

The Portuguese National Ecological Reserve – a mapping tool for Landscape Planning

Pena, Selma B.¹, Magalhães, Manuela R.², Abreu, M. Manuela³
Research Centre for Landscape Architecture “Prof. Caldeira Cabral”
Instituto Superior de Agronomia, Technical University of Lisbon

Introduction

In Portugal, one of the legal frameworks which directly protect the fundamental systems of landscape is the National Ecological Reserve (REN). This instrument was created by the landscape architect Ribeiro Telles in 1983 and at that time its inclusion in the legislative system was considered a pioneering concept in the field of environmental protection. Alongside, it was created the National Agricultural Reserve (1982) that aims agricultural land protection which together with the Natura 2000, other classified areas, and National Ecological Reserve assembles the Fundamental Network of Nature Conservation (2008).

The National Ecological Reserve safeguards fundamental natural cycles and also a wide range of interfaces with high ecological value and sensitivity (beaches, marshes, dunes, cliffs, banks and flood threatened area by floods and sea). This legal framework includes the landscape systems which are critical to ecological stability assurance. Therefore, it constitutes a basic and diversified biophysical structure that guarantees the ecosystems protection which is essential to human activities.

At the municipal land use plan the Ecological Reserve delimitation is mandatory and forbids urban construction on those areas. It has been understood by local administration and private promoters as a blockage for local development by preventing built up areas. Until now, it has been pointed some difficulties regarding the clarity of the delimitation criteria that led to discontinuities between adjacent municipalities and created some obstacles to its implementation. However, this legal framework has allowed landscape protection and prevented some serious environmental problems.

Currently, National Ecological Reserve is undergoing through profound regulation changes that are leading to its dissolution. This fact has become inconsistent with the current European guidelines which strengthen the necessity of biodiversity protection - European biodiversity strategy (2011) - and nature conservation through the implementation of green infrastructures. These infrastructures are a support network of biodiversity and ecosystems that integrate the National Ecological Reserve.

Since the beginning of the 90's, the Research Centre for Landscape Architecture “Prof. Caldeira Cabral” (CEAP / TUL) has been developing methodologies to improve the delineation of National Ecological Reserve criteria as part of the Ecological Network. This research is based on a positive vision of landscape as a resource of life-support services enlarging the current restrictive view of land use to a multifunctional approach.

Background and Literature Review

Ecology is the center and the basis for landscape planning (Magalhães *et al.*, 2007). Forman and Godron (1986) define landscape ecology as the study of structure, function and change in a heterogeneous land where ecosystems interact. Ecology is also intended by Odum (2004) as the study of structure and nature's functioning. These are the principles and concepts that sustain Nacional Ecological Reserve and allow the integration of ecology in landscape planning. REN has also become an important legal instrument that also protects landscape quality by defining the most valuable and fragile resources (Ribeiro & Beirão, 2006).

As an open system, landscape encompasses energy and matter exchanges between its components. Those ecological and cultural systems interact and are in permanent evolution (Pena & Abreu, 2012). Therefore, an important goal to achieve in planning is the positive balance between those two structures promoting landscape stability (Tricart, 1977; Pena *et al.*, 2010).

Ecological integration in planning is a component of the Landscape-System methodology (Magalhães *et al.*, 2007), that is being developed in the Research Centre for Landscape Architecture and which starting point is the landscape planning through two networks: the Ecological and Cultural Networks mapping.

REN is a part of the ecological network and also part of Fundamental Network of Nature Conservation (Table 1).

Table 1 - Relation between legal REN, Fundamental Network of Nature Conservation and Ecological Network from Landscape-Methodology approach

	Fundamental Network of Nature Conservation	Landscape-System Methodology
National Ecological Reserve (REN)	Corridor areas	Ecological Network
National Agricultural Reserve (RAN)		
Habitats Directive	Core Areas	
Geological and Geomorphologic patrimony		

The *continuum naturale* concept, created by Cabral (1980), is also the conceptual base of REN by considering the necessity of a continuous system of natural occurrences that contributes to the balance and stability of landscape by supporting wildlife and maintaining genetic potential.

