Towards harmonization in landscape unit delineation. An analysis of Spanish case studies

María VALLÉS[1], Francisco GALIANA[1], Rafael BRU[2]

[1] *Departamento de Ingeniería Rural y Agroalimentaria*
Universidad Politécnica de Valencia
Camino de Vera s/n, 46022 Valencia, España
e-mail: convalpl@agf.upv.es, fgaliana@agf.upv.es.

[2] *Departamento de Matemática Aplicada*
Universidad Politécnica de Valencia
Camino de Vera s/n, 46022 Valencia, España
e-mail: rbru@mat.upv.es

Corresponding author

María VALLÉS
Departamento de Ingeniería Rural y Agroalimentaria
Universidad Politécnica de Valencia
Camino de Vera s/n, 46022 Valencia, España
e-mail: convalpl@agf.upv.es
Tel: 96 387 91 36; 667 63 00 46.
Fax: 96 387 75 49.

1. Introduction

The European Landscape Convention (ELC; Council of Europe, 2000) called for the identification and assessment of landscapes but left its member states to devise their own methodologies (Brunetta and Voghera, 2008). The methodologies are very diverse as a consequence of the different conceptions of landscape, different goals and data sets used (Van Eetvelde and Antrop 2007a). However, it seems that many countries are now adopting the *Landscape Character Assessment (LCA)* approach.

Since its development in the late 1990s in England (Swanwick et al., 2002), LCA has spread to other European and non-European countries (Swanwick, 2004; Wascher, 2005; Kim & Pauleit, 2007), and it has been the selected approach for the European Landscape Classification Map (Mücher et al., 2010). The central concept in LCA is *landscape character*, which is defined as a distinct, recognisable and consistent pattern of elements in the landscape that makes one landscape different from another, rather than better or worse (Swanwick et al., 2002). This approach is related to the existing physiogeographic landscape classification approaches (e.g. Zonneveld, 1989) traditionally applied in land evaluation and, later on, in landscape ecology. Both are integrated approaches (they study the landscape as a whole), both consider human influence, both can be applied at different scales, and both recognise homogeneous tracts of land by their physiognomy. Their main difference, according to Van Eetvelde and Antrop (2007a), is that the LCA approach also includes cultural and perceptual aspects of the landscape and aims to be used in integrated spatial planning.

The concept of landscape character is also related to the concept of landscape as a holistic entity (Van Eetvelde and Antrop, 2007a). Holism means that all aspects are related to each other, and thus, the whole is more than the sum of its parts (Naveh & Lieberman, 1994; Naveh, 2000).

The concept of landscape character also involves the hierarchical organisation of landscapes. A landscape may be considered as a *holon* (Koestler, 1969; Naveh, 2000), which means that it can work as an individual component or as a whole according to the scale. Thus, there is not a single scale for landscape classification, and the emergent pattern is different when the scale varies.

Characterisation in a LCA involves identifying, mapping, classifying and describing a landscape character that is created from a particular combination of geology, landform, soil, vegetation, land use, field pattern and human settlement. To date, landscape characterisations have been frequently carried out by professionals, but there is a growing concern for the need to involve stakeholders in these tasks (Jones, 2007; Olwig, 2007). There are some examples emphasising public participation such as the ECOVAST guidelines (ECOVAST, 2006), which were designed to involve citizens in LCAs, or a work showing the experience of two landscape character assessments by community groups in Cheshire, United Kingdom (James & Gittins, 2007).

In Spain, the ELC has motivated the development of landscape classification works on the national scale (Mata et al., 2003). The ELC has also motivated the formulation of new policies and laws that are focused on landscapes, especially at the regional level, as they have full autonomy concerning territorial policies. Catalonia, Valencia and Galicia are the first regions that have developed landscape policies with regards to the ELC.

The approaches to landscape classification have been quite diverse in Spain as a consequence of the variety of disciplines involved (Pérez-Chacón, 2002; Mateu & Nieto, 2008). The first one is very similar to the physiogeographic landscape classification approaches referred to above (Zonneveld, 1989) and has traditionally been undertaken by geographers (Hernández-Pacheco, 1955-56) who consider the landscape unit as a tract of land that shows a homogeneous physiognomy or image that is able to integrate and synthesize natural and human factors and their spatial dimension. The second approach, which is more influenced by the American visual resource management systems developed by the Bureau of Land Management and USDA Forest Service (Ramos, 1979; MMA, 2006), places more emphasis on the visual aspects of a landscape. This approach emerged in the 1970s when forestry and civil engineers started to work on landscape classification and assessment methodologies that were oriented towards physical planning and environmental impact assessments. In this sense, the landscape unit is defined as a tract of land that is homogeneous in content, appearance and visibility behaviour (Español, 1998).

Both approaches have become closer, probably as a consequence of the ELC and the new landscape policies that have captured the ELC philosophy, and have adopted the LCA approach. This is shown in the definitions given to landscape units and types (similar to character areas and landscape types) in the legislation that has emerged in the first Spanish regions where the ELC has been adopted, Catalonia and Valencia. However, the ways that Catalonia and Valencia developed the landscape classification system are quite different. In Catalonia, there is a top-down approach such that the landscape units are first defined for the seven administrative regions in which physical planning is organised. In the Valencia region, each municipality develops its own landscape classification according to the local landscape studies. This poses a problem of inconsistency among landscape areas and types defined for the different territories because of the lack of shared criteria.

This problem has been previously discussed by different authors in other European regions. For example, the lack of consistency in the LCA in England is discussed by Griffiths et al. (2004, p. 13). In Belgium, Van Eetvelde and Antrop (2009) exposed the difficulties found when comparing classifications within regions because different scale levels, data sets and approaches were used. Also, in France, a report about the "atlas de paysages" performed during the last forty years reveals the diversity among the landscape types defined (Ministère de l'Écologie et du Développement Durable, 2007, p. 48). In all of these three examples, the need for harmonized and consistent classifications was outlined.

This paper focuses on landscape classifications in Spain, paying special attention to the type of differentiating variables used for the landscape unit delineation at each scale. Most of the reviewed works do not correspond to the LCA approach. However, we believe that because the LCA shares many aspects with previous landscape approaches that have been traditionally applied in Spain (*i.e.*, *physiogeographic and visual approaches*), some lessons might be learned from these previous experiences.

2. Methods

We examined a sample of 28 works (Appendix A) that comprise most of the landscape studies conducted in the Valencia region and a small sample of work carried out in other parts of Spain. Most of these works date from the beginning of the 21st century, although there were also works from the 1980s and 1990s and one earlier work directed by Angel Ramos, one of the Spanish pioneers in visual landscape analysis (Ramos et al., 1976). Almost all of the analysed classifications were developed for planning.

The sample includes works related to *the geographic* and *the visual* approach, as explained in the introduction. Also, it includes the integration of both approaches, which has become more common in recent years (Díez, 2008; Iranzo, 2009; Nogué & Sala, 2006; 2008; 2009). The scarce amount of Spanish works about this topic published in international databases required that the data be extracted from very different sources (i.e., internal reports, congresses, regional web pages, books and personal enquiries with the authors).

