Announcements

* Next class, please bring with you a calculator
- The slides were sent to your emails this morning.

1

Planning Process

1) Identify landowner objectives
    1) Vague objectives not easy to quantify
2) Management unit definition (land classification methods), if needed;
3) Inventory resources; identify management constraints
4) Identify potential management activities (Prescriptions)
    - including what, where and when
5) Evaluate and select management activities; write plan
    1) Goals are quantified
6) Implement management activities
7) Monitor implementation and outcomes
8) Periodically re-evaluate/revise the plan

2

Some terminology

- **Homogeneous:** of the same kind, composed of similar elements or parts; of uniform nature or character throughout.
- **Ecosystem:** A spatially explicit unit of the earth that includes all interacting organisms and components of the abiotic environment within its boundaries. Note that an ecosystem can be of any size. E.g., pond, field, forest…
- **Forest:** An ecosystem characterized by a more or less dense and extensive tree cover, often consisting of stands varying in characteristics such as species compositions, structure, age class, associated processes and commonly including meadows, streams, fish and wildlife. Can be a set of land parcels that has or could have tree vegetation and is managed as a whole to achieve the objective of the owner.

3

Some terminology

- **Physical land attributes:** the set of attributes used to characterize the permanent, physical nature of forestlands, including topography, soils, bedrock, climate, hydrology and habitat type.
- **Vegetation attributes :** The set of attributes used tree and other vegetation currently growing on forestland, including height, age, basal area, volume, average diameter, diameter distribution, crown density, species, cover type and community type.
- **Development attributes:** The set of attributes used to characterize the human organization, development and accessibility of forestland for human use, including ownership, roads, buildings, administrative boundaries, zoning boundaries and political boundaries.

4

Some terminology

- **Stand type:** Forestland considered homogeneous in terms of tree vegetation attributes
- **Stand:** A geographically contiguous parcel of land considered homogeneous in terms of tree vegetation
- **Stand polygon:** A stand, larger than some defined minimum size, that has been created through some mapping system. Its called a polygon because it's a multisided figure that represents a closed area on a map.
- **Land class:** Land is the homogeneous in terms of the physical, vegetation and development attributes chosen to classify the forest (synonyms: land type, analysis area, management unit).

5

Some terminology

- **Land class polygon:** A geographically contiguous parcel of land that is all of the same land class, larger than some defined minimum size, that has been created through some mapping system.
- **Spatial attributes:** Once a stand type or land classes are defined and mapped as individual stand or land class polygons a set of spatial can be measured or calculated such as distance of the polygon to a road or a stream , the fragmentation pattern of the polygons or the adjacency relation ships between polygons.
- **Stand and stand type prescriptions:** A schedule of activities (prescribed burns, harvests or other events) that, when implemented on a stand, stand type or land class is expected to achieve certain desired outcomes. Planting thinning, regeneration harvesting or fertilizing are typical activities used to achieve desired vegetation conditions or outcomes. Usually a myriad of different prescriptions are technically or biologically possible for each stand, stand type or land class as a function of a type of activity, the time of it application, and the sequence of activities that could be applied.

6

Identify Desired Future Forest Conditions

- Species composition
  - Conifers vs. hardwoods
  - Shrubs, invasive species, etc.
- Age structure
  - Even-aged vs. Uneven-aged
- Age-class distribution (even-aged)
  - For small properties, this may be more of a question of how many "stands" are there
- Wildlife
  - Dead wood, vertical structure, openings

7

Hierarchy of Planning

Strategic forest plans

- Performed annually or every 2 to 25 years
- Considers 40-100 years in to the future
- Necessary for looking at broad goals (e.g. balancing the age class distribution and long term sustainability)

Tactical forest plans

- Performed annually or every 2 to 3 years
- Considers 10-20 years in to the future
- Should be spatial explicit
- Look more in detail than strategic plans (e.g., spatial layout of treatments)

Operational forest plans

- Performed weekly or monthly
- Considers 1 week to 1 year in to the future
- Operational issues (e.g., budgets and manpower)

8

Inventory Resources

- Soils, topography, and water
  - Wetlands (lakes, ponds, vernal ponds, streams)
  - Access
- Timber
  - For each stand: area, dominant species, age, site class, volume, value, forest health, general condition (e.g., growth, basal area/stocking, advance regeneration, competing vegetation)
- Fish and wildlife
  - Threatened and endangered species
  - Biological diversity, dead wood, riparian zones
- Invasive species
- Recreation (e.g., trails); aesthetic features; archeological, cultural and historic sites

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Identify Management Constraints

- Threatened or endangered species
- Access
- Use zones
  - Buffers on home sites, streams, roads, trails, vernal ponds, etc.
  - No-harvest zones for topographic limitations (rocky, steep, wet, etc.), wildlife, or aesthetics
- Budgets
  - Landowners may be more willing to spend money when there is offsetting revenue

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Identify Potential Management Activities

- Regeneration harvests
  - Provide revenue
  - "Mature" stands
  - Is there advance regeneration?
    - If not, what treatments need to be done to establish advance regeneration?
  - Conversion/restoration options
    - E.g., natural to plantation, shift species composition

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Identify Potential Management Activities

- Thinnings
  - Can provide revenue now and improve revenues later
  - Create vertical structure
  - Usually in "poletimber" stands
  - May need markets for small-diameter and/or low-quality wood

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Identify Potential Management Activities

- Invasive species control
- Deer control
  - Fencing, Hunting
- Habitat improvement
  - Wildlife openings
  - Conifer cover
  - Dead wood

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Stand management prescriptions and the prediction of conditions and outcomes

- ***The empirical core of our professional claim to manage land scientifically and to ensure that owner objectives are met lies in our ability to predict the conditions and outcomes of current and future stands and stand types when managed under a specific prescription.***

- **Stand and stand type prescriptions:** A schedule of activities (prescribed burns, harvests or other events) that, when implemented on a stand, stand type or land class is expected to achieve certain desired outcomes. Planting, thinning, regeneration harvesting or fertilizing are typical activities used to achieve desired vegetation conditions or outcomes. Usually a myriad of different prescriptions are technically or biologically possible for each stand, stand type or land class as a function of a type of activity, the time of it application, and the sequence of activities that could be applied.