The National Ecological Reserve by itself protects different ecosystems with high ecological value. Besides this, it establishes the connection between different core areas (Table 1). The main characteristic of these corridor areas is that they result from the main physical structure of landscape, signifying more than a buffer area. The recognition of the importance of connecting isolated natural areas (Ahern, 1995) is also the basis of REN.

More recently, with the development of an European strategy for biodiversity (European Commission, 2011), the emergence of a new concept of green infrastructure (prosecutors of ecological network) (Council of Europe, 2011, European Commission, 2012; Shanfeng *et al.*, 2011; Weber *et al.*, 2006; Whickham *et al.*, 2010; Greca *et al.*, 2011) and the awareness of the ecosystems services and landscape services (Termoshuizen & Opdam, 2009), highlights the REN's potential for implementing these strategies.

In Portugal the REN legislation has been changing since 1983, and nowadays its substitution by risk assessment plan and water law has been operated. In this work it is considered that REN congregates high ecological value areas which are more than only risk areas and water features. The evolution of REN concept is presented in Table 2.

Table 2 - Evolution of legal REN concept

Decree-law n.º 321/83	Decree-law n.º 96/90	Decree-law n.º 166/2008
Areas necessary for the ecological stability of the environment and the rational use of natural resources to attain good planning	Biophysical and diversified structure which ensures the ecosystems protection and biological processes enhancement essential for the balanced framework of human activities	Biophysical structure that integrates all areas with ecological sensitivity and value or areas with susceptibility against natural hazards It is a restriction of public utility which applies a special territorial regime establishing a set of constraints to the occupation, use and processing of soil, identifying the uses and activities consistent with the objectives. Aims to contribute to the sustainable use of the territory by promoting: a) water and soil resources protection b) risk prevention and reduction c) ecological coherence and connectivity with Network Foundation for Nature Conservation; d) priorities of the Territorial Agenda of the European Union in the fields of environmental management and natural hazards.

REN legislation was established in a fast growing urban development context without any sound planning. The delimitation of REN areas had a strongly preventive character which avoided environmental problems during an accelerated urban growth. Currently, the European directives give priority to the achievement of biodiversity and green infrastructure mapping. In this framework, REN can be an opportunity to implement those priorities, by seeking compatible multifunctional uses.

However there are some fragilities of this legal feature:

- Lack of solid delimitation criteria;
- Absence of national and regional strategy of delimitation;
- Absence of articulation between adjacent municipalities;
- The social aversion to REN (consequence of its preventive character);
- Exclusion of REN delimitation in urban areas.

The considered principles in this research acknowledge landscape as a dynamic and open system where a set of interdependent processes interact to accomplish a natural equilibrium. Therefore, it is necessary to take into account the dynamic of landscape in the National Ecological Reserve criteria definition.

Goals

The main goal of this paper is to present the National Ecological Reserve framework, the improvement in REN delimitation that have been developed in CEAP / TUL and the changes that should be considered in this legal framework to allow the protection of a multifunctional landscape in accordance with land use suitability.

It will be present different case studies at the municipal scale in rural, peri-urban and highly dense urban areas that will demonstrate the strengths and opportunities of the National Ecological Reserve in the landscape planning.

Methods

The methodology (Figure 1) is embedded in the “landscape-system” methodology (Magalhães *et al.*, 2007) that considers the importance an ecologic based plan in the establishment of land use policies, using the ecological land suitability for different human activities perspective. For that, REN is not seen as a constraint but as a potentiality for other human activities besides those that need buildings.

The concepts underlying the National Ecological Reserve have already potentialities to be the base of green infrastructure delimitation. However there are some difficulties in the definition of REN criteria.

The first phase of the methodology is to improve the National Ecological Reserve delimitation with the definition of the landscape structural systems, which are the main physical systems of landscape. The REN's main landscape structural systems are hydrologic ecosystem, soil ecosystem and coastal ecosystem. The concept of each feature from the three systems is developed, and the mapping criteria are set out. In the second phase each feature is tested in order to create and improve a Geographic Information System model.