The compiled information focuses on two factors: the *spatial scale* and the *attributes for the landscape unit delineation*. The *scale* is related to the concepts of *extent* and *grain*. The *extent* is defined as *the area encompassed by an investigation or within the landscape boundary*. In this analysis, the administrative division type is used to describe this concept. The *grain* can be defined as *the size of the individual unit of observation* (Mc Garrigal and Marks, 1995). The most appropriate variable to characterize grain is the Minimum Mapping Unit of the cartography, but as these data are not always available in the analysed case studies, we used the cartographic scale, defined by the representative fraction which expresses the scale used for the landscape unit delineation.

In relation to *the attributes used for the landscape unit delineation*, a literature review on landscape analysis showed that *topography, land use (or vegetation)* and *visibility* are the most common attributes in Spanish landscape studies (MMA, 2006; Nogué & Sala, 2008). The first two attributes are shared by *physiogeographic and visual approaches*, while *visibility* is more common in *the visual approach*. Other attributes such as soil type or cultural and perceptual aspects such as the sense of place or historical pattern are only included in a few works within the sample, and they were not considered in this analysis.

The first two characteristics, i.e., *topography* and *vegetation or land use,* were considered as the elements that allow the identification of the different landscape structures. The vegetation/land use was the only attribute that described the cultural dimension of a landscape as in most of the European landscape classifications (Van Eetvelde & Antrop, 2007b).

For the consideration of topography, we first differentiated the works that used a physiographic classification of relief from the works that used classifications based only on the slope (Pedraza et al., 1996). Then, we distinguished among the three types of landform levels according to the terminology used by Martín-Duque (1997; 2003), who proposed a hierarchical physiographic classification system that consisted of three levels*: geomorphic region, domain* and *element*. The attribute *geology* was included in this group of variables even though it was used in only a few works in combination with the classifications based on the slope.

For the analysis of *vegetation/land use*, there was no classification system similar to the one found for landforms. Instead, we identified the use of two concepts: *land use* and *land cover*[1]. In this work, we included the most commonly used attributes in Spanish landscape studies, which are *land use, vegetation (more related to the land cover)* and *a combination of both.*

Visibility, in the context of landscape unit delineation, has traditionally been related to the concept of a *visual unit* that can be defined as a *portion of the landscape enclosed and limited by topography, bounding an observer's field of view, that enables the viewer to accumulate and form a unified impression of his surroundings* (Tetlow & Sheppard, 1979). Although the original definition of a *visual unit* only considers topographic elements as visual boundaries, many studies where there were no rough changes in the relief have also considered vegetation and built elements. In the analysis, we checked the type of visual boundaries considered on different scales by distinguishing between *first-level visual boundaries*, related to topography, and *second-level visual boundaries*, linked to natural or human-introduced land cover elements.

[1] *Land use* refers to the way that people use a certain piece of land, while *land cover* refers to the natural or human-introduced elements that cover the Earth's surface (Young, 1998).

The method used to analyse the relationships among these data was the Multiple Correspondence Analysis technique (MCA), which was applied with StatBox software (Grimmersoft Inc., France). For this purpose, the information was structured in a matrix (Appendix A) where each work (rows) is characterised by the category (columns) of the variables: *type of extent (A), scale (S), geomorphology (G), land matrix (V)* and *visual boundaries (L)* (see description of variables in Table 1). The decision about which categories should be considered in the analysis was a compromise between the MCA requirements (a homogeneous number of categories for all variables) and the expression of the variability of the original data. Overall, there were 5 variables and 18 categories (modalities).

3. Results

Relationships between the scale and type of extent

Figure 1 and table 2 show the prevailing relationships between *the scale and type of extent.* However correspondences were not always univocal, especially for the *intermediate scale*. Also, there were landscape works in the sample that inverted the general trend, such as the work that was performed for the landscape map of the Valencia regional coast [10] (DGC, 2001) using a *large scale*. This landscape work was an example of a planning-oriented study in which the object of the analysis was a linear corridor where a higher degree of detail was required.

Relationships between the scale and attributes related to the landscape character

The geomorphological and *land matrix* attributes were used at the three scales considered. However, the *land matrix attributes* were less frequently used on *small scales* (1:100,000 to 1:200,000), and the *geomorphological attributes* were less common on *large scales* (1:10,000).

When focusing on the relationships shown between the *geomorphology* and *scale,* we noticed that the *geomorphological regions* or *geological characteristics in combination with landform* were often used for differentiating landscapes on *small scales,* as in the Spanish Landscape Atlas [14] (Mata et al., 2003) or in the Andalusia regional landscape map [19] (Móniz et al., 2005). The classifications based on the *slope* were common on *intermediate scales,* as in the landscape analysis applied to the metropolitan area of Alicante-Elche [11] (Galiana et al, 2001). Finally, the *geomorphological domains* and *elements* were the most frequently used for attributes on *large scales* as in the Mariola Mountain Range Natural Park [17] (CTV, 2004). But they were also applied on *intermediate scales* (e.g. Alava landscape map [4] (Andrés Orive et al., 1991).

In contrast to the variables related to the *type of extent* and *geomorphology*, there did not seem to be a clear relationship between the *land matrix* and *scale* (Table 3).

Relationships between the scale and attributes related to visual boundaries

The use of visual boundaries on the different scales of analysis was not frequent on *small scales* (see Figure 2). On the *intermediate scale,* two trends were identified. Some works did not take into account visual boundaries while others did. Most of these works that considered the visual boundaries used *topographic elements* (first-level visual boundaries). In contrast, the *land cover elements* (second-level visual boundaries) were only taken into account in a few cases, e.g., the La Rioja regional landscape map [18] (Escribano et al., 2004). T*he large scale* also seemed to be associated with both the *first and second-level visual boundaries.* The use of one variable or another might depend on the characteristics of the area of analysis. For example, the *first-level visual boundaries (L1)* were used in the mountainous landscape of the Mariola Mountain Range Natural Park [17] (CTV, 2004), while the *second-level visual boundaries (L2)* were used in the flat landscape of the fertile, irrigated area of Valencia City [7] (Díaz & Galiana, 1996).

4. Discussion

The search for trends was structured into two questions: What scale was most commonly used for each type of extent? What factors (related to the landscape character and visual boundaries) were more frequently used in each scale of analysis?

Regarding the first question, the results suggested a hierarchical relationship between the *scale of analysis* and *the* type *of extent*, as was expected and stated by other authors (Swanwick et al., 2002). However, overlaps also existed, especially with the intermediate scales that were also used in local and regional extents (Figure 3). These overlaps may be caused by the differing areas within the same type of geographical division (regions, counties and municipalities can be very heterogeneous in size) or the availability of appropriate datasets or cartographies, especially at finer scales.

When focusing on the factors related to the character, it was expected that certain factors would be more appropriate for certain scales as expressed by authors such as Klijn (1994) who, when referring to land ecological units, stated that factors such as parent material and physiography were better suited for small mapping scales (1:>100.000), while others like soils and vegetation were better suited for larger scales (1:< 50.000). However, the results indicated that both the geomorphology and land matrix were used in the three analysed scales, which suggests that the differences between the variables used on each scale must be on the level of detail with which they were defined (Burel & Baudry, 2002, p. 75). This result fits the approach followed in England by Griffiths et al. (2004, p. 16), who proposed the same four definitive attributes of physiography, ground type, land cover and settlement, but their level of detail depended on whether the LCA was performed at the regional scale (level 1) or the county/district scale (level 2).

