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SuFoRun

Models and decision SUpport tools for integrated FOrest policy development underglobal change and associated Risk and UNcertainty

Multiple criteria approaches to forest management – recent advances and open problems

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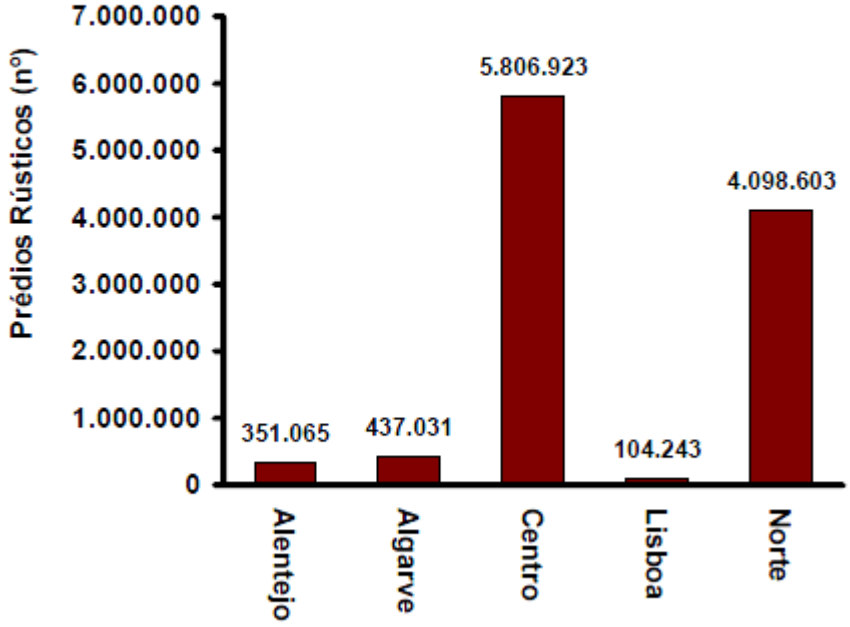
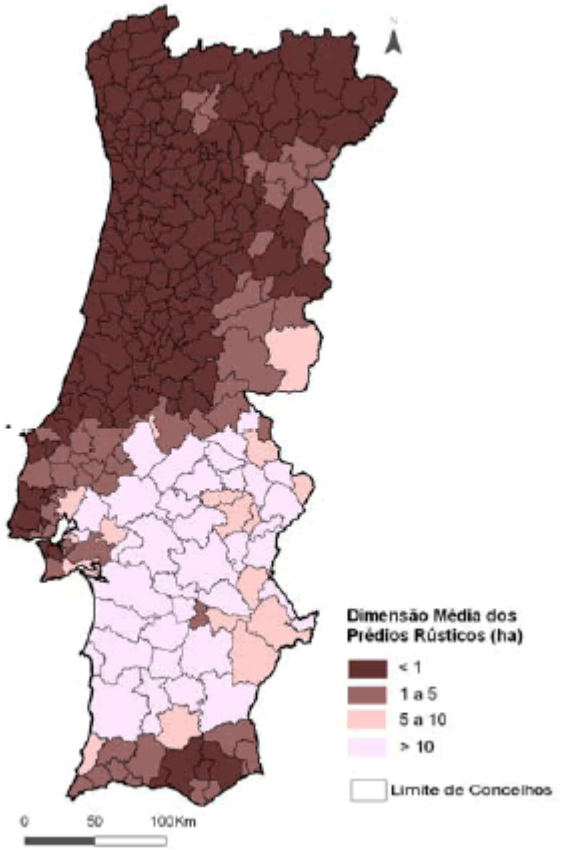
Outline

