



Instituto Politécnico de Castelo Branco  
Escola Superior Agrária



Erasmus+



## ***INTEGRATED PLANNING FOR FOREST AREAS USING A SPATIAL DECISION SUPPORT SYSTEM***

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# Objectives

Development of a spatial analysis methodology using **Spatial Multicriteria Analysis** (Analytic Hierarchy Process - AHP), based in **biophysical data** and **legal constraints** that could be useful to **land use planning**, in a perspective of **forest areas multifunctionality**:

- **production** function;
- **protection** function;
- **conservation** function;
- **silvopastoral, hunting and fishing** functions;
- **recreation** function;
- **landscape and aesthetic** function.

# Study area

**Territorial unit:**

**NUT III**

**District:**

**Castelo Branco**

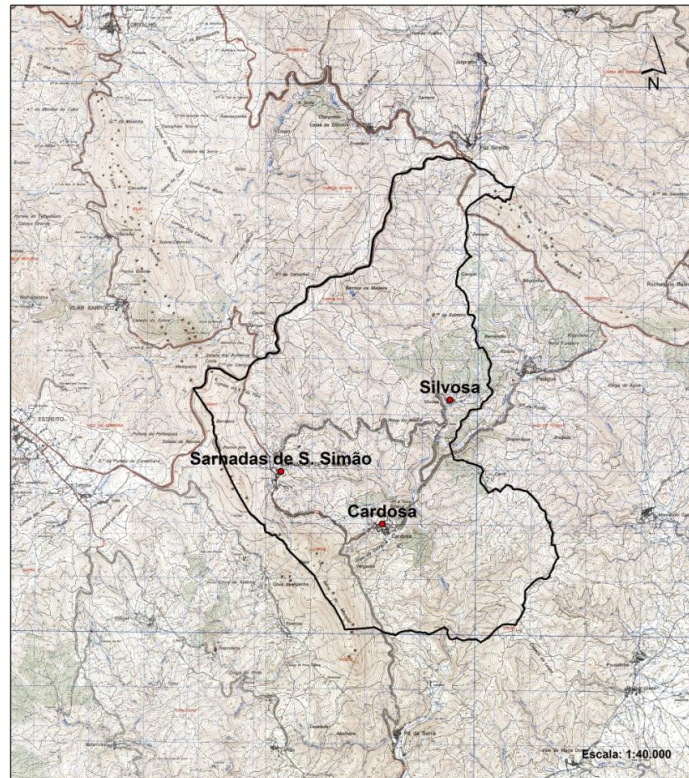
**Municipality:**

**Oleiros**

**Parish:**

**Sarnadas de São Simão**

**Area: 3.100 ha**



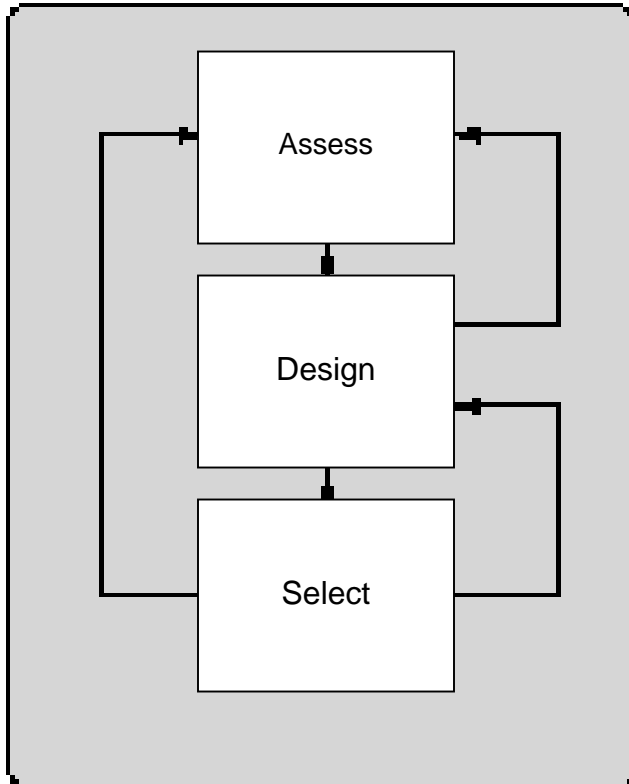
## ***SDSS - Spatial Decision Support System***

The Spatial Decision Support System (SDSS) are interactive systems conceived to help users in decision making about structured problems of spatial nature (Malczewski 1997).

### **Characteristics:**

- Existence of alternative scenarios.
- Each alternative is evaluated based in different scenarios (qualitative and quantitative).
- Participation of decision makers and stakeholders.
- The participants have different views about the problem.

# Decision Making Process



The model have 3 interactive steps:

- (1) **Assessment** – to identify the problem or the opportunity to change.
- (2) **Design** - to structure de decision alternatives.
- (3) **Selection** - to evaluate and select the better alternative.

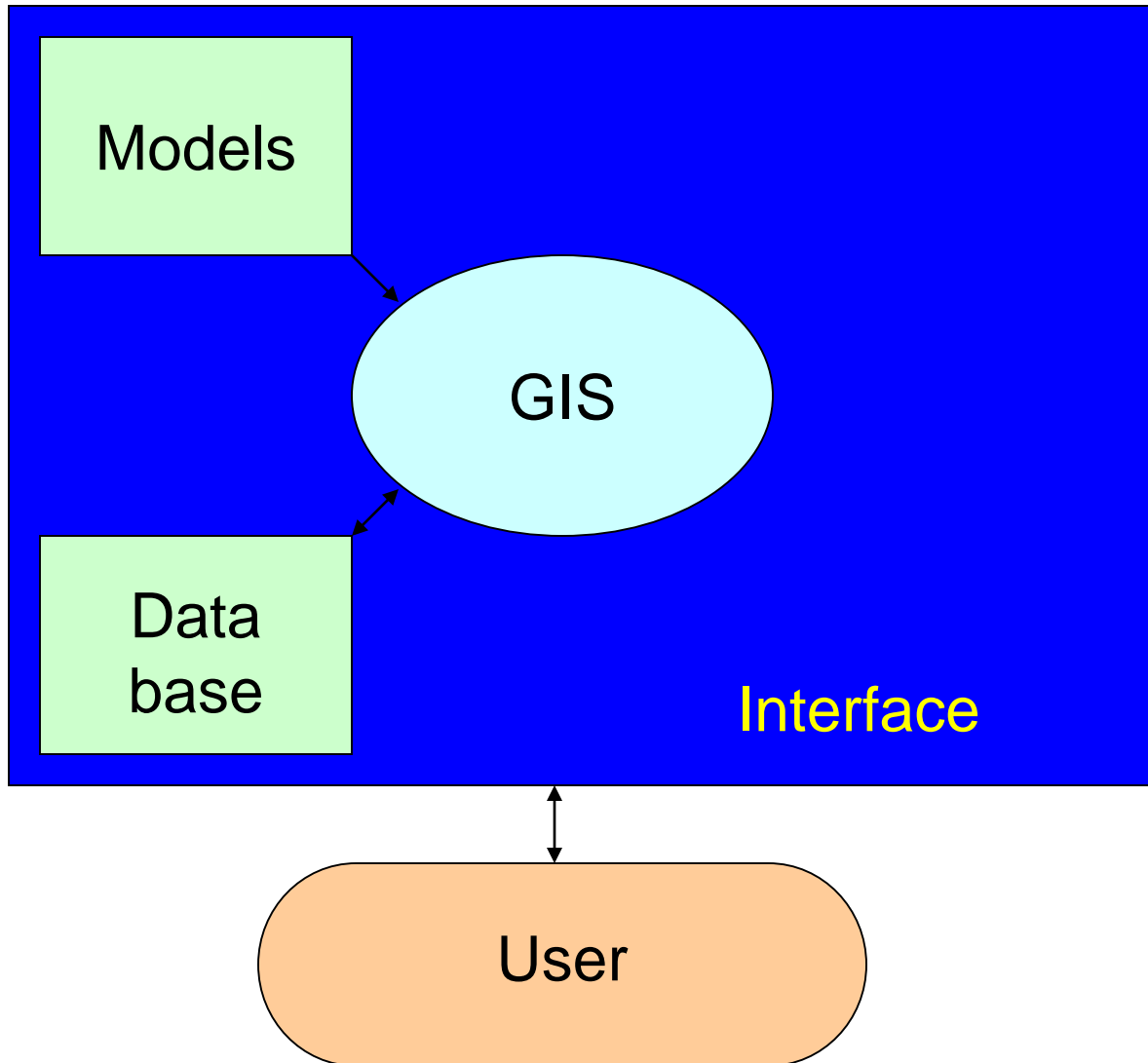
# Geographic Information Systems (GIS)

GIS are useful tools to support the decision making process:

- generating maps that allow the visualization of the problem.
- doing operations of spatial analysis (geoprocessing).
- modeling events that could happen in the future.