Regarding the use of geomorphological attributes, it was inferred that both the morphometric (related to relief geometry) and the physiographic (related to relief morphology) classifications, also called macro-morphological landform classifications, were used to define the landscape units at different scales, which was also shown in the landscape classifications developed in other parts of Europe. Morphometric classifications have been frequently used in parametric approaches such as the landscape classification map developed for all of Belgium (Van Eetvelde & Antrop, 2009). However, macro-morphological landform classifications are more usual in holistic approaches, e.g., the Atlas de paysages developed in France (Ministère de l'Écologie et du Développement Durable, 2004, page 14); this practice can be explained by the increasing availability of digital terrain models and GIS software that allow derivation of topographic attributes such as slope or aspect (Burrough et al., 2000) compared to the automated classifications of morphological landforms, which have been less developed (Dragut & Blaschke, 2006). On the other hand, the manual delineation of morphological landforms is more complex and time-consuming. Nevertheless, there have been advances in this field (Geneletti & Gorte, 2006; Klingseisen et al., 2008), and there are works such as the Australian landscape classification (Brabyn 2009) where this type of automated classification has been applied.

Attribute geology is scarcely used, and it is only related to small scales and intermediate scales due to the inexistence of geological maps with scales more detailed than 1:50,000, as observed for soil maps. Also, the scarce use of attribute geology can be motivated by the higher emphasis on the apparent part of the landscape when referring to landscape works in Spain (MMA, 2006).

For land matrix attributes, the result is a direct consequence of the definition. Land matrix attributes are not really independent variables because the land use maps frequently include types of vegetation, and they do not show the level of detail with which the attribute has been defined. For example, vegetation can refer to general types such as “wood” and “agricultural mosaic” or more detailed types such as “dense pine-tree wood” and “vineyards and brush mosaic”. We observed a vague or absent definition of the criteria used for the distinction of the different land matrix classes, which indicates that the Spanish landscape planners were not using any shared hierarchical classification framework for this variable. Previous works (Gulinck et al., 2001) discussed the advantages of using standardised land cover data in a landscape analysis that allows comparison between different areas.

The CORINE land cover classification system that was used in some of the analysed works (Móniz et al., 2005; Nogué & Sala, 2006; 2008; 2009) and in some of the landscape classifications developed in other parts of Europe such as Belgium, Germany or Ireland (Julie Martin Associates, 2006; Ministère de l'Écologie et du Développement Durable, 2004; Van Eetvelde & Antrop, 2009) could be a starting point for the definition of land cover classes in a standardised way. However, CORINE definition of classes is imprecise (Di Gregorio & Jansen, 1998), and its coarse resolution makes it inappropriate for local scales where high resolution is needed (Gulinck et al., 2001).

Other classification systems such as the FAO Land Cover Classification System (Di Gregorio & Jansen, 1998) have the advantage of providing a set of precise classifiers and being scale- and source-independent. Thus, they can be applied with classical approaches based on aerial photography interpretation or automated satellite remote sensing techniques, which are becoming the most effective method for land cover data acquisition (Gamanya, 2007).

Visual boundaries were used in many of the landscape works analysed in this paper for intermediate and large scales, which allowed the subdivision of tracts of land with the same character and thus provided areas that can be easily surveyed and managed. Visual boundaries were used in works related to the visual approach and also in works that followed the LCA approach (Nogué & Sala, 2006; 2008; 2009). Regarding the landscape classifications developed in other European countries, the use of visual boundaries is not so widespread but there are examples of countries that are applying them such as France, Ireland and Belgium (Julie Martin Associates, 2006; Droeven et al., 2004; Ministère de l'Écologie et du Développment Durable, 2004).

The results suggest that the visual boundaries were based mainly on the topographic features and less on the land cover features. Only a few landscape works included these landscape elements (Andrés, 1991; Díaz & Galiana, 1996; Escribano et al., 2004a; 2004b; Díez, 2008), possibly due to the characteristics of the area and also to the scarce availability of height data associated with the land cover (Sander & Manson, 2007). Nevertheless, emergent tools such as high-resolution light detection and ranging instruments (LIDAR) may provide the opportunity to model viewsheds more efficiently (Wilson et al., 2008).

In general terms, the analysis illustrates two different interpretations of the landscape unit concept which are associated to the double meaning of the term landscape, nature plus the human influence *vs.* scenery. On the one hand, the landscape unit is conceived as the area defined by its natural (abiotic and biotic) and human components, as in the landscape map of the Valencia Region Coast (DGC, 2001) or in the Andalusia Region landscape map (Moniz et al., 2005). In this sense, the consideration of the influence of human activity is the main difference between the concepts landscape unit and ecological unit, also called natural or biophysical unit (Bastian et al., 2006). Consequently, in some of the analysed works, there are not landscape units but ecological units because only natural factors are considered, as in the Valencia Province geoscientific map (Valencia County Council, 1986) and the landscape assessment in the metropolitan area of Alicante and Elche (Galiana et al., 2001). In these works, units are just based in geomorphological and geological attributes. On the other hand, the landscape unit can be understood as a portion of land with homogeneous visual character (e.g. Brabyn 2009). This approach is related to the second meaning of landscape, which is focused on its visual appearance, as in the landscape study in the fertile irrigated area of the Valencia City (Díaz & Galiana, 1996) or in the Madrid Region landscape map (Aramburu et al., 2003).

For the concept of landscape character area, it integrates both interpretations of the landscape unit concept but goes beyond them in terms of the cultural and perceptual aspects. The cultural dimension in LCA transcends the consideration of land use involving other factors such as settlement, enclosure or time depth while perception is not just focused on the visual appearance but also on feelings, memories or associations (Swanwick et al., 2002). In this way, just a small part of the analysed works can be considered as landscape character classifications (Díez, 2008; Iranzo, 2009; Nogué & Sala, 2006; 2008; 2009).

5. Conclusions

The aim of this paper was to describe the most commonly used differentiating variables when mapping landscape units at different scales by analysing a set of works in Spain, especially in the Valencia region. The analysis was focused on three attributes, i.e., *topography, land use/land cover* and *visibility*, which, up to now, have been the most common differentiating factors in Spanish landscape classifications.

The results suggest a lack of a clear trend about the level of detail in which the three analysed factors (*geomorphology, land matrix and visual boundaries*) were applied at the three scales considered. In relation to the *geomorphology*, two different approaches, i.e., *classifications based on slope and morphological landform classifications,* were applied indistinctively, especially on small (1:100,000 to 1:200,000) and intermediate (1:25,000 to 1:1:50,000) scales. Regarding the variable *land matrix*, no information about the level of detail used at each scale was found due to the imprecise way in which the *land use/cover* classes were generally defined. The *visual boundaries* were more frequently used on intermediate and large scales, but no clear differences were found between the types of visual boundaries applied for each of these scales. In general, the land cover elements were less frequently considered than the topographic elements.