1. The context
2. The case studies
3. Recent advances
4. Open problems

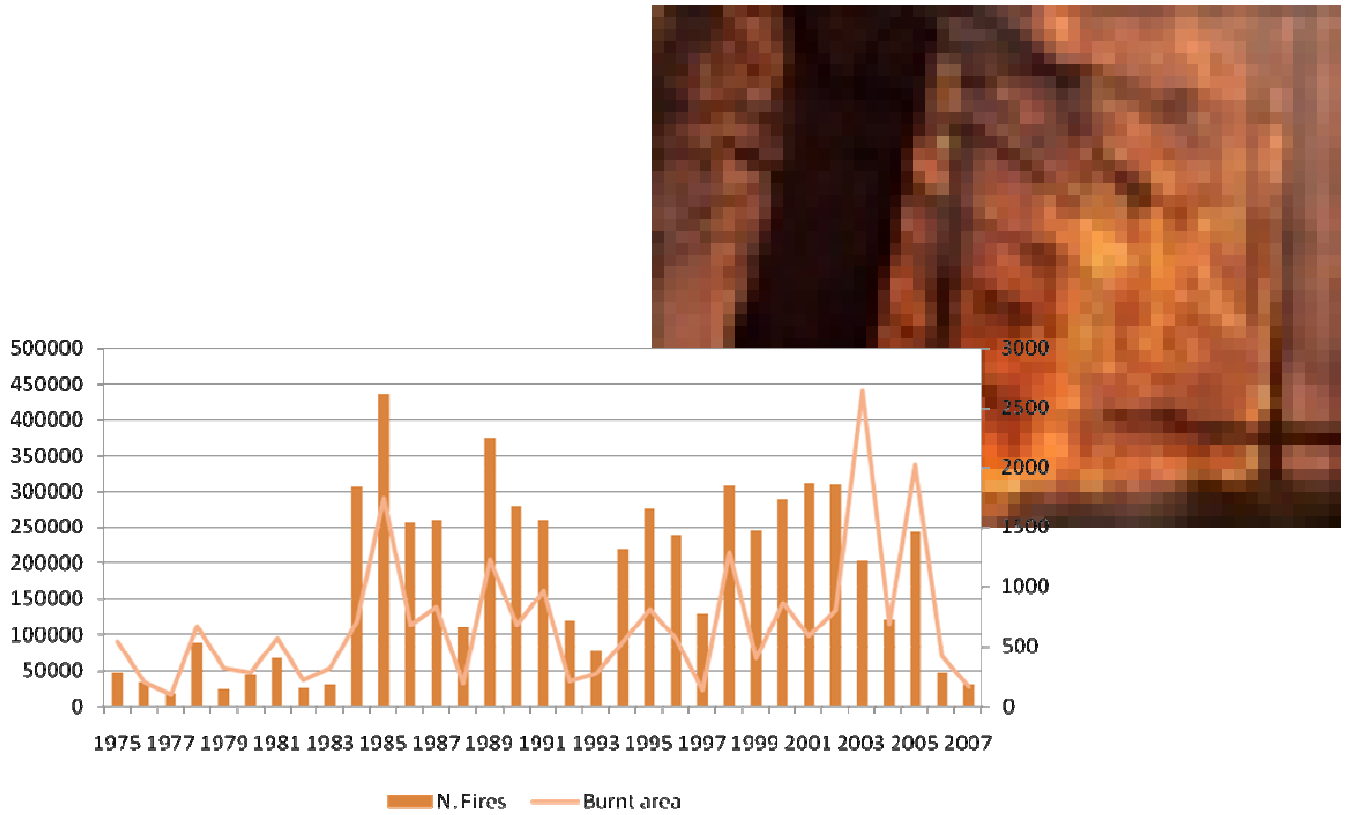
Context





Source: DGI

Context


500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
3000
2500
2000
1500
1000
500
0
1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007
N. Fires
Burnt area

Context

✓ **and yet**

- out of about 38% of the territory this fragmented the country gets

- > 2% of GDP (3rd largest in the EU), > 5 % of employment, > 9% of exports

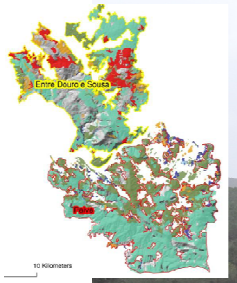
- only sector where Portugal is the first in the world (cork)

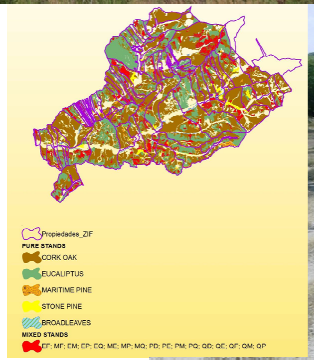
✓ **nevertheless property fragmentation may be an obstacle to landscape-level planning**