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Stand management prescriptions and the prediction of conditions and outcomes

-Definition of management alternatives (prescriptions) for each territorial unit

- In the presence of trees it involves the definition of silvicultural models
- Definition of land classification strategies
- Projection of results and conditions of interest associated with each management alternative in each territorial unit
- Definition of temporal and spatial hierarchies for management purposes
- Defining and implementing a management plan

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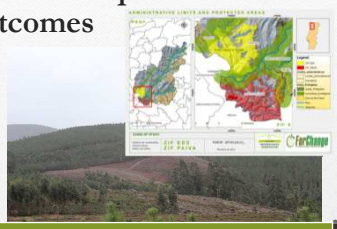
Stand management prescriptions and the prediction of conditions and outcomes

- ZIF Vale do Sousa, with about 14 388 ha Dominated by **eucalypt pure stands** (66%) and **mixed stands** of **eucalypt** and **Maritime pine** (33%) The remaining area is occupied by **hardwoods**.



Type of stand description	Prescription description
Mixed forest maritime pine (Pinus pinaster) and blue gum (Eucalyptus globulus), dominance of maritime pine	**Pine:** Rotation age: 40, 45, 50, 55 or 60 years, fuel treatments every 5 years, cleaning at 15 years of age, thinning occurring every five years in the period from 20 to 50 years of age (up to 5 years before the clearcut) based on a FW of 0.27. **Eucalypt:** Plantation with spacing of 1400 trees per ha. Rotation including 3 coppice cycles with 10 to 14 years. Stool thinning leaving an average 2 shoots per stool at year 2 of each cycle .
Mixed forest maritime pine (Pinus pinaster) and blue gum (Eucalyptus globulus), incipient management, dominance of eucalypt species	**Pine:** Rotation age: 40, 45, 50, 55 or 60 years, fuel treatments every 5 years, cleaning at 15 years of age, thinning occurring every five years in the period from 20 to 50 years of age (up to 5 years before the clearcut) based on a FW of 0.27. **Eucalypt:** Plantation with spacing of 1400 trees per ha. Rotation including 3 coppice cycles with 10 to 14 years. Stool thinning leaving an average 2 shoots per stool at year 2 of each cycle .
Plantation of sweet chestnut and cherry trees orchards in ancient agricultural fields	**Chestnut:** Plantation with spacing of 1250 trees per ha . Rotation age: 40, 45, 50, 55, 60, 65 and 70. Thinning occurring every five years in the period from 15 to 55 years of age (depending on the on tree diameter).
Blue gum (Eucalyptus globulus) plantations (short rotation) for short wood production	**Eucalypt:** Plantation with spacing of 1400 trees per ha. Rotation including 3 coppice cycles with 10 to 14 years. Stool thinning leaving an average 2 shoots per stool at year 2 of each cycle .

Stand management prescriptions and the prediction of conditions and outcomes

		Age Thinnings					Final
Id_presc	S	1º	2º	3º	4º	5º	harvest
301	20	20	30	35	50	-	55
302	20	20	30	35	50	55	60
303	20	20	30	35	50	55	65
304	20	20	30	35	50	55	70
305	23	15	25	40	45	-	55
306	23	15	25	40	45	-	60
307	23	15	25	40	45	-	65
308	23	15	25	40	45	-	70
309	26	15	20	25	30	35	40
310	26	15	20	25	30	35	45
311	26	15	20	25	30	35	50
312	26	15	20	25	30	35	55
313	26	15	20	25	30	35	60
314	26	15	20	25	30	35	65
315	26	15	20	25	30	35	70

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Stand management prescriptions and the prediction of conditions and outcomes

VS_Input_Optimizador_Castanheiro_DADOS3

id_UG	Area_ha	id_Presc	Year	Age	C	V	V_thin	V_harv	W_v@	W_a@	Wc	S
1045_Ct	2.458145971	305	2014	1	0.237686371	0.390968357	0	0	0	0	0	4
1045_Ct	2.458145971	305	2015	2	0.475372742	0.781936715	0	0	0	0	0	4
1045_Ct	2.458145971	305	2016	3	0.713059113	1.172905072	0	0	0	0	0	4
1045_Ct	2.458145971	305	...	…	...	...						
1045_Ct	2.458145971	305	2027	14	10.50848335	22.08804126	0	0	0	0	0	4
1045_Ct	2.458145971	305	2028	15	12.54138826	26.63263068	8.7	0	0	0	0	4
1045_Ct	2.458145971	305	2029	16	16.62135053	36.92102514	0	0	0	0	0	4
1045_Ct	2.458145971	305	...	...	...	...	0	0	0	0	0	4
1045_Ct	2.458145971	305	2038	25	48.58084683	125.0041225	8.9	0	0	0	0	4
1045_Ct	2.458145971	305	2039	...	...	...	...	0	0	0	0	4
1045_Ct	2.458145971	305	2052	39	68.68514921	197.6936599	0	0	0	0	0	4
1045_Ct	2.458145971	305	2053	40	68.57769119	198.631873	141.5	0	0	0	0	4
1045_Ct	2.458145971	305	2054	41	68.28136285	198.7453109	0	0	0	0	0	4
1045_Ct	2.458145971	305	…	…	…	…	…					
1045_Ct	2.458145971	305	2058	45	67.09604949	199.1990624	67.8	0	0	0	0	4
1045_Ct	2.458145971	305	...	...	...	...	...					
1045_Ct	2.458145971	305	2068	55	84.55540603	255.1977868	0	255.1977868	0	0	0	4
1045_Ct	2.458145971	305	2069	1	0.237686371	0.390968357	0	0	0	0	0	4
1045_Ct	2.458145971	305	2070	2	0.475372742	0.781936715	0	0	0	0	0	4