These results agree with the diversity found in other European countries when analysing different landscape classifications within countries such as France, Belgium or Ireland. The diversity of approaches can be enriching, but it poses problems when the landscape units (character areas) are assumed to be the spatial framework used to implement the European Landscape Convention objectives related to the preservation, planning, and management of landscape. In this way, future Spanish landscape classifications should take into account the lessons learned from other European countries and try to harmonize them by defining clear criteria that allow comparable classifications between regions and within the same region.

Also, as with most of the European landscape classifications (Van Eetvelde & Antrop, 2007a), most of the reviewed works were not really landscape character classifications because they scarcely included the cultural and perceptual aspects. In most of the analysed works, the land cover/land use was the only differentiating variable related to the cultural dimension of the landscape. Additional cultural variables such as the settlement types and patterns, farming styles or field patterns should be involved (Van Eetvelde & Antrop, 2007b). The visual boundaries were related to the visual perception, but the character goes beyond the visual appearance of the landscape. The sense of place must be also involved in landscape character classifications. In this sense, concepts such as the social catchment can be of interest to integrate the sense of community attachment (Brunckhorst & Reeve, 2006).

Harmonization in landscape unit delineation goes through the adoption of a common approach. ELC provided the foundations for harmonization by giving a broad and inclusive definition of the term landscape that could be shared by the different disciplines and by defining the goals of landscape classification which should be linked to the establishment of landscape quality objectives (Council of Europe, 2008). The fact that, among the works analysed, the most recent ones have adopted the LCA approach suggests that a process of harmonization may have started in Spain.

List of references

Aramburu, M.P., Escribano, R., Ramos Gonzalo, L., Rubio Maroto, R. (2003) **Madrid Region landscape map** (Madrid, Regional Department of Environment) [in Spanish]. http://www.madrid.org/cs/Satellite?c=CM_InfPractica_FA&cid=1109168179748&idTema=1109265601134&language=es&pagename=ComunidadMadrid%2FEstructura&segmento=1&sm=1 (accessed February 2009).

Andrés Orive, L., Bañón Irujo, S., Casado Pérez, A., López De Maturana, A., Ros Gamuza, L.(1991) Landscape mapping for historic land conservation in Alava, in: Saint Quirce History and Art Academy, Association for Natural and Cultural Heritage "El Duratón" & Cultural Horizon (Ed.) **IV Conferences on landscape. Alternatives for landscape development and conservation**, pp. 131-137 (Segovia) [in Spanish].

Bastian, O., Krönert, R., Lipsky, Z. (2006) Landscape diagnosis on different space and time scales – a challenge for landscape planning, **Landscape Ecol**. 21, pp. 259-374.

Blanco, A., González, S., Ramos, A. (1982) Visual Landscape Classification in the Coastal Strip of Santander (Spain), **Coast. Zone Manage. J.** 9, pp. 271-297.

Brabyn, L.K. (2009) Classifying Landscape Character. **Landscape Research** 34, pp. 299-321.

Brunckhorst, D., Reeve, I. (2006) A geography of place: principles and application for defining “eco-civic” resource governance regions. **Australian Geographer** 37(2), pp. 147-166.

Brunetta, G, Voghera, A. (2008) Evaluating Landscape for Shared Values: Tools, Principles, and Methods. **Landscape Research**, 33, pp. 71 – 87.

Burel, F., Baudry, J. (2002) **Landscape Ecology. Concepts, methods and applications** (Madrid, Mundi-Prensa).

Burrough, P.A., Van Gaans, P.F., MacMillan, R.A. (2000) High-resolution landform classification using fuzzy k-means, **Fuzzy Sets Syst**. 113, pp. 37-52.

Cancer Pomar, L. (1995) **Alto Gallego landscape geography (**Zaragoza, Council for nature preservation in Aragon) [in Spanish].

Council of Europe (2000) **Landscape European Convention** (Florence).

Council of Europe (2008) **Recommendation CM/Rec(2008)3 of the Committee of Ministers to member states on the guidelines for the implementation of the European Landscape Convention** http://www.coe.int/t/dg4/cultureheritage/heritage/landscape/versionsorientation/anglais.pdf (accessed May 2011).

CTV (2000a) **Landscape thematic report in the Valencia Region** (Valencia, Regional Department of Environment) (unpublished) [in Spanish].

CTV (2000b) **Natural Resource Plan of Mariola Mountain Range Natural Park** (Valencia, Regional Department of Environment) (unpublished) [in Spanish].

CTV (2004) **Natural Resource Plan of Albufera Natural P**ark (Valencia, Regional Department of Environment) (unpublished) [in Spanish].

DGC (2001) **Land use map of the Valencia Region coast** (Valencia, Regional Department of Public Works and Transport) (unpublished) [in Spanish].

Di Gregorio, A., Jansen, L. J. M. (1998) **Land Cover Classification System (LCCS). Classification Concepts and User Manual** (Rome, Natural Resources Management and Environment Department, Food and Agricultural Organization of the United Nations).

Díaz, M., Galiana, F. (1996) **Landscape study in the fertile irrigated area of the Valencia City** (Valencia, Valencia City Council) [in Spanish].

Díez, I. (coord) (2008) **Land Use Plan for the fertile irrigated area of the Valencia Region** (Valencia, Regional Department of Environment) [in Spanish].

Dragut, L., Blaschke, T. (2006) Automated classification of landform elements using object-based image analysis, **Geomorphology** 81, pp. 330-344.

Droeven E., Feltz C., Kummert, M. (2004) **Les territoires paysagers de Wallonie**, CPDT, Ministère de la Région Wallonne.

ECOVAST (2006) **A Guide to Good Practices**, The International Ecovast. European Council for the Village and Small Town.

Escribano, R., Aramburu, M.P. (1999) **Landscape evaluation in Navarra Region** (Madrid, TRAGSATEC-U.P.M) (unpublished) [in Spanish].

Escribano, R.; Aramburu, P.; Mascaraque, A.; Iglesias, E., Valero, F. (2004a) **Landscape study in Alcornocales Natural Park (Cádiz)** (Madrid, Spanish Electrical Newtwork, OTT-UPM) (unpublished) [in Spanish].

Escribano, R., Aramburu, M.P., López, R., Sánchez, P. (2004b) **La Rioja Region landscape map** (2 volumes: report and maps) (Logroño, Department of Tourism, Environment and Land Policy in La Rioja Region) [in Spanish]. http://www.larioja.org/npRioja/default/defaultpage.jsp?idtab=455987&IdDoc=461894 (accessed February 2009).

Español, I.M., 1998. **Public works in the landscape. Guide for the analysis and evaluation of landscape environmental impacts** (Madrid, CEDEX) [in Spanish].

Galiana, F., Martí, A., Balaguer, M. (2001) Visual fragility in Alicante and Elche, in: FUNDICOT (Ed.) **III Land Use Planning International Congress** (Gijón) [in Spanish].

Gamanya, R., De Maeyer, P., De Dapper, M. (2007) An automated satellite image classification design using object-oriented segmentation algorithms: A move towards standardization, **Expert Systems with Applications** 32, pp. 616-624.

Geneletti, D., Gorte, B.G.H. (2003) A method for object-oriented land cover classification combining Landsat TM data and aerial photographs, **Int. J. Remote Sensing** 24 (6), pp. 1273-1286.

