SPATIAL MULTISCALE MODEL FOR THE FOREST AREAS OF PLANNING: AN EXAMPLE IN THE REGION OF EASTERN MARINE (GALICIA NE)

Díaz Varela, E. R.

Rodríguez Vicente, V.

Marey Pérez, M. F.

University of Santiago de Compostela

Abstract

Development in recent years of new trends in forestry planning - in the framework of Sustainable Forestry Planning - has acknowledged the need to widen the scope of action to one with multiple scales or functional levels in forestry areas. It also required from the compatibilization of different objectives of forestry production, corresponding with the multi-functional possibilities of the forest, oriented to the economical, social-cultural and ecological sustainability of forestry systems. In this work an application of spatial strategies at multiple scales is proposed, with the goal of establish a coherent compartimentation of the territory for forestry activities. With this objective, successful examples of spatial planning are analyzed, in order to identify the key spatial concepts that ensure their successfulness. Next, a multi-scale structure is developed responding to the dynamics and spatial arrangement of land uses in a shire in NE Galicia (Spain). As a result, a reference model is obtained for forestry planning, adapted to the characteristics and needs of land use in the study area, and which inter-connects three spatial levels. micro-, meso- and macroscale.

Keywords: *Sustainable Forestry Planning; multi-scale; spatial concept; land use; land use planning.*

1. Introduction

The sustainable forest management seeks the multifunctionality of forest ecosystems and landscapes, assuming that they can assume a variety of functions: to the basic productive function (wood and wood products, plus other alternative uses) is joined to the carbon sequestration, protection aquifer, habitat for plant and animal species, biodiversity, recreation, social uses, cultural identity, etc. (Von Gadow et al, 2000). In order to maintain or increase such multifunctionality, several factors must be taken into account. Among them, the search for spatial complexity of forest landscapes has been identified as a critical factor that can have positive effects on the ecological character of the forest areas (ecosystem stability, diversity of species ...), as in the productive (increased production, resistance to pests ...). Consequently, the inclusion in forest planning strategies to increase the spatial complexity is of great importance. However, it is precisely the definition of two components: first, a spatial oriented design to optimize the different functions of the forest; on the other, the ability of actual implementation of normative instruments and management.

The development of an optimal spatial design can take the form of a spatial concept (Van Lier, 1998) which orientates in a strategic and precise way the actions to specific points in the territorial system. Such concepts should not only serve as static references for planning, but allow the development of strategies that allow the development of agroforestry activities, while avoiding the removal of elements of ecological importance with the evolution in land uses. But for the application in the real world of a spatial concept is successful, it must include the distinction between different levels or spatial scales with different functional characteristics, depending on the objectives of the planning, and development to provide tailored solutions to the specific properties of such level. This utility to consider several hierarchy levels in the planning was highlighted in the specialized literature (Dramstad et al, 1996; Mander et al, 2003).

2. Objectives

This work seeks the development of spatial strategies to multiple scales with the goal of establishing consistent different territorial areas in forest planning. The basis for this development is, on the one hand, the analysis of successful examples in spatial planning, to obtain spatial concepts of general interest that can be combined in a multiscale strategy of planning. Moreover, the differentiation of scales or levels of planning from the structural analysis of the landscape. The subsequent analysis of the dynamic of land uses in the considered area, will allow determining the necessary concepts for planning at each level.

3. Methodology and/or Case of study

3.1. Study area

The study area is the region of Eastern Marine in the northeastern part of the Autonomous Community of Galicia (Spain, EU). This region presents a great diversity in their geographical characteristics due to a marked gradient interior-coast, as well as imbalances between agricultural and forest areas with different intensities of production. This diversity is reflected in the landscape pattern, providing an interesting source of study for planning at different levels in different areas.