But a GIS is not by itself a Spatial Decision Support System...

# SDSS STRUCTURE



# Land use and Forestry management plans

## Regional Plan for Forest Management of “Pinhal Interior Sul”

<b>PROF region</b>	<b>Sub-region</b>	<b>1.st Function</b>	<b>2.nd Function</b>	<b>3.rd Function</b>
Pinhal Interior Sul	Pampilhosa e Alvéolos	Silvopastoral, hunting and fishing	Protection	Production

## Municipal Plan for Forest Fires Protection of Oleiros

### Municipality Master Plan of Oleiros

- Land use management map
- National Ecological Reserve (REN) map
- National Agricultural Reserve (RAN) map
- Legal constraints Map

**GIS-based forest  
land use models**

**Production function**

Evaluation of the forest species suitability

**Protection function**

Evaluation of the sensitive areas in terms of  
soil and water resources

**Conservation function: habitats, fauna and flora**

Habitat, flora and fauna conservation  
(Natura 2000 network and protected areas)

**Silvopastoral, hunting and fishing functions**

**Recreation and landscape aesthetic function**

# Evaluating the suitability of forest species

21 forest tree species were selected following the indications of **PROF PIS**

Reclassification of maps based in literature and experts

Soil analysis

Classification:

**higher than reference (3)**

Without limitations to the species development.

**Reference (2)**

Without severe limitations to the species development.

**Lower than reference (1)**

Severe limitations to the species development.

Ecological zonation

Land use suitability

(Intersection)

Suitability maps by species

Phytoclimatic classification

## Reclassification

		Land use suitability		
		1	2	3
Phytoclimatic classification	1	1	1	1
	2	1	2	2
	3	1	2	3

# Production function

## Classification of the soil constraints to forestry use by species in 3 suitability levels

N.º	Cod. veg.	Espécies	Superior à referência (3)	Referência (2)	Inferior à referência (1)
1	Pp	Pinheiro-bravo	Profundidade expansível	Descontinuidade textural	Afloramento rochoso Áreas improdutivas
2	Ppn	Pinheiro-manso	Profundidade expansível	-	Descontinuidade textural Afloramento rochoso Áreas improdutivas
3	Ec	Eucalipto-comum	Profundidade expansível	-	Afloramento rochoso Áreas improdutivas
4	Qp	Carvalho-negral	Descontinuidade textural	-	Afloramento rochoso Áreas improdutivas
5	Qs	Sobreiro	Profundidade expansível	Descontinuidade textural	Afloramento rochoso Áreas improdutivas
6	Qfb	Carvalho-português	Profundidade expansível	-	Afloramento rochoso Áreas improdutivas
7	Qr	Azinheira	Profundidade expansível	-	Afloramento rochoso Áreas improdutivas
8	Cs	Castanheiro	Descontinuidade textural	-	Afloramento rochoso Áreas improdutivas
9	Pa	Cerejeira-brava	-	Profundidade expansível	Descontinuidade textural Afloramento rochoso Áreas improdutivas
10	Pll	Azereiro	-	Profundidade expansível	Afloramento rochoso Áreas improdutivas
11	Au	Medronheiro	Profundidade expansível	Descontinuidade textural	Afloramento rochoso Áreas improdutivas
12	Fa	Freixo	-	-	Profundidade expansível
13	Ag	Amieiro	-	-	Descontinuidade textural
14	Sa	Borrazeira-preta	-	-	Afloramento rochoso
15	Ss	Borrazeira-branca	-	-	Áreas improdutivas
16	Csp	Cipreste-comum	Profundidade expansível	Descontinuidade textural	Afloramento rochoso Áreas improdutivas
17	Cl	Cipreste-do-Buçaco	Profundidade expansível	Descontinuidade textural	Afloramento rochoso Áreas improdutivas
18	Jn	Nogueira-preta	Profundidade expansível	Descontinuidade textural	Afloramento rochoso Áreas improdutivas
19	Ap	Plátano-bastardo	Profundidade expansível	Descontinuidade textural	Afloramento rochoso Áreas improdutivas
20	Pn	Choupo-negro	Profundidade expansível	Descontinuidade textural	Afloramento rochoso Áreas improdutivas
21	Pal	Choupo-branco	Profundidade expansível	Descontinuidade textural	Afloramento rochoso Áreas improdutivas

## Classification of ecological zones by species in 3 suitability levels

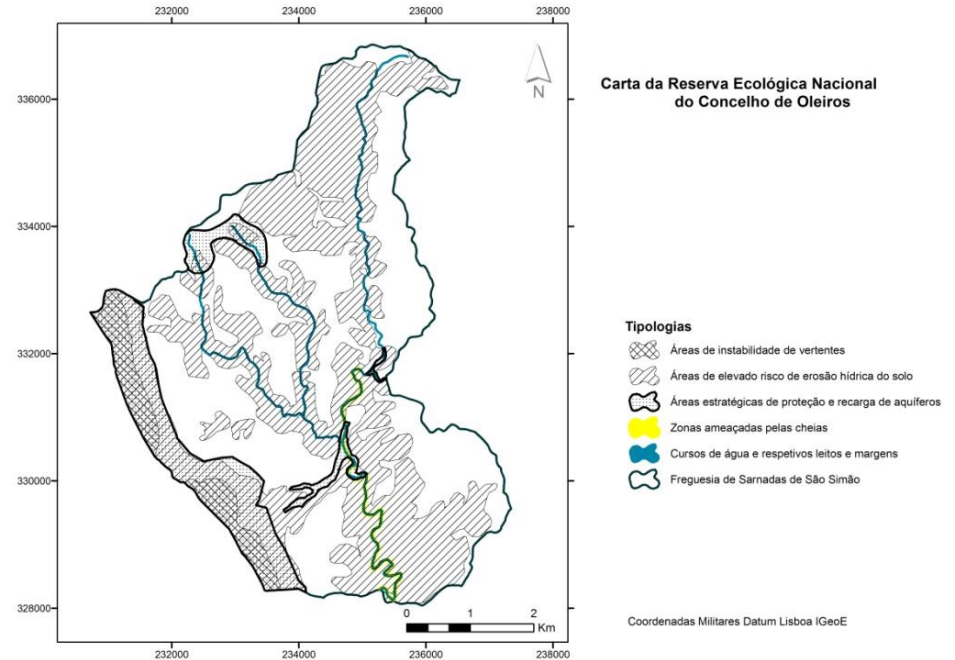
N.º	Cod. veg.	Nome científico	Superior à referência (3)	Referência (2)	Inferior à referência (1)
1	Pp	Pinheiro-bravo	SA x SM	SM e SA	SA
2	Ppn	Pinheiro-manso	SM	SA x SM	SA
3	Ec	Eucalipto-comum	SM	SA x SM	SA
4	Qp	Carvalho-negral	SA	SA x SM	SM
5	Qs	Sobreiro	SM	SA x SM	SA
6	Qfb	Carvalho-português	SM	SA x SM	SA
7	Qr	Azinheira	SM	SA x SM	SA
8	Cs	Castanheiro	SA e SA x SM	-	SM
9	Pa	Cerejeira-brava	SA	SA x SM	SM
10	Pll	Azereiro	SA x SM	SA	SM
11	Au	Medronheiro	SM e SA x SM	SA	-
12	Fa	Freixo	SA x SM e SA	SM	-
13	Ag	Amieiro	SA x SM e SA	SM	-
14	Sa	Borrazeira-preta	SA x SM e SA	SM	-
15	Ss	Borrazeira-branca	SA x SM e SA	SM	-
16	Csp	Cipreste-comum	-	SM	SA x SM e SA
17	Cl	Cipreste-do-Buçaco	SA x SM	SM e SA	-
1	Jn	Nogueira-preta	-	SA x SM e SA	SM
19	Ap	Plátano-bastardo	SA	SA x SM	SM
20	Pn	Choupo-negro	-	SM, SA x SM e SA	-
21	Pal	Choupo-branco	-	SM, SA x SM e SA	-

**The potential forest use map** was elaborated using the *Combine* function, considering the áreas with suitability 2 (**reference**) and 3 (**higher than reference**).