Griffiths, G., Porter, J., Simmons, E., Warnock, S. (2004) **The Living Landscapes Project. Landscape character and biodiversity. Final Report. English Nature Research Report 75** (Peterborough, English Nature).

Gulinck, H., Múgica, M., De Lucio, J.V., Atauri, J.A. (2001) A framework for comparative landscape analysis and evaluation base don land cover data, with an application in the Madrid region (Spain) **Landscape Urban Plan.** 55, pp. 257-270.

Hernández-Pacheco, E. (1955-56) **Solar Hispano Physiography,** Exact Sciences Royal Academy, Natural Sciences Series 16, 1-2 (Madrid) [in Spanish].

Iranzo, E. (2009) **Landscape as rural heritage. Proposal of an integrated methodology for the analysis of Valencia Region landscapes**. Doctoral thesis (Valencia, Valencia University) [in Spanish].

Julie Martin Associates (2006) **Final Report to The Heritage Council. Landscape Character Assessment in Ireland: Baseline Audit and Evaluation** (North Yorkshire, England).

James, P., Gittins, J.W. (2007) Local Landscape Character Assessment: An Evaluation of Community-led Schemes in Cheshire, **Landscape Research** 32, pp. 423-442.

Jones, M. (2007) The European Landscape Convention and the Question of Public Participation, **Landscape Research** 32, pp. 613-633.

Kim, K., Pauleit, S. (2007) Landscape character, biodiversity and land use planning: the case of Kwangju Region, South Korea. **Landscape Policy** 24, pp. 264-274.

Klingseisen, B., Metternicht, G., Paulus, G. (2008) Geomorphometric landscape analysis using a semi-automated GIS-approach, **Environmental Modelling & Software** 23, pp.109-121.

Kljin, F. (1994) **Ecosystem Classification for Environmental Management. Ecology & Environment. Volume 2** (The Netherlands, Kluwer Academia Publishers).

Koestler, A. (1969) Beyond atomism and holism – the concept of the holon, in: Koestler, A, Smithies, J.R. (Eds.) **Beyond Reductionism: New Perspective in the Life Sciences**, pp. 192-216 (London, Hutchinson).

Martín-Duque, J. F. (1997) **Geomorphology in the physical environment Studies and land use planning. Methodological proposal and application in the Central System.** Doctoral thesis (Madrid, Complutense University) [in Spanish].

Martín-Duque, J. F., Pedraza, J., Sanz, M.S., Bodoque, J.M., Godfrey, A.E., Diez, A., Carrasco, R.M. (2003) **Landform Classification for Land Use Planning in Developed Areas: An Example in Segovia Province (Central Spain).** Environ. Manage. 32, pp. 488-498.

Mata, R., Gómez, J., Allende, F., López, N., Molina, P., Galiana, L., Sanz, C. (2003) **Spanish Landscape Atlas** (Madrid, General Technical Secretary's Office of Environment) [in Spanish].

Mateu, J.F., Nieto, M. (Eds.) (2008) **Return to landscape. Philosophical, cultural and scientific landscape knowledge in Spain** (Valencia, Evren) [in Spanish].

McGarigal, K., Marks, B.J. (1995) **FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure**. Gen. Tech. Rep. PNW-351 (Portland, USDA Forest Service, Pacific Northwest Research Station).

Ministère de l'Écologie et du Développement Durable (2004) **Méthode pour les Atlas de paysages. Enseignements méthodologiques de 10 ans de travaux** (Paris, France).

Ministère de l'Écologie et du Développement Durable (2007) **Les unités et structures paysagères dans les Atlas de paysages** (Paris, France).

MMA (2006) **Guidelines for the development of physical environment studies. Contents and methodology** (Madrid, Department of Environment) [in Spanish].

Moniz, C., Moreira, J.M., Ojeda, J.F., Rodríguez, J., Venegas, C., Zoido, F. (2005) Andalucia Region Landscape Map, in: Andalucia Government, Department of Public Works and Transport, Department of Environment (Eds.) **Andalucia Atlas II**, pp. 221-239 (Sevilla) [in Spanish].

Mücher, C.A., Klijn, J.A., Wascher, D.M. (2010) A new European Landscape Classification (LANMAP): A transparent, flexible and user-oriented methodology to distinguish landscapes. **Ecol. Indic.** 10, pp. 87-103.

Naveh, Z. (2000) What is holistic landscape ecology? A conceptual introduction. **Landscape Urban Plan**. 50, pp. 7-26.

Naveh, Z., Lieberman, A.S. (1994) **Landscape Ecology. Theory and Applications**. 2nd Edition (New York, Springer).

Nogué, J., Sala, P. (2006) **Tarragona Lands Landscape Catalogue** (Landscape Observatory, Cataluña) [in Spanish]. http://www.catpaisatge.net/esp/cataleg.php (accessed December 2009).

Nogué, J., Sala, P. (2008) **Lleida Lands Landscape Catalogue** (Landscape Observatory, Cataluña) [in Spanish]. http://www.catpaisatge.net/esp/cataleg.php (accessed December 2009).

Nogué, J., Sala, P. (2009) **Ebro Lands Landscape Catalogue** (Landscape Observatory, Cataluña) [in Spanish]. http://www.catpaisatge.net/esp/cataleg.php (accessed December 2009).

Ode, A., Tveit, M.S., Fry, G. (2008) Capturing Landscape Visual Character Using Indicators: Touching Base with Landscape Aesthetic Theory. **Landscape Research** 33, pp. 89-117.

Olwig, K.R. (2007) The Practice of Landscape 'Conventions' and the Just Landscape: The Case of the European Landscape Convention, **Landscape Research** 32, pp. 579-594.

Pedraza, J. De., Carrasco González, R., Díez Herrero, A., Martín Duque, J.F., Martín Ridaura, A., Sanz Santos, M.A. (1996) **Geomorphology. Principles, methods and applications** (Madrid, Rueda Editorial) [in Spanish].

Pellicer, F., Cancer Pomar, L. (1992) The Juslibol Gully (Middle Ebro River): zoning, evaluation, and proposal for landscape conservation in a space of natural interest, in: Saint Quirce History and Art Academy, Association for Natural and Cultural Heritage "El Duratón" & Cultural Horizon (Ed.) **IV Conferences on landscape. Alternatives for landscape development and conservation**, pp. 107-128 (Segovia) [in Spanish].

Perez-Chacon, E. (2002) Landscape units: scientific approach and applications, in Zoido, F., Venegas, C. **Landscape and Land use planning** (Seville, Regional Department of Public Works and Transport) [in Spanish].

P&G (2005a) **Landscape study for an urban plan in Cullera (Valencia)** (unpublished) [in Spanish].

P&G (2005b) **Landscape study for residential sectors in Pobla del Duc (Valencia)** (unpublished) [in Spanish].

Prieto, A., Fernández, S.C., Sancho, J.C. (coord.) (2009) **Murcia Region landscape atlas** (Murcia, Department of Public Works and Land Use Planning) [in Spanish].

Ramos, A. (Dir.) (1979) **Physical planning and ecology: models and methods** (Madrid, EMESA) [in Spanish].

Ramos, A., Ramos, F., Cifuentes, P., Fernández-Cañadas, M. (1976) Visual Landscape Evaluation, a grid technique, **Landscape Plan.** 3, pp. 67-88.