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Evaluate Management Alternatives

- Priorities
- Sustainability
  - Sustainability of a product flow (e.g. timber, cork)
  - Sustainability of some goods and services flows (e.g. timber, wildlife,...)
  - Sustainability of the ecosystem
- Timing
  - Cash flow
  - Work flow
- Optimization
  - Linear/integer/goal programming
  - Dynamic programming
  - Heuristics…

… The sustainability of a particular forest product flow may not be an appropriate indicator to assess the management impact on the satisfaction and the welfare of present and future generations. It suggests the integration of ecological and socio-economic interpretations of the sustainability concept over a hierarchy of temporal and spatial scales (Borges 1999)

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Characterizing decision making process

The view from Management sciences

3 types of decision making process:

- Rational
  - Data gathering, all scenarios analysis, best solution
  - Time and resources consuming, decisions based on complicated mathematical formulas
- Irrational
  - Limited (or no) data
  - Few alternatives are assessed
  - *Semi-rational (*best info in short period of time, uncertainties and short-commings of DB and models are assumed – *status quo)*
- *Garbage can model* (Cohen et al) (rarely used)
  - Unclear/conflicting/subjective goals

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Planning for the management of natural resources

Decision making is the process of identifying and selecting management alternatives and its based on the values and preferences of the decision makers.

There is no complete understanding of all alternatives and their impact and outcomes

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Planning for the management of natural resources

Decision Analysis

- All the analysis that precedes the decision
- Includes planning
- Goal analysis
- Sensitivity analysis
- Risk analysis

…decision analysis will not solve a decision problem, nor is intended to. Its purpose is to **produce insight** and **promote creativity** to help decision makers make better decisions (Keeney 1982)

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Outline for a Forest Management Plan

- Owner and Forester Information
  - Names, addresses, date
- Forest Description
  - Location, legal description, map, air photos
  - Special features
  - Stand descriptions
  - Area by forest type, site class, age-class
  - Inventory, growth by species group
  - Management issues
    - Advance regeneration, competing vegetation, threatened and endangered species, deer, invasive species, access, site limitations, stocking, access, etc.
  - Management zones

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Outline for a Forest Management Plan (continued)

- Management Objectives/Issues
  - Rationale, priorities, challenges, etc.
- Planned Management Activities
  - Activity schedule
    - By stand or by period
    - Including projected costs, revenues, products
  - Summaries of projected cash flows, products
  - Projected forest condition
    - Age-class distribution; species comp.
- Analysis of Management Alternatives
  - G&Y data and output
  - Financial analysis

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Outline for a Forest Management Plan (continued)

- Monitoring Plan
  - Recordkeeping plan
  - Items to monitor
    - E.g., regeneration, invasive species
  - Expected revision date
- Appendices
  - E.g., sources of information
  - Detailed calculations
  - Cost-share programs
  - Contractor information

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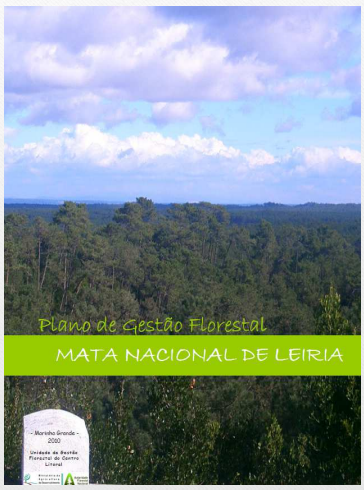
Forest Management Plan (Example)

http://www.icnf.pt/portal/florestas/gf/pgf/publicitacoes/encerradas/dcnf-centr/pgf-mn-leiria



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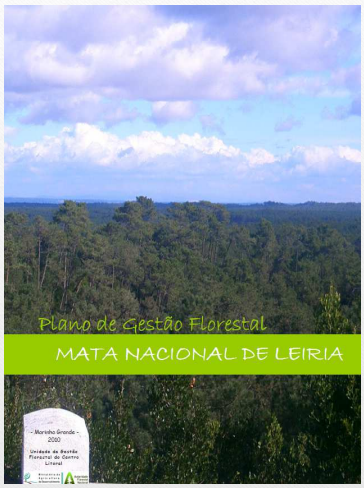
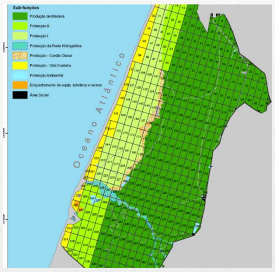
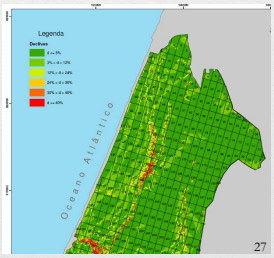
Forest Management Plan (Example)







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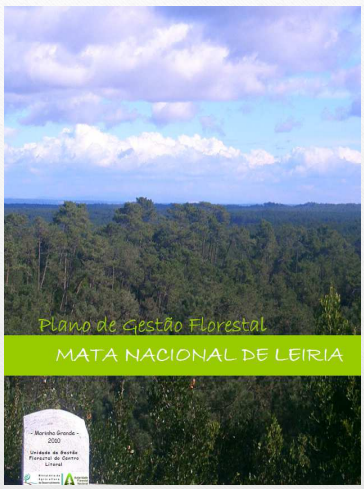
Forest Management Plan (Example)



RELATÓRIO

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SIMULAÇÃO DE PLANOS ESTRATÉGICOS PARA A MATA NACIONAL DE LEIRIA

SUMÁRIO

Objectivo do trabalho: Simulação de planos estratégicos para a área de pinheiro bravo da MATA NACIONAL DE LEIRIA no período entre 2007 e 2106, de forma a regularizar a distribuição de área por classes de idade e o fluxo de madeira ao longo do horizonte temporal de planeamento.