# Production function

- National Ecological Reserve (REN)
- National Agricultural Reserve (RAN)
- Water resources

## National Ecological Reserve Map

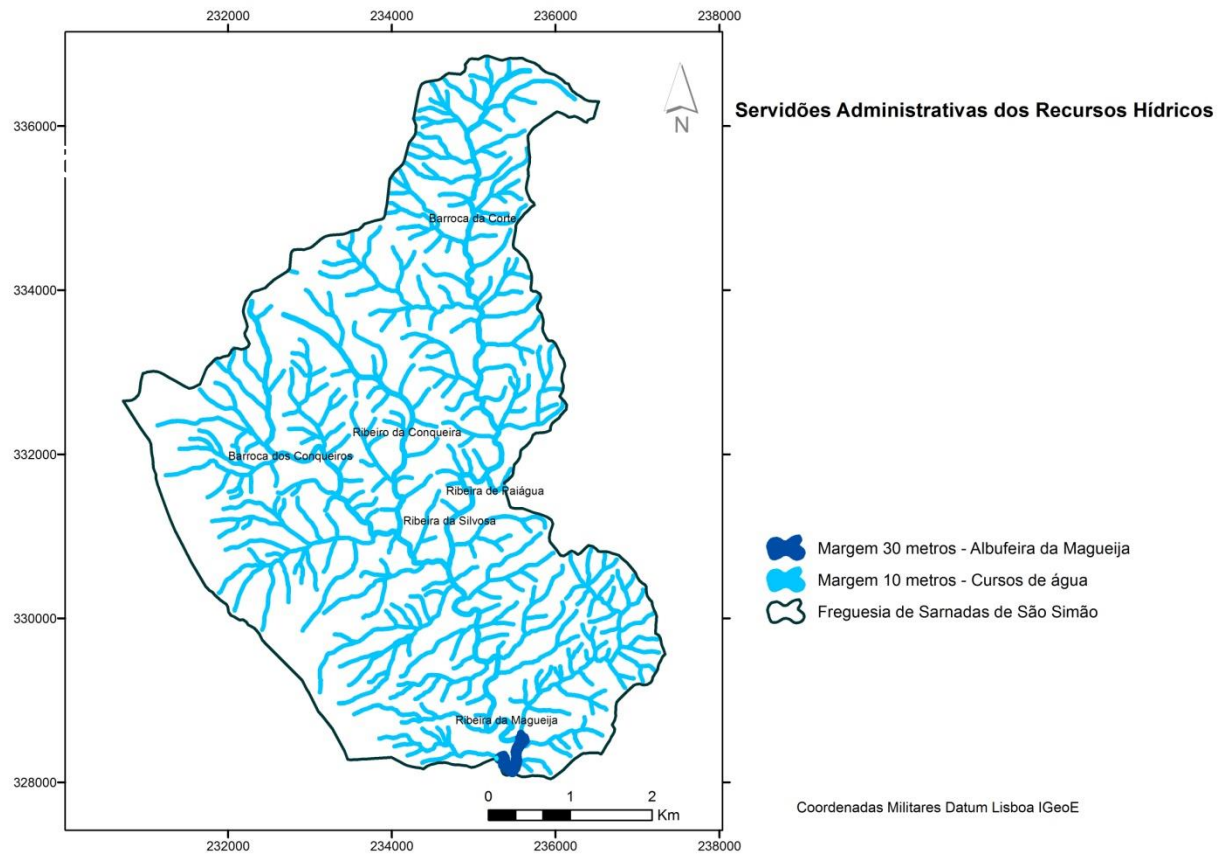


## REN areas by type:

Type	%
Cliffs and instable slopes	5,0
<b>Erosion risk</b>	<b>54,8</b>
Aquifer recharge sensitive areas	13,7
Water courses and margins	1,4
Flooding risk	0,3

# Protection function

## Legal constraints for water courses and water bodies



## Conservation function: habitats, fauna and flora

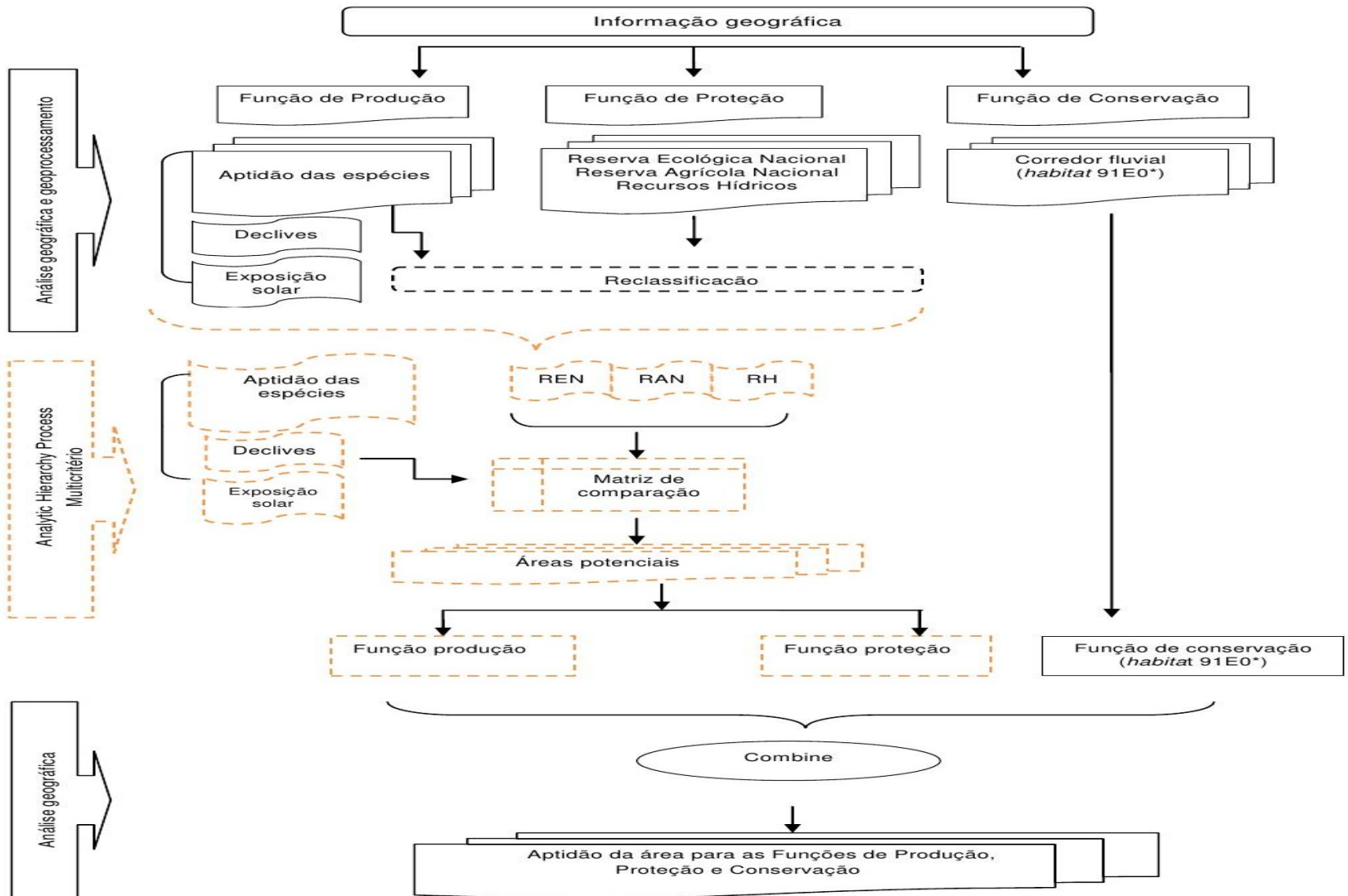
### Water courses corridors

It was defined a 30 m buffer to each margin in the protected habitat 91E0\* (*Aluvial forests of *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)*).