- **and thus the provision of** Ecosystem services – carbon, biodiversity, nature conservation, timber

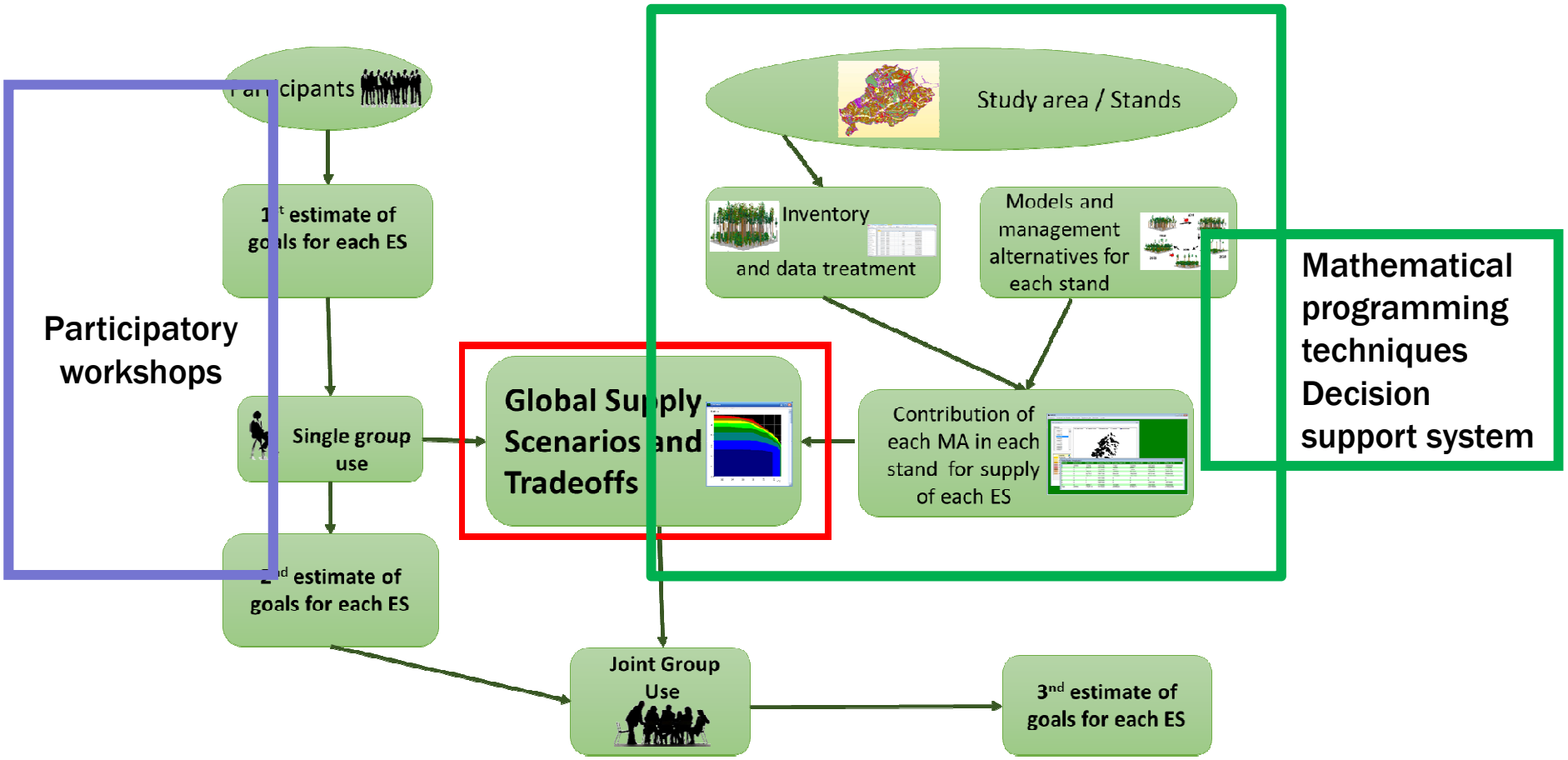
- **and thus to adequate wildfire prevention levels**