Sander, H.A., Manson, S.M. (2007) Heights and locations of artificial structures in viewshed calculation: How close is close enough?, **Landscape and Urban Plan**. 82, pp. 257-270.

Swanwick, C., Department of Landscape, University of Sheffield, Land Use Consultants (2002) **Landscape Character Assessment: Guidance for England and Scotland** (Edinburgh, Countryside Agency and Scottish Natural Heritage).

Swanwick, C. (2004) The assessment of countryside and landscape character in England: an overview, in: Bishop, K., Philipps, A. (Eds.) **Countryside Planning. New Approaches to Management and Conservation,** pp. 109-124 (Earthscan, London).

Tetlow, R.J. Y Sheppard, S.R.J. (1979) Visual Unit Analysis: A Descriptive Approach to Landscape Assessment, in: **Proceedings of Our National Landscape**. General Technical Report PSN-35 (Nevada, USDA Forest Service).

TRAGSATEC (2002) **Valencia Region Forestry Plan** (Valencia, Regional Department of Environment) (unpublished) [in Spanish].

Valencia County Council (1986) **Valencia Region Geoscientific map** (Valencia, Valencia County Council) [in Spanish].

Van Eetvelde, V., Antrop, M. (2007a) Landscape character beyond landscape typologies. Methodological issues in trans-regional integration in Belgium, in: **18th International Annual ECLAS Conference 2007**, pp. 229-239 (Belgrade Serbia).

Van Eetvelde, V., Antrop, M. (2007b) Integrating cultural themes in landscape typologies, in Z. Roca, T. Spek, T. Terkenli, F. Höchtl (Eds.), **European Landscapes and Lifestyles: The Mediterranean and Beyond. Proceedings of the 21st PECSRL Conference "One Region, Many Stories: Mediterranean Landscapes in a Changing Europe", Limnos and Lesvos, 2004,** pp. 399-411 (Lisboa: Ediçoes Universitárias Lusófonas).

Van Eetvelde, V., Antrop, M. (2009). A stepwise multi-scaled landscape typology and characterisation for trans-regional integration, applied on the federal state of Belgium. **Landscape Urban Plan.**, 91(3), 160-170. doi:10.1016/j.landurbplan.2008.12.008

Visual Resource Management: http://www.blm.gov/nstc/VRM/

Wascher, D.M. (Ed.) (2005) **European Landscape Character Areas. Typologies, Cartography and Indicators for the Assessment of Sustainable Landscapes.** Final Project Report as deliverable from the EU´s Accompanying Measure project European Landscape Character Assessment Initiative (ELCAI), funded under the 5th Framework Programme on Energy, Environment and Sustainable Development.

Wilson, J., Lindsey, G., Gilbert, L. (2008) Viewshed characteristics of urban pedestrian trails, Indianapolis, Indiana, USA, **Journal of Maps** 108-118.

Young, A. (1998) **Land resources. Now and for the future** (Cambridge, Cambridge University Press).

Zoido, F. (2005) Landscape preservation, management and planning in Seville North Mountain Range, in: **Second meeting of workshops for Landscape European Convention**

application, European land and landscape planning 72, pp. 229-243 (Strasbourg, European Council) [in French].

Zonneveld, I.S. (1989) The land unit: a fundamental concept in landscape ecology, and its applications. **Landscape Ecol.** 3, pp. 67-86.

List of tables

Table 1

Variable	Category	Acronym	Description
Type of extent	Country or regional	A1	The extent of analysis involves a whole country or a region like the "Comunidad Autónoma de Madrid"
	County	A2	The extent of analysis involves a county
	Local	A3	The extent of analysis involves a municipality or a part of different municipalities that share a landscape with a similar character, such as the Huerta de Valencia.
Scale of analysis	Small scale	E1	1:200 000 or 1:100 000
	Intermediate scale	E2	1:50 000 or 1:25 000
	Large scale	E3	1:10 000
Geomorphology	No geomorphology	G0	No variable representing geomorphology is used in the definition of landscape units
	Geomorphological region	G1	They are large subdivisions of relief like mountains, plains, etc.
	Geomorphological domain and element	G2	The domains subdivide the relief into mountain peaks, mountain slopes, rolling plains, floodplains, and so forth, while the elements divide it into torrent gorges, piedmont hills, rocky ridges, etc.
	Landform	G3	Landform classification based on slope, such as flat, undulated, steep slope, etc.
	Landform + Geology	G4	A combination of landform and geological characteristics
Land matrix	No land matrix	V0	No variable representing land matrix is used in the definition of landscape units
	Land use	V1	Human activities that are related to land
	Vegetation	V2	Type of vegetation involving type of strata and composition
	Land use and vegetation	V3	A variable including type of land use and type of vegetation
Visual boundaries	No visual boundaries	L0	No variable representing visual boundaries is used in the definition of landscape units
	First level visual boundaries	L1	Visual boundaries related to topographic features
	Second level visual boundaries	L2	Visual boundaries related to topographic features and other elements like vegetation, buildings or infrastructures that can act as visual limits

Table 2

	Small scale works (E1)		Intermediate scale works (E2)		Large scale works (E3)	
	Number	%	Number	%	Number	%
National/Regional extent works (A1)	6	100	4	24	1	20
County extent works (A2)	0	0	9	52	1	20
Local extent works (A3)	0	0	4	24	3	60
Total works by scale	6	100	17	100	5	100

Table 3

	Small scale works (E1)		Intermediate scale works (E2)		Large scale works (E3)	
	Number	%	Number	%	Number	%
Works using land use (V1)	2	67	3	27	2	50
Works using vegetation (V2)	0	0	1	9	1	25
Works using land use and vegetation (V3)	1	33	7	64	1	25
Works using land matrix attributes	3	100	11	100	1	100