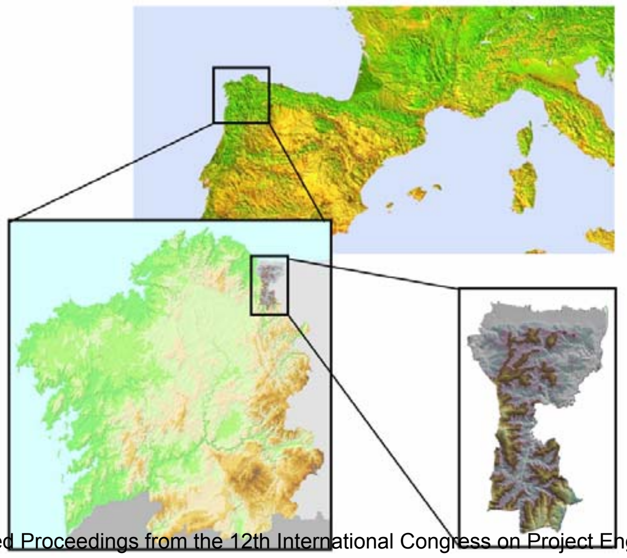

Figure 1: Location of the study area (Region of Eastern Marine-Galicia).

3.2. Identification of appropriate scales for planning

The identification of reference scales for planning in the study area of previous works (Díaz Varela, 2005; Díaz Varela & Crecente, 2007), through an analysis of spatial heterogeneity done on digital mapping of land cover in raster format. Such mapping has been obtained from interpretation of aerial photographs 1:18.000 scale and post field tests (Marey, 2007), and then processed with software ArcView 3.3 ®. The pixel size is 10x10m, and the Minimum Area Mapping of 400 m^2. On the same, the Shannon-Wiener index was applied (Shannon & Weaver, 1949) by mobile windows of different sizes, allowing generating maps of spatial distribution of landscape heterogeneity in the study area at different scales. For this, it has used the software FRAGSTATS (Mcgarigal et al, 2002). As a result, it is identified three scales of interest: "microscale", consisting of areas of change in the heterogeneity of the landscape in small areas (between 4 and 40 ha), inserted into larger units, which define a "mesoscale" and that divided the study area in different areas for its landscape heterogeneity (see Figure 2). A third level, "macroscale", defines the regional context of the study area, which can be defined by working on such levels. The multiscale model of planning will answer, therefore, these three levels.