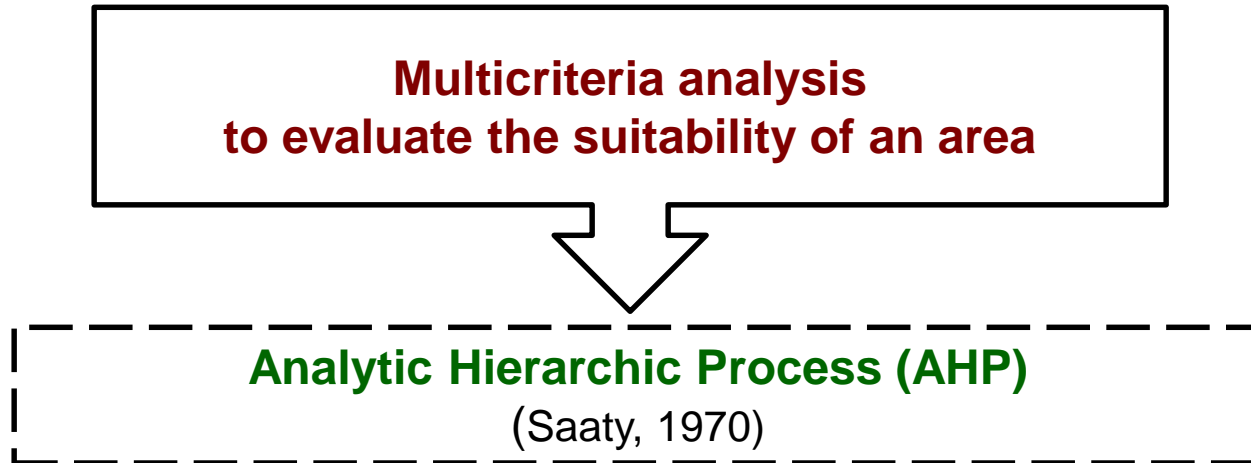
## Recreation and landscape aesthetic function

Recreation map based in field work and other assessment studies with identification of important sites.

# Spatial Multicriteria Analysis Method



# Conceptual model to evaluate the forest spaces potential



- Pairwise comparison between criteria to define the weight of each criteria.
- The AHP was made only for **production and protection functions**.

# Conceptual model to evaluate the forest spaces potential



## Production function

### Criteria reclassification

Criteria		Description	Weight
Production function	Forest species suitability	higher than reference	3
		Reference	2
		Lower than reference	1
	Slope	$0 < d \leq 8\%$	3
		$8 < d \leq 15\%$	2
		$15 < d \leq 30\%$	2
		$d > 30\%$	1
	Aspect	$0^\circ < e \leq 147^\circ$	3
		$147^\circ < e \leq 188^\circ$	2
		$188^\circ < e \leq 242^\circ$	1

- 1 – Low or without suitability
- 2 – Medium suitability
- 3 – High suitability

# Conceptual model to evaluate the forest spaces potential



## Protection function

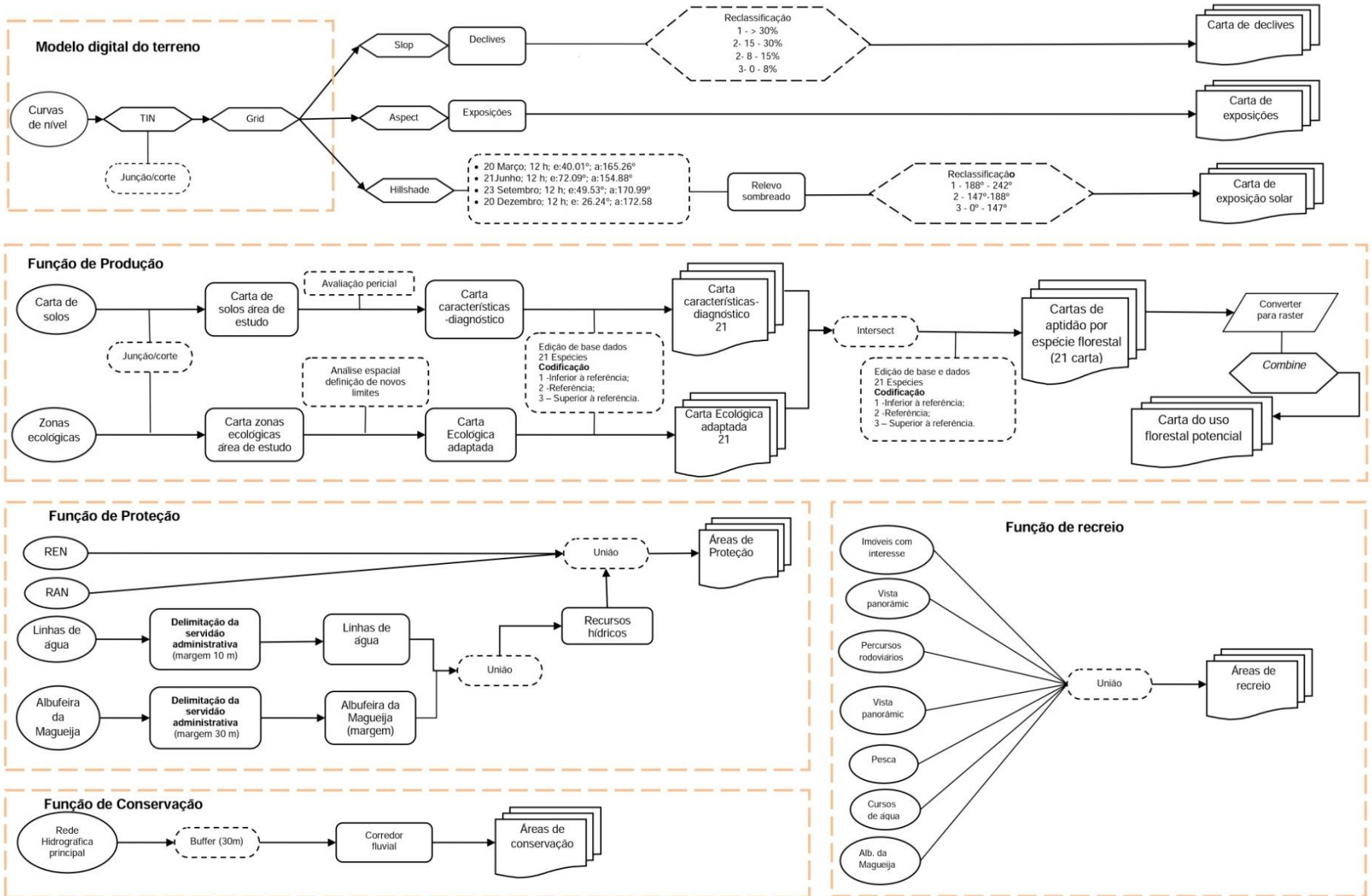
### Criteria reclassification

The criteria corresponding to the constraints were reclassified in 0 and 1 (Boolean).

Critérios		Descrição	Ponderação
Protection function	National Ecological Reserve (REN)	National Ecological Reserve	0
		Areas without restrictions	1
	National Agricultural Reserve (RAN)	National Agricultural Reserve	0
		Areas without restrictions	1
	Hydric resources (RH)	Legal restriction	0
		No restriction	1

0 – Areas with legal restrictions; 1 – Area without legal restrictions.