List of figures

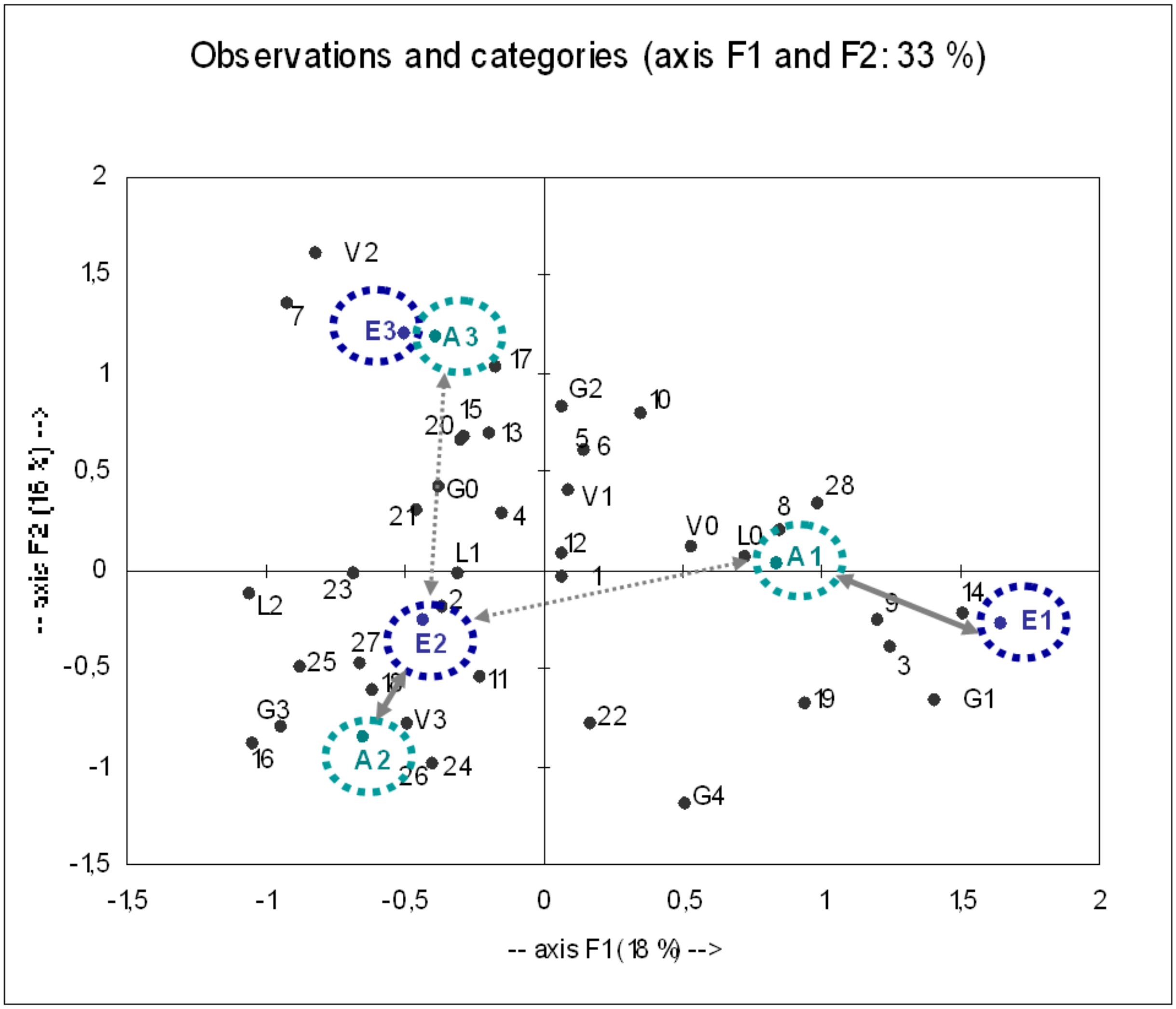

Figure 1. The projections of the works and modalities showing the relationships between the scale of analysis and the type of extent. The dotted lines show that the intermediate scales (E2) are also related to the county and national/regional extents

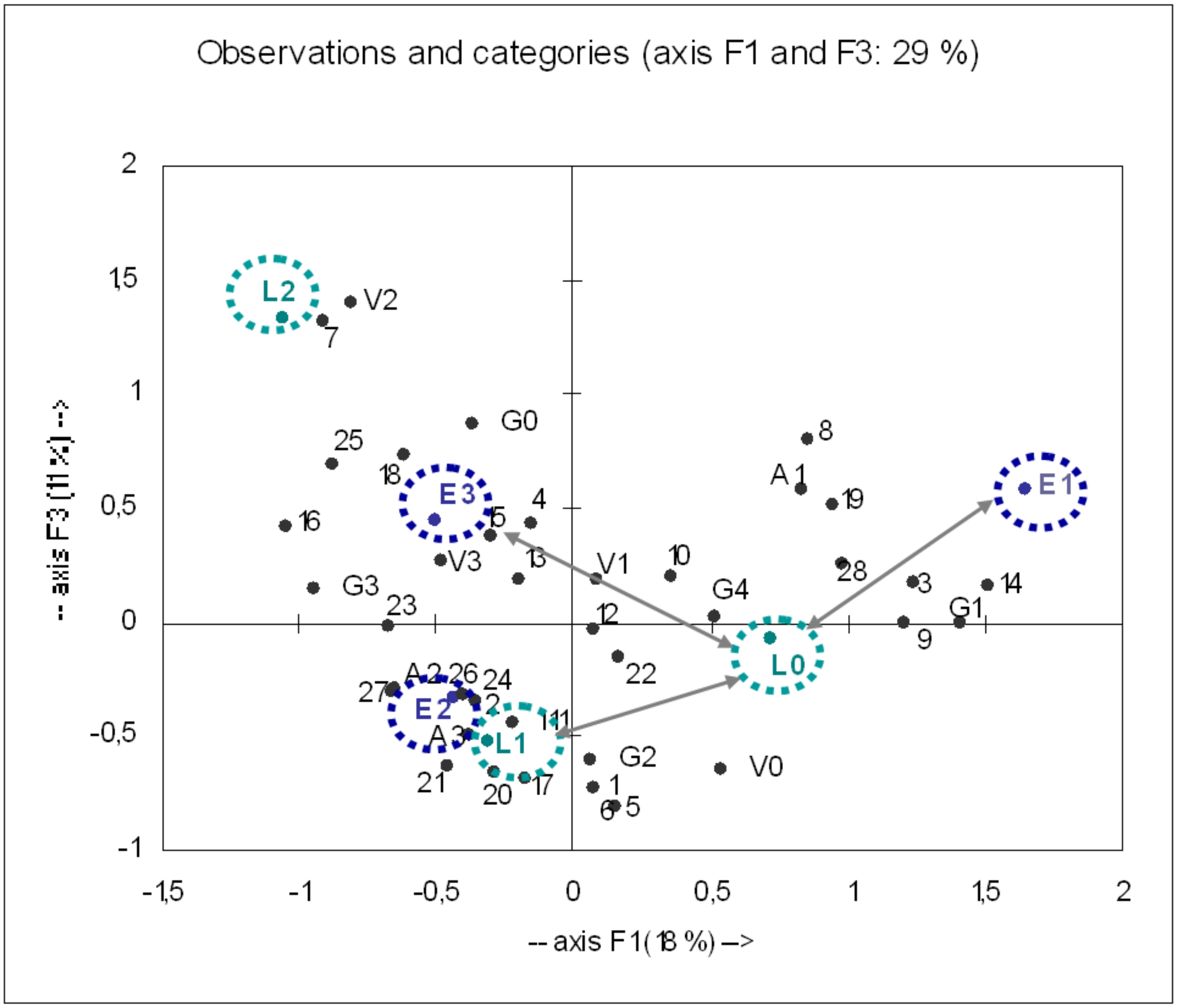

Figure 2. The projections of the works and modalities showing the relationships between the scale of analysis and the visual boundaries.

