instrument to measure landscape value using metrics widely accepted in landscape science, and raises potential issues of content validity (Johnston et al., 2012; Tagliafierro et al., 2013). On the other hand, landscape ecology has developed metrics and methods to identify visual indicators able to capture landscape characteristics (Ode et al., 2008; Tveit et al., 2006). Theories on the origin of landscape preferences, developed within the landscape aesthetic literature, confirm that an individual's visual perception of the landscape is of paramount importance. The visual dimension of many ecological indicators (Fry et al., 2009) is the key to the integration of landscape economic values.

In this paper we provided an example of how landscape visual indicators can be used in landscape economic valuation. We outline a transdisciplinary approach and apply it to the case study of the Sorrento Peninsula, in Italy. It stems from two considerations: (i) people's perception of landscape, and (ii) how landscape can be defined in a way that is acceptable and meaningful to scientists, policy makers and other stakeholders. The integration of the ecological and socio-economic perspectives makes it possible to achieve a more comprehensive understanding of landscape. SP studies provide the ideal framework to promote a transdisciplinary approach, as we demonstrate in this paper. The attribute-based approach makes it possible to use landscape visual indicators as attributes.

Within a CV framework, we use ecologically and economically meaningful visual indicators as variables, able to work as an interface between the different landscape dimensions, providing a quantitative measure of landscape character and changes and of their effects on a community's welfare.

Our approach is amenable to extensions. In particular, a further step should be to incorporate landscape evolution models (Pazzaglia, 2003) that can simulate actual landscape evolution processes, according to drivers of change in a study area. SP landscape studies could benefit from these models, as they could provide realistic alternative scenarios of landscape change under different planning options and corresponding visual representations. Qualitative descriptions and photomontage-based landscape single-attribute changes, commonly used in SP, could therefore be replaced by photographs representing the potential future scenarios that capture all the changes potentially occurring in the landscape components. This would enhance the credibility of SP studies and their realism to support public decision making approaches, such as integrated strategic environmental assessments. In addition, as our approach estimates WTP values for preserving specific landscape visual indicators that can be measured for any landscape using metrics well established in landscape ecology, a natural extension of our research would be to test for transfer error in value transfer studies (Navrud and Ready, 2007).

Nonetheless, our study has some limitations that should be acknowledged. Firstly, this study does not provide a test to assess whether our proposed method produces WTP estimates different from more “traditional” SP studies that describe landscape changes through qualitative levels, for example, ‘low, medium, high’ or ‘no action, some action, a lot of action’. Future research should investigate whether the “traditional” approaches are able to produce WTP estimates not different from the method proposed in this paper. Secondly, this paper has not investigated several econometric issues that may arise in discrete choice analysis, such as attribute non-attendance (Scarpa et al, 2009), learning and fatigue (Campbell et al, 2015), or exploring the impact of attitudes on choices (Hoyos et al, 2015). However, we believe that exploring these issues goes beyond the scope of this paper, which is to show a method that merges landscape ecology with non-market valuation techniques to produce monetary estimates for preserving landscape visual indicators, which are considered a fundamental unit of measure by landscape ecologists, as well as by government and non-government organizations such as the - DG AGRI, EUROSTAT, the Joint Research Centre of the European Commission, and the European Environmental Agency, to evaluate landscapes (European Commission, 2000).

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