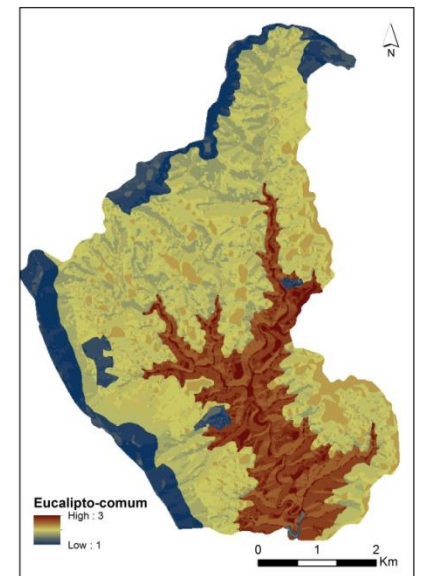
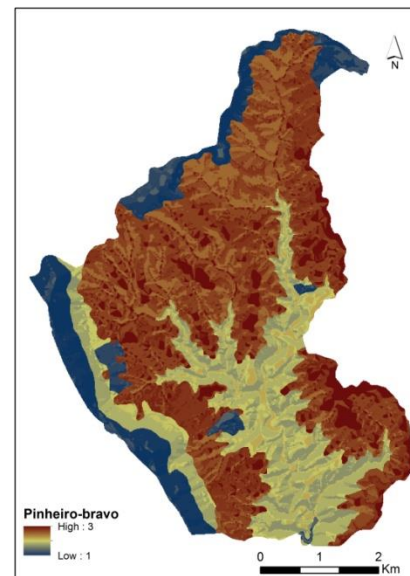
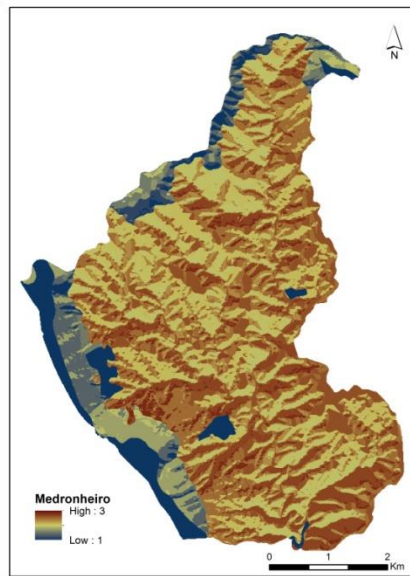
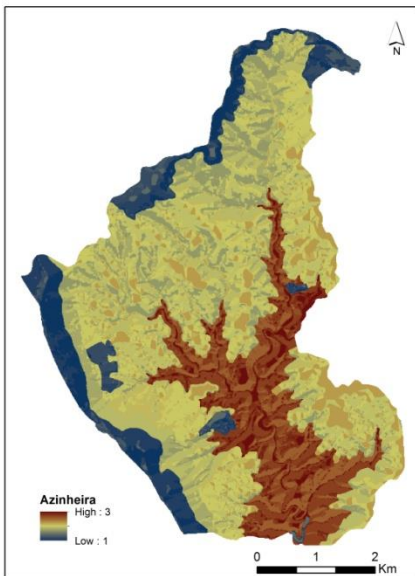
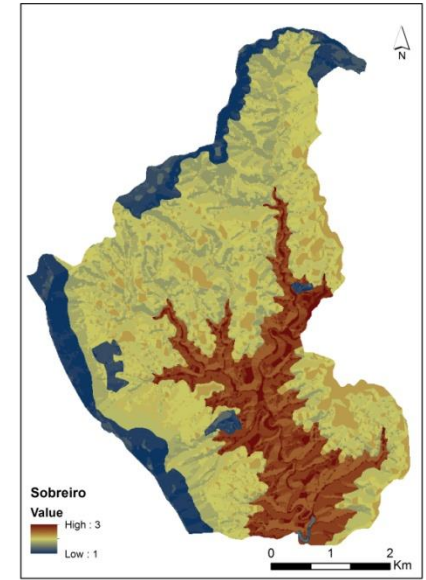
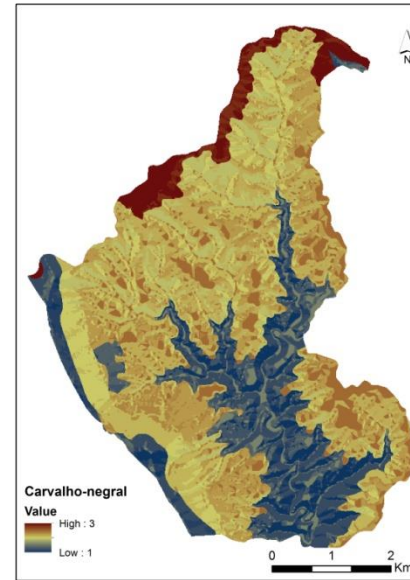
# GIS model



# Land use management model

## Production function

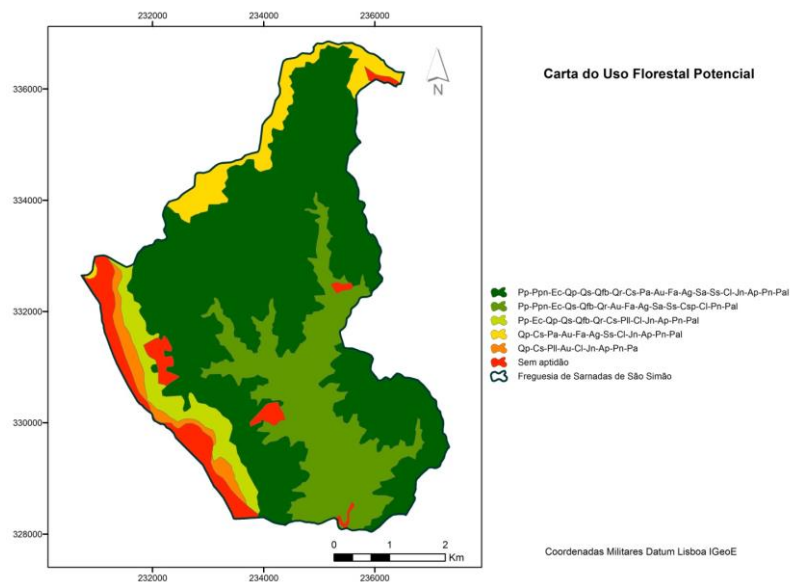
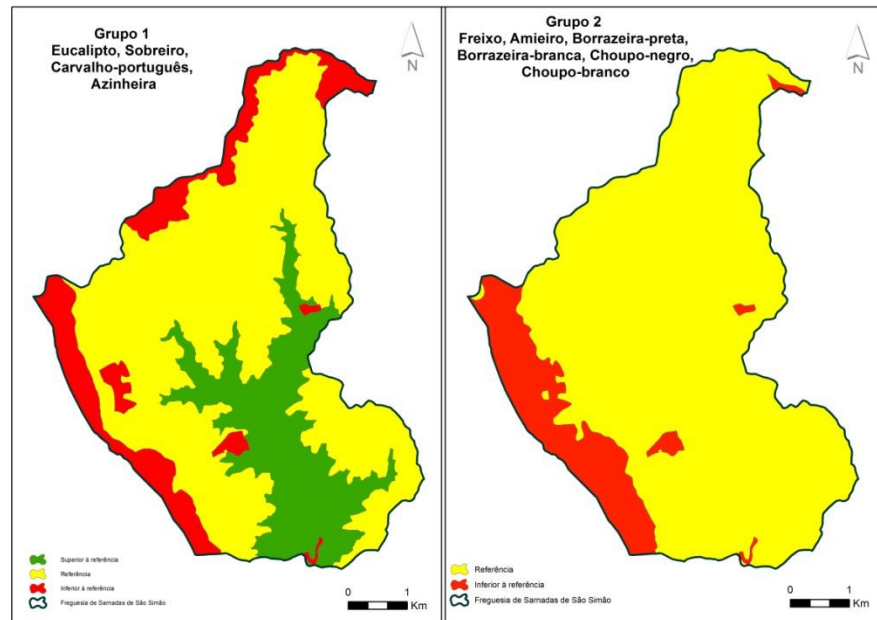
Some examples of maps for each forest species. The higher suitability values are the **red** ones and the lower values are represented in **blue**.