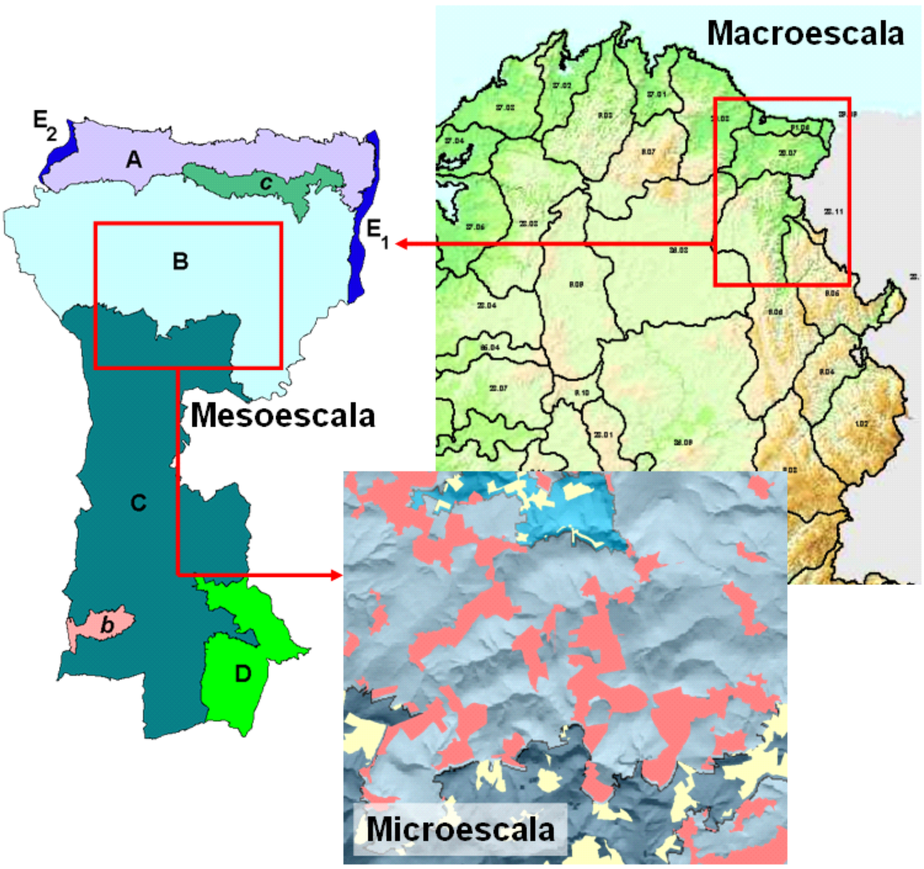

Figure 2: Landscape differentiated units to macro-, meso and microscale. The units to mesoscale are divided into "A", homogeneous mosaic. "B", agroforestry homogeneous mosaic. "C" agroforestry heterogeneous mosaic. "D", large seminatural stain. E1 and E2, marshes. "b" and "c" correspond, respectively, to small heterogeneous and homogeneous areas in mosaic the contrary trend in terms of heterogeneity.

3.3. Correspondence between scales of planning and forest planning instruments

The units and scales identified in the different levels of planning must have a Correspondence with planning instruments currently in the study area. In Galicia, and with special emphasis on forest planning, can perform the following identification of instruments:

- *Microscale*: Units of forest management (UXFOR) / Forest Management Plan
- *Mesoscale*: Plan Management of Forest Resources (PORF)

The instruments to *macroscale* must be dependent of determinations of a larger spatial ambit, such as Territorial Development Guidelines, which are not currently approved in Galicia.

The UXFOR, established by autonomic law 3/ 2007, *"Prevention and Protection against Forest Fire of Galicia",* are defined as forest management units requested by any number of forest owners in excess of 50% of the area of forest contiguous plots with a minimum extension of 15 ha. This type of groupings has by objectives to avoid the process of leaving the forest property, the creation forest economies with a minimum scale to return profitable the forestry activity and fire-fighting and finally the promotion and multifunctional enhancement of forest.

Management Forest Plans under the Forestry Law 43/2003 with the structure established in the General Guidelines for Management of Forest Trees (IGOMA) adopted in 1970 which is the main instrument for sustainable forest intrinsic management to the forest Spanish and thus Galician forest that achieving an adequate scale that in any case exceed 50 ha.

The PORF are defined in state Law 10/2006, of 28 April, amending the Law 43/2003 of November 21, of forests. This law established the need for forest planning on a global scale, creating the existence of the Spanish Forest Strategy and Spanish forest Plan. In this area, the most important innovation of the law is the plans for the management of forest resources (PORF). They are configured as forest planning tools of regional space integrated in the framework for regional planning, so that the forest management and planning are connected with the crucial area of territorial management. In Galicia in 2002 took out the first proposal of PORF in Spain (Marey et al, 2004).

3.4. Generating strategies spatial of planning

Identification of spatial concepts of interest

A detailed analysis of spatial concepts such as ecological networks (Cook Van Lier,1994; Jongman, 1995; Jongman et al, 1995), the territorial systems of ecological stability (Petch & Kolegka, 1995; Miklös, 1996; Sustek, 1998), the concept framework (Van Langevelde, 1994; Vrijlandt & Kerkstra, 1994; Van Lier, 1998), or the spatial solution (Forman, 1995a; Forman, 1995b; Forman & Collinge, 1996; Forman & Collinge, 1997) can distinguish a generic set of common general principles, that underlie the basis for application. These could be summarized as follows:

- Ecological Stabilization: Protection of the ecological function in natural and seminatural ecosystems, protection areas of water resources, or areas with little intensive dynamic in terms of land use, training areas of compensation against other land uses (agriculture, forestry, urban) more intensive.
- Spatial strategical disposition: Using the spatial configuration of the elements in the territory to promote the multifunctionality in it.

- Connectivity: Ensuring the continuity of processes across geographical areas with similar functions (e.g. between areas of high ecological value, productive forest areas, etc.).
- Segregation: Separation of the territory in different areas according to their different characteristics, which will protect through administrative intervention.
- Protection: Elaboration of spatial strategies for the protection of elements of high quality or fragility.
- Divergence of scales: Alternance of elements or areas of fine and thick grain in the mosaic of landscape.