The case studies





Recent advances



The mathematical programming model

$$\sum_{j=1}^{M_i} x_{ij} = a_i, \quad i = 1,\ldots,N \tag{1}$$

$$\sum_{i=1}^{N}\sum_{j=1}^{M_i} pinew_{ijt} x_{ij} = PineW_t, \quad t = 1,\ldots,T \tag{2}$$

$$\sum_{i=1}^{N}\sum_{j=1}^{M_i} eucalyptw_{ijt} x_{ij} = EucalyptW_t, \quad t = 1,\ldots,T \tag{3}$$

$$\sum_{i=1}^{N}\sum_{j=1}^{M_i} chestnutw_{ijt} x_{ij} = ChestnutW_t, \quad t = 1,\ldots,T \tag{4}$$

$$\sum_{i=1}^{N}\sum_{j=1}^{M_i} corkA_{ijt} x_{ij} = CORKA_t, \quad t = 1,\ldots,T \tag{5}$$

$$\sum_{i=1}^{N}\sum_{j=1}^{M_i} cones_{ijt} x_{ij} = Cones_t, \quad t = 1,\ldots,T \tag{6}$$

$$\sum_{i=1}^{N}\sum_{j=1}^{M_i} carb_{ijt} x_{ij} = CARB_t, \quad t = 1,\ldots,T \tag{7}$$