The third phase is to apply the methodology at national scale, regional scale and municipal scale. As it was already said, the REN delimitation is mandatory at municipal scale, being part of the municipal land use plan. It will be possible to improve the articulation between scales and regulate the use of REN areas.

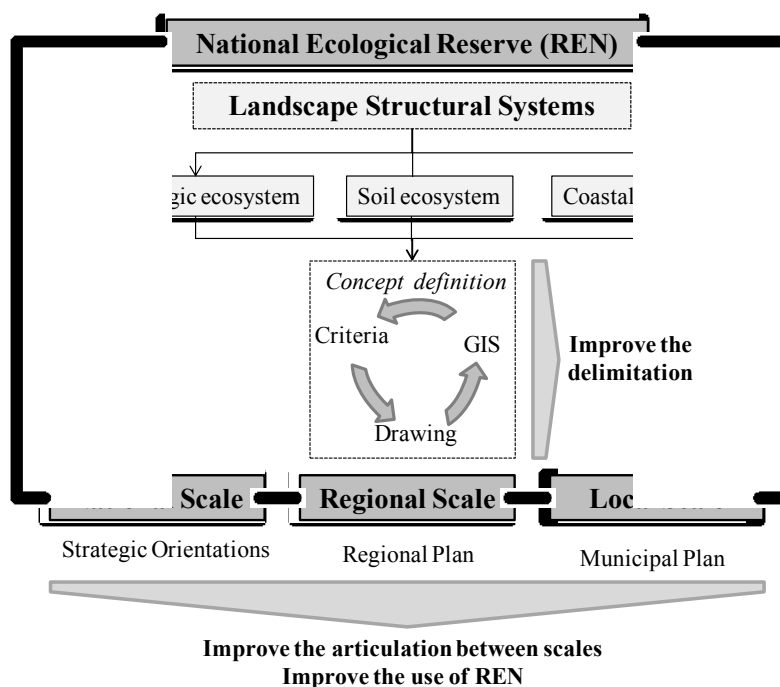


Figure 1 - Methodology scheme

Results

The methodologies to better define the typologies of REN are being tested and applied to different municipal case studies and also at national scale. In this paper it is presented the REN delimitation – according to CEAP methodology – in Sintra, Loures and Odivelas (Figure 2). These municipalities belong to Lisbon Metropolitan Area and they are characterized by highly dense urban areas alternating with rural areas. Among the three case studies Odivelas municipality had the biggest urban growth rate, with 70% of urban area (Table 3).

Table 3 - Area and percentage of urban areas in the case studies – from Corine Land Cover 2006

	Urban areas (artificial surfaces)		other uses (agriculture, forest, wetlands, water bodies)	
	Area (ha)	% in the total municipality area	Area (ha)	% in the total municipality area
Loures	4539	27	12391	73
Sintra	8839	28	23084	72
Odivelas	1833	70	803	30

In the table 4 it is summarized the developed components, concepts, methods and cartography that are related to each structural system of REN. All the procedures were applied into a Geographic Information System.

Table 4 Concept, methods and cartography needed to define different REN delimitation

Structural	Components	Concept	Method	Cartography
------------	------------	---------	--------	-------------

Systems				
Hydrologic ecosystem	Streams	Areas determinant for the good functioning of hydrologic basin (energy and water circulation).	Study the terrain morphology, the geology and soil map	Water Lines Terrain Morphology Soil Map Geology Map
	Contiguous areas to streams			
	Headwater stream area			
	Maximum infiltration areas			
Soil ecosystem	Soil erosion risk areas	Soil is an important system witch support different functions on the landscape.	Evaluate the soil characteristics and the slope degree	Soil Map Slope Map
Coastal ecosystem	Coastal morphology (dunes, beaches, cliffs)	The coastal areas have important geomorphologic dynamics and high ecologic value.	Study the coastal morphology, its fragility and ecological value	Geology Map Hypsometric Map
	Bathymetric (30 m)			
	Protection strip			

The REN delimitation in the three case studies is presented in the figure 2, with the different typologies and the same criteria to define them. The protected area of Sintra/ Cascais and the Natura 2000 network site - Tagus Estuary is also represented.