The use of these principles in the generation of spatial design allows the adaptation them to the characteristics, needs and opportunities in each hierarchical level of planning.

Dynamic classification of the territory

In order to facilitate the process of design of the spatial concept, it has classified the different land cover in terms of the dynamic of uses that has generated it. This will allow differentiating areas according to their dynamic, optimizing the location of the elements of the spatial concept according to their Correspondence to areas with a high dynamics of land use, or more stable trend. Five classes have been distinguished to a better adaptation to the characteristics of the study area, and the evaluated criteria for application in the spatial design. These five categories are:

- Metastable: the dynamic is based in natural biogeochemical cycles, and in disruption of non-human origin. The intervention of man, although existing, is weak and hardly affects the development of the ecosystem (seminatural deciduous forests, vegetation of marshes, etc.).
- Transition: associated coverages with neglect or lack of management in land uses. They are constituted mainly of scrub trees with seminatural species, forest mixed of seminatural species and intensive production.
- Low intensity: Insensitive dynamic but with some length of time periods (12-50 years) between cycles of production. It is formed, in general, for activities of forest production.
- High intensity: Intensive dynamic with short time periods between production cycles (0-3 years). Agricultural areas of forage production, horticulture, fruit, etc.

Artificial: Urban areas and infrastructures.

Once defined this basic legend, the map of land cover of the original ground is reclassified obtaining a map of the intensity in land uses. This map represents the spatial distribution of areas based on their dynamic of use. Based on, the location of the components of spatial concepts can be done precisely according to the spatial detected dynamic.

4. Results

Spatial concepts applied to microscale

Centers of ecological stabilization (1). Spots of major stability, large size and spatial continuity, a high percentage of interior area (to minimize edge effects), and an edge adapted to the characteristics of the surrounding land uses. Two types are differed: centers of native deciduous forests (1a) and centers of thicket (1b).

Areas of stabilization (2). Grouping of spots of seminatural ecosystems whit adjacent areas, not seminatural, which was intended to be in a metastable state by a decrease in the dynamics of land use.

Transition zones (3).- They are abundant areas in spots of transitional coverage, although not directly adjacent to seminatural areas, its position become them in strategic to give continuity to the spatial concept. This is essentially a connective element, based in spots of coverage the use of which shows a decrease in the dynamics of land use.

Corridors of connection (4). Elements used for the increase of the connective capacity between constituent elements of the spatial concept.

Areas of forest intensive production (5). Broad areas in which, by the current existence of forest crops, or their potential for production, are designated for carrying out an intensive forest production, with high homogeneity in species (usually *Eucalyptus globulus* and *Pinus radiata*)

Areas of agricultural intensive production (6). Broad areas in which, by the current existence agricultural or fodder crops, livestock activity, or their potential for agricultural production, are designated for the realization of agricultural production more intensive.

Urban zones (7). Populated areas, usually embedded in areas of intensive agricultural production.