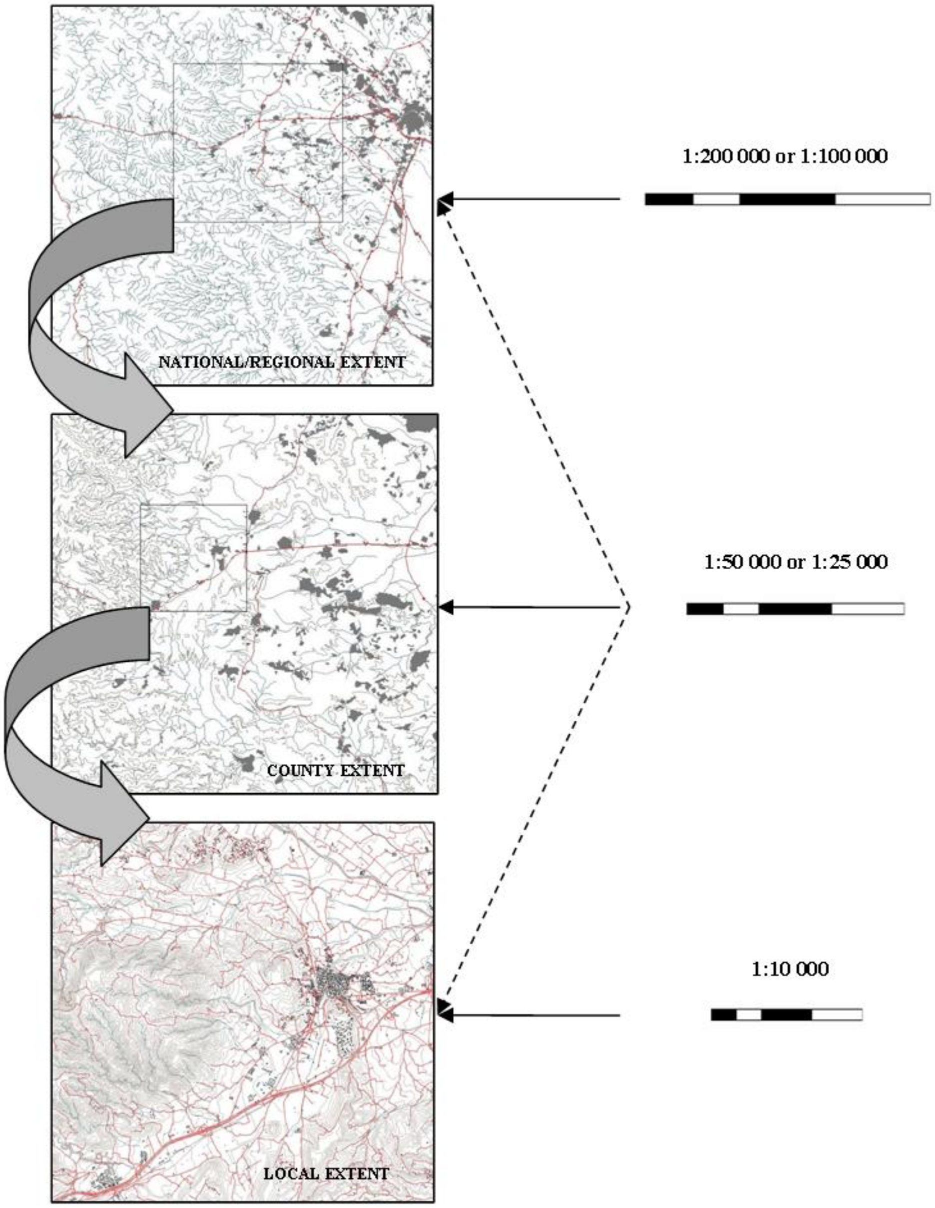

Figure 3. The relationships between the scale of analysis and the type of extent. The intermediate scale (E2) was used for the three types of extent: national/regional, county and local extent

List of appendices

Appendix A. The data used for the analysis of the Spanish landscape works.

ID: work identification number. Variables: type of extent (A), scale (E), geomorphology (G), land matrix (V), visual boundaries (L). Categories: country or regional extent (A1), county extent (A2), local extent (A3), small scale (E1), intermediate scale (E2), large scale (E3), no geomorphology (G0), geomorphological region (G1), geomorphological domain and element (G2), landform (G3), landform in combination with geology (G4), no land matrix (V0), land use (V1), vegetation (V2), land use and vegetation (V3), no visual boundaries (L0), first-level visual boundaries (L1) and second-level visual boundaries (L2).

Appendix A

REFERENCE	ID	A	E	G	V	L
Visual landscape evaluation in the coastal strip of Santander (Ramos et al., 1976)	1	A2	E2	G2	V0	L0
Visual landscape classification in the coastal strip of Santander (Blanco et al., 1982)	2	A2	E2	G0	V0	L1
Valencia Province Geoscientific map (Valencia County Council, 1986)	3	A1	E1	G4	V0	L0
Álava landscape map (Andrés Orive et al., 1991)	4	A1	E2	G2	V1	L2
El Galacho de Juslibol (Ebro Medio) (Pellicer & Cáncer Pomar, 1992)	5	A3	E2	G2	V0	L0
Ecogeography in Alto Gallego landscapes (Cáncer Pomar, 1995)	6	A3	E2	G2	V0	L0
Landscape study in *the fertile irrigated area of the Valencia City* (Díaz & Galiana, 1996)	7	A3	E3	G0	V2	L2
Landscape evaluation in Navarra Region (Escribano & Aramburu, 1999)	8	A1	E1	G0	V1	L0
Landscape Thematic Report in the Valencia Region (CTV, 2000a)	9	A1	E1	G1	V0	L1
Landscape map of the Valencia Region coast (DGC, 2001)	10	A1	E3	G2	V1	L0
Landscape assessment in the metropolitan area of Alicante and Elche (Galiana et al., 2001)	11	A2	E2	G3	V0	L0
Valencia Region Forestry Plan (TRAGSATEC, 2002)	12	A1	E2	G0	V0	L1
Madrid Region landscape map (Aramburu et al., 2003)	13	A1	E2	G2	V2	L1
Spanish Landscape Atlas (Mata et al., 2003)	14	A1	E1	G1	V0	L0
Natural Resource Plan in Albufera Natural Park (CTV, 2004)	15	A3	E3	G0	V3	L0
A study of the landscape of Alcornocales Natural Park (Escribano et al., 2004)	18	A2	E2	G3	V3	L2
Natural Resource Plan in Mariola Mountain Range Natural Park (CTV, 2000b)	17	A3	E3	G2	V0	L1
La Rioja Region landscape map (Escribano et al., 2004)	16	A1	E2	G3	V3	L2
Andalusia Region landscape map (Moniz et Al., 2005)	19	A1	E1	G4	V3	L0
Landscape study for an urban plan in Cullera (Valencia) (P&G, 2005a)	20	A3	E2	G2	V1	L1
Landscape study for residential sectors in Pobla del Duc (Valencia) (P&G, 2005b)	21	A3	E2	G2	V3	L1
Landscape study in Seville North Mountain Range Natural Park (Zoido, 2005)	22	A2	E2	G1	V3	L0
Analysis of cultural landscapes in Valencia (Iranzo, 2009)	23	A2	E3	G3	V1	L1
Tarragona Lands landscape catalogue (Nogué & Sala, 2006)	24	A2	E2	G4	V3	L1
Land use plan for *the fertile irrigated area of the Valencia Region* (Díez, 2008)	25	A2	E2	G0	V3	L2
Lleida Lands landscape catalogue (Nogué & Sala, 2008)	26	A2	E2	G4	V3	L1
Ebro Lands landscape catalogue (Nogué & Sala, 2009)	27	A2	E2	G3	V1	L1
Murcia Region landscape atlas (Prieto et al., 2009)	28	A1	E1	G2	V1	L0