The arrow represents a potential REN corridor that connects both Natura 2000 network site and Sintra/Cascais protected area.

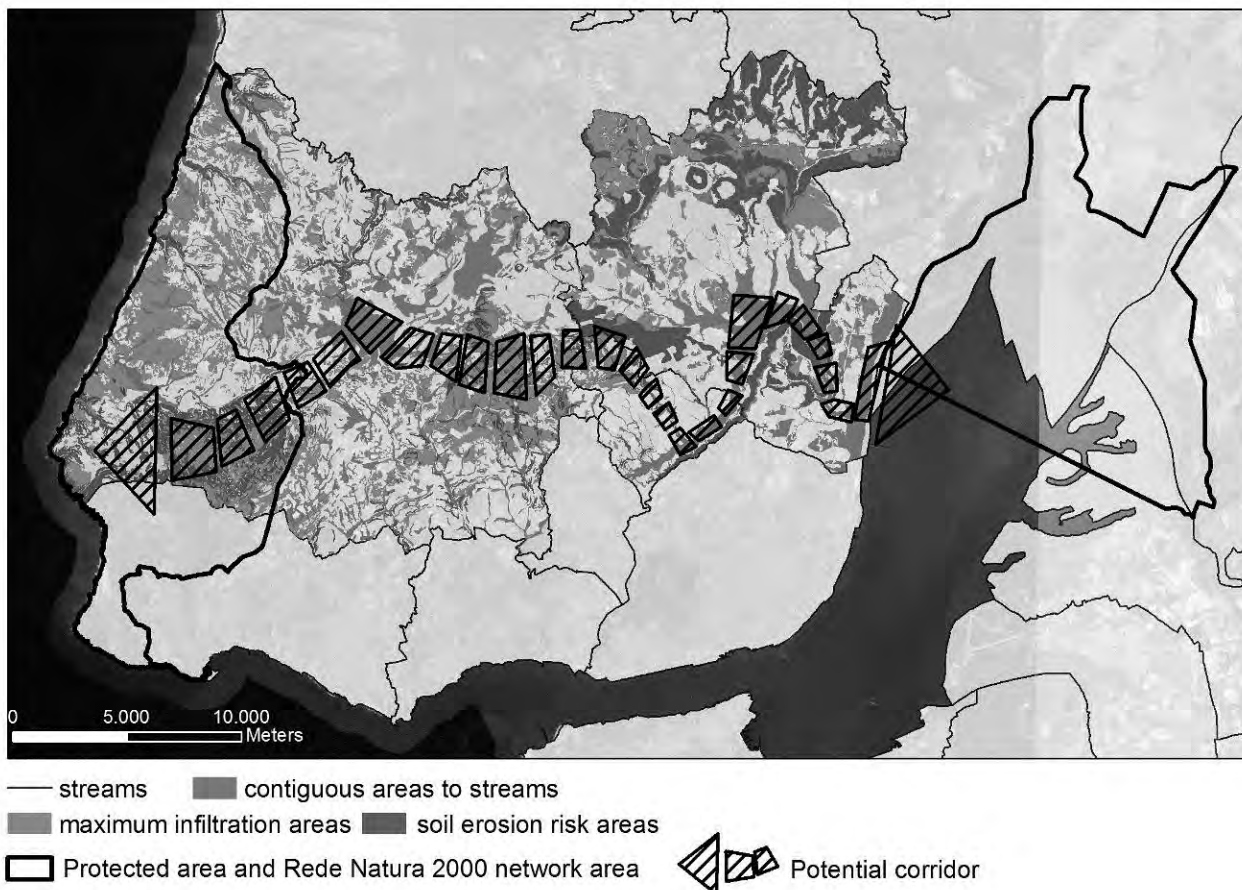
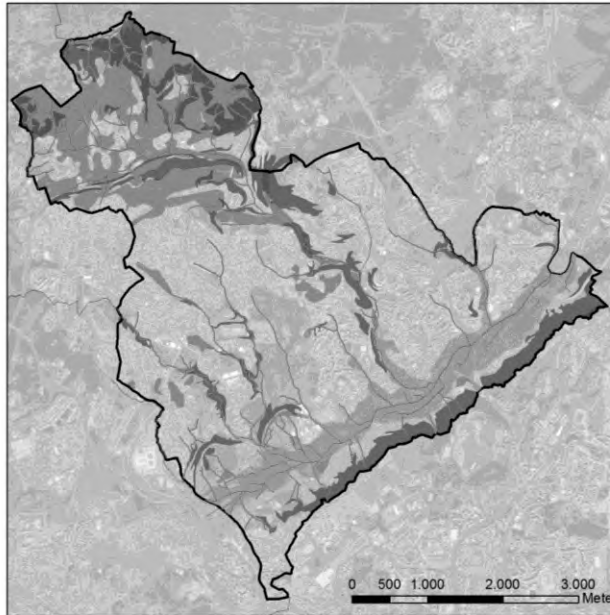