# Land use management model

## Production function

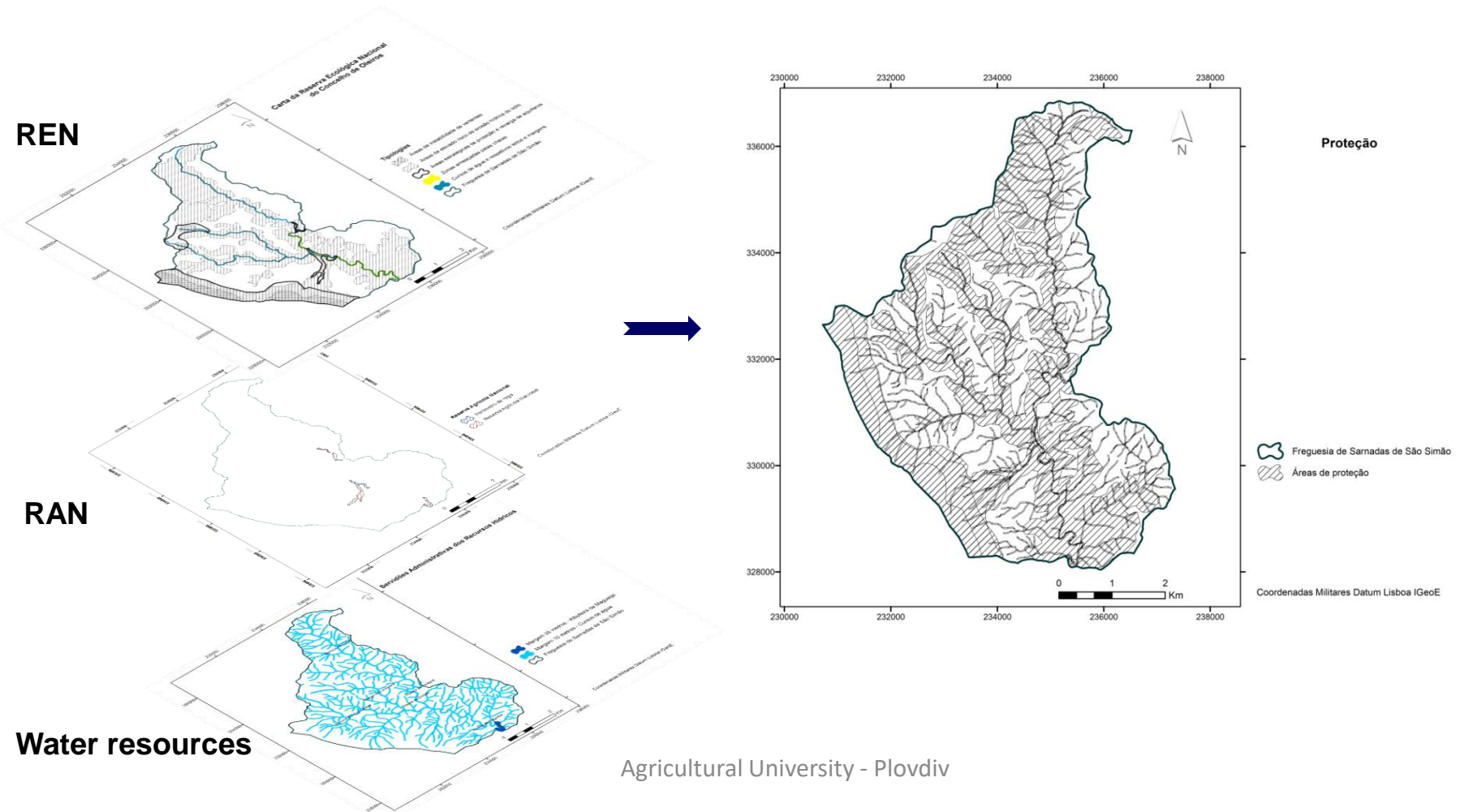
- 21 suitability maps were generated (one for each species)
- Based on the aggregation of the 21 suitability maps a **Potential Forest Use map** was produced.



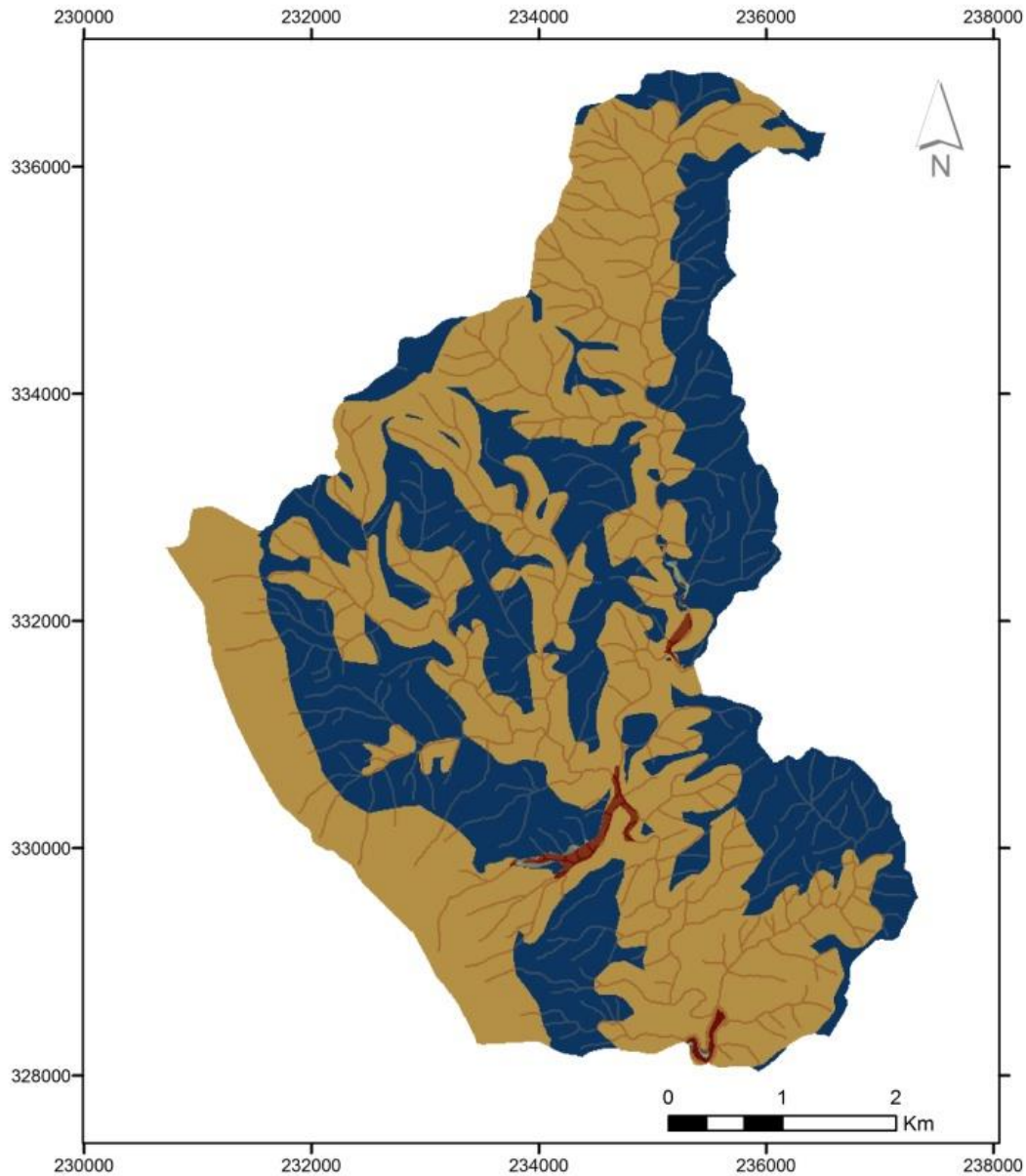
# Land use management model

## Protection function

From the overlay of the different legal restrictions we obtain the protected areas.