$$NPV = \sum_{i=1}^{N}\sum_{j=1}^{M_i} c_{ij} x_{ij} \tag{8}$$

The mathematical programming model

$$Cork = \sum_{t=1}^{T} CORKA_t \quad (9)$$

$$Cones = \sum_{t=1}^{T} Cones_t \quad (10)$$

$$PineSawlogs = \sum_{t=1}^{T} PineW_t \quad (11)$$

$$EucalyptPulpwood = \sum_{t=1}^{T} EucalyptW_t \quad (12)$$

$$ChestnutSawlogs = \sum_{t=1}^{T} ChestnutW_t \quad (13)$$

$$Carb = \sum_{t=1}^{T} CARB_t \,/T \quad (14)$$

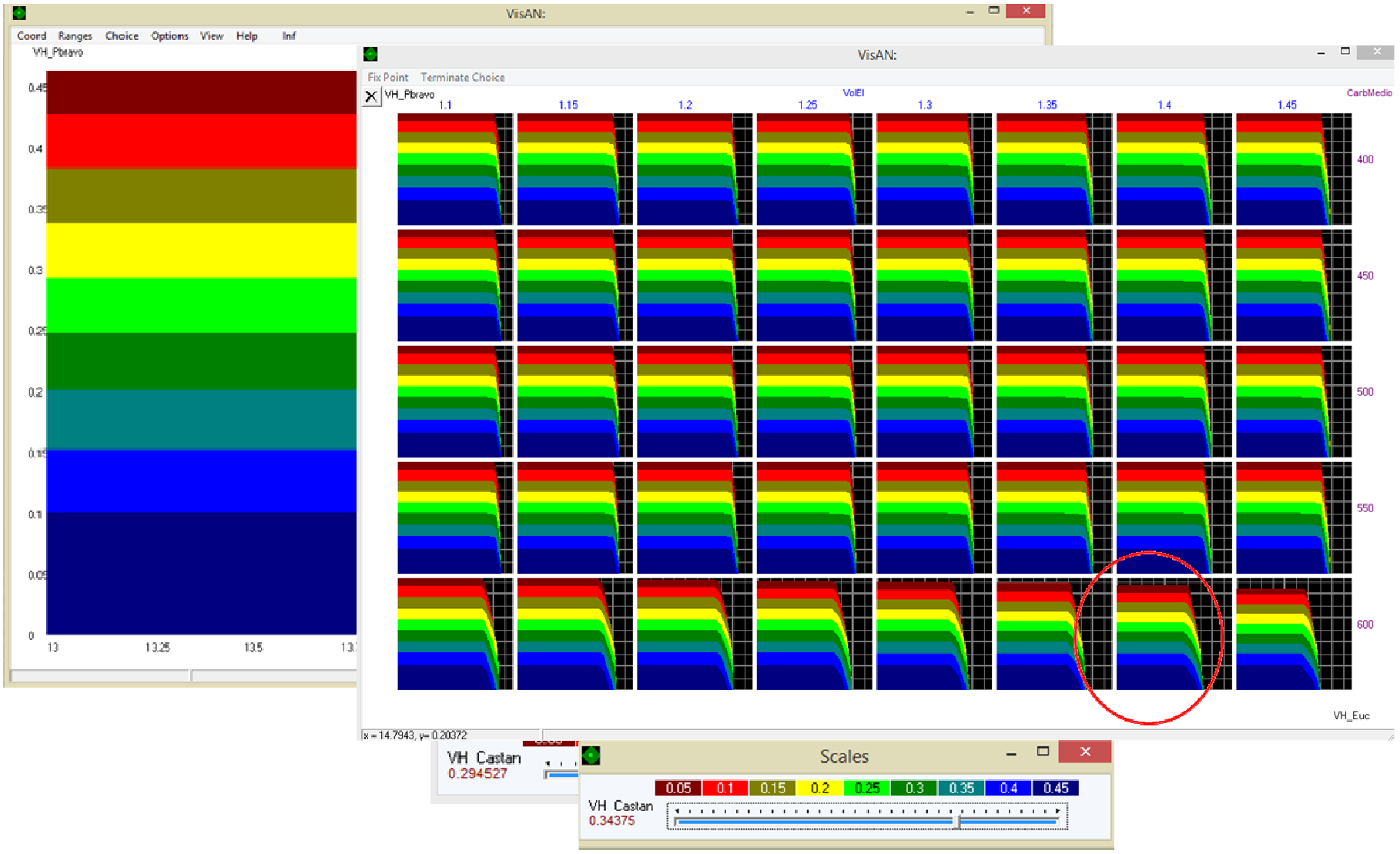
$$VEI = \sum_{i=1}^{N} \sum_{j=1}^{M_i} vei_{ij} x_{ij} \quad (15)$$

$$A\_FMP_f = \sum_{i:1}^{N} \sum_{j=1}^{M_i} x_{ij} \text{ , where } j \in FMP_f \text{ , } f = 1,..,\ 3,\ \text{F} \quad (16)$$

$$x_{ij} \geq 0, \forall i, j \quad (17)$$

Borges, J. G., J. Garcia-Gonzalo, V.A. Bushenkov, M. E. McDill, S. Marques and M.M. Oliveira 2014 Addressing multi-criteria forest management with Pareto Frontier methods: an application in Portugal *Forest Science* 60: 63-72. DOI: http://dx.doi.org/10.5849/forsci.12-100