Dados e informação utilizados: A simulação teve por base:

- A organização da área de pinheiro bravo em 367 povoamentos, de acordo com critérios definidos pela Autoridade Florestal Nacional (AFN).
- Os dados biométricos relativos a cada povoamento e respectiva área, disponibilizados pela Autoridade Florestal Nacional.
- Horizonte de planeamento definido pela AFN.

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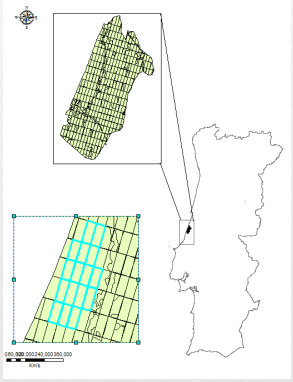
Elements and basic concepts of forest management and planning and forest resources management certification

A case study in Leiria National Forest



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Stand	Age (years)	Area (ha)	Vol (m^3)
1	43	31	268.9
2	43	29.8	268.9
3	43	30	268.9
4	43	28.9	268.9
5	53	29.2	331.3
6	53	29.8	331.3
7	53	29.8	331.3
8	53	30	331.3
9	33	29	193.6
10	33	29.5	193.6
11	33	29.6	193.6
12	33	30.5	193.6
13	23	28.5	107.5
14	23	28.9	107.5
15	23	29	107.5
16	23	29.7	107.5
Total		**473.2**	
Average	**38**	**29.6**	**225.3**

3 to 5 prescriptions with different harvest ages

Constant price = 15.5 €/m3
Discount rate = 3%

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Table 6.2 Prescription summaries for the 16 stands example forest

		FMA 1					FMA 2					FMA 3					FMA 4					FMA 5				
Stand	Period	Age	Vol	Cash	DR	HY	Age	Vol	Cash	DR	HY	Age	Vol	Cash	DR	HY	Age	Vol	Cash	DR	HY	Age	Vol	Cash	DR	HY
1	1	2	307.4	61.3	3,874.5	8	52		90.2			52		90.2			52		90.2			52		90.2		
	2	12		2.4			7	335.7	20.1	3,649	13	2	361.4	72.6	3,385.3	18	62		105.8			62		105.8		
	3	22		20.6			17		9.2			12		2.4			7	385.0	22.9	3,114.7	23	2	406.6	31.8	2,837.2	28
	4	32		47.2			27		31.9			22		20.6			17		9.2			12		2.4		
	Age			32					27					22					17					12		
	NPV			5,039.4					4,636.6					4,241.3					3,889.7					3,471.2		
	Vol El			181.8					140.0					96.6					54.3					20.7		
	VEI			1,144.9					987.6					852.0					735.0					634.0		
2	1	2	320.0	63.8	4,032.6	8	52		93.8			52		93.8			52		93.8			52		93.8		
	2	12		2.5			7	349.4	20.9	3,797.9	13	2	376.2	75.6	3,527.7	18	62		110.1			62		110.1		
	3	22		21.4			17		9.6			12		2.5			7	400.8	23.8	3,241.9	23	2	423.2	35.2	2,953.0	28
	4	32		49.1			27		35.3			22		21.4			17		9.6			12		2.5		
	Age			32					27					22					17					12		
	NPV			5,234.3					4,825.9					4,414.4					4,006.8					3,612.9		
	Vol El			189.2					145.8					100.6					56.5					21.5		
	VEI			1,151.7					1,028.0					886.7					764.9					659.9		
3	1	2	310.6	61.5	3,914.0	8	52		91.1			52		91.1			52		91.1			52		91.1		
	2	12		2.4			7	339.1	20.4	3,686.2	13	2	365.1	73.3	3,423.9	18	62		106.9			62		106.9		

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Optimization - Linear and integer programming

a) Objective function Z. In this abbreviated form it displays the decision variables $x_{kj,}$ i.e. the area of stand k assigned to prescription j, for stands 1, 2 and 16:

$$MAX\ Z = 5.0x_{11} + 4.6x_{12} + 4.2x_{13} + 3.9x_{14} + 3.5x_{15} + 5.2x_{21} + 4.8x_{22} + 4.4x_{23} + 4.0x_{24} + 3.6x_{25} + \cdots + 2.9x_{161} + 2.7x_{162} + 2.4x_{163} + 2.3x_{164}$$

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The maximization is subject to

b) The set of area constraints stating that the sum of the stand area assigned to each prescription cannot exceed the total stand area

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} = 31$$
$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} = 29.8$$
$$\dots$$
$$x_{161} + x_{162} + x_{163} + x_{164} = 30$$

c) The set of accounting equations to determine the volume harvested in each period H1 to H4.

$$30.7x_{11} + 32.0x_{21} + 31.2x_{31} + 32.0x_{41} + \cdots + 34.3x_{81} + 36.9x_{82} - H1 = 0$$
$$33.6x_{12} + 36.1x_{13} + 34.9x_{22} + 37.6x_{23} + \cdots + 31.6x_{111} + 32.3x_{121} - H2 = 0$$
$$38.6x_{14} + 40.7x_{15} + 40.1x_{24} + 42.3x_{25} + \cdots + 32.5x_{151} + 32.0x_{161} - H3 = 0$$
$$39.9x_{95} + 42.1x_{95} + 40.1x_{104} + 42.3x_{105} + \cdots + 34.9x_{162} + 37.6x_{163} - H4 = 0$$

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d) The set of accounting equations to determine the area harvested in each period AH_1 to AH_4.

$$x_{11} + x_{21} + x_{31} + \dots + x_{73} + x_{83} - AH_1 = 0$$
$$x_{12} + x_{13} + x_{22} + \dots + x_{111} + x_{121} - AH_2 = 0$$
$$x_{14} + x_{15} + x_{24} + \dots + x_{151} + x_{161} - AH_3 = 0$$
$$x_{94} + x_{95} + x_{104} + \dots + x_{162} + x_{163} - AH_4 = 0$$

e) The set of volume control constraints. It expresses a policy aiming at non-declining volume flows and at a maximum 10 percent increase of volume harvested in consecutive periods.