# Protection function Map



**Função proteção**

**Value**



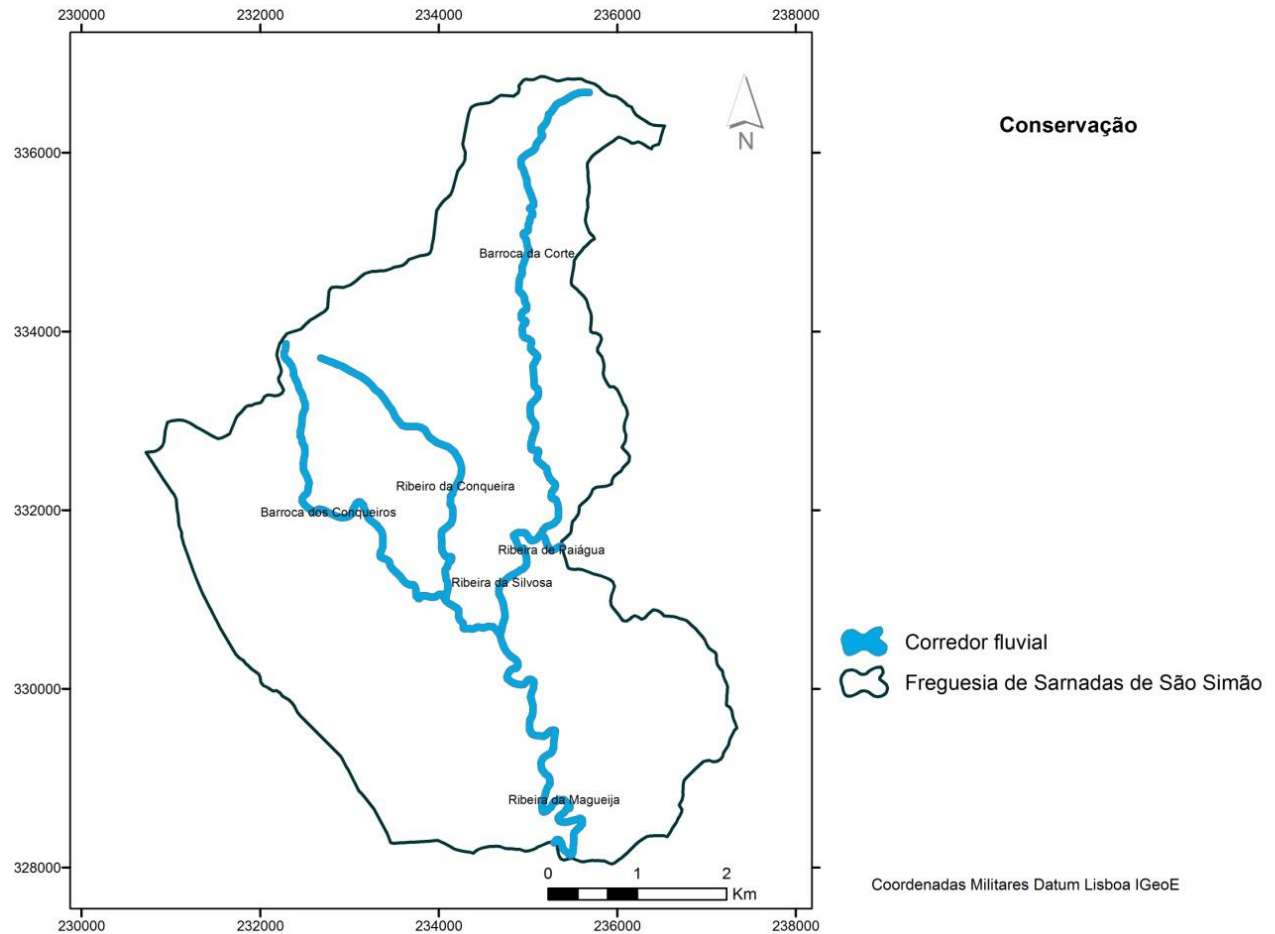
Coordenadas Militares Datum Lisboa IGeoE

# Land use management model

## Conservation function: habitats, fauna and flora

### Habitat 91E0\*

Aluvial forests of *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*).