The decision support system MCDM module



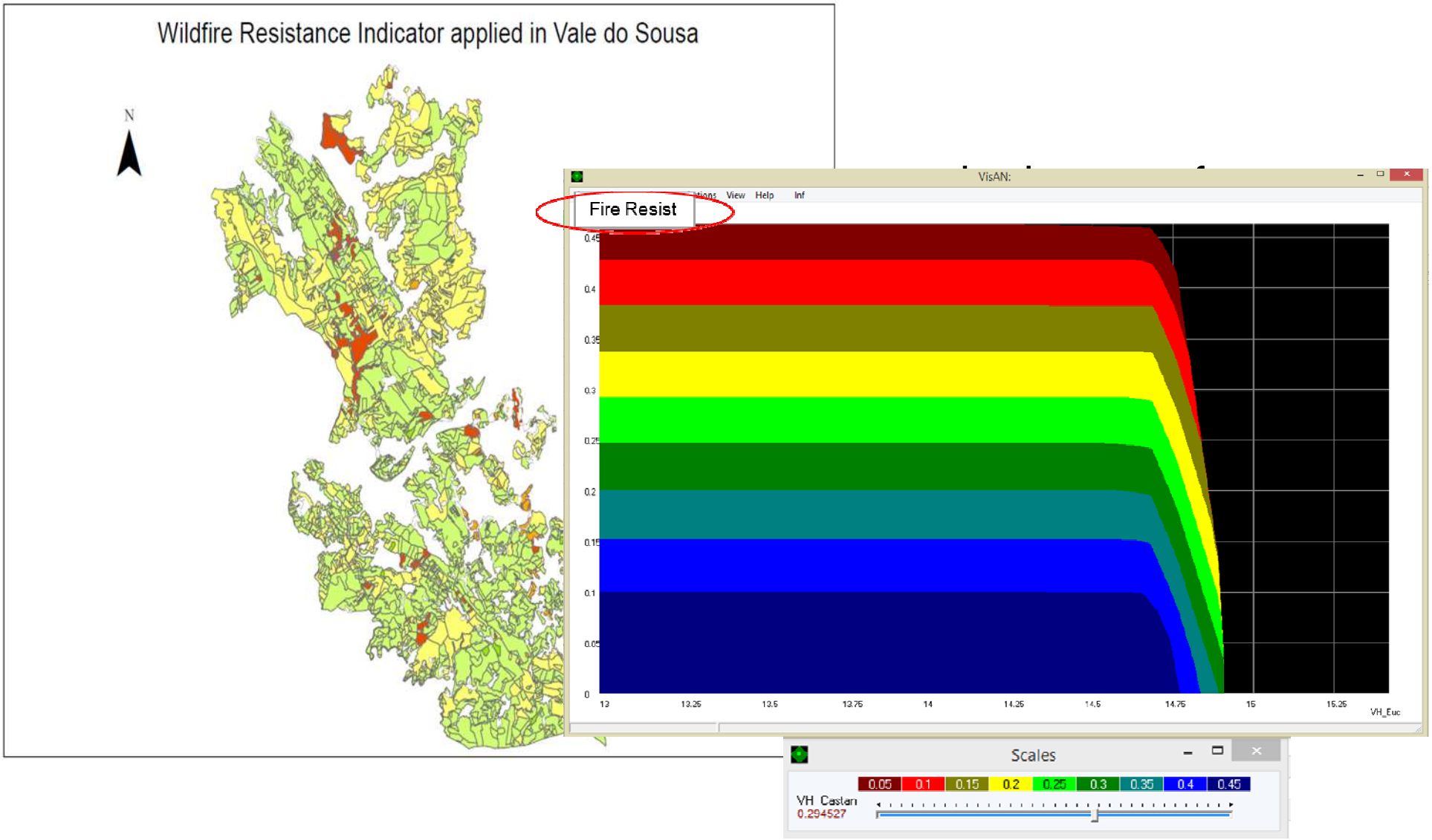
Results

Ecosystem Services	Units	2014-2104				
		1st estimate	2nd estimate			3rd estimate solution
			Group 1	Group 2	Group 3	
Eucalypt pulpwood	m^3	15.4 x 10^6	14.6 x 10^6	14.6 x 10^6	14.9 x 10^6	14.5 x 10^6
Pine saw logs	m^3	0.69 x 10^6	0.01 x 10^6	0.24 x 10^6	0.27 x 10^6	0.2 x 10^6
Chestnut saw logs	m^3	0.01 x 10^6	0.45 x 10^6	0.31 x 10^6	0.27 x 10^6	0.34 x 10^6
Volume of ending inventory	m^3	-	1.5 x 10^6	1.5 x 10^6	1.1 x 10^6	1.4 x 10^6
Average carbon stock	Mg/year	-	0.6 x 10^6	0..6 x 10^6	0.6 x 10^6	0.6 x 10^6