$$H1 - H2 \leq 0$$
$$H2 - H3 \leq 0$$
$$H3 - H4 \leq 0$$
$$H2 - 1.1H1 \leq 0$$
$$H3 - 1.1H2 \leq 0$$
$$H4 - 1.1H3 \leq 0$$

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f) The set of area control constraints. It expresses a policy aiming at maximum 10 percent fluctuations of area harvested in consecutive periods.

$$AH2 - 0.9AH1 \geq 0$$
$$AH2 - 1.1AH1 \leq 0$$
$$AH3 - 0.9AH2 \geq 0$$
$$AH3 - 1.1AH2 \leq 0$$
$$AH4 - 0.9AH3 \geq 0$$
$$AH4 - 1.1AH3 \leq 0$$

g) The set of non-negativity constraints.

$$x_{11}, x_{12}, x_{13} \ldots, x_{164}, x_{165} \geq 0$$

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A case study in Leiria National Forest

Harvest Plan		Problem 1	
Stand	Period	Year	LP
1	**1**		
	2	13	31.0
	3	23	
	4		
	No harvest		
2	**1**	8	0.8
	2	13	29.0
	3	23	
	4		
	No harvest		

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SADfLOR
A Web-Based Forest and Natural Resources Decision Support System
Welcome to SADfLOR
The SADfLOR web application is a decision support system to Eucalypt, Maritime Pine, Umbrella Pine and Chestnut stands. More...
New version to Maritime Pine simulator.
New Management Area: Vale do Sousa.
Incorporated the Pareto Frontier.
Seleccionar idioma
Tecnologia do Google Tradutor
Username:
Password:
Enter
Register
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cef Centro de Estudos Florestais
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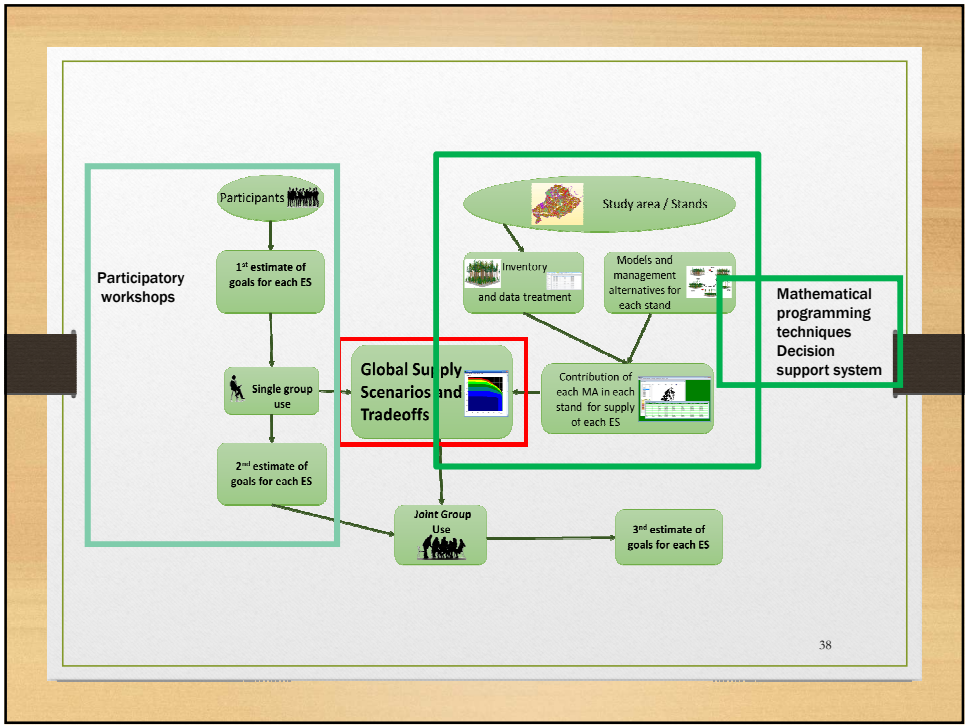
UNIVERSIDADE DE ÉVORA
CIMA
37


Participants
Participatory workshops
1st estimate of goals for each ES
Single group use
2nd estimate of goals for each ES
Joint Group Use
3nd estimate of goals for each ES
Study area / Stands
Inventory and data treatment
Models and management alternatives for each stand
Global Supply Scenarios and Tradeoffs
Contribution of each MA in each stand for supply of each ES
Mathematical programming techniques Decision support system
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CASE STUDIES

- **ZIF VALE DO SOUSA, Northern Portugal**

- About 14 388 ha with 1976 management units;
- Dominated by **eucalypt pure stands** (66%) and **mixed stands** of **eucalypt** and **Maritime pine** (33%) The remaining area is occupied by **hardwoods**.
- Ecosystem services:
  - Eucalypt pulpwood,
  - Maritime pine saw logs;
  - Chestnut saw logs ;
  - Carbon storage and
  - Volume of ending inver

- **ZIF CHOUTO PARREIRA, Central Portugal**

- Extends about 19526 ha and was classified into 5681 stands;
- Dominated by **cork-oak** (63%) and **eucalypt**(30%). Also have **Maritime pine** and **Umbrella pine** (7%).
- Ecosystem services:
  - Eucalypt pulpwood;
  - Cork;
  - Maritime pine saw;
  - Cones (pine nuts)
  - and carbon storage.