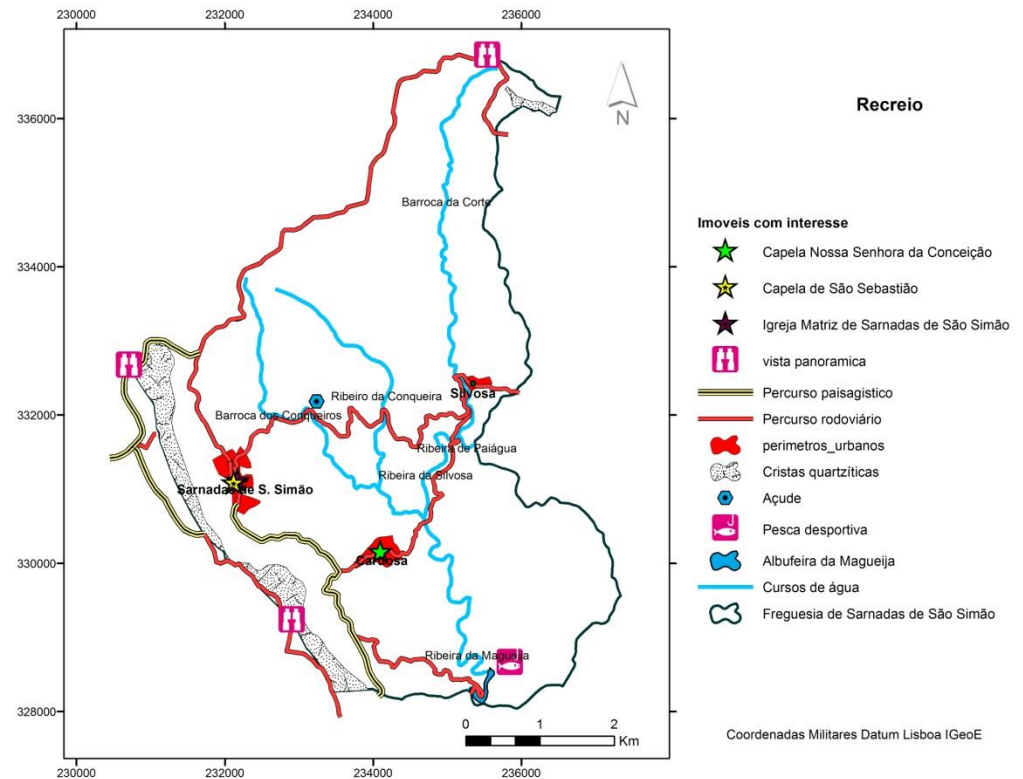


# Land use management model

## Recreation and landscape aesthetic function

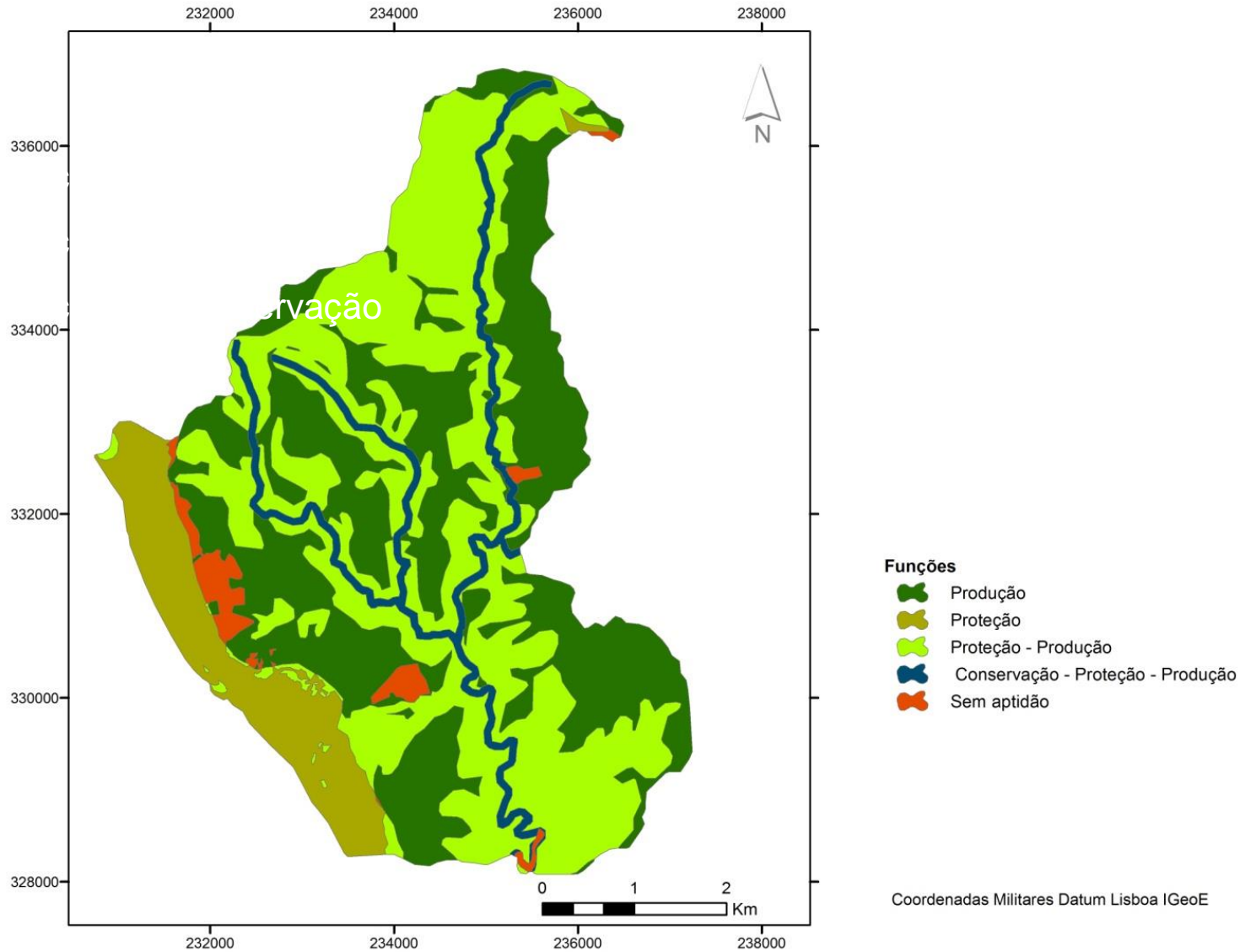
### Areas of landscape value:

- Appalachian relief of **Serra do Muradal** (quartzitic mountains);
- **Religious monuments;**
- **Pedestrian routes;**
- **Water bodies with fishing interest.**

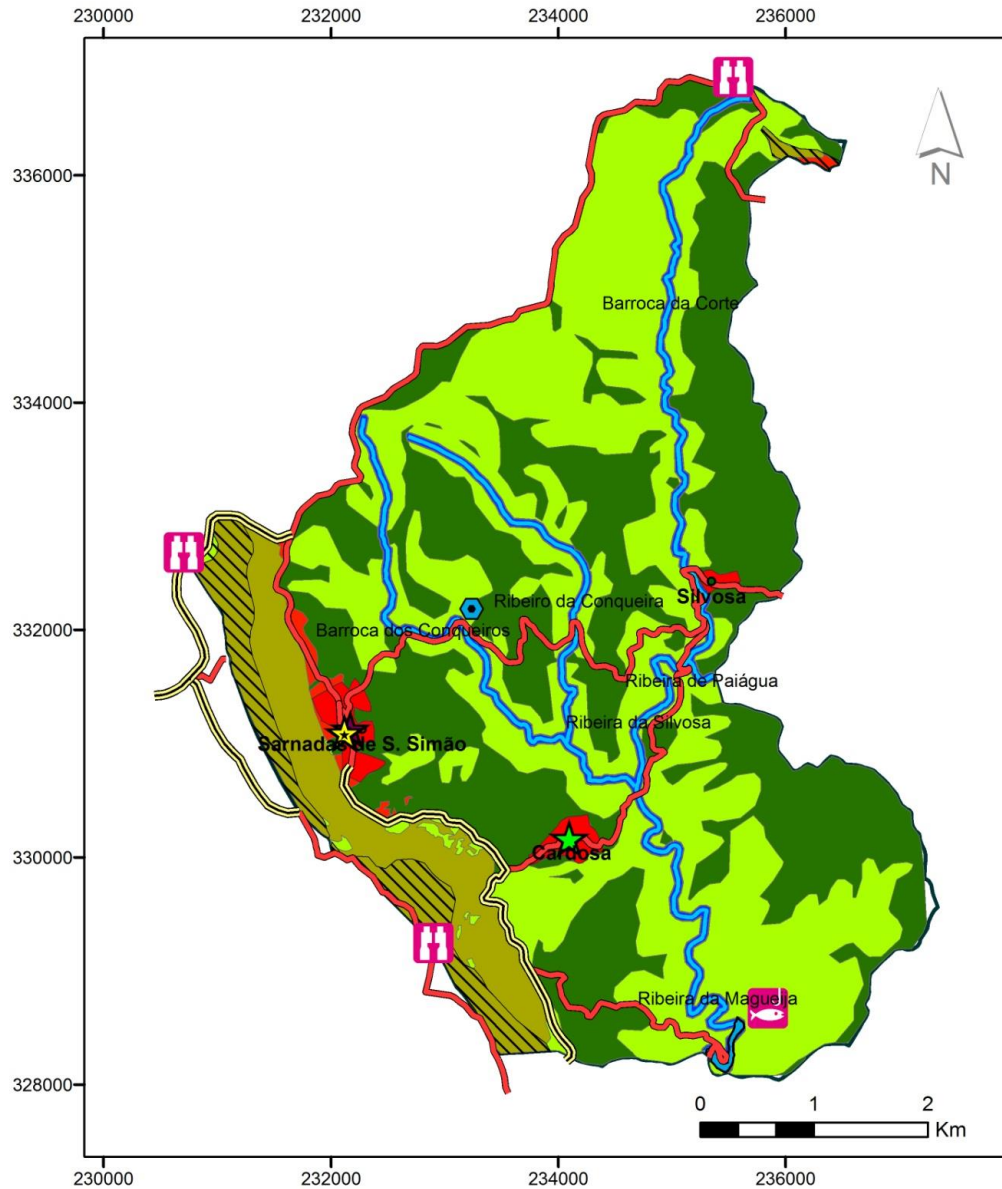


# Suitability map - *Quercus pyrenaica*

Resulting from the combination of Production, Protection and Conservation functions







# Final Forest Suitability Map




## Função de Recreio

### Imoveis com interesse

-  Capela Nossa Senhora da Conceição
-  Capela de São Sebastião
-  Igreja Matriz de Sarnadas de São Simão
-  vista panoramica

 Percurso paisagístico

 Percurso rodoviário

 perimetros\_urbanos

 Cristas quartzíticas


 Açude

 Pesca desportiva

 Albufeira da Magueija

 Cursos de água

### Funções

 Produção

 Proteção

 Proteção - Produção

 Conservação - Proteção - Produção

 Sem aptidão

 Freguesia de Sarnadas de São Simão

Coordenadas Militares Datum Lisboa IGeoE

## Final remarks

- ❑ The methodology AHP is valid to support **Forest Management Plans** (PGF) allowing to make the zonation based in a dominant function.
- ❑ This type of analytic models gives information about **biophysical suitability** of the territory to forest tree species, being a important tool for forest management.
- ❑ From the analysis of the **Potential Forest Use map** we verify that 6 species (maritime pine, eucalyptus, Pyrenean oak, cork oak, holm oak and strawberry tree) present a **medium to high suitability**.



**Blagodarya!**