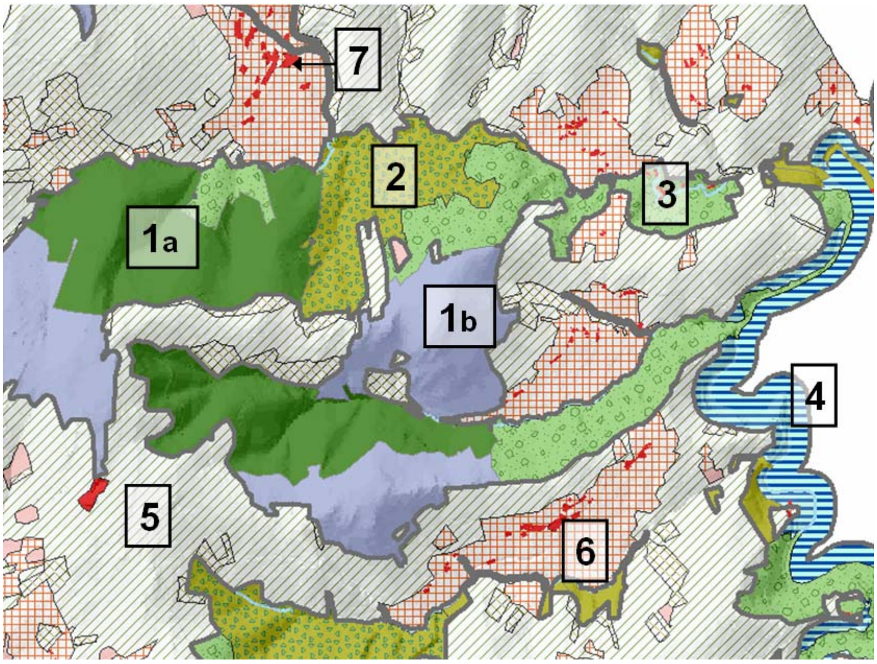

Figure 3: Elements of the spatial concept to microscale (fragment). The numbering corresponds to that adopted in the text.

Spatial concepts applied to mesoscale

The elements described above are combined spatially depending on the characteristics of the territorial structure and each planning unit identified to mesoscale. The combination of elements leads to three basic structures:

A matrix of forest uses (a) and agricultural (b) of medium intensity, which is alternated agricultural land for the production of forage and different types of crops, and forest areas with plantations of eucalyptus and pine.

A network of stabilization (c) (in areas of low dynamic) and/or protection (d) (in areas of dynamic algae), that surrounding the agroforest matrix and establishes a structure in which the forest uses are low dinamic. They are composed of cores and areas of stabilization and transition to microscale, and by connecting corridors. Usually they are areas of deciduous native vegetation, corridors of vegetation of riverside and abandoned areas that seem to advise a transition to low land use dynamic.

Cores of stabilization (e). Structures formed by a set of centers and areas of stabilization, whose main function is segregation and preservation of areas of high metastabilization which occupy a high extension.

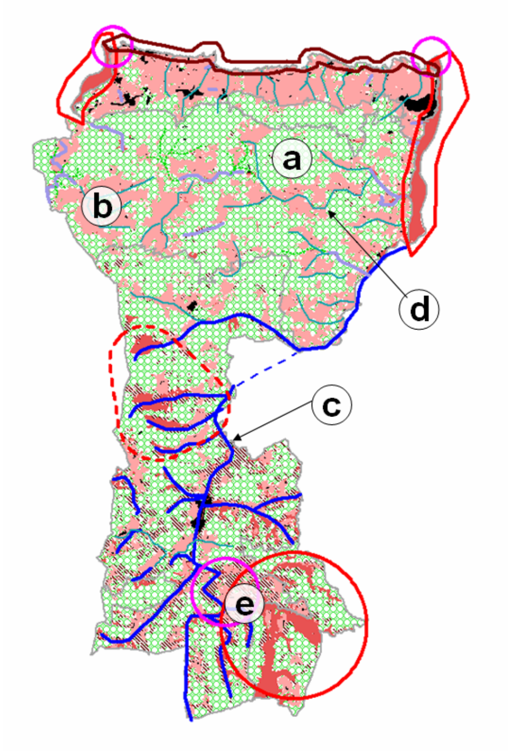

Figure 4: Elements of spatial concept to mesoscale (fragment). The numbering corresponds to that adopted in the text.

Spatial concepts applied to macroscale

There are three major territorial units, functioning as:

Units of intensive land use.- They are consisted by areas with an productive outstanding vocation, both agricultural and forest. Consequently, they are areas with great development of urbanization and infrastructures. Its main function is the agricultural and forest production.

Units of transition .- Units in which are compatible the intensive use of land (agriculture, forest activities, urbanization) with extensive uses (traditional and ecological agriculture, etc.) and conservation of natural resources, through the spatial concepts developed in lower levels. The result is a zone of transition between units of stabilization and other intensive land uses.

Units of stabilization.- The elemental function is the ecological stabilization, on the basis of structures that promote for the whole unity of the low dynamic in land use, with human intervention affecting natural processes minimally.