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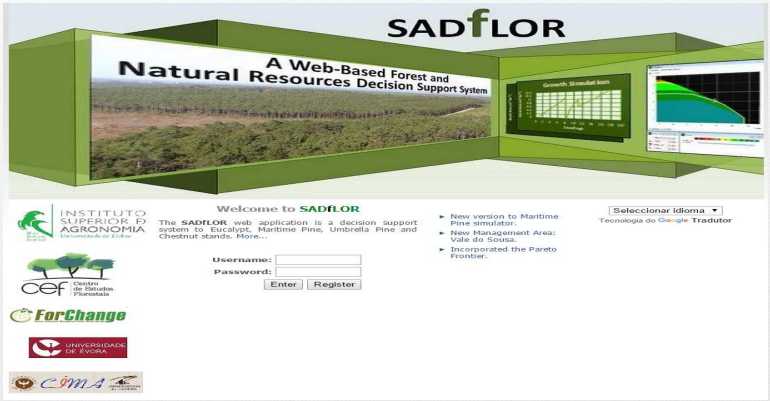
SADfLOR, a web-based Forest and Natural Resources DSS



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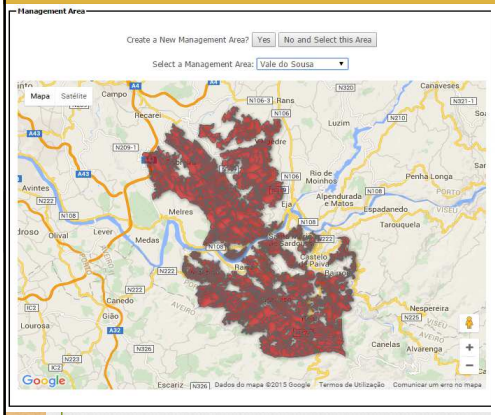
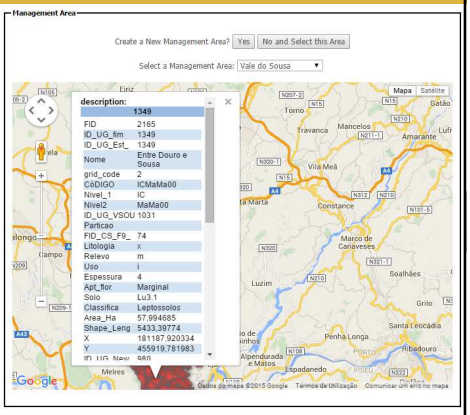
I. Management Area





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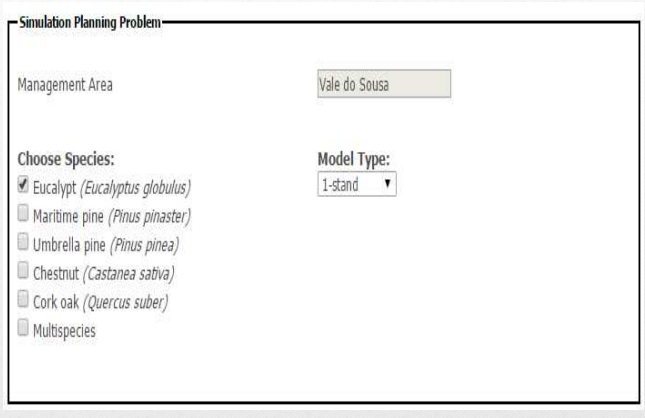
II. Simulation Planning Problem



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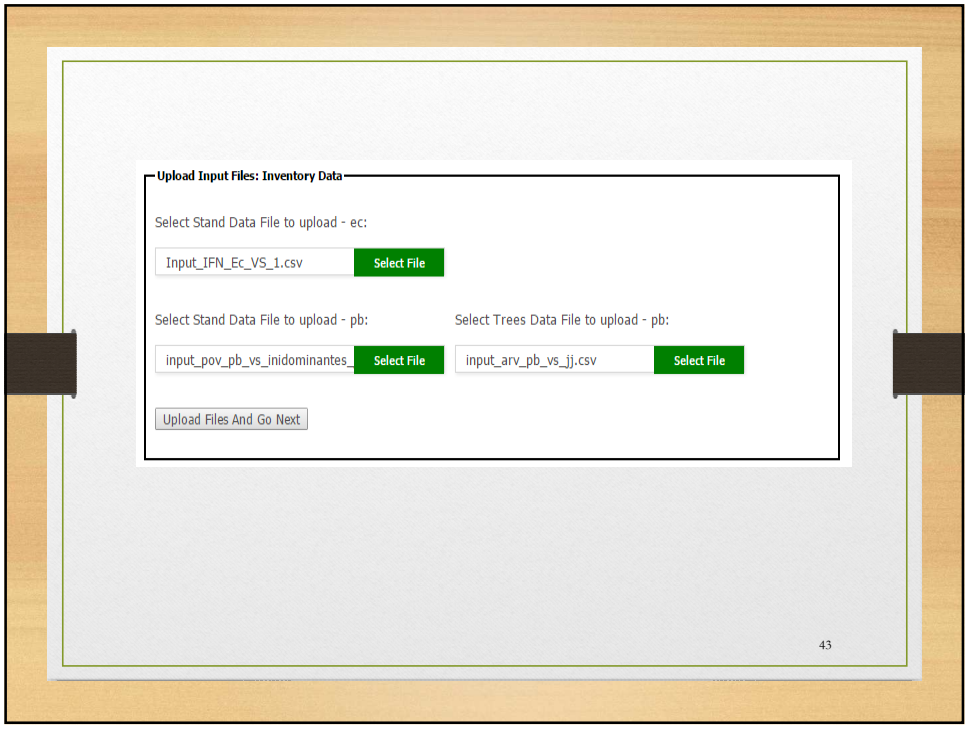
Upload Input Files: Inventory Data
Select Stand Data File to upload - ec:
Input_IFN_Ec_VS_1.csv
Select File
Select Stand Data File to upload - pb:
input_pov_pb_vs_inidominantes_
Select File
Select Trees Data File to upload - pb:
input_arv_pb_vs_jj.csv
Select File
Upload Files And Go Next
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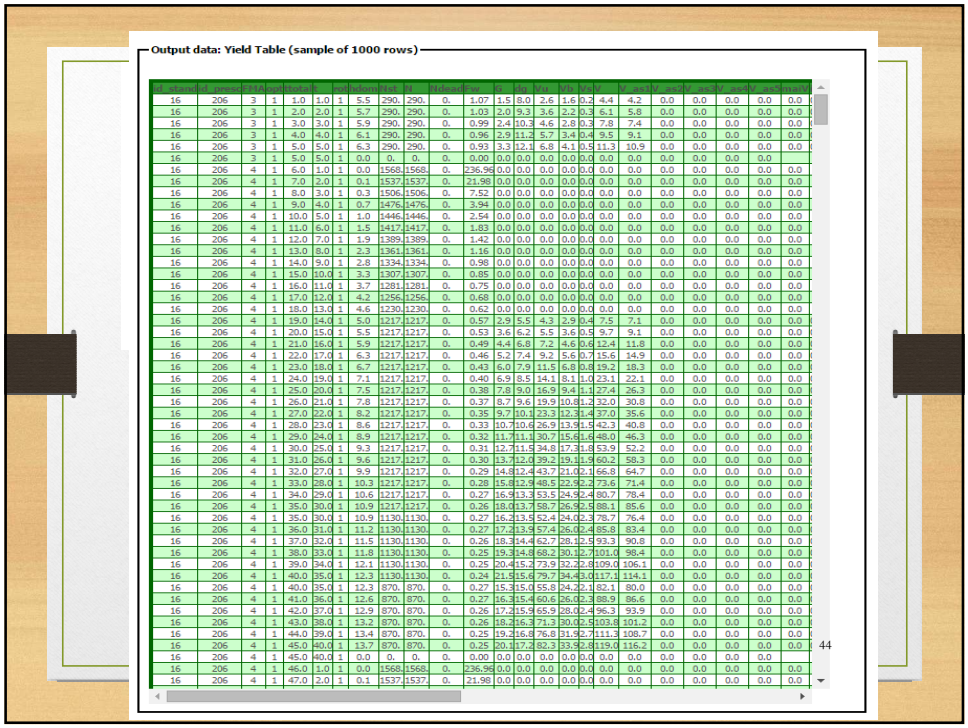
Output data: Yield Table (sample of 1000 rows)
44