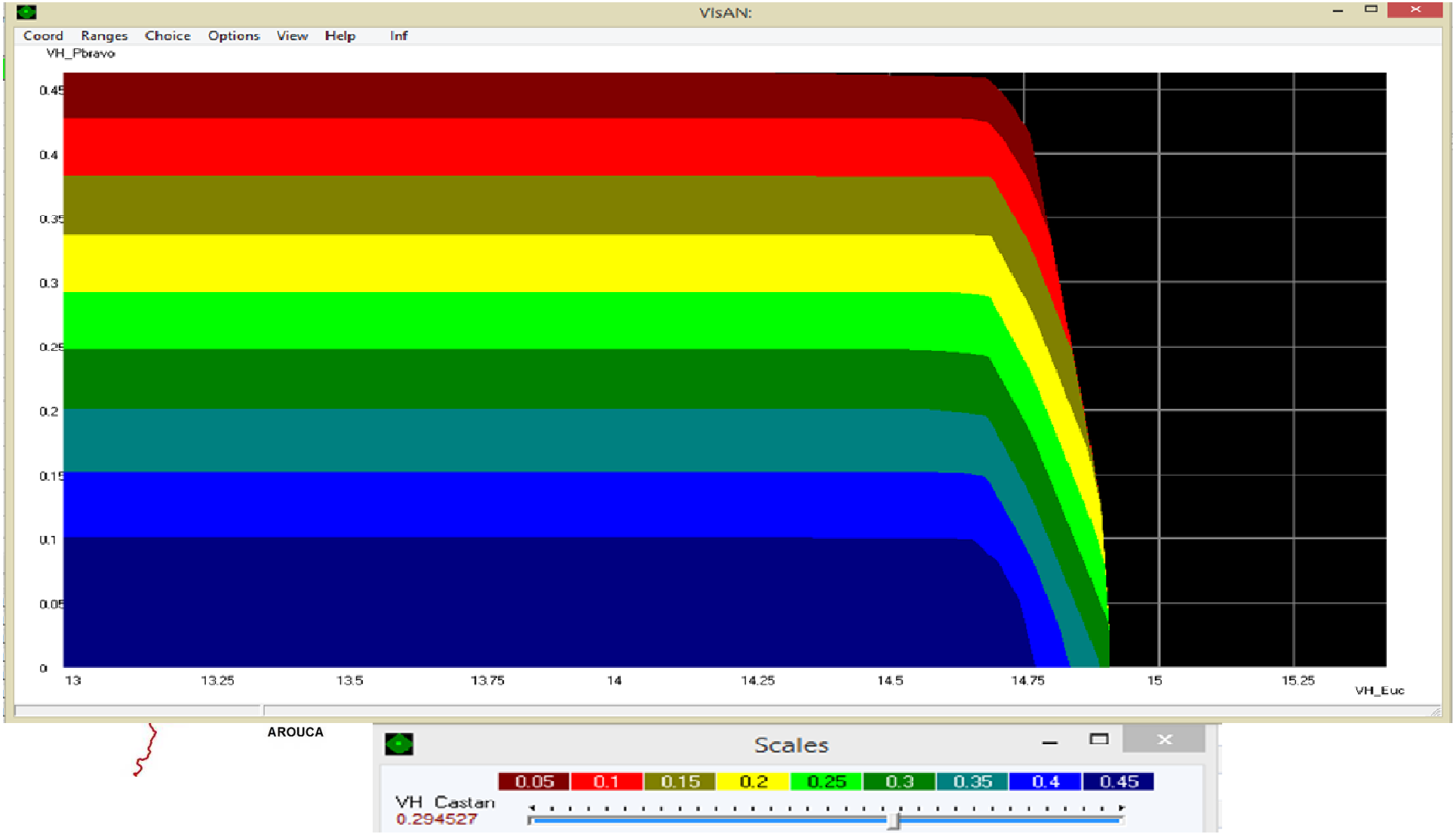
Results

Management Programs	Current		To meet targets (3rd estimate)	
	ha	%	ha	%
1 - Mixed maritime pine (*Pinus pinaster*) and eucalypt (*Eucalyptus globulus*) forest system, dominance of maritime pine	2302	16.0	462	3.2
2 - Mixed maritime pine (*Pinus pinaster*) and eucalypt (*Eucalyptus globulus*) forest system, dominance of eucalypt	2446	17.0	769	5.3
3 – Chestnut (*Castanea* sativa) forest systems for production of chestnut saw logs	101	1	1282	8.9
4 - – Eucalypt (*Eucalyptus globulus*) forest system for pulpwood production	9499	66.0	11875	82.5