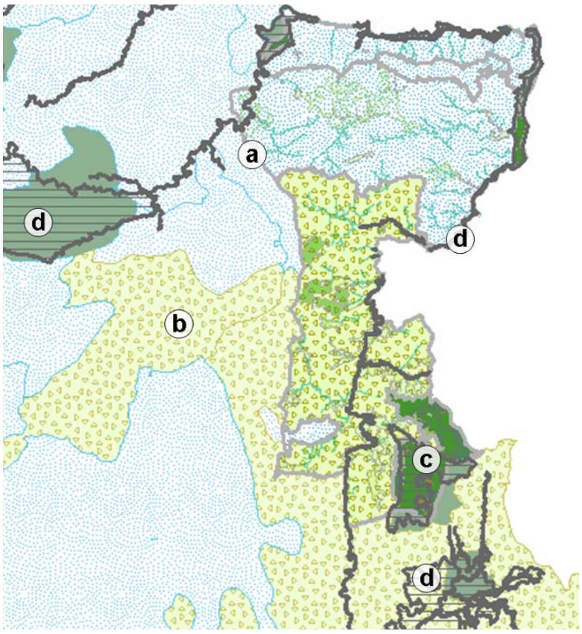

Figure 5: Spatial concept to macroscale. a, units of intensive land use; b, units of transition; c, units of stabilization; d, elements of the network Natura 2000 are shown for comparison of the area of action.

Integration into a multiscale model

The integration of spatial concepts developed for each different level or differenciated scale initially is essential for the validity of the model. The structuring of the model about spatial coordinated strategy with the dynamics of land use at various scales allows the consistency of the same in different areas of intervention through planning. Also, once defined the spatial model, it must develop its implementation through policy current instruments, previously described.

5. Conclusions

The differentiation of units of planning depending of the variation of its heterogeneity is one of the basis of the exposed methodology, and has allowed the identification of relevant scales in the planning of the study area (Diaz Varela, 2005). However, this study has helped to articulate the descriptive aspect about the hierarchical organization of agroforestry landscape, in a planning methodology at multiple scales. Microscale design focuses on the individual properties of territorial elements. To mesoscale, is the spatial structure which harbors the properties of interest, once formed by elements the lower level, which combined effect leads to a functionality adapted to local conditions of land use in the area. To macroscale, the structures reflect regional dynamics, both socioeconomic as the geographical and climate conditions belong to this level. The obtained result is a multilevel structure adapted to the local peculiarities of the forest production and with ability to coordinate with other spatial strategies of planning in its different administrative and geographical levels.

The ultimate objective of this structure is to facilitate, through a spatial strategy disposition, the realization of a consonant planning with ecological integrity of the landscape system, as with the multifunctional use of natural resources, through the simultaneous combination of an analytical perspective for each levels and synthetic for the system in set. The combination of areas of different intensities of land use allows the coexistence of productive activities in the forest and agricultural fields, with others ecological, cultural and social functions of the mosaic agroforest.

The implementation of the spatial presented model precise of the development, updating and implementation of current instruments of forest planning. The UXFOR, to microscale, and the PORF and PORN to mesoscale, and appropriate guidelines of orientation seem, in a first analysis, the most appropriate instruments to capture in the territory a multilevel strategy that allows the multifunctional use of agroforest mosaic.

References

Cook, E.A.; Van Lier, H.N., 1994, Landscape Planning and Ecological Networks. *Elsevier Science* B. V. Amsterdam.

Díaz Varela, E., 2005*: Ecological Planning multiscale with sytems of geographic information for sustainable landscapes: application to the region of Eastern Marine (NE of Galicia, Spain).* PhD thesis. University of Santiago of Compostela, Service of Publications and Scientific Exchange. Santiago of Compostela.

Díaz-Varela, E.; Crecente, R., 2007: *Delineation of landscape units at diverse scales using moving windows for heterogeneity analysis*. In R.G.H. Bunce, R.H.G. Jongman, S. Weel, L. Hojas: 25 Years of Landscape Ecology: Scientific Principles in Practice. Proceedings of the 7th IALE World Congress. Wageningen, Holland.