XII. Optimization (Wood Products)

Parametrization of Decision Problem

Planning Horizon: 90 Planning Period: 5 Discount Rate: 5 %

Criteria: Wood Forest Products

Pine Timber(sawlogs) (m3/ha/year)	MAX	
Pulp wood (m3/ha/year)	Max flow deviation %	10
Chestnut wood (m3/ha/year)	Non Decreasing Flow	
Value of Ending Inventory (m3)	Specify a goal	10

45

XII. Optimization (Wood Products)

Parametrization of Decision Problem

Planning Horizon: 90 Planning Period: 5 Discount Rate: 5 %

Criteria: Wood Forest Products

Pine Timber(sawlogs) (m3/ha/year)	MAX	
Pulp wood (m3/ha/year)	Max flow deviation %	10
Chestnut wood (m3/ha/year)	Non Decreasing Flow	
Value of Ending Inventory (m3)	Specify a goal	10

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XII. Optimization (Non-Wood Products)

Parametrization of Decision Problem

Criteria: Non-Wood Forest Products

☑ AVG Carbon Stock (Mg/year)	MAX	
☑ Cones (Mg)	MAX	
☑ Cork (@)	Maximum Flow	45
☑ Recreation Area (ha)	Non Decreasing Flow	
☑ Total NPV (€)	Specify a goal	23
☑ NPV per Period (€)	Max flow deviation %	10

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XII. Optimization (cont.)

Parametrization of Decision Problem

Goals: ec

	Min dev	Max dev
Harvested Area (ha)	1	4
Contiguous Area Harvested (ha)	1	4
Harvested Area per age classe (ha)	1	4

Goals: pb

	Min dev	Max dev
Harvested Area (ha)	1	4
Contiguous Area Harvested (ha)	1	4
Harvested Area per age classe (ha)	1	4

Goals: ct

	Min dev	Max dev
Harvested Area (ha)	1	4
Contiguous Area Harvested (ha)	1	4
Harvested Area per age classe (ha)	1	4