Figure 2 REN delimitation and potential corridor (arrow)

By comparing the proposed (Figure 3) and the approved REN (Figure 4) it can be said that the case study of Odivelas municipality is an example of an insufficient REN delimitation. As an example, Odivelas had two major floods in 1967 and 1983 and this is not mapped in the approved REN. In Table 5 is the comparison between REN approved and proposed in Odivelas municipality.

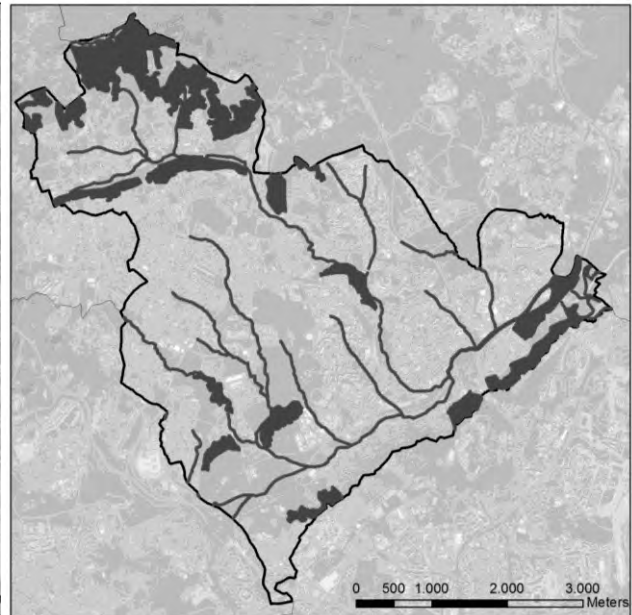
Table 5 Comparison between REN approved and proposed

	REN		without REN	
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
REN - approved	264	10	2375	90
REN - proposed	1018	39	1618	61



National Ecological Reserve (REN) - Proposal
 — streams ■ contiguous areas to streams
 ■ maximum infiltration areas ■ soil erosion risk areas

Figure 3 Odivelas REN - Proposal



National Ecological Reserve (REN) - approved
 ■ REN

Figure 4 Odivelas REN approved

Discussion and conclusion

This paper demonstrates the importance of having consistent criteria to map REN. This will bring advantages in the vertical relation of plans (national – regional – local) and in the horizontal articulation with adjacent municipalities.

REN is an important Portuguese legal tool and could be seen as the basis of green infrastructure plan, achieving the purpose of connecting natural and high ecological values areas. The biggest advantage of using REN to map connectivities is its structural character by resulting from landscape ecological interpretation, instead of a buffer corridor approach.

Mapping National Ecological Reserve allows the integration of green areas in urban dense territories in a continuous system connecting urban areas with peri-urban and rural areas.