Dramstad, W.; Olson, J.D.; Forman, R.T.T., 1996: *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning*. Island Press, Washington.

Forman, R.T.T., 1995a. *Land mosaics: The ecology of landscapes and regions.* Cambridge University Press, Cambridge.

Forman, R.T.T., 1995b. *Some general principles of landscape and regional ecology.* Landscape Ecology, 10 (3): 133-142.

Forman, R.T.T.; Collinge, S.K., 1996. *The "Spatial Solution" to Conserving Biodiversity in Landscapes and Regions*. In R.M. DeGraaf; R.I. Miller (Eds.): *Conservation of Faunal Diversity in Forested Landscapes*. Chapman & Hall, London, pp. 537-568.

Forman, R.T.T.; Collinge, S.K., 1997. *Nature conserved in changing landscapes with and without spatial planning*. Landscape and Urban Planning, 37: 129-135.

Jongman, R.H.G., 1995. *Nature conservation planning in Europe: developing ecological networks. Landscape and Urban Planning*, 32: 169-163.

JongmaN, R.H.G.; Külvik, M.; Kristiansen, I., 2004. *European ecological networks and greenways*. Landscape and Urban Planning, 68:305-319.

Mander, Ü.; Külvik, M.; Jongman, R.H.G., 2003. *Scaling in territorial ecological networks*. Landschap, 20(2): 113-127.

Marey-Pérez, M.F., 2003. *Land tenure in Galicia. Model for the characterization of forest owners.* PhD thesis. Digital Publishing (CD). Publications Service of the University of Santiago de Compostela.

Marey-Pérez, M. F., Fernández-Alonso, S., Crecente, R., Aboal-Viñas, J., 2004. *Manual for the realization of PORF in Galicia,* Xunta de Galicia.

Mcgarigal, K.; Cushman, S.A.; Neel, M.C.; Ene, E., 2002: *FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps.* Disponible en internet, URL: www.umass.edu/landeco/research/fragstats/fragstats.html.

MIKLÖS, L., 1996. *The concept of the territorial system of ecological stability in Slovakia*. In: R.H.G. Jongman (Ed.): Ecological and landscape consequences of land use change in Europe. Proceedings of the first ECNC seminar on land use change and its ecological consequences, Tilburg 16-18 February 1995. ECNC publication series on Man and Nature, vol. 2. European Centre for Nature Conservation, Tilburg, pp. 385-406.

Petch, J.R.; Kolejka, J., 1993: *The tradition of landscape ecology in Czechoslovakia*. In R. Haines-Young; D.R. Green; S.H. Cousins: *Landscape Ecology and GIS*. CRC Press, Boca Raton-Florida, pp. 39-56.

Shannon, C. E.; Weaver, W., 1949. *The mathematical theory of communication.* University of Illinois Press, Urbana, Illinois.

SUSTEK, Z., 1998. *Biocorridors. Theory and practice*. In J.W. Dover; R.G.H. Bunce (Eds.): Key concepts in landscape ecology. IALE (UK), Preston, pp. 281-296.

Van Langevelde, F., 1994. *Conceptual integration of landscape planning and landscape ecology, with a focus on the Netherlands*. In E.A. Cook; H.N. van Lier: Landscape Planning and Ecological Networks. Elsevier, Amsterdam, pp. 27-69.

Van Lier, H.N., 1998. The role of land use planning in sustainable rural systems. Landscape and Urban Planning, 41:83-91.

Von Gadow, K., Pukkala, T. and Tome, M., 2000. *Sustainable Forest Management.* Kluwer Academic Publishers, Dordrecht, 356 p.

VrijlandT, P.; Kerkstra, K., 1994. *A strategy for ecological and urban development*. In T. Cook; H.N. van Lier (Eds.): *Landscape Planning and Ecological Networks*. Elsevier, Amsterdam, pp. 71-88.

Correspondence (for further information, please contact):
Emilio Díaz Varela.

University of Santiago de Compostela. Agricultural Engineering Department..

Polytechnic University. University Campus. 27002 Lugo. Spain.
Phone: +34 982252231
Fax: +34 982241835
E-mail: ediazv@lugo.usc.es