Open problem 1



Open problem 2



Open problem 3

Table of Results per Period and Species

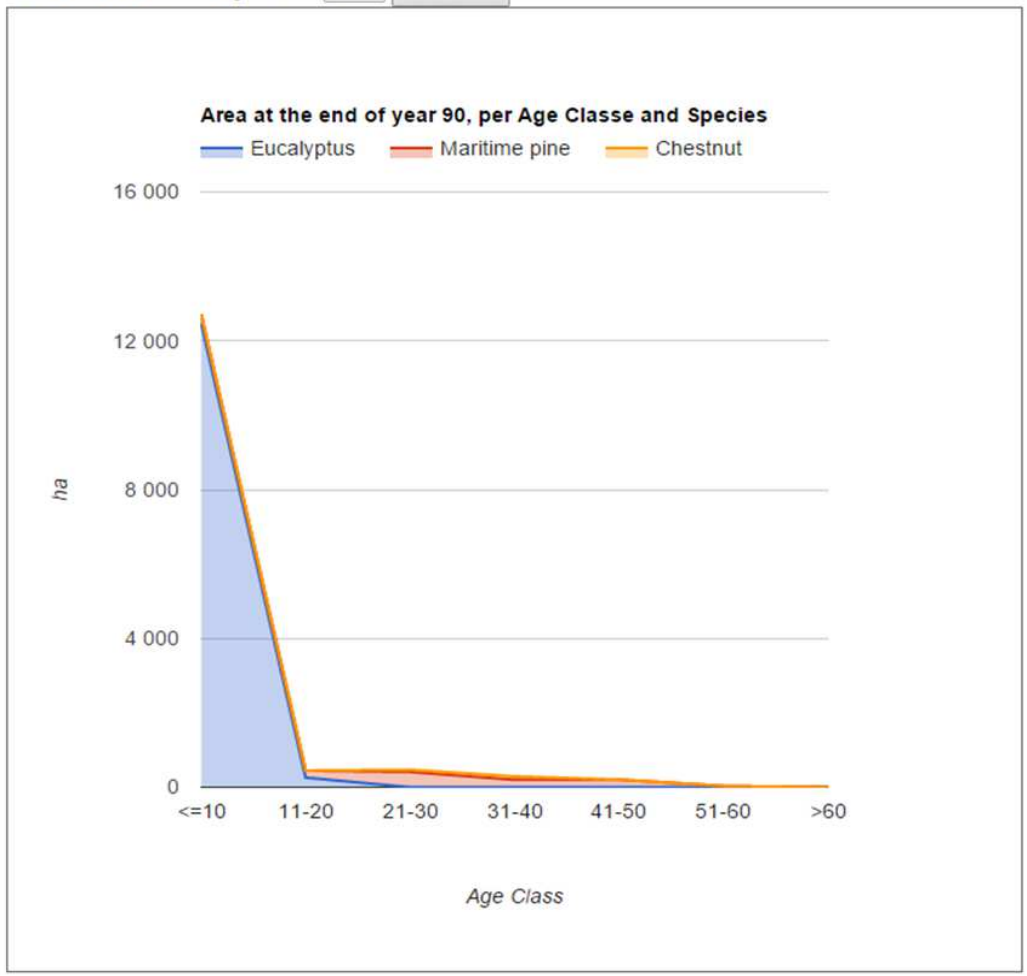
Choose one Species: Chestnut ▼ Show Table

Var	Period1	Period2	Period3	Period4	Perio
Volume of Ending Inventory (m3)	3 398,27	16 847,9	25 200,88	32 744,69	37 70
Harv. Volume (m3)	0	0	0	400,87	1 67
Thin. Volume (m3)	0	1 942,03	10 546,8	13 323,02	6 24
Timber Volume (m3)	0	1 942,03	10 546,8	13 723,88	7 91
Carbon Stock (Mg/y)	993,47	6 098,75	9 408,82	11 126,4	13 75

Area at the end of year 90, per Age Class and Species

Eucalypt Area = 89.89% | Maritime pine Area = 9.01% | Chestnut Area = 1.1%

Choose one Year of Planning Horizon: 90 ▼ Show Chart



Open problem 4

- ✓ Extend the functionality of the web based decision support system and develop integration with platforms such as Ecosel to provide payments for ecosystem services

BIOECOSYS

Thank you