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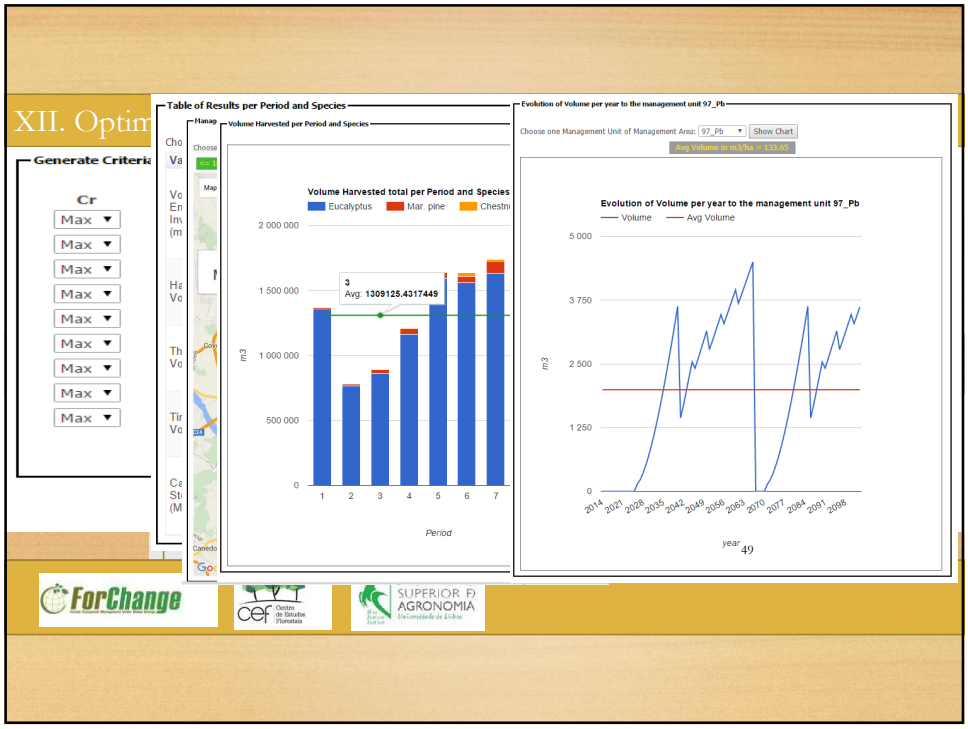
XII. Optim
Generate Criteria
Cr
Max
Table of Results per Period and Species
Volume Harvested per Period and Species
Volume Harvested total per Period and Species
Eucalyptus
Mar. pine
Avg: 1309125.4317449
Period
Evolution of Volume per year to the management unit 97_Pb
Choose one Management Unit of Management Area:
97_Pb
Show Chart
Volume
Avg Volume
year
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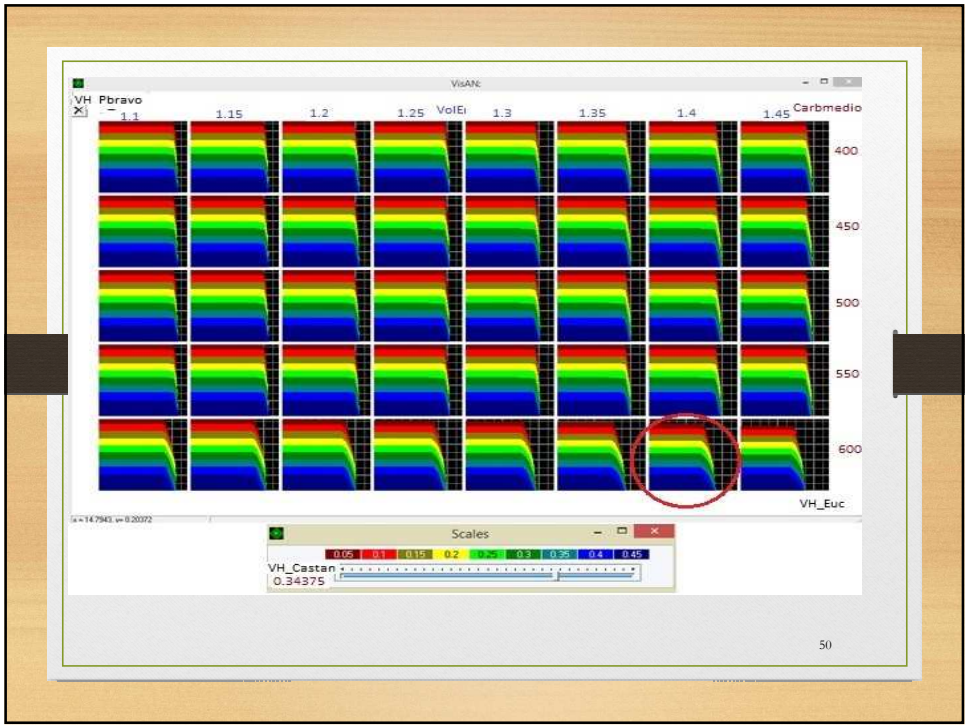
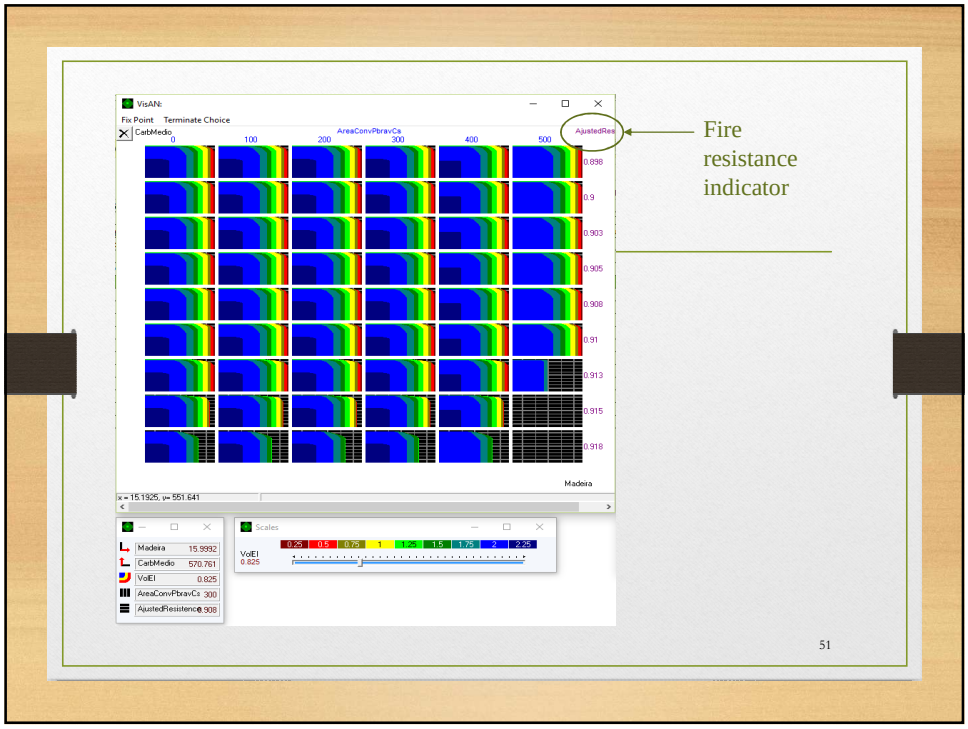

VisAN:
VH_Pbravo
VolEi
Carbmedio
VH_Euc
Scales
VH_Castan
0.34375
50



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

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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

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