Very dense urban municipalities should have a higher attention to the necessity of REN delimitation, and this should not be excluded from urban perimeter. The REN areas in urban areas can have the potentiality to be use as parks, cycle paths, for example, maintaining its functionality according to each REN typology.

References

Ahern, J., (1995). Greenways as planning strategy. *Landscape and Urban Planning* 33,131-155, doi: [http://dx.doi.org/10.1016/0169-2046\(95\)02039-V](http://dx.doi.org/10.1016/0169-2046(95)02039-V)

- Cabral, F. C., (1980). *O “Continuum Naturale” e a Conservação da Natureza*, Comunicação no seminário “Conservação da Natureza”, Lisboa: Serviços de Estudos do Ambiente, 18 e 19 de Abril de 1980, pp. 35-54.
- Council of Europe, (2011). *The Future of Ecological Network in Europe*. A discussion Paper. http://www.coe.int/t/dg4/cultureheritage/nature/EcoNetworks/Meeting_092011_en.asp
- European Commission, (2011). *Our life insurance, our natural capital: an EU biodiversity strategy to 2020*. available in: http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/1_EN_ACT_part1_v7%5b1%5d.pdf
- European Commission, (2012). *The Multifunctionality of Green Infrastructure*. Report. available in: http://ec.europa.eu/environment/nature/ecosystems/docs/Green_Infrastructure.pdf
- Forman, R.T.T & Godron, M., (1986). *Landscape ecology*. Wiley, 619pp. (1986)
- Greca, P.L., Rosa, D.L., Martinico, F. Privitera, R., (2011). Agricultural and green infrastructures: the role of non-urbanised áreas for eco-sustainable planning in a metropolitan region. *Environmental Pollution* 159, 2193-2202. doi: <http://dx.doi.org/10.1016/j.envpol.2010.11.017>,
- Magalhães, M.M.R, Abreu, M.M, Lousã, M., Cortez, N. (2007). *Estrutura Ecológica da Paisagem. Conceitos e Delimitação – escalas regional e municipal*. ISAPress, 361pp.
- Pena, S.B., Abreu, M.M, Teles, R., Espirito-Santo, M.D., (2010). A methodology for creating greenways through multidisciplinary sustainable landscape planning. *Journal of Environmental Management*. 91 (4), 970-983. doi:10.1016/j.jenvman.2009.12.004
- Pena, S.B. & Abreu, M.M, 2012. Landscape Stability Evaluation with Landscape Geomorphologic Dynamics (LGD) Assessment. Planning and Managing Landscape" in Suthar, S. (Editor) *Land Management*. (pp 79-111). NOVA Science Inc., USA.
- Ribeiro L. & Beirão T., 2006. Greenways for recreation and maintenance of landscape quality: five case studies in Portugal. *Landscape and Urban Planning* 76: 79-97 doi: <http://dx.doi.org/10.1016/j.landurbplan.2004.09.042>.
- Shanfeng, Z., Yuandong, H., Shaohang, S., 2011. Green Infrastructure: New approach to urban forest planning and managing. *Energy procedia* 11, 2818- 2825
- Tricart, J., (1977). *Ecodinâmica*. Rio de Janeiro : Superintendência de Recursos Naturais e Meio Ambiente, 97 p.
- Weber T., Sloan, A., Wolf, J. 2006. Maryland’s Green Infrastructure Assessment: Development of a comprehensive approach to land conservation. *Landscape and urban planning* 77, 94-100. Doi: <http://dx.doi.org/10.1016/j.landurbplan.2005.02.002>.
- Whickham, J.D., Riitters, K.H., Wade, T.G., Vogt, P. 2010. A national assessment of green infrastructure and change for the conterminous United States using morphological image processing. *Landscape and Urban Planning*. 94, 186-195. Doi: doi:10.1016/j.landurbplan.2009.10.003
- Termoshuizen, J.W. & Opdam, P., 2009. Landscape services as a bridge between landscape ecology and sustainable development. *Landscape ecology* 24, 1037-1052. Doi 10.1007/s10980-008-9314-8